APPENDIX 7C

FRESHWATER AQUATIC HABITAT AND FISH BASELINE REPORT

Baffinland Iron Mines Corporation

Mary River Project

November 2010

Freshwater Aquatic
Biota and Habitat
Baseline Synthesis Report
2005-2010

North/South Consultants Inc.
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Mary River Project

FRESHWATER AQUATIC BIOTA AND HABITAT BASELINE SYNTHESIS REPORT 2005-2010

November 2010

Report Prepared for Baffinland Iron Mines Corporation

by

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EXECUTIVE SUMMARY

The Mary River Project ("the Project") is a proposed iron ore mine and associated facilities located on North Baffin Island, in the Qikiqtani Region of Nunavut. The Project involves the construction, operation, closure, and reclamation of a 21 million tonne-per-annum (Mt/a) open pit mine that will operate for 21 years. The high-grade iron ore to be mined is suitable for international shipment after only crushing and screening with no chemical processing facilities. Three Mt/a of iron ore will be transported via an upgraded existing road to Milne Inlet where it will be stockpiled for shipment during the open-water season. A railway system will transport an additional 18 Mt/a of the ore from the mine area to an all-season deep-water port and ship loading facility at Steensby Port where the ore will be loaded into ore carriers for overseas shipment through Foxe Basin. A dedicated fleet of cape-sized ice-breaking ore carriers and some non-icebreaking ore carriers and conventional ships will be used during the open-water season to ship the iron ore to markets.

This environmental baseline study report has been prepared in support of an Environmental Impact Statement (EIS) for the Project, to be submitted by the Baffinland Iron Mines Corporation ("Baffinland") to the Nunavut Impact Review Board (NIRB).

This baseline study report presents a synthesis of information related to freshwater biota, including fish and lower trophic level communities, and aquatic habitat. Results for hydrology and water and sediment quality are presented in separate baseline reports (see Volume 7 Appendices 7A and 7B).

This baseline synthesis report is intended to provide a detailed description of the freshwater biota and habitat within the Project study areas and includes results of baseline studies conducted in support of the Project, information collected under the Inuit Qaujimajatuqangit (IQ) study, and literature review.

Freshwater biota and aquatic habitat are characterized for five study areas as follows:

- Milne Port Area;
- Milne Inlet Tote Road Area;
- Mine Area;
- Railway /Access Road Area; and
- Steensby Port Area.

Freshwater aquatic baseline studies for the Project were conducted by Knight Piésold Ltd. (Knight Piésold) and North/South Consultants Inc. (NSC) from 2005-2010. Fish and aquatic habitat baseline

studies were initiated by Knight Piésold in 2005, designed by Knight Piésold and implemented by NSC in 2006, and conducted by NSC in 2007-2010. Lower trophic level baseline studies were initiated by Knight Piésold in 2005 and 2006 and continued by NSC in 2007 and 2008. Freshwater aquatic field programs were limited to monitoring related to the Milne Inlet Tote Road in 2009 and limited baseline studies were conducted in 2010 across the five study areas.

Baseline study programs for describing aquatic biota and habitat included collection of information on:

- Aquatic habitat (streams and lakes);
- Primary producers (phytoplankton, periphyton, and aquatic plants);
- Secondary producers (zooplankton, invertebrate drift, and benthic invertebrates);
- Fish communities and populations;
- Fish condition;
- Fish movements; and
- Metals in Arctic char (*Salvelinus alpinus*) tissues.

There are only two fish species – Arctic char and ninespine stickleback (*Pungitius pungitius*) – present in the study areas. While both are generally abundant and widespread in distribution, ninespine stickleback are absent from the freshwater lakes and streams that were surveyed near the Milne Inlet coast. As all streams with the possible exception of large rivers freeze solid in winter, lakes provide the only overwintering habitat for both species and spawning habitat for Arctic char across the study areas. Many streams provide rearing and foraging habitat and potential protection from predators for juvenile Arctic char. Most of the drainage basins that support Arctic char either contain barriers preventing anadromous migrations and/or are distant from the coast and most populations in the five study areas are land-locked. Nearshore zones of larger lakes also provide rearing and foraging habitat and potential protection from predators for juvenile Arctic char, foraging and, in some cases, spawning habitat for adult Arctic char, and overwintering habitat for all life stages. Arctic char feed primarily on benthic invertebrates, although cannibalism occurs in a small proportion of at least some populations. Mercury concentrations in Arctic char muscle exceeded guidelines for human consumption in some fish captured in the Mine Area, although concentrations were similar to those reported for other land-locked Arctic char populations.

In general, the lower trophic level communities are similar to other areas of the Canadian Arctic. As is typical of Arctic ecosystems, the freshwater environment is relatively nutrient-poor and primary productivity is relatively low. In general, Arctic freshwater ecosystems are characterized by relatively low diversity of zooplankton communities due to low temperatures and nutrients; results of

the baseline studies for Mine Area lakes are consistent with this generalization. The benthic invertebrate communities in the Mine Area are generally moderately diverse, although higher diversity is found in some small tributaries, and are dominated by chironomids.

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1.0 INTRODUCTION

The Mary River Project ("the Project") is a proposed iron ore mine and associated facilities located on North Baffin Island, in the Qikiqtani Region of Nunavut (Figure 1-1). The Project involves the construction, operation, closure, and reclamation of a 21 million tonne-per-annum (Mt/a) open pit mine that will operate for 21 years. The high-grade iron ore to be mined is suitable for international shipment after only crushing and screening with no chemical processing facilities. Three Mt/a of iron ore will be transported via an upgraded existing road to Milne Inlet where it will be stockpiled for shipment during the open-water season. A railway system will transport an additional 18 Mt/a of the ore from the mine area to an all-season deep-water port and ship loading facility at Steensby Port where the ore will be loaded into ore carriers for overseas shipment through Foxe Basin. A dedicated fleet of cape-sized ice-breaking ore carriers and some non-icebreaking ore carriers and conventional ships will be used during the open-water season to ship the iron ore to markets.

This environmental baseline study report has been prepared in support of an Environmental Impact Statement (EIS) for the Project, to be submitted by the Baffinland Iron Mines Corporation ("Baffinland") to the Nunavut Impact Review Board (NIRB).

The freshwater baseline studies were developed using an ecosystem-based approach to provide information to prepare an EIS for the Project. For the freshwater aquatic environment, studies were designed to collect baseline information on specific aquatic ecosystem components including:

- Hydrology;
- Water quality;
- Sediment quality;
- Aquatic habitat;
- Lower trophic level biota (phytoplankton, zooplankton, periphyton, invertebrate drift, and benthic invertebrates);
- Fish populations/communities; and
- Metals and select elements in fish tissues.

This baseline study report presents a synthesis of information related to freshwater biota, including fish and lower trophic level biota, and aquatic habitat. Results for hydrology and water and sediment quality are presented in separate baseline reports (see Volume 7, Appendices 7A and 7B).

1.1 STUDY AREAS

This report presents baseline information on aquatic biota and habitat collected in five general study areas over the period of 2005 to 2010. These areas are:

- The Mine Area (Figure 1.1-1): lakes, rivers, and streams in the vicinity of the mine and camp that may be affected by the construction and operation of the Project. The area ranges from upstream of Project activities (i.e., upper Tom and Mary River watersheds) downstream to Angajurjualuk Lake. This area includes the Mary and Tom Rivers, Camp, Sheardown NW, Sheardown SE, and Mary, and Angjurjualuk lakes, and small tributaries to these larger waterbodies.
- Railway/Access Road Area (Figure 1.1-2): waterbodies that may be potentially affected by construction and operation of the rail line and access road. The Study Area includes stream crossing locations along these watercourses, lake encroachment sites, temporary camps, and quarry/borrow pit areas.
- The Steensby Port Area (Figure 1.1-3): lakes and streams in the vicinity of the Steensby Inlet Port Site, including waterbodies in the vicinity of the port infrastructure, the airstrip, and those that may serve as drinking water sources.
- Milne Port Area (Figure 1.1-4): lakes and streams in the vicinity of the Milne Inlet Port Site, including waterbodies in the vicinity of the port infrastructure, the airstrip, and ore stockpiles.
- Milne Inlet Tote Road Area (Figure 1.1-5): waterbodies that may be potentially affected by construction and operation of the upgraded and extended Tote Road and those that may serve as drinking water sources for the Milne Port.

1.1.1 Mine Area

The mine site is located approximately 160 km south of Pond Inlet on north-central Baffin Island. The site is situated on an elevated plateau to the south of a mountain range occurring along the north-eastern coast of Baffin Island (Figure 1.1-1). Elevation decreases gradually to the south before reaching Foxe Basin. The mine site area is characterized by low to moderate relief, rising from 160 m above sea level (ASL) at Mary Lake to 700 m ASL at Nuluujaak Mountain.

The mine site lies within the Mary River drainage, which forms part of the headwaters of the Ravn River watershed. The Mary River originates at a small icefield located on an elevated plateau to the north of Baffinland's ore deposits and drains to Angajurjualuk Lake, a large headwater lake in the Ravn River system. There are three major lakes (Camp, Sheardown, and Mary lakes) within the Mary River drainage in the Mine Area. Camp Lake has a surface area of approximately 2 km^2, a

shoreline length of 6.2 km, and an average depth of approximately 13 m. Several small tributaries that arise to the northwest of Nuluujaak Mountain drain into Camp Lake. In turn, Camp Lake flows into the north arm of Mary Lake.

Sheardown Lake is composed of two basins: a larger basin located to the northwest ("Sheardown Lake NW") approximately 0.7 km^2 in area, with a shoreline length of 4.6 km, and an average depth of 12 m; and, a smaller basin to the southeast ("Sheardown Lake SE") with a surface area of 0.24 km^2, a shoreline length of 2.8 km, and an average depth of 7.4 m. Several small tributaries in the area drain into Sheardown Lake, which in turn discharges to the Mary River.

Mary Lake, which has a surface area of approximately 14 km^2, a shoreline length of 55 km, and an average depth of 12 m, drains via the Mary River into Angajurjualuk Lake. The lake consists of a southern basin and a shallower, elongated north arm.

Lakes and streams in the area experience long periods of ice cover and rivers and creeks, possibly excepting very large systems, freeze to the bottom in winter (Volume 7, Appendix 7A). Flow typically begins in streams and rivers in early to mid-June with the onset of snow and ice melt, peaking in June or July. Lakes thaw more slowly and ice cover is typically gone by July. Flows and water levels may change rapidly in response to substantive precipitation events (Volume 7, Appendix 7A).

1.1.2 Railway/Access Road Area

The proposed Project includes a railway that stretches 143 km from the Mine Site to the southern terminus at the Steensby Port site (Figure 1.1-2). The railway corridor, which will include a construction access road, several spur roads to access aggregate source sites (borrow pits/quarries) and four construction camps, will traverse three major watersheds. From the mine site to approximately km 69 the line will traverse numerous watercourses that drain generally westward as part of the Ravn River watershed. From km 69 to approximately km 127 the line will pass through the Cockburn River watershed that flows southward to Steensby Inlet. The remainder of the line will lie within the Ikpikitturjuaq River watershed that drains southwestwardly and empties into Ikpikitturjuaq Bay, north of the Steensby Port site.

The access road will run adjacent to the railway for most of its length, with several minor deviations and two major deviations, one at Cockburn Lake and one to the north of the Ravn River crossing. Construction camps will be located north of the Ravn River crossing (Ravn River Camp), at Mid-Rail Camp Lake (Mid-Rail Camp), on the east side of the middle basin of Cockburn Lake (Cockburn Tunnels Camp), and near the southern end of Cockburn Lake (Cockburn South Camp). Numerous lakes in the vicinity of these camps were included in the study area.

The railway and access road will intersect numerous streams that will be crossed by culverts or bridges, and will encroach upon a number of lakes and ponds. Field studies generally were focused within the lease right-of-way for the railway and access road alignments, but ground or aerial surveys were also employed to identify the nearest upstream and downstream barriers to fish passage.

Railway and access road construction will require large volumes of aggregate material and numerous potential aggregate source sites have been identified. Most of these lie adjacent to either the railway or access road alignment, but some would be accessed via spur roads from the main access road.

1.1.3 Steensby Port Area

The Steensby Port Area consists of numerous lakes and streams in small, coastal watersheds and various components of larger catchments such as the watersheds of the Cockburn and Ikpikitturjuaq rivers (Figure 1.1-3). Most of the fresh water in this region lies in areas of relatively low relief with permanent or intermittent outflows to the sea.

1.1.4 Milne Port Area

The Milne Port Area includes a major coastal watershed (Phillips Creek), several small, coastal streams that drain directly into Milne Inlet, small, shallow headwater ponds near the coast, and deeper headwater lakes in the highlands to the southeast (Figure 1.1-4). Most of the freshwater streams in this region drain mountains to the east and west of Phillips Creek. Coastal areas within the footprint of existing and proposed port infrastructure are of relatively low relief with most streams having direct connections to Milne Inlet.

Existing facilities at the Milne Port Site were constructed in 2007-2008 to support the shipping of a bulk sample of iron ore from the Mine Area (see Section 8.0 for a description of the Bulk Sample Program and Milne Inlet Tote Road) and for sea lift shipments of supplies.

1.1.5 Milne Inlet Tote Road Area

As a component of advanced exploration at the Project site, Baffinland proposed baseline environmental and monitoring studies concerning the completion of a Bulk Sampling Program. The purpose of the Bulk Sampling Program, which was completed in 2007-2008, was to confirm the quality and marketability of the Mary River iron ore. As part of the Bulk Sampling Program initiative, upgrades to the original Milne Inlet Tote Road (Tote Road) were necessary to facilitate the transport of the ore to the coast at Milne Inlet, where the iron ore was transported via sealift to Europe for testing.

The Milne Inlet Tote Road, which was first established in the 1960s, runs approximately 105 km from the Mine Area near Mary River to Milne Inlet (Figure 1.1-5). It was designated as a public use road during the Nunavut Land Claims Agreement process and is defined as such in the North Baffin Land Use Plan. The completed road upgrades included adjustments to the road alignment to facilitate haul road travel, roadbed improvements, road widening and installation of drainage crossings along the route. Most of the existing drainage crossings from the 1960s were in very poor condition; many were built with makeshift, fuel barrel culverts which had collapsed or had been washed out. The Tote Road upgrades were designed to enhance the flow conditions of the waterways, reduce potential erosion related effects and improve the opportunity for fish to access approximately 53,000 m^2 of mainly upstream habitat. A more detailed description of the Bulk Sampling Program can be found in annual reports submitted to the Department of Fisheries and Oceans (DFO) and the no net loss plan (NNLP; Knight Piésold 2006, 2008, Baffinland Iron Mines Corporation 2009).

1.2 OVERVIEW OF BASELINE FIELD STUDIES

Freshwater aquatic baseline studies were conducted by Knight Piésold Ltd. (Knight Piésold) and North/South Consultants Inc. (NSC) over the period of 2005-2010. Fish and aquatic habitat studies were initiated by Knight Piésold in 2005, designed by Knight Piésold in 2006 but implemented by NSC, and conducted by NSC in 2007-2010. Lower trophic level baseline studies were initiated by Knight Piésold in 2006 and continued by NSC in 2007-2008.

1.2.1 Mine Area

The majority of the baseline studies were conducted in the Mine Area (2005-2010; Figure 1.1-1). Programs included collection of information on:

- Aquatic habitat (streams and lakes);
- Primary producers (phytoplankton, periphyton, and aquatic plants);
- Secondary producers (zooplankton, invertebrate drift, and benthic invertebrates);
- Fish communities and populations;
- Fish condition;
- Fish movements; and
- Metal and select elements in Arctic char (*Salvelinus alpinus*) tissues.

The programs involved characterization of the biological communities and their habitat in four lakes (Sheardown Lake NW and SE, Camp Lake, Mary Lake, and Angajurjualuk Lake) and their small tributaries, and the Mary and Tom rivers. In addition, a desktop screening exercise was conducted to

identify candidate references lakes for the area. One lake, hereafter referred to as the "Candidate Reference Lake" was identified in the screening and a field reconnaissance survey was conducted in 2008.

1.2.2 Railway/Access Road Area

Field studies within the Railway/Access Road study area (Figure 1.1-2) were initiated in 2007, expanded in 2008, and completed in 2010. Most of the stream crossing, lake encroachment and aggregate source sites were surveyed in 2007 to identify and assess fish habitat that could potentially be affected by Project activities. Follow-up work conducted in 2008 and 2010 was focused on gathering additional information from these identified sites, completing site surveys from locations that could not be surveyed in 2007, and surveying additional sites that were added subsequent to railway and access road alignment adjustments made in 2008.

Cockburn Lake is the largest lake within the study area and the railway will run adjacent to it for most of the lake's length. The lake will also be crossed at its north end by a multispan railway bridge that is 289 m in length and two temporary construction camps will be located near its shores. Given these various Project interactions and the fact that the lake is known to be important fish habitat, a number of studies were conducted to specifically focus on the habitat and fish populations within the lake. These included detailed bathymetric and substrate classification surveys, as well as gillnetting and electrofishing surveys.

The four proposed construction camps may potentially affect the aquatic environment because of physical footprints, access roads, and infrastructure associated with drinking water withdrawal and sewage disposal. Habitat and fish population studies were conducted on all relevant waterbodies to provide the information necessary to identify and assess the potential effects. In some case (e.g., Mid-Rail Camp), surveys were conducted to ascertain connectivity between waterbodies and direction of surface water flow.

1.2.3 Steensby Port Area

Aquatic biota and habitat baseline studies at the Steensby Port Area (Figure 1.1-3) were largely conducted in 2008 and 2010 once the Project description was advanced, although limited work was also conducted in 2007. Studies included surveys to determine fish presence/absence and distribution, fish barriers, interconnectivity of waterbodies, and habitat assessments. Information on primary production (i.e., phytoplankton) was obtained in 2008 at selected lakes in conjunction with the water quality sampling program.

1.2.4 Milne Port Area

Streams in the area crossed by the Milne Inlet Tote Road (Figure 1.1-4) were assessed for fish and fish habitat during construction and monitoring phases of the Bulk Sample Program from 2006-2010 (see Section 8.0 for more details regarding methods and results). The current Project includes proposed expansion of port facilities to support trucking of ore from the Mine Area and subsequent loading to ships.

Additional aquatic baseline studies were conducted in 2010 to supplement data collected during Milne Inlet Tote Road studies (Section 8.0) and support potential expansion of Milne Port Area infrastructure and operations. Baseline studies focused primarily on aquatic habitat and fish presence/absence in streams and lakes in the Milne Port Area.

1.2.5 Milne Inlet Tote Road Area

The purposes of Milne Inlet Tote Road environmental baseline studies were to identify and describe fish habitat in watercourses crossed by the Milne Inlet Tote Road (Figure 1.1-5) and determine the extent of fish use of available habitat. Monitoring studies were conducted following completion of road upgrades and the Bulk Sampling Program to enhance and compare with information collected during baseline studies. Monitoring studies were also designed to identify and mitigate any potential issues that may arise during the upgrading and maintenance phases of the Milne Inlet Tote Road. Work was initiated in 2006 and continued from 2008 through 2010.

1.3 OVERVIEW OF REPORT

This report presents information on:

- Information collected under the Inuit Qaujimajatuqangit (IQ) study. Information relevant to freshwater biota and habitat for the Project areas and Regional Study Area has been summarized (Section 2.0).
- A literature review was conducted to compile relevant scientific information for the Project areas and the RSA as a whole. This information is presented in Section 3.0; and
- An overview of methods and results of the aquatic biota and habitat baseline studies programs conducted for the Mary River Project from 2005-2010. Information is presented according to the five Project areas in Sections 4 through 8.

2.0 INUIT QAUJIMAJATUQANGIT STUDIES

2.1 INTRODUCTION

Inuit Qaujimajatuqangit (IQ) studies began in Pond Inlet in 2006, expanded to Igloolik and Arctic Bay in early 2007, and to Hall Beach and Clyde River in 2008. Studies were initiated in those communities with the closest ecological and socioeconomic ties to the Project first, and then expanded to the other potentially affected communities.

The primary objectives of the IQ study were to:

- Obtain local knowledge of wildlife, land use and areas of cultural value;
- Identify potential Project interactions with the above; and,
- Support Project decision-making and environmental assessment.

A total of 45 individual surveys were conducted with elders and several workshops were held within the five communities. During the surveys elders were asked the following questions with respect to Arctic char and were asked to identify key features (i.e. the presence of Arctic char or harvest locations) on maps:

- Can you identify the lakes and rivers that have fish? Are they land-locked or fish that go downstream to the sea?
- For sea-run char, when do they run upriver and downriver?
- Where do Arctic char spawn? What time of year do they spawn?
- What do the fish eat?
- Have you noticed any change in the size of the Arctic char? Have there been any changes in the health of the Arctic char?
- Can you show the rivers and lakes that are important to you and explain why they are important?

This section synthesizes IQ pertaining to freshwater fish habitat and fish communities. Although this section does not explicitly describe Inuit resource use, local observations that were likely made during resource use activities are included. IQ observations included: fish distribution; locations of freshwater resident and anadromous (sea migrating) char populations; age distributions of fish populations, water conditions affecting fish movements; fish heath and condition; changes in and observations of fish abundance; and locations of fish barriers. Where available, IQ study knowledge was compared and contrasted with additional literature sources.

2.2 CURRENT CONDITIONS

The following sections summarize IQ information for the RSA and the five Project study areas. Lakes identified explicitly as containing anadromous (sea-run) and freshwater resident (identified as "land-locked") char in the RSA are shown in Figure 2.2-1.

2.2.1 Regional Study Area

IQ recognizes the existence of anadromous and freshwater resident forms of Arctic char. Freshwater resident char were reported to be either land-locked (i.e. physically isolated from the ocean by a barrier) or non-migratory (i.e. physical barriers were not preventing migration to the sea). Those char that undertake migrations from freshwater out to the sea (anadromous) are called Ivisaaruit and freshwater forms that do not migrate and are land-locked are called Ivisarualuit [Piuyuq Tatatuapik (AB), Matthew Akoomaklik (PI), Joannasie Mucpa (PI)]. A sub-group of freshwater resident char were reported to be generally smaller and are referred to as Nutigliarjuk, translated as "small fish" [Samuelie Ammaq (IG)], which may be in reference to char with a form of dwarfism also noted by Stewart and MacDonald (1981). However, larger freshwater resident char specimens have been noted by IQ [Joannasie Mucpa (PI)] and in literature (DFO 2005). In general, freshwater resident populations were also noted to be darker with "dots" [Joannasie Mucpa (PI)], and widespread in most lakes, even small lakes [Samuelie Ammaq (IG), Gideon Taqaogak (IG)]. Anadromous populations were noted to be red in colour [Daniel Komangapik (PI)] and are preferred for eating.

Locations further inland without sufficient outflows to the sea were stated to contain land-locked char [Gamailie Kikukishak (PI)]. Numerous small lakes in the Milne area were noted to contain land-locked char as well as Nina Bang Lake and Angajurjualuk Lake [Ishmailie Katsak (PI)]. Downstream of Angajurjualuk on the Ravn River system, Inuktorfik and Patiok Lakes were reported to have land-locked char populations. Also on the Ravn River system, overwintering was stated to occur in lakes such as Quartz and Erichsen [Taqqaugaq (IG), Theo Ikummaq (IG), Abraham Ulayuruluk (IG)]. Literature supports the presence of anadromous char below Erichsen Lake (Stewart and MacDonald 1981).

For anadromous populations, migration downstream begins in June or July after break-up [Muctar Akumalik (AB), Abraham Ulayuruluk (IG)] returning at the end of August. It was noted however, on rivers with weaker currents, fall migration might begin earlier [Abraham Ulayuruluk (IG)].

Spawning was stated to occur in the fall [Sanguya Qamaniq (PI)] with spawners building nests of small stones to lay their eggs in (redds) and in close proximity to other spawners [Ishmael Katsak (PI)]. Spawning was thought to occur annually [Joannasie Mucpa (PI), Matthew Akoomalik (PI)]

though literature suggests that spawning is more likely to occur every two to four years (Sprules 1952, Johnson 1989, Richardson et al. 2001, Evans et al. 2002).

IQ acknowledges that char diet consists of cod, shrimp, minnows, eel blenny and Tuligunnaaq [Daniel Komangapik (PI), Qamaniq Sanguya (PI)], which is thought to be a pteropod of the genus *Limacina,* when in the marine environment. When char migrate to freshwater environments, IQ reported that little was eaten during winter months in the freshwater environment. It was believed that freshwater char fed on smaller fish [Ishmael Katsak (PI)].

IQ study participants did not report on changes in the abundance of fish over time in the RSA. Near Pond Inlet two participants noted that char abundance had declined in the past but numbers were recovering [Daniel Komangapik (PI), Gamalailie Kilukishak (PI)] though another participant noted declines in abundance in Tuugaq Lake [Ishmael Katsak (PI)].

With regard to fish health, no information was specific to the RSA. IQ stated that indicators of fish illness included a skinny appearance [Gamailie Kilukishak (PI)], evidence of thickness in the intestines and that fish tend to spoil or get mushy very quickly [Ishmael Katsak (PI)]. Several individuals noted that skinny fish are not eaten. No changes in fish health were reported.

Lake trout (*Salvelinus namaycush*) were reported to be absent in the RSA [Hall Beach Marine Mammal Workshop participant]. No IQ information was recorded with regard to ninespine stickleback (*Pungitius pungitius*). Site-specific fish barriers which were identified are displayed on Figure 2.2-1, though reporting of fish barriers was subject to some misinterpretation as some study participants understood fish barriers to mean fishing weirs.

2.2.2 Project Study Areas

2.2.2.1 Mine Area

Although general agreement occurred with regard to freshwater resident char overwintering primarily in lakes, one study participant thought that the Mary River might support overwintering char which is suggestive of a riverine population being present in the study area, though a precise location was not specified [Gamailie Kilukishak (PI)]. Mary Lake was stated to have a char population. Although no specific char IQ was collected with respect to Camp Lake and the two Sheardown Lakes, indications that downstream Angajurjualuk Lake contains land-locked Arctic char would suggest that no anadromous char would be present in these lakes.

2.2.2.2 Railway/Access Road Area

Cockburn Lake was reported to be an overwintering lake for char [Abraham Ulayuruluk (IQ)] with a resident non-migratory population in the main basin [Muctar Akumalik (AB)]. An Igloolik resident suggested that migration of anadromous char occurred between Steensby Inlet and Cockburn Lake via the Cockburn River system [Theo Ikummaq (IQ)] suggesting that both anadromous and freshwater char reside in the lake. Kroeker (1987) reported that local fishers had observed upstream movement of anadromous char to Cockburn Lake on August 25th of the previous year, the lateness of which was noted as unusual for char but considered normal by local fishers for this river.

2.2.2.3 Steensby Port Area

Three lakes close to the Steensby port site were reported to have char populations including Ikpikitturjuaq also known as Lake ST-347 and its largest upstream lake, ST-176, located to the east southeast. The third lake noted with char populations was ST-352 [Hall Beach Marine Mammal Workshop participant].

Fish were noted to be abundant in Ikpikitturjuaq in summer and anadromous. Kroeker (1986) as part of a Steensby test fishery investigation documented that local fishers felt that anadromous char moved freely from Ikpikitturjuaq and the sea via the Ikpikitturjuaq River. The fish were reported to be concentrated at the mouth of the river. There was no indication of anadromy occurring in ST-352 or ST-176. Both Ikpikitturjuaq and ST-352 lakes were specified as important by five Igloolik IQ study participants. These lakes were also noted to be drinking water sources [Ikey Kigutikkarrjuk (IG)].

2.2.2.4 Milne Port Area

Little IQ information was provided with regard to freshwater environments in the immediate vicinity of the Milne Port site. The presence of char was noted for some inland lakes, some of which were indicated to be land-locked (Figure 2.2-1). Agreement generally existed that char were ubiquitous in most lakes in the area.

2.2.2.5 Milne Inlet Tote Road Area

Muriel and McQuat Lakes were noted to contain char. Anadromy or freshwater resident characteristics of these populations were not specified.

3.0 LITERATURE REVIEW

Literature searches were conducted to identify any existing scientific literature that was relevant to discussing the lower trophic biota and fish communities within the Project study areas, but very little relevant information was found. Lower trophic information was limited to one report by Stewart and MacDonald (1981).

Stewart and MacDonald (1981) also provided some information on fish populations for several lakes and streams within the RSA, and this report represented the only source of existing information for inland fish populations. Kroeker (1986, 1987) reported the results of test fisheries conducted on 10 rivers in the Steensby Inlet area, including the Ravn, Cockburn and Ikpikitturjuaq rivers, all of which support anadromous populations of Arctic char. Additional information regarding coastal Arctic char fisheries, including commercial/domestic quotas, harvest statistics and test fisheries, was derived from various published reports by DFO.

4.0 MINE AREA: BASELINE STUDIES

The following provides a description of methods and results of baseline field programs for freshwater biota and habitat for the Mine Area. Information is presented for aquatic habitat (Section 4.1), primary producers (Section 4.2), secondary producers (Section 4.3), fish populations (Section 4.4) and fish metals (Section 4.5).

4.1 AQUATIC HABITAT

Fish habitat is defined in the *Fisheries Act* as "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".

Because fish habitat is defined by its capability to support fish life processes (including food production), the term aquatic habitat is used in this section to describe the structure of the environment within which fish, and the aquatic biota on which they feed, live. Aquatic habitat is typically described on the basis of water depth, water velocity, water temperature, substrate type, and cover (including deep pools, boulders and undercut banks). These characteristics determine whether individuals, communities, and populations of fish and other aquatic biota may find the biophysical features they require for life, such as suitable areas for reproduction, feeding sites, resting sites, cover from predators and adverse environmental conditions, movement corridors, and overwintering. The biophysical characteristics of the habitat play a large role in determining the species composition and biomass of the biotic community that can be sustained.

A description of primary producers, secondary producers and the fish community occupying the aquatic habitat of the Mine Area is area is provided in sections 4.2, 4.3 and 4.4, respectively.

4.1.1 Lakes

The following provides a description of methods and results of studies conducted to describe aquatic habitat in lakes in the Mine Area.

4.1.1.1 Methods

Field Methods

Minimal information to describe the aquatic habitat of lakes specific to the Mary River Mine Area has been documented prior to 2007. The 2007-2010 lake aquatic habitat studies were intended to characterize and quantify aquatic habitat in a number of Study Area lakes, including Camp, Sheardown, and Mary lakes, and a candidate reference lake (for Sheardown Lake) in the Mine Area,

during the open-water period. Detailed aquatic habitat information was collected during open-water using established techniques through bathymetric and substrate surveys (single beam sonar system), deployment of staff gauges and temperature loggers (Onset HOBO Water Temp Pro v2 temperature loggers), and surveys of shoreline habitat at selected locations in lakes. Methods are described in detail in NSC (2008a).

Data Analysis and Aquatic Habitat Classification

Lake habitats were mapped with Geographic Information System (GIS)-based techniques (QTC VIEW V data analyzed using IMPACT software; geo-referenced depth values and substrate distribution patterns were mapped using ESRI ArcGIS 9.2®) (NSC 2008a). To provide a framework for assessing and describing the represented lake habitat types, a hierarchical classification system was devised. The classification system devised was based on one developed by the USGS (1998), which was modified to reflect the conditions in the Mine Area. It should be noted that estimates of the spatial extent of aquatic habitat types are based on extrapolations from bathymetric maps.

A classification system was developed for lake habitats within the Mine Area using the following categories: relative water depth (bathymetric surveys) and the maximum depth of light penetration (depth of euphotic zone estimated using Secchi Disk depth); substrata type (e.g., fine sand, silt/clay; gravel/pebble); and presence/ absence of aquatic macrophytes (macrophyte samples were collected opportunistically during sediment quality, benthic macroinvertebrate, and gill net sampling in Camp, Sheardown and Mary lakes in 2007, and during a fish spawning survey conducted in Mary Lake in 2010; Table 4.1-1). Methods are described in detail in NSC (2008a).

Aquatic habitats of lakes were classified into three zones with respect to relative water depth and the maximum depth of light penetration:

- Shoreline Zone (≤ 2 m water depth) – the portion of the nearshore bounded by the water level recorded at the time of the bathymetric surveys and lower extent of ice depth (approximated as 2 m in thickness). This area represents a band along the edge of a lake that experiences water level fluctuations (typically approximately ±0.2 m, i.e., intermittently exposed aquatic habitat), ice scour, and wind/wave exposure.
- Littoral/ Euphotic Zone (> 2-12 m water depth) – the portion of the nearshore that is wetted all the time, is beyond the lower extent of average ice depth, and receives sufficient light penetration for photosynthesis. The upper border of the zone corresponds to the lower extent of the approximated ice depth (2 m) and the lower border was identified visually (the selected depth separated most shallow water areas and bays from the main basin of the lake) and defined by the extent of the euphotic zone (estimated to be at approximately 12 m water depth based on open-

water Secchi Disk depth measurements in 2007 for Camp, Sheardown, and Mary lakes; euphotic zone depth was estimated using a non-linear relationship [5*√Secchi Disk depth] to better reflect the relationship between Secchi depth and euphotic zone in relatively clear lakes [Tilzer, 1988]).

- Profundal Zone (> 12 m water depth) – all areas of a lake between the lower extent of the nearshore and the deepest area of the lake (i.e., deeper than the lower extent of the euphotic zone).

Each of the above zones was divided into categories of substrata type present. Substrata information was generally combined into five classifications:

- Cobble/Boulder;
- Gravel/Pebble;
- Sand;
- Sand/Gravel; and
- Fine Sand, Silt/Clay.

Aquatic macrophytes (aquatic plants large enough to be apparent to the naked eye) include vascular (e.g., pondweeds) and non-vascular (e.g., aquatic moss, macroalgae) groups and grow within the littoral zone. The littoral zone is defined as the area of a lake near the shore from the region of the highest seasonal water level to the deepest point at which aquatic plants occur (i.e., where there is sufficient light for photosynthesis to occur). The extent to which the littoral zone can support aquatic macrophytes depends on the availability of bottom sediments sufficiently fine-textured and stable to permit roots to take hold, the degree of wave exposure, and water levels stable enough to minimize disruption of the roots by ice scour during the winter months or desiccation due to exposure (periodic dewatering) during the open-water season. Macroalgae (i.e., *Chara* sp.) are similar to vascular aquatic macrophytes in size, form, and function and can be comparable to production by vascular plants; therefore they are considered equivalent habitat. Investigations have shown that the depth of light penetration in the Mary River Mine Area lakes sampled ranges from approximately 9 to14 m (when euphotic zone depth is estimated as 5*√Secchi Disk depth), and that most aquatic macrophytes were observed within this estimated euphotic zone.

Areas were calculated in the GIS by overlaying (i.e., combining) the three relevant mapping layers: habitat zones (defined by water level and light penetration); substrata type present; and presence/absence of aquatic macrophytes. Lake habitats were classified base on the overlap of the components of the three layers.

4.1.1.2 Results

Based on preliminary surveys conducted in 2007, macrophytes (particularly vascular) appear to be sparse in the lakes investigated. The presence of *Nostoc* sp., a genus of fresh water cyanobacteria that forms spherical colonies composed of filaments of moniliform cells in a gelatinous sheath, was noted on a variety of substrate types, but not included in the classification of lacustrine habitats.

Camp Lake

Within Camp Lake, the shoreline, littoral/euphotic, and profundal zones occupy approximately 16 ha (8%), 117 ha (37%), and 78 ha (55%), respectively (Table 4.1-2; Figure 4.1-1). Camp Lake has a maximum depth of 35.1 m and a mean depth of 13.0 m. In general, depth extends to 10 m within approximately 100-200 m from the shoreline with a relatively uniform depth (10-20 m) throughout the majority of the lake (Figure 4.1-2). In general, the shoreline in Camp Lake consists primarily of gravel/pebble (or smaller-sized substrate, particularly in the southwest), with small, isolated areas of cobble/boulder shoreline in the east, southeast, and northwest sections of the lake. Sand is the dominant substrate in Camp Lake and is found throughout the nearshore and offshore areas (Figure 4.1-2). Small patches of finer substrates are dispersed primarily in deeper, offshore areas while patches of cobble/boulder substrate are found primarily in shallower, nearshore areas (i.e., shoreline zone). Gravel/ pebble sized substrates are dispersed throughout the lake.

Sheardown Lake

The aquatic habitat of Sheardown Lake has been separated into northwest and southeast basins due to the lack of connectivity that occurs between the two basins during winter.

Sheardown Lake NW

Within the northwest basin of Sheardown Lake, the shoreline, littoral/euphotic, and profundal zones occupy approximately 8 ha (12%), 28 ha (42%), and 32 ha (46%), respectively (Table 4.1-2; Figure 4.1-3). Sheardown Lake NW is characterized by maximum and mean depths of 30.1 m and 12.1 m, respectively. This basin typically reaches depths of greater than 10 m at distances of less than 50 m from shore (Figure 4.1-4). The exception is a broad, shallow area in the southeast section of this basin. Shoreline in Sheardown Lake NW is primarily sand or gravel/pebble with a few areas of cobble/boulder. Substrate in the northwest basin consists largely of sand or gravel/pebble with some cobble/boulder areas (usually in the littoral zone) and a few, small patches of fine substrates (typically in the profundal zone) (Figure 4.1-4).

Sheardown Lake SE

The southeast basin of Sheardown Lake is shallower than the northeast basin with maximum and mean depths of 26.7 m and 7.4 m, respectively. The shoreline, littoral/euphotic, and profundal zones occupy approximately 5 ha (19%), 16 ha (65%), and 4 ha (15%), respectively (Table 4.1-2; Figure 4.1-5). Relatively large areas of this basin are less than 10 m in depth (Figure 4.1-6) and, combined with high water clarity, the littoral/euphotic zone dominates. The southeast basin has a similar proportion of sand to the northwest basin, but lacks finer substrates (Figure 4.1-6); however, an area of relatively dense aquatic macrophyte growth (likely non-vascular plants [macroalgae]; for example, *Chara* sp.) was observed in the southern extent of this basin.

Mary Lake

Similar to Camp Lake, Mary Lake is relatively deep with a maximum depth (41.1 m) observed in the large, south basin; however, the mean depth for the entire lake is shallower (12.0 m) and more similar to the NW basin of Sheardown Lake. The shoreline, littoral/euphotic, and profundal zones occupy approximately 493 ha (36%), 365 ha (26%), and 522 ha (38%), respectively (Table 4.1-2; Figure 4.1-7). Expansive, shallow, nearshore areas in the north end of the south basin and in proximity to the Mary River inlet and outlet contribute to the comparatively shallow mean depth (Figure 4.1-8). Nearshore substrate in Mary Lake, like other surveyed lakes, consists primarily of sand with patches of finer substrates and cobble/boulder (Figure 4.1-8). The substrata type in the shallower north arm is sand, while relatively fine sand mixed with silt/clay predominates throughout the deeper south basin.

In 2010, aquatic macrophytes were observed almost exclusively along the northeast shore of the lake, where substrates consist of fines (i.e., sand, silt, and clays). Where macrophytes occurred, growth was patchy and generally occurred in waters 1 to 3 m deep. The two aquatic macrophyte species observed were *Ranunculus* sp. (water crowfoot) and aquatic moss.

Candidate Reference Lake

The candidate reference lake is relatively shallow and has a notably lower maximum depth (10.1 m) and mean depth (4.0 m) than the other lakes in the Mine Area (Figure 4.1-9). As a result, the reference lake habitats were classified into only two zones with respect to relative water depth and depth fluctuations for the existing environment: the shoreline (24 ha or 21%); and the littoral/euphotic (92 ha or 79%) zones (Table 4.1-2; Figure 4.1-10). Nearshore substrate consists primarily of fine sand and silt/clay with a small proportion of cobble/ boulder mixed throughout the waterbody (Figure 4.1-9). More extensive sand beaches are found in the most northern extent and in

discrete areas along the southern extent of this basin. Similar to Mary Lake, the substrata type throughout the basin is very uniform.

Summary and Regional Context

The lakes investigated in the Mary River Mine Area are relatively shallow (mean water depth ranges from 4.0 to 13.0 m) and comparable in water depth to other smaller Arctic lakes (e.g., lakes in the High Lake area, Western Nunavut [Wolfden 2007]) (Table 4.1-2). During the 2008 open-water season, the lake surface elevation of Sheardown Lake fluctuated by approximately 0.75 m due to run-off events (e.g., snowmelt, precipitation, etc.; Volume 7, Appendix 7A). Overall, these lakes are clear (high Secchi Disk depth and corresponding maximum depth of light penetration estimated to be 12 m), substrate is dominated by sand interspersed with patches of cobble/ boulder, and aquatic macrophytes rarely occur and are sparsely distributed. The waters of Arctic lakes are typically highly transparent, as was also observed in Contwoyto Lake, in the in the Kitikmeot region of Nunavut, where sufficient quantity of light for primary production reached depths of at least 12 m (Rescan 2007). Aquatic macrophytes are often sparse in Arctic lakes with few species represented due to a lack of suitable substrate (e.g., littoral zone dominated by sand, cobble, and boulder [R.L. & L. / Golder 2002]) and insufficient growing season (e.g., low temperatures and extended periods with minimal daylight). Although shallow water areas with fine substrate were present in the subarctic lakes of the Jericho Study Area (Nunavut), submergent aquatic macrophytes were rare in most (R.L. & L. 2000). Aquatic plants were also absent from the project lakes investigated for the Meadowbank Gold Project in the Kivalliq region of Nunavut (Cumberland Resources 2005). Any macrophytes in the Mine Area lakes appeared to be predominantly macroalgae (e.g., *Chara* spp.) with the exception of Mary Lake where water crowfoot (*Ranunculus* sp.) and aquatic moss were observed. The presence of *Nostoc* sp., a genus of fresh water cyanobacteria that forms spherical colonies composed of filaments of moniliform cells in a gelatinous sheath, was noted on a variety of substrate types, but not included in the classification of lacustrine habitats.

4.1.2 Streams

The following provides a description of methods and results of studies conducted to describe aquatic habitat in streams in the Mine Area.

4.1.2.1 Methods

Field Methods

Minimal information to describe the aquatic habitat of streams specific to the Mine Area had been documented prior to 2007. The 2007 and 2008 stream aquatic habitat studies were intended to characterize and quantify aquatic habitat in the tributaries of Camp, Sheardown and Mary Lakes, as

well as the Mary and Tom rivers. A habitat survey was also conducted at two potential reference streams for Mary River.

Surveys generally focussed on reaches of streams between larger lakes and the first impassable barrier to upstream fish movement. In some instances, where project-related activities are likely to occur upstream of areas directly accessible to fish, aquatic habitat was described to characterize potential indirect effects to fish (e.g., provide habitat information to support the assessment of effects to the downstream drift of invertebrates). Streams were initially inspected and divided into reaches of similar habitat. Detailed surveys were conducted at cross sections representing each major habitat type present along the length of the stream surveyed. Protocols for stream habitat assessments in the Mine Area were based on protocols outlined in DFO and BCMOE (1989) and NSC (2006) and are described in detail for this Project in NSC (2008a). Habitat characteristics evaluated for each reach included channel gradient (measured using a Suunto clinometer), channel confinement, channel morphology, substrate composition, and amount of available stream cover. Maximum depth and point velocities of each habitat type were measured using a Swoffer 2100 velocity meter. Where possible, bank height, D95 (diameter of substrate particle larger than 95% of all substrate particles within the assessment area), D (diameter of substrate particle that can be transported by the stream), and bankfull and wetted widths were measured. Riparian and aquatic vegetation were also identified where possible.

Streams were classified according to flow characteristics that are typical for the region as follows:

- Perennial – Large river or stream channels with continuous flow during the open-water period (persistent), except during extreme droughts. Larger watercourses may have some winter flow, but most either freeze to bottom in winter or are left with isolated shallow pools of water under the ice. These larger streams may provide fish habitat throughout the year.
- Intermittent – Intermediate streams with continuous flow for much of the open-water season. They typically dry up in late summer or fall, or may be reduced to isolated pools. In some cases, streams are or may become spatially intermittent if flow is reduced to subsurface flow through coarse bed material. Intermittent streams freeze to bottom in winter. They provide fish habitat during periods of flow, provided that access is available, but fish use in winter is non-existent.
- Ephemeral – Small streams with flow only during the spring freshet or following rain events. Ephemeral streams do not provide fish habitat except in the lowest reaches (i.e., where they empty into a lake or larger stream) where they may provide limited habitat for brief periods.

Streams were generally surveyed in more than one season (at least two of spring, summer and/or fall) to identify changes in velocity, depth and width of the wetted channel related to differences in discharge. Representative photographs were taken from the same vantage points in each season.

Data Analysis

Stream habitat data were summarized and tabulated, along with photographs, into habitat assessment sheets. Assessment sheets are provided in Appendix 4.1-1.

4.1.2.2 Results

The Mine Area LSA includes streams that are persistent perennial, intermittent and ephemeral (Section 4.1.2.1), but all area streams freeze to the bottom in winter. Persistent perennial streams generally consisted of riffle habitat, with occasional pools. Substrate was often dominated by cobble, with sand, gravel and boulders present in varying amounts. Streams were generally shallow (<0.5 m deep) with, particularly during lower flow periods, extremely shallow sections (<0.1 m) that limited connectivity between upstream and downstream reaches. Intermittent and ephemeral streams provided marginal to no habitat for fish, and very limited habitat to other aquatic biota, even during peak run-off periods; therefore, aquatic habitat in intermittent and ephemeral tributaries was not surveyed in greater detail. Results of habitat surveys at representative reaches are provided in Appendix 4.1-1. In general, stream width and depth decreased substantially between high and low flow periods. Riparian vegetation is limited, and generally consists of moss and grass and, in some locations, willows.

The following text provides an overview of habitat for the inflows/tributaries of the three major lakes in the area (Camp, Sheardown and Mary lakes) as well as the larger streams (Tom and Mary rivers). Reaches surveyed and the locations of barriers to fish movements are shown in Figure 4.1-11.

Camp Lake Inflows

Numerous small (<200 m long), ephemeral tributaries enter Camp Lake, particularly on its southern shore, all of which have insufficient flow to support fish. Detailed habitat surveys were conducted on four longer tributaries (Figure 4.1-12). These are all small (the longest, Tributary 1, has less than 5 km of fish-bearing habitat), generally shallow (typically < 0.5 m deep), with predominantly cobble substrates. Habitat in the upper reaches of the tributaries typically consists of a shallow series of cascades and riffles, with intermittent flow that provides only small amounts of habitat for aquatic life. Tributary 1, which extends from the north eastern shore of Camp Lake approximately 1,400 m before reaching an impassable falls, consists predominantly of riffle/pool habitat with cobble substrata. Undercut banks, deep pools and boulders provide ample cover in this stream. A secondary

channel (Tributary 1b) continues an additional 0.5 km from near the impassable falls into a series of broad and shallow ponds. Habitat in Tributary 1b was not surveyed but is similar to that of the upper sections of Tributary 4 (see below). The other tributaries surveyed (tributaries 2, 3 and 4) are all extremely shallow (typically <0.2 m deep), with limited cover. Typically, cobble is the predominant substrate and the channels are primarily riffle and pool sequences in the lower gradient areas near Camp Lake. Cascades are present in reaches further upstream where the gradient is higher. Cover is limited to some large cobble and few undercut banks. The upper section of Tributary 4, approximately 1 km upstream of Camp Lake, flows through a low gradient area where several large, shallow (0.5 m) pools with cobble bottoms and limited cover have formed. Tributary 5, which enters Camp Lake near Tributary 4, was not surveyed, but is expected to be similar to Tributary 4 as it flows through similar terrain. Numerous small drainages enter these tributaries, but there is insufficient flow in many to provide habitat for most aquatic biota. In addition, the presence of waterfalls or other barriers to fish movement restrict the use of these streams by fish.

Sheardown Lake Inflows

As with Camp Lake, numerous small tributaries flow into the two basins of Sheardown Lake (Figure 4.1-13). However, the majority of these, particularly those on the southwest shore of the northwest basin, provide very limited aquatic habitat due to intermittent and limited flow and shallow depth.

Only four tributaries support fish (Section 4.4), and of these, only one is of substantial size. This tributary (Tributary 1) and its main branch (Tributary 1b) flow into the northwest basin of Sheardown Lake and provide approximately 3 km of fish-bearing stream channel before reaching sections that would not be passable to fish. Much of the stream is riffle or riffle/pool habitat over a predominantly cobble substrate, and is extremely shallow (<0.1 m deep). Depth increases in the mid section (up to 0.5 m) and both riffles and pools are present. Further upstream, the tributary forms a series of broad shallow pools. Stream habitat upstream of these pools is limited, consisting of an extremely shallow (<0.1 m) stream with a cobble/boulder substrate and little cover. Cover in Tributary 1 varies among sections, but is provided by boulders, undercut banks, and deep pools.

Two other tributaries (tributaries 9 and 12 in Figure 4.1-13) are characterized by cascade/pool habitat over cobble with varying amounts of boulder, gravel and/or sand. Although fish use of tributary 12 is limited by an impassable waterfall, Tributary 9 extends to a small lake with sufficient depth for overwintering that provides fish habitat. However, use of Tributary 9 can be limited due to lack of connectivity to Sheardown Lake under low flow conditions. A fourth tributary (Tributary 7), the only one flowing into Sheardown Lake from the southwest that supports fish, is extremely shallow (typically <0.2 m deep) and is characterized by riffle/pool habitat over primarily sand substrate in the

lower reaches. Habitat in the upper reaches consists of cascade/pool over cobble/gravel, providing more limited fish habitat.

Mary Lake Inflows

Mary Lake is separated into a small northern basin and a large southern basin by a shallow section that freezes to the bottom in the winter. The largest inflow to the north basin of Mary Lake is the Tom River, joined by the outflow of Camp Lake just upstream of its junction with Mary Lake. During periods of high water (e.g., spring melt), the northern basin of Mary Lake expands northward so that the Camp Lake outflow and Mary Lake – North Tributary 2 appear to flow directly into the lake and not the Tom River. Habitat in the Tom River is discussed in a subsequent section. The largest inflow to the south basin of Mary Lake is the Mary River, which is also described in a subsequent section.

As with the other lakes in the Study Area, the majority of inflows are small and provide limited aquatic habitat (Figure 4.1-14). Six tributaries were surveyed in detail.

Mary Lake North – Tributary 1 is characterized by a lower reach of flat/riffle over sand changing to riffle/pool over cobble/sand/boulder substrata further upstream. Depths in Tributary 1 are shallow (typically <0.5 m). Mary Lake – North Tributary 2 will be discussed with the Tom River in a subsequent section.

Mary Lake – North Tributary 3 is the longest (approximately 4-5 km of fish-bearing habitat) of the small inflows to the north basin of Mary Lake. The reach immediately upstream of the lake consists of essentially standing water in pools (0.5 m deep) over sand and gravel. Further upstream the gradient increases and the tributary consists of a shallow (<0.5 m deep) channel with riffles, cascades and pools over a predominantly cobble substrate. Cover is limited. The only barrier to upstream fish movements in this stream is insufficient water levels in the uppermost reaches. The other tributary surveyed in the north basin, Tributary 4, is adjacent to the lower reach of Tributary 3 and is formed over a very low gradient section, and in summer is essentially standing water. The substratum was sand. Macrophytes were present.

Mary Lake- South Tributary 1 is a small tributary that enters along the channel separating the north and south basins of Mary Lake. In spring, under higher flows, it consists of a run/pool sequence, while in the summer it forms a pool. The substrate is sand with limited cover in the form of undercut banks.

A considerable number of small inflows enter the southern basin of Mary Lake, but the majority of these are not expected to support fish and were not surveyed for aquatic habitat. It is expected that

habitat in these would be similar to that in Mary Lake – South Tributary 3. The lower reaches of both tributaries 2 and 3 were of very low gradient with a sand or sand/gravel substratum. Tributary 2 was very shallow (0.1 m) while tributary 3 was deeper (<0.5 m) but neither reach contained abundant cover. Further upstream in Tributary 3, gradient increased and habitat consisted of riffles and cascades over a primarily cobble substrate. Cover was limited and consisted of boulders and large cobbles. Low water levels in the uppermost reaches were the only barriers identified on the inflows to Mary Lake.

Mary and Tom Rivers

Two larger streams connecting the major lakes occur in the Mine Area (Figure 4.1-11). The Mary River arises north of the Mine Area and flows south west, receiving inflow from Sheardown Lake before entering the south basin of Mary Lake. The Mary River then flows from Mary to Angajurjualuk Lake. The Tom River originates north of the Mine Area and receives inflow from Camp Lake before entering the north basin of Mary Lake. Habitat in these rivers, and selected major tributaries, is described below. Aquatic habitat was generally not surveyed in any of the tributaries flowing into these rivers, as they support few if any fish, due to their greater distance from suitable overwintering habitat (Section 4.4).

Habitat in the Mary River was described in the approximately 15 km from Mary Lake to the Mary River Falls, which are impassable to fish (Figure 4.1-15). A reach upstream of the falls was also surveyed. High flows in spring result in abundant fast water habitat; lower flows in summer and fall reduce the wetted area and water velocity. The river is perennial and persistent throughout the open-water season, but like all streams in the Study Area it freezes to the bottom in winter. However, flow is substantially greater than the lake inflows described above and it persists through the open-water season.

The 1 km reach of the Mary River immediately upstream of Mary Lake consists entirely of shallow (<0.5 m) run/flat habitat over 100% sand. There is no cover or aquatic vegetation. Habitat in the reaches extending approximately 14 km upstream of this initial reach is more diverse, with a combination of riffle/run/pool habitat over cobble/boulder/gravel substrata. The river is shallow (<0.5 m deep) and with sections of riffles that are extremely shallow (<0.1m), particularly under lower flows in summer and fall. Cover consists of boulders.

A representative reach of approximately 9 km of the Mary River upstream of the falls consisted of primarily riffle in spring and a riffle/run sequence in summer and fall. Substrate was mainly cobble and boulder.

The Mary River between Mary and Angajurjualuk lakes extends for approximately 6 km. Habitat in a representative reach consisted of 40% riffle – 40 % rapids – 20% pool habitat over predominantly cobble substrate. Cover was limited to some boulders.

Two small streams adjacent to a salt-mixing station near Deposit 2 (E3-01 & E4-01) were also assessed for aquatic habitat. These streams were not accessible to fish due to steep cascades near their confluences with the Mary River. Habitat consisted of cascades and pools over predominantly cobble with some sand, gravel, and boulder.

The Tom River flows into the northern portion of Mary Lake (Figure 4.1-16). As with the Mary River, it is perennial, but freezes solid during winter. Water depth in the lower portion of the river in spring was > 1 m and declined to approximately 0.5 m in summer and fall. The initial 1,500 m upstream of Mary Lake is 90% run – 10% riffle during spring and 85% riffle – 15% run during summer and fall when water levels are lower. Substrate was mainly sand with small amounts of gravel and cobble. Undercut banks provide cover. The 4,500 m section extending to the Tom River Falls is considerably shallower, with sections < 0.1 m deep in summer and fall. Cobble is the dominant substrate type and limited cover is provided by boulders. This reach consists of several braided channels at the crossing of the Tote Road; under high flows in spring these channels combine to form one large run/rapids habitat.

Aquatic habitat upstream of Tom River Falls, which form a barrier to upstream fish movement, consists of rapids (in spring)/riffle habitat over a cobble/boulder substrate. Stream depth varies from 0.25—0.50 m and boulders provide the majority of cover.

Numerous small drainages enter the Tom River; aquatic habitat in the majority of these was not assessed as it is not expected to be directly impacted by the project and would not support substantial use by fish. The outflow from Camp Lake also enters the Tom River just upstream of its junction with the north basin of Mary Lake. Habitat was not surveyed but is expected to be similar to that in the Tom River at this location. A small tributary (just upstream of the confluence with Mary Lake) referred to as Mary Lake -North Tributary 2 had essentially no gradient and consisted of nearly standing water over sand.

Candidate Reference Streams

Two potential candidate reference streams (Streams 2 and 3) for Mary River were surveyed for habitat in 2008. Candidate Reference Stream 2 is shallow (depths typically <0.3 m) with relatively high water velocities in some areas. Habitat is primarily rapids/run during spring and run/pool during summer with cobble/boulder/sand the dominant substrata. Boulders and large cobble provide the majority of available cover.

Candidate Reference Stream 3 is a broad (>140 m), river with depths of 0.5-1.0 m and a low gradient. It is a persistent perennial stream but likely freezes to the bottom during the winter. Habitat is characterized by run over sand substrates with limited cover. Of these two candidate streams, Stream 2 is most similar to Mary River in terms of available aquatic habitat.

4.2 PRIMARY PRODUCERS

Primary producers are organisms that create biomass from inorganic compounds; in most cases this is achieved through photosynthesis. There are typically three primary groups of photosynthetic organisms present in the aquatic environment: microscopic algae known as phytoplankton that live suspended in the water column; attached algae (periphyton) that grow on rocks, along the mud surface, and on aquatic plants; and rooted plants that live along the shorelines where conditions, such as substrate and light availability, are suitable. All photosynthetic organisms require solar radiation for survival.

Typically, the most important source of energy to the aquatic environment is solar radiation. Energy from solar radiation may be used directly by photosynthetic organisms such as plants and algae within the waterbody itself (i.e., autochtonous organic matter), or be supplied to a waterbody or portion of a waterbody indirectly via organic material originating from the terrestrial environment (i.e., allochtonous organic matter) or upstream aquatic areas. In lentic systems, the relative importance of these two sources of energy depends on the lake's size relative to its watershed, and the nature of the watershed. Whereas in lotic systems, allochtonous organic matter is generally of greatest importance.

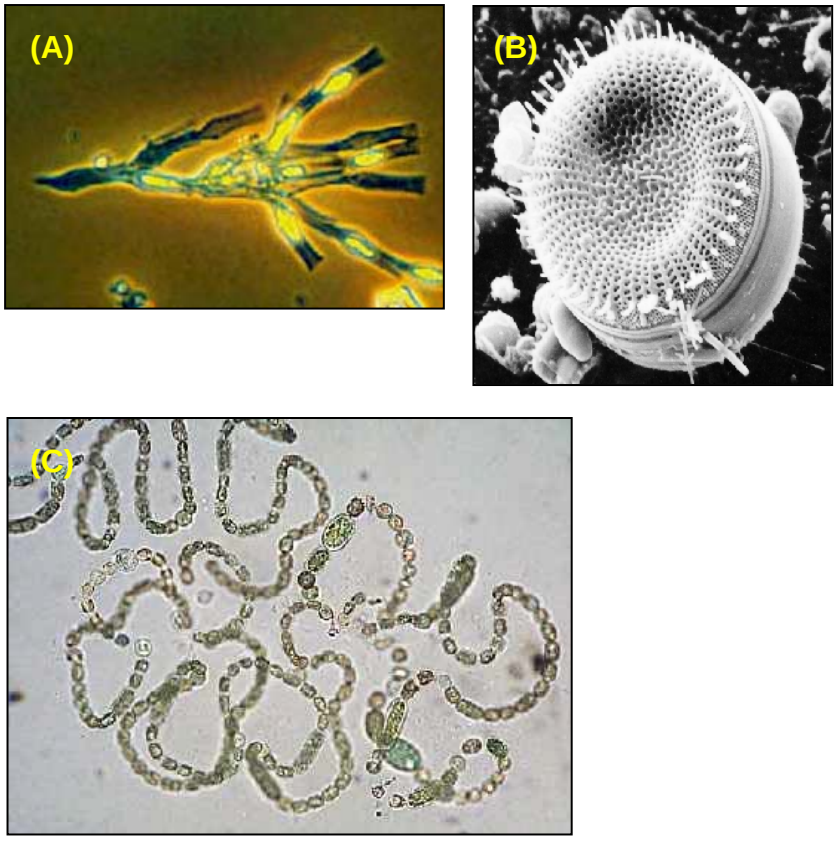
The availability of light is generally the primary determinant of the distribution of photosynthetic organisms in aquatic ecosystems, although other factors also affect the distribution and abundance of primary producers. The growth of photosynthetic organisms is limited to the photic zone, which extends from the water surface to the lower limit at which there is sufficient light for photosynthesis. This lower limit of the photic zone depends on the clarity of the water, which in turn is affected by water colour, organic matter, and suspended materials. Rates of production by photosynthetic organisms are also strongly affected by the availability of nutrients, temperature, and water movement (e.g., turbulence, velocity). Of the nutrients, nitrogen and phosphorus are typically the limiting nutrients and their supply frequently determines the quantity and type of producers observed. The rates of physiological processes (photosynthesis, assimilation, respiration, and reproduction) tend to increase with temperature to an upper limit, after which warmer temperatures are harmful. Water movement plays a key role in determining the productivity of photosynthetic organisms. A certain degree of wave action or mixing within the photic zone is essential to maintain supplies of nutrients and carbon dioxide; however, excessive mixing can decrease the extent of the

photic zone by increasing turbidity and can cause sloughing of attached algae. In Arctic ecosystems, primary production is typically low due to low concentrations of nutrients and relatively cool temperatures.

The following provides a summary of the results from the baseline environmental studies conducted to characterize phytoplankton and periphyton in waterbodies in the Mine Area. A description of aquatic macrophytes in the Mine Area is provided in Section 4.1.

4.2.1 Phytoplankton in Lakes and Streams

Several groups of freshwater algae comprise the phytoplankton: Chrysophyceae (yellow-green or yellow-brown algae); Bacillariophyceae (diatoms); Chlorophyceae (green algae), Cyanophyceae (blue-green algae or cyanobacteria), Peridineae (dinoflagellates), Cryptophyceae (cryptomonads) and Euglenophyceae (euglenophytes). Phytoplankton abundance and species composition vary spatially and temporally in response to changes in light, nutrient availability, and other growing conditions.



Representatives of the freshwater phytoplankton: (A) chrysophyte; (B) diatom; and (C) blue-green algae.

Chlorophyll *a* is a commonly used indicator of phytoplankton biomass in surface waters. It is typically related to the concentrations of nutrients, notably phosphorus in water, and is commonly used as a general indicator of the trophic status of aquatic ecosystems. In addition to those based on total phosphorus, there are a number of trophic categorization schemes for freshwater ecosystems that are based on concentrations of chlorophyll *a* (Table 4.2-1 and 4.2-2). Taxonomic composition of phytoplankton communities also generally varies according to trophic status; in general, as trophic status (and nutrient enrichment) increases, phytoplankton diversity decreases and cyanophytes tend to become more abundant and more dominant.

4.2.1.1 Methods

The following provides a description of the sampling and analysis methods for studies of phytoplankton in lakes and streams.

Sampling Locations and Timing

Samples were collected for analysis of phytoplankton to characterize the existing phytoplankton community composition and biomass from Mine Area lakes in the open-water seasons of 2007 and 2008. The sampling program was conducted in conjunction with and, therefore, at the same locations and times, as the water quality sampling program (Figure 4.2-1). These locations included:

- Mary Lake (BL0-01, BL0-03, BL0-04, BL0-05, and BL0-06);
- Sheardown Lake Northwest (DL0-01-1, DL0-01-2, DL0-01-4, DL0-01-5, and DL0-01-7);
- Sheardown Lake Southeast (DL0-02-1, DL0-02-3, and DL0-02-4); and
- Camp Lake (JL0-01, JL0-02, and JL0-09).

Sampling for phytoplankton was conducted twice each year:

- August 7-14, 2007 and July 29-August 6, 2008 (summer sampling); and
- September 13-20, 2007 and September 2, 2008 (fall sampling – Sheardown Lake only [1]).

In addition to phytoplankton biomass and taxonomic composition, chlorophyll *a* was measured in lakes and streams as a component of the water quality sampling program. These locations included the aforementioned sites, as well as the following locations (Figure 4.2-1):

[1] Fall sampling was not completed at Camp or Mary lakes in 2008.

- Mary River (A0-01, A0-10, G0-03, G0-09, E0-01, E0-03, C0-01, C0-05, and C0-10);
- Tom River (I0-01 and I0-04);
- Sheardown Lake Tributaries (D-Stream-1, D-Stream-2, D-Stream-3, D-Stream-4, D-Stream-5, D-Stream-6, D1-00, D1-01, D1-05);
- Nearshore areas of Sheardown Lake NW (SDL-1 to -6);
- A tributary of Mary Lake (MLST-2); and
- A candidate reference lake (CRL-3).

Sampling for chlorophyll *a* was generally conducted during three sampling periods (i.e., spring, summer, and fall) in each of the open-water seasons of 2007 and 2008; however, not all sites were sampled during all sampling periods (see Table 4.2-3 for details).

Sampling and Sample Processing

Algal (phytoplankton) abundance in the water column was estimated through measurement of chlorophyll *a* at all lakes where water quality sampling was conducted as well as several of the stream water quality sampling sites. Grab samples of water for chlorophyll *a* analysis were collected 1 m below the surface and 1 m from the sediments at lake sites, and from just below the surface at stream sites. All samples were shipped to Exova Laboratories, Ottawa, ON for analysis.

Phytoplankton biomass and species composition were also examined in lakes in the Mine Area. Samples for taxonomic identification and enumeration were collected in the 2007 and 2008 open-water seasons as depth-integrated samples of surface water collected across the euphotic zone (estimated as 3 times the Secchi Disk depth measured at the time of sampling, Cole 1983). Samples were preserved with Lugol's solution and submitted to ALS Laboratories, Winnipeg, MB for taxonomic identification and enumeration. A detailed description of methods is provided in NSC (2008b).

The relative abundance of phytoplankton biomass was calculated for the major algal classes, along with total biomass for each sample.

4.2.1.2 Results for Lakes

Camp Lake

Total phytoplankton biomass in Camp Lake ranged from 43 mg/m^3 to 250 mg/m^3 throughout the open-water seasons of 2007 and 2008 (Figure 4.2-2). At all three sites, phytoplankton biomass was

similar in the summer and fall sampling periods in 2007. However, total biomass was higher in 2008 than in 2007.

Diatoms (Bacillariophyceae) dominated the phytoplankton catch at most sites and times sampled. However, the south-west area of Camp Lake (JL0-09) was co-dominated by diatoms (primarily *Cyclotella* sp.) and blue-greens (Cyanophyceae, only *Aphanothece* sp. was observed) in summer 2008 (Figure 4.2-3). Typically, *Cyclotella* sp. was the most abundance species; although, *Stephanodiscus* sp. comprised a considerable portion of the phytoplankton community in the center of Camp Lake (JL0-01) in summer 2007.

Chlorophyll *a* concentrations in Camp Lake were low year-round (Table 4.2-4). During the open-water season, chlorophyll *a* ranged from <0.2 µg/L to 1.5 µg/L near the surface, and from <0.2 µg/L to 1.7 µg/L near the bottom. Under ice cover, chlorophyll *a* near the surface ranged from <0.2 µg/L to 1.5 µg/L.

Sheardown Lake NW

Total phytoplankton biomass in Sheardown Lake NW was higher during the open-water season 2008 than in open-water season of 2007 (Figure 4.2-2). Biomass was generally greater during the fall sampling period than during the summer.

Diatoms (Bacillariophyceae) dominated the phytoplankton community at most sites and times sampled; however, one site (DL0-01-2) was co-dominated by diatoms and blue-greens in summer 2008 (Figure 4.2-3). Typically *Cyclotella* sp. was the most abundant species; although, *Pinnularia* sp. comprised a considerable portion of the phytoplankton community at a site near the middle of the basin (DL0-01) in summer 2007. The next most abundant algal class was Chlorophyceae at the majority of sites and times.

Chlorophyll *a* concentrations in Sheardown Lake NW were low during both the open-water and ice-cover seasons (Table 4.2-4). During the open-water season chlorophyll *a* ranged from <0.2 µg/L to 0.9 µg/L at the surface, and <0.2 µg/L to 2.7 µg/L near the bottom. Under ice cover chlorophyll *a* ranged from 0.4 µg/L to 2.5 µg/L at the surface, and <0.2 µg/L to 2.2 µg/L near the bottom. In the nearshore areas of the lake, chlorophyll *a* concentrations were slightly higher and ranged from <0.2 µg/L to 4.4 µg/L.

Sheardown Lake SE

Total phytoplankton biomass in Sheardown Lake SE during the open-water seasons of 2007 and 2008 ranged from 43 mg/m^3 to 336 mg/m^3 (Figure 4.2-2). In general, total biomass was either similar to or greater during the fall sampling period compared to the summer. Additionally,

phytoplankton biomass in fall 2008 was notably higher than in fall 2007; although, this may reflect differences in the timing of sampling between years.

Diatoms (Bacillariophyceae) dominated the phytoplankton community at most sites and times sampled; however, the northern area of the basin (DL0-02-1) was co-dominated by diatoms and blue-greens (*Aphanothece* sp. was the only Cyanophyceae observed) in summer 2008 (Figure 4.2-3). Again, *Cyclotella* sp. was typically the most abundant diatom. The next most abundant algal class was Chlorophyceae at the majority of sites and times. Dinoflagellates (Peridineae) and euglenophytes (Euglenophyceae) were also abundant at various times.

As observed in other lakes in the Mine Area, chlorophyll *a* concentrations in Sheardown Lake SE were low during both the open-water and ice-cover seasons (Table 4.2-4). During the open-water season chlorophyll *a* ranged from <0.2 µg/L to 2.1 µg/L at the surface, and <0.2 µg/L to 7.6 µg/L near the bottom. Under ice-cover chlorophyll *a* near the surface was consistently <0.2 µg/L.

Mary Lake

Total phytoplankton biomass in Mary Lake ranged from 28 mg/m^3 to 415 mg/m^3 throughout the open-water seasons of 2007 and 2008 (Figure 4.2-2). No seasonal trend in biomass was observed in Mary Lake; although biomass generally varied between sampling periods it was not consistent between sites. Phytoplankton density was higher in the south basin than in the north basin (site BL0-01) of Mary Lake; densities in the south basin of Mary Lake were also the highest of the Mine Area lakes in 2007.

Diatoms (Bacillariophyceae) dominated the phytoplankton at most sites and times sampled; however, the northern basin of Mary Lake was dominated by Chlorophyceae in summer 2007. During summer 2007, the north basin of Mary Lake (BL0-01) was dominated by the chlorophyte *Zygnema* sp., which comprised 56% of the total phytoplankton biomass (this is the only location this alga was observed). *Cyclotella* sp. and *Synedra* sp. were the dominant diatoms in the north basin during the other times sampled. In general, *Melosira* sp. was the dominant diatom in the south (BL0-03, -04, -05, -06) basin of Mary Lake although *Cyclotella* sp. was prominent in the middle of the south basin (BL0-04) during the summer of 2008. This differed from the other lakes in the Mine Area, where the diatoms were generally represented by *Cyclotella* sp., *Synedra* sp. and *Melosira* sp. During the summer 2007, blue-green algae, composed almost entirely of *Microcystis* sp., comprised 25% of the phytoplankton biomass at one site in Mary Lake (BL0-03; Figure 4.2-3). This alga was not recorded for any other site or time.

Chlorophyll *a* concentrations in Mary Lake were low during both the open-water and ice-cover seasons (Table 4.2-4). During the open-water season chlorophyll *a* ranged from <0.2 µg/L to 2.1

µg/L at the surface, and <0.2 µg/L to 7.6 µg/L near the bottom. Under ice cover chlorophyll *a* near the surface was consistently <0.2 µg/L.

Candidate Reference Lake

Chlorophyll *a* was only measured on one occasion in the Candidate Reference Lake. In August 2008, chlorophyll *a* was <0.2 µg/L in both the surface and bottom samples.

Summary and Regional Context

Lakes in the Mine Area (Camp, Sheardown, Mary and Candidate Reference lakes) are characterized by low primary productivity (i.e., low chlorophyll *a* concentrations and phytoplankton biomass) as is typical in Arctic aquatic ecosystems. Lake-wide mean concentrations of chlorophyll *a* measured in the open-water season indicate a trophic status of ultra-oligotrophic to oligotrophic (Table 4.2-5). Means for the 2007-2008 period were very similar between lakes ranging between 0.2 and 0.7 µg/L.

Total phytoplankton biomass in Mine Area lakes ranged from 28 mg/m^3 to 456 mg/m^3 throughout the open-water seasons of 2007 and 2008 (Figure 4.2-2). Biomass was higher in 2008 in Camp and Sheardown lakes but was similar across sampling periods in Mary Lake. In general, biomass was similar between the summer and fall sampling periods. Overall lake means for the 2007-2008 period were relatively similar across the lakes, ranging between 122 and 204 mg/m^3 (Table 4.2-6).

A total of 82 species of phytoplankton were recorded in Mine Area lakes in 2007 and 2008. Phytoplankton biomass was dominated by diatoms (Bacillariophyceae) at most sites and times (Figure 4.2-3); *Cyclotella* and *Melosira* were ubiquitous and relatively abundant across the lakes. However, in summer 2007, the north arm of Mary Lake was dominated by the chlorophyte *Zygnema* sp. (this is the only location this alga was observed). In addition, blue-green algae were most abundant at one site in each of the basins of Sheardown Lake and Camp Lake in summer 2008; the dominant species was *Aphanothece* sp. Generally, the next most abundant algal class was either Chlorophyceae or Cryptophyceae, although, Chrysophyceae, Euglenophyceae, Myxophyceae, and Peridineae were also present in relatively high amounts at various sites and times.

Concentrations of chlorophyll *a* measured in the Mine Area lakes were similar to concentrations measured by Stewart and MacDonald (1981) in three lakes in northern Baffin Island in August 1980 (0.42 – 1.22 µg/L). Comparison between the Mine Area lakes and information collected in other Canadian Arctic lakes indicates a relatively similar total phytoplankton biomass and chlorophyll *a* concentration (Table 4.2-7). In general, Arctic lakes are oligotrophic and contain relatively low concentrations of chlorophyll *a* and biomass; the results for Mine Area lakes agree with this general pattern.

Unlike many nutrient-poor Arctic lakes, where chrysophytes reportedly typically dominate or co-dominate (e.g., DDMI 1998, Welch et al. 1989), the Mine Area lakes are typically dominated by diatoms. However, other studies of phytoplankton taxonomy in Arctic lakes have noted that chrysophytes and/or bacillariophytes (diatoms) have dominated the phytoplankton community overall; and, dominance or co-dominance of diatoms has been observed for some Arctic Lakes (Table 4.2-8). For example, diatoms were relatively abundant in Lac du Sauvage, notably in the fall (DDMI 1998), and in some lakes sampled under the Meadowbank Gold Project (Cumberland Resources Ltd. 2005).

Moore (1978) reported that *Cyclotella* – the most common and abundant genus in the Mine Area lakes in general – was the most common diatom in 153 lakes, streams, and pools surveyed in the Northwest Territories. Although *Dinobryon* (a chrysophyte) was the most widespread and abundant Genus in the survey, *Cyclotella* was notably the most abundant diatom in high arctic lakes and was generally more common than chrysophytes in that area. Similarly, Shortreed and Stockner (1986) reported that *Cyclotella* spp. were the only diatoms common in most of 19 lakes surveyed in the Yukon.

Similar to observations for the Mine Area lakes, cyanophytes have also been observed to dominate in some lakes during some years (e.g., lakes in the Meadowbank Gold Project study area, Cumberland Resources Ltd. 2005; some Saqvaqjuac lakes, NT, Welch et al. 1989; lakes in the Doris North Project area, R.L. & L./Golder Associates 2002; subarctic lakes in the Yukon, Shortreed and Stockner 1986).

4.2.1.3 Results for Streams

Mary River

Chlorophyll *a* concentrations in the Mary River are low, ranging from below detection (<0.2 µg/L) to a maximum of 4.0 µg/L (Table 4.2-9). Productivity generally increased over the open-water season. The mean chlorophyll *a* concentration for the open-water season was slightly higher in the 2008 (1.5 µg/L) than in 2007 (0.3 µg/L).

Tom River

Chlorophyll *a* concentrations in the Tom River were the lowest of all the streams sampled, ranging from below detection (<0.2 µg/L) to 0.3 µg/L (Table 4.2-9). There was no indication of a seasonal trend in chlorophyll *a* concentrations in the Tom River.

Sheardown Lake Tributaries

Chlorophyll *a* concentrations in the tributaries of Sheardown Lake were also generally low; however, relatively higher concentrations were measured on occasion in Tributary 1 in 2008 (Table 4.2-9). Chlorophyll *a* ranged from <0.2 µg/L to 0.4 µg/L in 2007 and from <0.2 µg/L to 7.7 µg/L in 2008 in Sheardown Lake tributaries. No seasonal trend in chlorophyll *a* concentrations was observed during the baseline studies.

Mary Lake Tributaries

Chlorophyll *a* concentrations were measured at one tributary to Mary Lake in 2008. Chlorophyll *a* at this location was the highest measured for the Mine Area and ranged from <0.2 µg/L to 8.9 µg/L (Table 4.2-9).

Summary and Regional Context

Similar to lakes studied for this project, streams in the Mine Area are characterized by low phytoplankton productivity (i.e., low chlorophyll *a* concentrations) with mean concentrations of chlorophyll *a* ranging from <0.2 µg/L to 4.5 µg/L across sites (Table 4.2-9). Overall, means for the Mary and Tom rivers, and tributaries to Sheardown Lake were less than 1 µg/L and similar to means observed in Mine Area lakes. Applying the stream trophic classification scheme of Dodds et al. (1998), streams in the Mine Area are oligotrophic on the basis of phytoplankton chlorophyll *a*. Concentrations are similar to ranges reported for other Arctic streams (Table 4.2-7).

4.2.2 Periphyton in Streams

Periphyton – or attached algae – may colonize the surfaces of plants, rocky substrates such as boulder and bedrock shorelines, and open areas of fine sediment (i.e., mud flats). Factors known to affect the distribution and abundance of periphyton include the stability of the substrate (e.g., shifting sand limits the growth of algae), water level fluctuation (i.e., algae will not grow if exposed to air for prolonged periods at low water levels or if increased water depth reduces light availability below required levels for extended periods), water velocities (high velocities may cause sloughing and low velocities reduce the delivery of nutrients), nutrient concentrations and availability, and overall light availability. Periphyton frequently forms an important component of the primary production in streams, although growth may also be significant in some lakes.

Production by attached algae can be comparable to production by rooted vascular plants due to the rapid growth and turnover time of these microscopic organisms. Many herbivorous invertebrates consume algal cells directly rather than the plants to which the algae are attached. Algal cells that grow on the surface of plants often provide the basis for a rich community consisting of the algal

cells, detrital particles trapped by the matrix of algal cells, bacteria and fungi digesting the detritus and organic material released by the plant, and microfauna such as protozoa consuming the detritus, decomposers, and algae. This mix of producers, consumers, and decomposers provides nutrition for many kinds of herbivorous and deposit-feeding animals such as snails, certain minnows, and aquatic insect larvae.

Periphyton biomass is commonly measured as the density of chlorophyll *a* expressed on an aerial basis and trophic categorization schemes as well as water quality guidelines have been developed using this indicator of biomass (Table 4.2-2). British Columbia has adopted a guideline of 100 mg/m^2 chlorophyll *a* for the protection of aquatic biota (British Columbia Ministry of Water, Land and Air Protection 2001). Biomass may also be expressed as ash free dry weight (AFDW) which is a measure of organic matter (Biggs 2000). Periphyton biomass typically increases in response to nutrient enrichment but may also decrease due to increases in metals.

4.2.2.1 Methods

Periphyton (attached algae) was sampled at a number of sites in the Tom and Mary rivers as well as small tributary streams in the open-water season of 2007 to characterize the primary productivity of Mine Area streams. Additionally, periphyton was measured in a small tributary of Sheardown Lake NW and one tributary to Mary Lake in 2008 (Table 4.2-10; Figure 4.2-4). Sampling was attempted in spring, summer, and fall. However, site conditions prevented sampling during some periods (e.g., high water levels in spring).

At each sampling site, three representative samples were collected from periphyton-covered cobble (one sample from each of the right bank, left bank, and centre channel) and submitted to an accredited analytical laboratory (ALS Laboratories, Winnipeg, MB) for the determination of algal biomass as chlorophyll *a*/pheophytin *a* and AFDW. Samples were collected with a scalpel or toothbrush from a known area of the cobble surface to facilitate calculation of densities on an aerial basis. A detailed description of sampling methods is provided in NSC (2008b).

AFDW and chlorophyll *a*/pheophytin *a* densities were calculated using the formulas:

- AFDW (g/m^2) = AFDW (g)/sampling area (m^2); and
- Chlorophyll *a* (mg/m^2) = Chlorophyll *a* (µg)/sampling area (m^2)/1000.

4.2.2.2 Results

Mary River

Periphyton density at five sites in the Mary River ranged from <0.05 g/m^2 to 104.1 g/m^2 for AFDW and from <0.05 mg/m^2 to 47.1 mg/m^2 for chlorophyll *a* (Table 4.2-11). Total chlorophyll *a* (a combination of chlorophyll *a* and pheophytin *a*) ranged from<0.5 mg/m^2 to 80.0 mg/m^2 with a mean of 12.9 mg/m^2. Overall, the Mary River had the second lowest periphyton density of all waterbodies sampled in 2007 with a mean AFDW of 21.5 g/m^2 and the lowest chlorophyll *a* mean density at 7.4 mg/m^2. Similar to other streams in the Mine Area, periphyton abundance increased over the open-water season in the Mary River.

Tom River

Periphyton density from the two sites on the Tom River ranged from 4.6 g/m^2 to 23.3 g/m^2 for AFDW and from <0.5 mg/m^2 to 29.7 mg/m^2 for chlorophyll *a* (Table 4.2-11). Total chlorophyll *a* ranged from <0.5 mg/m^2 to 32.5 mg/m^2 with a mean of 16.1 mg/m^2. Overall, the Tom River had the lowest AFDW of all streams (mean of 11.9 g/m^2) and the second lowest chlorophyll *a* density (mean of 8.3 mg/m^2).

Camp Lake Tributaries

Periphyton density measured in two Camp Lake Tributaries ranged from 4.7 g/m^2 to 109.5 g/m^2 based on AFDW and from 1.4 mg/m^2 to 136.6 mg/m^2 based on chlorophyll *a* (Table 4.2-11). Total chlorophyll *a* ranged from 6.1 mg/m^2 to 277.8 mg/m^2 with a mean of 60.5 mg/m^2. Overall, Camp Lake Tributaries had the second highest AFDW density of all waterbodies sampled in 2007 with a mean of 32.6 g/m^2 and the highest chlorophyll *a* density at 28.8 mg/m^2.

Sheardown Lake Tributaries

During the open-water season of 2007, periphyton density measured in three Sheardown Lake tributaries ranged from 1.4 g/m^2 to 342.5 g/m^2 based on AFDW and from <0.5 mg/m^2 to 108.3 mg/m^2 based on chlorophyll *a* (Table 4.2-11). Total chlorophyll *a* ranged from <1.0 mg/m^2 to 164.8 mg/m^2 with a mean of 45.1 mg/m^2. Overall, the Sheardown Lake tributaries had the highest periphyton density of all waterbodies sampled in 2007 with a mean AFDW of 60.8 g/m^2 and the second highest chlorophyll *a* mean density at 18.9 mg/m^2. Periphyton densities were similar in Tributary 1 in 2007 and 2008. Sheardown Lake tributaries were the only streams sampled during the spring sampling period. In general, periphyton abundance was highest in fall and lowest in spring at these sites.

Mary Lake South Tributary

Periphyton density was measured at one tributary to Mary Lake during the open-water season of 2008. Periphyton abundance (which ranged from 0.3 g/m^2 to 66.9 g/m^2 based on AFDW and <0.5 mg/m2 to 17.1 mg/m^2 based on chlorophyll *a*) was similar to that measured for the Mary River in 2007 (Table 4.2-11).

Summary and Regional Context

Periphyton density within the Mine Area streams ranged from <0.05 g/m^2 to 342.5 g/m^2 for AFDW and <0.5 mg/m^2 to 136.6 mg/m^2 for chlorophyll *a* at sites sampled in 2007 and 2008 (Table 4.2-11). Overall, periphyton densities were highest in the tributaries to Sheardown and Camp lakes and lowest in the Mary and Tom rivers. In general, periphyton abundance increased over the open-water season (i.e., periphyton densities were higher during the fall survey period than during the summer), although in some instances, densities were greatest in spring (where spring sampling was completed) or summer. In addition, periphyton was more abundant at the most upstream sites in all streams except the Tom River (Figure 4.2-5).

Most individual measurements and all site means of periphyton chlorophyll *a* were <100 mg/m^2. Application of the trophic categorization scheme proposed by Dodds et al. (1998) for streams indicates that some streams or areas of streams in the Mine Area would be considered oligotrophic while others mesotrophic on the basis of benthic chlorophyll *a* (Figure 4.2-5). Chlorophyll *a* densities were relatively similar to those reported for streams in the area of the Jericho Project, NT (R.L. & L. 2000), in control reaches of the artificially nutrient-enriched Kuparuk River, Alaska (Bowden et al. 1992), and other Arctic streams, but lower than those reported for the Bathhurst Inlet Port and Road Project (Rescan Environmental Services Ltd. 2007; see Table 4.2-12). AFDW of periphyton was generally higher in the Mine Area streams than observed in a number of streams near Lac de Gras, NT (Jones et al. 2003a and b). However, the general seasonal pattern of greater densities in fall is in agreement with results of studies conducted in Alaskan streams (LaPerriere et al. 1989).

4.3 SECONDARY PRODUCERS

The following sections describe methods and results of baseline field studies conducted to characterize secondary producers in the Mine Area.

4.3.1 Zooplankton in Lakes

4.3.1.1 Overview of Biology

Zooplankton are very small animals without backbones (invertebrates) living in the water column and are consumed by larval, juvenile, and adult fish. This study includes all zooplankton retained by a 63 µm mesh size. Three important groups in the open-water are Cladocera (water fleas) and calanoid and cyclopoid Copepoda (copepods; Figure 4.3-1).

Cladocerans reproduce asexually for the majority of the year in most habitats, enabling this group to increase rapidly in density in response to favourable environmental conditions (e.g., warming water temperatures, increasing food availability). Copepod reproduction is exclusively sexual; their life cycle is quite prolonged to accommodate several developmental stages. In comparison to cladocerans, copepods are slow reproducers requiring several months to years to complete a life cycle. As a result, cladocerans are able to take advantage of favourable growing conditions and peak in abundance, while the copepods are not.

Most species of cladocerans and copepods feed by filtering or grazing particles (bacteria, detritus, and phytoplankton) from the water, though there are a few predatory species. The availability and quality of food (e.g., amount and kinds phytoplankton), the number of predators (e.g., other invertebrates, fish), and water residence time affect the abundance of zooplankton; in rapidly flushed lakes and rivers little zooplankton biomass accumulates except in areas where there is little current.

4.3.1.2 Methods

Field Methods

As the abundance and composition of zooplankton varies throughout the year due to seasonal variations in food availability and water temperature, zooplankton sampling was conducted in conjunction with the surface water quality program in summer (August 7-14, 2007; July 30-August 6, 2008) and fall (September 13-20, 2007; September 2, 2008) from Camp Lake, Sheardown Lake NW, Sheardown Lake SE, and Mary Lake (Figure 4.3-2). Only Sheardown Lake NW was sampled in September 2008 for logistical reasons. Location, sampling date, and a description of each vertical net tow in terms of sampling depth and volume of water filtered are provided in Table 4.3-1.

Zooplankton samples were collected at each site using a 1.0 m long, 63 µm mesh conical net, complete with a weighted PVC cod-end attached to a single 0.25 m diameter steel hoop frame. The net was lowered to the bottom at each site, cod-end first, then slowly retrieved by hand. Upon retrieval, zooplankton captured in the net were rinsed into the cod-end collecting cup, washed into a labelled sampling jar, and fixed in 10% formalin. As a sufficient number of individuals were

collected (>100 individuals) in a single tow, only one tow was required per site. Samples were then transported to the laboratory at North/South Consultants in Winnipeg, MB, and transferred to 70% ethanol for storage. Water depth and the number of vertical tow samples were also recorded at each site.

Samples were submitted to an aquatic invertebrate taxonomist for analysis. Zooplankton were identified to species using the keys of Balcer et al. (1984), Edmondson (1959), Pennak (1978), and Smith and Fernando (1978), and enumerated. Rotifera were not evaluated as the mesh size used in this study was not appropriate for this group; typically, a mesh size of 35 µm or smaller is recommended for the collection of rotifers as larger mesh sizes may underestimate the density of this group (Likens and Gilbert 1970). Cladocera were identified to species and enumerated. Copepoda were counted as Cyclopoida and Calanoida copepodites, and Cyclopoida, Calanoida, and Harpacticoida adults; of the copepods only Cyclopoida and Calanoida adults were identified to species. When possible, at least 200 individuals were counted in each sample. Large samples were sub-sampled depending on the density of organisms. Larger and/or relatively rare specimens were enumerated for the entire sample prior to sub-sampling. Scientific names were updated in accordance with the Integrated Taxonomic Information System (ITIS 2010).

Data Analysis

The estimate of abundance for each taxon per tow was calculated as the number of individuals per cubic metre of water (individuals/m^3). Volume of water filtered was estimated by multiplying the net mouth area (0.049 m^2) by the sample depth (i.e., length of tow in meters) and the number of vertical tows.

Summary statistics (i.e., means, medians, percent abundances, standard deviations [SD], standard errors [SE], ranges [minimums and maximums], and taxonomic richness) were determined for each season by waterbody and overall for each waterbody using pooled data collected in the open-water seasons of 2007 and 2008. Taxonomic richness (i.e., the number of taxa) was determined at the species level. If a group was identified to a higher level (e.g., order), then it was assumed that only one species was represented and this possibly resulted in a conservative estimate of the number of taxa; immature Calanoida copepodites and Cyclopoida nauplii were not included in the determination of richness.

4.3.1.3 Results

The following is an overview of the existing zooplankton density and community composition in Mine Area lakes for the open-water seasons of 2007 and 2008.

Camp Lake

Overall, a total of five crustacean zooplankton taxa were identified from vertical tows conducted in Camp Lake during the open-water seasons of 2007 and 2008 (Table 4.3-2). Zooplankton density varied among sites and sampling periods within Camp Lake, with densities notably higher during summer 2008 in comparison to both 2007 sampling periods (Appendix 4.3-1). Overall mean density for the waterbody was higher in the summer (11,772 ± 3,447 individuals/m^3 ± SE) in comparison to the fall (9,829 ± 3,620 individuals/m^3 ± SE), although taxonomic richness was marginally lower during the summer sampling period (Table 4.3-2; Figure 4.3-3).

Copepoda, particularly Cyclopoida, comprised the majority of the zooplankton catch during summer and fall sampling periods in Camp Lake (Figure 4.3-4). The copepod community was dominated by the cyclopoid *Cyclops scutifer*, and immature calanoid copepodites and cyclopoid nauplii during both seasons (Appendix 4.3-1). Cladocerans were comparatively denser and comprised a larger proportion of the zooplankton community in the summer than in the fall (Figure 4.3-4). The cladoceran community was comprised of two taxa, *Bosmina longirostris* and *Daphnia longiremis* (Appendix 4.3-1). A relatively dense community of *D. longiremis* was observed in the summer, particularly in 2008, which resulted in the relatively high overall density of this cladoceran in Camp Lake.

Sheardown Lake NW

Overall, a total of seven crustacean zooplankton taxa were identified from vertical tows conducted in Sheardown Lake NW during the open-water seasons of 2007 and 2008 (Table 4.3-2). Like Camp Lake, zooplankton density varied among sites and sampling periods within Sheardown Lake NW, with densities notably higher during summer 2008 in comparison to summer 2007; the opposite was true for the fall sampling period where densities were typically considerably higher in 2007 (Appendix 4.3-1). Overall mean density for the waterbody was higher in the fall (19,966 ± 5,487 individuals/m^3 ± SE) in comparison to the summer (11,878 ± 2,636 individuals/m^3 ± SE), although taxonomic richness was marginally lower during the fall sampling period (Table 4.3-2; Figure 4.3-3).

Copepoda, particularly Cyclopoida, comprised the majority of the zooplankton catch during summer and fall sampling periods in Sheardown Lake NW (Figure 4.3-4). The copepod community was dominated by the cyclopoid *C. scutifer*, the calanoid *Diaptomus minutus*, and immature cyclopoid nauplii during both seasons; however, the calanoid *Limnocalanus macrurus* was present in the summer at comparatively low densities (Appendix 4.3-1). Cladocerans were comparatively denser and comprised a larger proportion of the zooplankton community in the fall than in the summer (Figure 4.3-4). The cladoceran community was primarily comprised of two taxa, *B. longirostris* and

D. longiremis; however, *Alona guttata* and *Chydorus sphaericus* were also present at comparatively low densities (Appendix 4.3-1). A relatively dense community of *D. longiremis* was observed in the fall, particularly in 2008, which contributed to the relatively high overall density of this cladoceran in Sheardown Lake NW.

Sheardown Lake SE

Overall, a total of seven crustacean zooplankton taxa were identified from vertical tows conducted in Sheardown Lake SE during the open-water seasons of 2007 and 2008 (Table 4.3-2). Zooplankton density varied among sites and sampling periods within Sheardown Lake SE, with densities notably higher during summer 2008 in comparison to summer 2007; the opposite was true for the fall sampling period where densities were considerably higher in 2007 at two of the three sites sampled (Appendix 4.3-1). Overall mean density for the waterbody was higher in the summer (13,127 ± 4,136 individuals/m^3 ± SE) in comparison to the fall (10,578 ± 2,330 individuals/m^3 ± SE), however taxonomic richness was the same during both sampling periods (Table 4.3-2; Figure 4.3-3).

Copepoda, particularly Cyclopoida, comprised the majority of the zooplankton catch during summer and fall sampling periods in Sheardown Lake SE (Figure 4.3-4). The copepod community was dominated by the cyclopoid *C. scutifer*, the calanoid *D. minutus*, and immature cyclopoid nauplii during both seasons; however, the calanoid *L. macrurus* was present in the fall at comparatively low densities (Appendix 4.3-1). Cladocerans comprised a somewhat larger proportion of the zooplankton community in the fall than in the summer (Figure 4.3-4). The cladoceran community was primarily comprised of two taxa, *B. longirostris* and *D. longiremis*, however, *A. guttata* and *C. sphaericu*s were present at comparatively low densities (Appendix 4.3-1). *D. longiremis* was relatively dense in both the summer and fall, particularly in 2008 at two of the three sites sampled, which contributed to the relatively high overall density of this cladoceran in Sheardown Lake SE.

Mary Lake

Overall, a total of nine crustacean zooplankton taxa were identified from vertical tows conducted in Mary Lake during the open-water seasons of 2007 and 2008 (Table 4.3-2). Zooplankton density varied among sites and sampling periods within Mary Lake, with densities typically higher during summer 2007 in comparison to summer 2008 (Appendix 4.3-1). Overall mean density for the waterbody was higher in the fall (6,147 ± 2,307 individuals/m^3 ± SE) in comparison to the summer (2,713 ± 749 individuals/m^3 ± SE), although taxonomic richness was substantially higher during the summer sampling period (Table 4.3-2; Figure 4.3-3).

Copepoda, particularly Cyclopoida, comprised the majority of the zooplankton catch during summer and fall sampling periods in Mary Lake (Figure 4.3-4). The copepod community was dominated by

the cyclopoid *C. scutifer*, the calanoid *D. minutus*, and immature calanoid copepodites and cyclopoid nauplii during both seasons; however, the calanoid *L. macrurus* and harpacticoid copepods were both present in the summer at comparatively low densities (Appendix 4.3-1). Cladocerans were comparatively denser and comprised a larger proportion of the zooplankton community in the fall than in the summer (Figure 4.3-4). The cladoceran community was primarily comprised of two taxa, *B. longirostris* and *D. longiremis*, however, *A. guttata, C. sphaericus*, and *Holopedium gibberum* were present at comparatively low densities (Appendix 4.3-1). *B. longirostris* and *D. longiremis* were each relatively dense in the fall of 2007, which contributed to the relatively high overall density of cladocerans in Mary Lake.

Summary and Regional Context

In general, Arctic freshwater ecosystems are characterized by relatively low diversity zooplankton communities due to low temperatures and nutrients (Hebert and Hann 1986). Diversity also generally decreases with increasing latitude, but regional differences in communities are observed independent of latitude (Hebert and Hann 1986). Variations in Arctic zooplankton community composition have been related to latitude, lake morphometry, and biotic interactions, sometimes more so than to differences in water chemistry (Kling et al. 1992). Lakes in the Mine Area are characterized by low primary productivity (trophic status of ultra-oligotrophic to oligotrophic due to low chlorophyll *a* concentrations and phytoplankton biomass) as is typical in Arctic aquatic ecosystems (Section 4.1). A total of nine crustacean zooplankton taxa were identified from vertical tows in the Mine Area lakes during the open-water seasons of 2007 and 2008. Zooplankton density varied among sites and between sampling periods within the lakes, as well as among lakes. Mean total zooplankton density was higher during the summer in Camp and Sheardown SE lakes in comparison to the fall, whereas total density was higher during the fall in Sheardown NW and Mary lakes. During the summer, mean total zooplankton density was highest in Sheardown Lake SE (13,127 ± 4,136 individuals/m^3 ± SE), whereas density was highest in Sheardown Lake NW in the fall (19,966 ± 5,487 individuals/m^3 ± SE; Figure 4.3-3). Overall mean total zooplankton density (seasons and years combined) was highest in Sheardown Lake NW (15,922 ± 3,104 individuals/m^3 ± SE), followed by Sheardown Lake SE (11,852 ± 2,296 individuals/m^3 ± SE), Camp Lake (11,125 ± 2,479 individuals/m^3 ± SE), and Mary Lake (3,939 ± 1,007 individuals/m^3 ± SE; Table 4.3-2; Figure 4.3-3).

The distribution of zooplankton is inherently patchy (i.e., these organisms are often highly aggregated). Spatial (e.g., within a lake or among lakes in the same area) and temporal (e.g., seasonal) variation in lake zooplankton density is typical and may be related to physical (e.g., lake area and water depth, flushing rates or water residence times), climatic (e.g., prevailing wind direction, air temperature), chemical (e.g., dissolved oxygen and temperature regimes, turbidity),

and/or biotic (e.g., type, amount, and distribution of phytoplankton, fish predation pressure) differences that often occur within and among lakes, even when lakes are within the same type of geographic region (e.g., Arctic tundra).

Copepoda, particularly Cyclopoida, comprise the majority of the zooplankton in most samples collected from Mine Area lakes (Figure 4.3-4). The copepod community consisted of four taxa with *C. scutifer* and *D. minutus* being the predominant species identified. The cladoceran community was dominated by two species, *B. longirostris* and *D. longiremis*; both of these species are small-bodied in size. Smaller crustacean zooplankton species are more likely to be present in lakes with fish predators, such as Arctic char (O'Brien et al. 2004). Other cladocerans tended to be rare; however, *H. gibberum* was occasionally more abundant in Mary Lake. Bushnell and Byron (1979) observed *H. gibberum* to be an infrequent member of Arctic zooplankton communities and found it in only the two largest lakes they investigated on Baffin Island.

Similar to observations for the Mine Area lakes, the crustacean zooplankton community has been found to be dominated by copepods in other northern areas, such as those investigated as part of the Doris Hinge Project (typically cyclopoid copepods; R. L. & L. / Golder 2002), the Jericho Diamond Project (calanoid copepods; R.L. & L. 2000), and the Meadowbank Gold Project (typically calanoid copepods; Cumberland Resources 2005; Table 4.3-3). The dominance of *C. scutifer* is in general agreement with the literature regarding zooplankton communities in Arctic lakes, in which this species is generally both abundant and widespread. Stewart and MacDonald (1981) captured a total of seven crustacean zooplankton species in three lakes on northern Baffin Island (Nina Bang Lake, Unnamed Lake at Milne Inlet, and Erichsen Lake) in August 1980. Total densities were similar to those measured from the Mine Area lakes in two of the lakes (11,870 individuals/m^3 in Nina Bang Lake and 24,700 individuals/m^3 in Erichsen Lake), but lower in the third (280 individuals/m^3 in the Unnamed Lake). The zooplankton species present and the relative abundance of the species were also similar to results of this study; copepods were dominant, with *C. scutifer* being the most abundant species, and the cladoceran community was dominated by *D. longiremis*. Similarly, O'Brien et al. (2005) reported that Lake N-2 (Arctic Alaska) was characterized by densities of crustacean zooplankton between 10,000 and 30,000 individuals/m^3 with the most common species being *D. longiremis*, *B. longirostris*, *Diaptomus pribilofensis* (calanoid copepod), and *C. scutifer*. Shortreed and Stockner (1986) also reported that *C. scutifer*, *D. longiremis*, and *D. pribilofensis* were the most common species in 19 subarctic lakes (Yukon) surveyed in 1982. Oliver (1964) indicated Nettilling Lake, Baffin Island, was dominated by *C. scutifer*, *D. longiremus*, and D. *minutus*.

4.3.2 Overview of Macroinvertebrate Biology

Aquatic macroinvertebrates are small animals without backbones living on or in the substrata of lakes and rivers. This study includes macroinvertebrates that are retained by a 500 µm mesh size. Macroinvertebrates are important food items to vertebrates (particularly fish) and useful bioindicators of environmental change.

Aquatic macroinvertebrates are typically a diverse assemblage, and are adapted to the range of substrate types and water flow regimes (e.g., fast-flowing streams, sheltered bays in lakes with no discernable flow) found in the aquatic environment. Beds of aquatic vegetation typically harbour the greatest density and diversity (i.e., number of taxa) of macroinvertebrates, with invertebrates living on leaf surfaces (epiphytic invertebrates) as well as on and within the sediments beneath the plants (benthic invertebrates or benthos). These include grazers of attached algae [e.g., Chironomidae (chironomids or midges), and Ephemeroptera (mayflies)], organisms that consume organic-rich sediment [e.g., Oligochaeta (aquatic worms)], and a few carnivores (e.g., certain types of chironomids; Figure 4.3-5); Amphipoda (amphipods, scuds, or freshwater shrimp), which consume a variety of decaying plant and animal matter, are also present (Figure 4.3-5). The higher densities of macroinvertebrates in aquatic macrophyte beds reflect higher productivity (via photosynthetic and detrital foodweb pathways) and protection from predators provided by the plants.

Shallow areas (i.e., littoral zone) with mud or mud-sand bottoms provide habitat for filter- and sediment-feeding organisms, and a variety of insect larvae, many of which have terrestrial adult forms. Emergence of larval insects to terrestrial adults results in a loss of numbers and biomass from the aquatic system. Substrata such as sand or gravel usually harbour fewer animals because water currents (e.g., wave action on shorelines) readily disturb these substrata. Sand (0.063-2 mm in diameter) is generally considered to be a poor substrate for macroinvertebrates due to its relative instability (i.e., susceptible to water movement) and the tight packing of particles (i.e., minimal interstitial space) reducing the trapping of organic matter (i.e., detritus) and limiting the presence of dissolved oxygen. In general, diversity and abundance of macroinvertebrates increase with substrate stability or the presence of organic matter. However, sand-dwelling fauna includes some macroinvertebrates typically exhibiting adaptations associated with respiration [e.g., certain types of Trichoptera (caddisflies)].

Generally, in riverine environments invertebrates are more abundant in (i.e., show a preference for) shallow water and in gravel or coarser substrates (i.e., cobble) [particularly insects, such as mayflies, Plecoptera (stoneflies), and caddisflies] (Minshall 1984, Jowett et al. 1991). Total benthic invertebrate production tends to be relatively low on extremely fine (e.g., silt/clay, sand) and extremely coarse (e.g., boulder, bedrock) substrates, while productivity is typically highest for

substrate particles averaging 10 mm in diameter (i.e., coarse gravel; Morin 1997). Similar substrate preferences in lentic environments could be expected.

Deeper areas of lakes are typically depositional environments with fine-textured sediments. Organisms that feed on sediment and detritus (e.g., aquatic worms and chironomids) usually dominate in these areas. Many of these animals are adapted to low-oxygen conditions that can develop at greater water depths.

The aquatic macroinvertebrate community within a riverine system is comprised of benthic, epiphytic, and drifting organisms. Drifting invertebrates, organisms that move downstream in the water current, are a composite of invertebrates originating from a larger area and diverse array of habitats, but the drifting community tends to be biased towards those groups that drift as a life history strategy (predominantly aquatic insects). Aquatic invertebrate drift is an important and well documented component of stream structure and function (Brittain and Eikeland 1988). The tendency for aquatic invertebrates to drift, and the distance traveled when drifting, is dependent on life history, and environmental, physical, biological, and chemical cues; and can result from: i) accidental dislodgment from substratum; ii) changes in the physical environment (i.e. discharge, velocity); iii) interactions with other invertebrates; and iv) colonization (Elliott 1971). Drift varies over space (e.g., position in the river) and time (e.g., daily and seasonally). A well-documented temporal feature of aquatic invertebrate drift is the dusk peak, related to a change in light intensity and as an anti-predatory response; temperature and discharge are likely features dictating drift variation over longer periods such as seasons (Shearer et al. 2002). Reliable quantification of drift is necessary for investigating some aspects of trophic interaction between invertebrates and drift-feeding fish (Shearer et al. 2002). Drift-invertebrate sampling is useful for assessing habitat quality and food availability by examining the abundance and diversity of invertebrate taxa. Non-drifting and drifting macroinvertebrates are an important food source for fish and therefore, their abundance and distribution helps define the importance of an aquatic area as feeding habitat. Drifting invertebrates may also be important for food web dynamics in some lakes (i.e., where drift from inflowing streams is a significant contributor to energy flow in the lake).

4.3.3 Invertebrate Drift in Streams

4.3.3.1 Methods

Field Methods

Drifting macroinvertebrate samples were collected in spring (June 25-29, 2007; June 24-25, 2008), summer (July 28 to August 4, 2007; July 25-26, 2008), and fall (August 31 to September 3, 2007; September 11, 2008) from the mouths of Sheardown Lake Tributary 1 (2007, 2008), Sheardown

Lake Tributary 9 (2007), Sheardown Lake Tributary 12 (2007), Camp Lake Tributary 1 (2007), Camp Lake Tributary 2 (2007), and Mary Lake South Tributary 2 (2008). Due to minimal or absent flows, samples were not collected in the summer and fall, 2007 from Sheardown Lake Tributary 9. For logistical reasons, sampling was only partially completed at the mouth of Sheardown Lake Tributary 1 and not conducted at Mary Lake South Tributary 2 in fall 2008. Locations of drifting macroinvertebrate sampling sites are presented in Table 4.3-4 and Figure 4.3-6.

Drift traps were used to estimate macroinvertebrate drift density in representative tributaries to Sheardown, Camp, and Mary lakes in the morning, evening, and night during the 2007 and 2008 (tributaries to Sheardown NW and Mary lakes only) open-water seasons to estimate stream productivity as well as to provide a measure of the contribution of macroinvertebrate drift from these streams to the lakes.

In order to obtain a representative sample of the drifting macroinvertebrates present in any given stream, three drifting macroinvertebrate samples were collected during each of the sampling periods over a 24-hour period (Jones et al. 2003a and 2003b). The three samples were collected at eight hour intervals to represent a morning sample, an evening sample, and a night sample (collected at approximately 10:00-12:00, 18:00-20:00, and 02:00-04:00, respectively).

Drift samples were collected using a standard drift trap (0.225 m^2) that filtered into a 500 µm mesh net. At the end of the net, the sample was collected in a 1 L plastic Nalgene bottle that contained 500 µm mesh-covered holes, which permitted water to flow through the bottle.

Drift traps were deployed as close as possible to the mouth of each stream, facing into the current, at a depth that allowed the mouth of the trap to remain submerged. After the trap was installed, the velocity at its mouth was measured using either a Swoffer or a Price Current Meter. Each drift trap remained submerged until it had filtered a total of 5 m^3 of water. The amount of time required for a given trap to remain in the water was calculated using the formula: 60 s x (5 m^3 / (water velocity [m/s] x area of the trap mouth [m^2]).

Once the allotted time had elapsed, the drift trap was removed from the stream, the sample was washed into the collecting bottle, and the sample was transferred into a 250 or 500 mL sample jar. Samples were fixed as soon as possible by adding sufficient volume of concentrated formalin to produce a final concentration of 10% formalin.

Samples were shipped to the laboratory at NSC in Winnipeg for processing. In Winnipeg, all samples were sieved using a 500 µm mesh, rinsed with water, and sorted under a magnifying lamp. Samples were sorted to separate macroinvertebrates from debris. Drifting macroinvertebrates were enumerated and identified to major group (i.e., subclass, order, or family) using a Leica MZ12.5

stereomicroscope (maximum 100x magnification) and reference texts from Merritt and Cummins (1996), Peckarsky et al. (1990), and Clifford (1991). Scientific names used followed the Integrated Taxonomic Information System (ITIS 2010) classification. Sample processing, taxonomy, and quality assurance were completed in accordance with NSC procedures (Appendix 4.3-2).

Data Analysis

Macroinvertebrate drift density was calculated with the formula: [number of individuals x 100] divided by [time (seconds) x drift trap height (metres) x drift trap width (metres) x water velocity (metres/second)]; Ramirez and Pringle 1998).

Summary statistics (i.e., means, medians, percent abundances, standard deviations [SD], standard errors [SE], ranges [minimums and maximums], taxonomic richness, and the dominant taxon) were determined for each season by waterbody and overall for each waterbody using pooled data collected in the open-water seasons of 2007 and 2008, where available. Taxonomic richness (i.e., the number of taxa) was determined at the family level; if a group was identified to a higher level (e.g., class or order), then it was assumed that only one family was represented and this likely resulted in a conservative estimate of the number of taxa.

4.3.3.2 Results

Camp Lake Tributaries

Overall, a total of seven macroinvertebrate taxa were identified in drift traps deployed in two Camp Lake tributaries during the open-water season of 2007 (Table 4.3-5). Drifting macroinvertebrate density varied between Camp Lake tributaries and between sampling periods within a tributary, particularly among morning, evening, and night samples (Appendix 4.3-3). Overall mean total drifting macroinvertebrate density was comparable between summer (66.30 ± 27.27 individuals/100 m^3 ± SE) and fall (67.91 ± 17.20 individuals/100 m^3 ± SE), and taxonomic richness was the same (four taxa observed at family level; Table 4.3-5).

Orthocladiinae larvae (midges [Chironomidae]) were dominant in the drift catch during both summer (48% of catch) and fall (85%) in 2007 (Appendix 4.3-3). Nematodes (4%), Hymenoptera adults (2%), midge pupae (4%) and adults (38%), and mosquito larvae (2%) were present at comparatively lower densities in the summer, whereas mites (2%), Nemouridae larvae (stoneflies [Plecoptera]) (2%), and crane fly larvae (11%) were observed in the fall.

Sheardown Lake Tributaries

Overall, a total of 16 macroinvertebrate taxa were identified in drift traps deployed in three tributaries to Sheardown Lake NW and SE during the open-water seasons of 2007 and 2008 (Table 4.3-5). Drifting macroinvertebrate density varied among Sheardown Lake tributaries and among sampling periods within a tributary, particularly among morning, evening, and night samples (Appendix 4.3-3). Overall mean total drifting macroinvertebrate density was highest in the spring (185.52 ± 67.72 individuals/100 m^3 ± SE), but comparable between summer (16.33 ± 6.35 individuals/100m^3 ± SE) and fall (18.94 ± 6.73 individuals/100 m^3 ± SE); the high spring drift density was due to the abundant Orthocladiinae larvae catch at SDLT-9 and SDLT-12 in 2007 (Appendix 4.3-3). Additionally, taxonomic richness was highest in the spring (nine taxa observed at family level) and comparable between summer (seven taxa) and fall (six taxa; Table 4.3-5).

Orthocladiinae larvae (midges [Chironomidae]) were dominant in the drift catch during both spring (96% of catch) and fall (75%) in the open-water seasons of 2007 and 2008, whereas midge pupae (27%), midge adults (30%), and Orthocladiinae (24%) co-dominated the drift in the summer (Appendix 4.3-3). Nematodes (6%) and black fly larvae (6%) notably contributed to the drift community in the summer, whereas ostracods (6%), dipteran adults (6%), and midge pupae (7%) dominated in the fall.

Mary Lake South Tributary

Overall, a total of six macroinvertebrate taxa were identified in drift traps deployed in one tributary to the southern basin of Mary Lake during the open-water season of 2008 (Table 4.3-5). Drifting macroinvertebrate density varied between sampling periods within the tributary, particularly among morning, evening, and night samples (Appendix 4.3-3). Overall mean total drifting macroinvertebrate density was higher in the summer (13.30 ± 6.11 individuals/100 m^3 ± SE) in comparison to the spring (7.10 ± 5.28 individuals/100 m^3 ± SE); taxonomic richness was also higher during the summer (five taxa observed at family level) (Table 4.3-5).

Orthocladiinae larvae (midges) were dominant in the drift catch during the spring (48% of catch), but other types of annelids (worms) were co-dominant (33%) with Orthocladiinae (29%) in the summer (Appendix 4.3-3). Hymenopterans (9%), mayfly larvae (9%), and Chironominae (27%) and Tanypodinae larvae (9%) (midges) were present at comparatively lower densities in the spring, whereas oligochaetes (worms) (5%), springtails (5%), hymenopterans (19%), midge adults (5%), and Chironominae larvae (5%) were observed in the summer.

Summary and Regional Context

A total of 21 macroinvertebrate taxa were identified at the family level in drift traps deployed in the open-water seasons of 2007 and 2008 at the mouths of tributaries flowing to Camp, Sheardown, and Mary lakes. Drifting macroinvertebrate density varied among tributaries and among sampling periods within a tributary, particularly among morning, evening, and night samples. During the spring, mean total density was highest in tributaries to Sheardown Lake (185.52 individuals/100 m^3), whereas density was highest in tributaries to Camp Lake during the summer (66.30 individuals/100 m^3) and fall (67.91 individuals/100 m^3); however, tributaries to Camp Lake were not sampled during the spring and the tributary to Mary Lake was not sampled during the fall to allow for a complete comparison (Figure 4.3-7). Overall mean total drifting macroinvertebrate density (seasons and years combined, where applicable) is highest in tributaries to Sheardown Lake (87.06 individuals/100 m^3), followed by tributaries to Camp (67.11 individuals/100 m^3) and Mary lakes (10.20 individuals/100 m^3; Table 4.3-5; Figure 4.3-7).

Miller and Stout (1989) have suggested that drift density is related to benthic density. Drift density in Mine Area streams appears to be related to benthic macroinvertebrate density, as both followed the same pattern in terms of relative density among tributaries sampled (Section 4.3.5). Taxonomic richness of drift also followed the same spatial pattern with 16 taxa observed at the family level in tributaries to Sheardown Lake, seven in tributaries to Camp Lake, and six in tributaries to Mary Lake (Table 4.3-5). Overall, drift density is dominated by Orthocladiinae larvae in tributaries to Camp (67%), Sheardown (91%), and Mary lakes (34%). Other taxa are often present in samples from tributaries to Camp and Sheardown Lakes, but typically at much lower densities. Other types of annelids (22%), hymenopterans (16%), and Chironominae larvae (13%) notably contribute to the overall drift in the tributary to Mary Lake (Appendix 4.3-3). Orthocladiinae larvae are also found to typically dominate the benthic macroinvertebrate community in Mine Area streams (Section 4.3.5).

Drifting invertebrate densities were similar to those observed in streams in northern Alaska Arctic and subarctic streams (Miller and Stout 1989), but somewhat lower than those reported for lake outlet streams in the Barrenlands near Lac de Gras (NWT; Jones et al. 2003b) and lake outlet streams sampled as part of the Doris Hinge Project, east of Bathurst Inlet, Nunavut (R.L. & L. / Golder 2002; Table 4.3-6). The differences observed between Mine Area streams (tributaries to lakes) and lake outlet streams may be partly explained by the positioning of drift nets in lake outlet streams in close proximity to a lake outlet and/or high flushing rates from the corresponding lakes. When microcrustaceans (e.g., cladocerans, copepods) are removed from the overall drift community composition, it was found that chironomids typically dominate the community of Arctic and subarctic streams (Table 4.3-6). However, Simuliidae (black-fly larvae) may also be an important component of the drift community, as observed in northern Alaska, NWT and other Nunavut

streams. Although methods were not directly comparable, it appeared that in addition to having higher drifting invertebrate densities, lake outlet streams in NWT and Nunavut also were more diverse with a greater number of invertebrate taxa represented than observed in Mine Area streams (Table 4.3-6). Differences in abundance and composition of drift organisms are likely partly attributable to different physical characteristics among streams sampled (e.g., substrate types, variability in discharge, sampler position in relation to lake outlet, stream order, etc.).

4.3.4 Benthic Macroinvertebrates in Lakes

4.3.4.1 Methods

Field Methods

Benthic macroinvertebrate sampling in lakes was conducted in fall (August 31 and September 5, 2006; August 31 to September 20, 2007; September 8-12, 2008) from Camp (2007), Sheardown NW (2007, 2008), Sheardown SE (2007), and Mary (2006, 2007) lakes. Inclement weather reduced the length of the fall sampling season in 2008, which prevented the completion of the full planned program for Sheardown Lake NW. Locations of benthic macroinvertebrate sampling sites are presented in Table 4.3-7 and Figure 4.3-8.

Lake benthic macroinvertebrate samples were collected using either an Ekman dredge (2006) or a petit Ponar dredge (2007, 2008) sampling device (each with a sampling area of 0.023 m^2). Sample characteristics, which included substratum composition, colour, odour, sample depth, and UTM coordinates for each replicate site, were documented.

In 2006 and 2007, three replicate samples were collected at each sampling site while in 2008 three to seven replicate stations were sampled for each habitat type investigated in Sheardown Lake NW. Each replicate sample was a composite of five grabs (i.e., five sub-samples were combined per replicate site); however, at Mary Lake in 2007 each replicate sample was composed of only a single grab due to equipment malfunction. At each sampling location, the dredge was slowly lowered until it rested on the bottom to prevent shock waves that could physically move or disturb organisms and sediment from beneath the sampler. Following completion of a grab, the dredge was slowly raised, to minimize turbulence, and the sample was immediately placed into a pail. An acceptable sample required that the jaws be completely closed upon retrieval. If the jaws were not completely closed the sample was discarded into a bucket (and disposed of once sampling was completed) and the procedure was repeated.

For each replicate collected in 2006 and 2007, five sub-samples approximately 1 m apart were collected from the same side of the boat. The three replicate samples were separated by

approximately 10 m. For each habitat type sampled in 2008, three to seven replicate stations were sampled, each resulting in a single composite sample consisting of five benthic macroinvertebrate field sub-samples/grabs. The geographic extent of each replicate station was at least 10m x 10m and replicate stations were separated by at least 20 m.

Samples were taken to shore and sieved through a 500 µm sieve bucket. A weed sprayer was sometimes used on a gentle setting to help break down clay. Samples were then rinsed into labelled sampling jars and fixed in 10% formalin. Sodium bicarbonate ('baking soda') was used to buffer samples where molluscs/shells were present. Sampling equipment was rinsed on shore before the next site was sampled.

Benthic macroinvertebrate samples were submitted to Zaranko Environmental Assessment Services (ZEAS) Inc. (Nobleton, ON) for processing and identification. The results of the 2008 QA/QC program are provided in Appendix 4.3-4 (results of the 2006 and 2007 QA/QC programs were provided in Knight Piésold (2007) and North/South Consultants Inc. (2008b), respectively); laboratory methods were consistent over the three years of investigation and may be referred to in Knight Piésold (2007) and/or North/South Consultants Inc. (2008b).

Data Analysis

Locations sampled for benthic macroinvertebrates were classified according to water level and light availability, substrata type, and the presence or absence of rooted aquatic vegetation (see Section 4.1.1.1). Data were processed and community descriptors (i.e., metrics) were calculated; these included total macroinvertebrate density (individuals/m^2±SE), taxonomic richness, taxon proportion (percentage abundance), evenness, and the Simpson's Diversity Index (Magurran 1988, 2004). Metrics were calculated for each replicate sample and summary statistics were generated for each sampling site, habitat type, and waterbody using pooled data collected in the open-water seasons of 2006, 2007, and 2008, where available. Efforts were made to include as many taxa as possible in the analysis; however, Diptera, Chironomidae and Empididae pupae were excluded from metric calculations where genus level identification was used (e.g., evenness, Simpson's Diversity Index). Taxonomic richness (i.e., the number of taxa) was determined at the genus level. If a group was identified to a higher level (e.g., class or order), then it was assumed that only one genus was represented and this likely resulted in a conservative estimate of the number of taxa; pupae were not included in the determination of richness.

Evenness (Shannon's Equitability, EH) measures the similarity of population sizes of different species, with evenness values closer to 1 indicating that macroinvertebrates of different species are more similar in abundance and an evenness value of 0 indicating that only one species is present. For

the purposes of calculating summary statistics for evenness, a value of 0 was used when no individuals were present at site.

Simpson's Diversity Index (1-D) quantifies biodiversity by measuring the probability of two individuals in a sample belonging to the same species while accounting for taxonomic richness and abundance patterns. The higher the index (0 to 1), the greater the biodiversity and the less likely that two individuals would belong to the same species. For the purposes of calculating summary statistics for the index, a value of 0 was used when no individuals were present at a site.

4.3.4.2 Results

Camp Lake

Overall, a total of 23 macroinvertebrate taxa were identified in 15 benthic samples in Camp Lake (Table 4.3-8). Two macroinvertebrate taxa were identified from three benthic grab samples in Habitat 4 while 23 macroinvertebrate taxa were identified from 12 benthic grab samples within Habitat 14. Overall mean total benthic macroinvertebrate density was 2,122 individuals/m^2 ± 443 SE, with the majority of macroinvertebrates and taxa occurring in Habitat 14 (Table 4.3-8).

Total diversity (Simpson's Index of Diversity [1-D]) values ranged from 0.60 (Habitat 4) to 0.78 (Habitat 14) (Table 4.3-8).With a mean diversity value of 0.64, this waterbody was considered moderately diverse with a variety of insect genera represented. The mean evenness value for Camp Lake was 0.50; evenness values were lowest in Habitat 4 (0.24) and highest in Habitat 14 (0.56) (Table 4.3-8).

Chironomidae (midges) was dominant and comprised 96% of all taxa collected in benthos samples from Camp Lake (Table 4.3-8). The subfamilies Chironominae (namely *Microspectra* 34%) and Orthocladiinae (*Heterotrissocladius* 43%) were most abundant, comprising 45% and 47% of the total macroinvertebrate density (Appendix 4.3-5). Nemata (3%), Acari (1%), Harpacticoida (0.2%), Ostracoda (<0.1%), Collembola (<0.1%), and *Apatania* (0.1%; Trichoptera) were also present, though at comparatively lower densities.

Sheardown Lake NW

Overall, a total of 34 genera were identified in 39 benthic macroinvertebrate samples in Sheardown Lake NW (Table 4.3-8). Twenty-six taxa were collected in Habitat 4, 31 taxa were collected in Habitat 9, and 14 taxa were collected in Habitat 14. Overall mean total benthic macroinvertebrate density was 2,488 individuals/m^2 ± 468 SE. The majority of macroinvertebrates occurred in Habitat 9 (3,658 individuals/m^2 ± 731 SE), followed by Habitat 14 (1,101 individuals/m^2 ± 245 SE), and Habitat 4 (829 individuals/m^2 ± 277 SE) (Table 4.3-8).

Total diversity values ranged from 0.38 (Habitat 14) to 0.76 (Habitat 9; Table 4.3-8). With a mean diversity value of 0.67, this waterbody was considered moderately diverse with a variety of insect genera represented. The mean evenness value for the Sheardown Lake NW was 0.63; evenness values were lowest in Habitat 14 (0.41) and highest in Habitat 9 (0.72; Table 4.3-8).

As observed in Camp Lake, Chironomidae was dominant and comprised 82% of all taxa collected in benthos samples from Sheardown Lake NW (Table 4.3-8). The subfamilies Chironominae (specifically *Stictochironomus* 22%) and Orthocladiinae (*Heterotrissocladius* 23%) were most abundant, comprising 43% and 31% of the total macroinvertebrates (Appendix 4.3-5). Ostracoda (14%), Acari (2%), and Nemata (1%) were also present in addition to Oligochaeta (Enchytraeidae and *Lumbriculus*), Harpacticoida, *Apatania*, and *Dicronata* (Tipulidae); each group contributed to less than 1% of total macroinvertebrate density.

Sheardown Lake SE

Overall, a total of 29 macroinvertebrate taxa were identified in 12 benthic samples in Sheardown Lake SE (Table 4.3-8). Twenty-three taxa were collected in Habitat 4, 19 taxa were collected from Habitat 10, and 15 taxa were collected from Habitat 14. Overall mean total benthic macroinvertebrate density was 8,229 individuals/m^2 ± 2,413 SE, with the highest mean density occurring in Habitat 10 (18,562 individuals/m^2 ± 6,531 SE). Densities in Habitats 4 and 14 were similar (4,270 individuals/m^2 ± 3,543 SE and 5,042 individuals/m^2 ± 551 SE, respectively; Table 4.3-8).

Total diversity values ranged from 0.59 (Habitat 14) to 0.73 (Habitat 4; Table 4.3-8).With a mean diversity value of 0.66, this waterbody was considered moderately diverse with a variety of insect genera represented. The mean evenness value for the Sheardown Lake SE was 0.62; evenness values were lowest in Habitat 14 (0.59) and highest in Habitat 4 (0.67; Table 4.3-8).

Chironomidae (midges) was dominant and comprised 82% of all taxa collected in benthos samples (Table 4.3-8). The subfamily Chironominae comprised 66% of the total macroinvertebrates, consisting mainly of *Stictochironomus* (24%), *Chironomus* (17%), and *Micropsectra* (14%) (Appendix 4.3-5). Orthocladiinae (7%) and Tanypodinae (9%) were also present, and primarily consisted of *Heterotrissocladius* (4%), *Arctopelopia* (4%), and *Procladius* (5%). Ostracoda (15%), Acari (2%), and *Apatania* (1%) were also identified from benthic samples collected in Sheardown Lake SE, though at comparatively lower densities. The following groups were also present: Nemata, Oligochaeta (Enchytraeidae and Lumbriculidae), Harpacticoida, and Tipulidae (*Dicronata* and *Tipula*), each contributing to less than 1% of the overall macroinvertebrate total.

Mary Lake

Overall, a total of 30 macroinvertebrate taxa were identified in 12 benthic samples in Mary Lake (Table 4.3-8). Nineteen taxa were collected in Habitat 9 and 26 taxa were collected from Habitat 14. Overall mean total benthic macroinvertebrate density was 3,270 individuals/m^2 ± 556 SE, with the highest mean density occurring in Habitat 9 (4,005 individuals/m^2 ± 960 SE). Macroinvertebrate density in Habitat 14 was comparatively similar (2,668 individuals/m^2 ± 620 SE) to Habitat 9 (Table 4.3-8).

Total diversity values ranged from 0.50 (Habitat 14) to 0.67 (Habitat 9; Table 4.3-8). With a mean diversity value of 0.57, this waterbody was considered moderately diverse with a variety of insect genera represented. The mean evenness value for the Mary Lake was 0.63; evenness values were lowest in Habitat 14 (0.52) and highest in Habitat 9 (0.70; Table 4.3-8).

Chironomidae (midges) was dominant and comprised 95% of all taxa collected in benthos samples (Table 4.3-8). The subfamily Chironominae comprised 74% of the total macroinvertebrates, consisting mainly of *Micropsectra* (43%); with *Sergentia* (16%), *Chironomus* (7%), *Stictochironomus* (7%) and *Tanytarsus* (1%) also present (Appendix 4.3-5). Orthocladiinae represented 14% of the total macroinvertebrates and primarily consisted of *Heterotrissocladius* (10%); *Procladius* was the only genus collected from the subfamily Tanypodinae (5% of the mean total of macroinvertebrates). Nemata (2%), Acari (1%), and Ostrocoda (2%) were also identified from benthic samples collected in Mary Lake, though at comparatively lower densities. Oligochaeta (Enchytraeidae and Lumbriculidae), Harpacticoida, Collembola, and Tipulidae (*Ormosia* and *Tipula*) each contributed to less than 1% of the overall macroinvertebrate total.

Summary and Regional Context

A total of 45 macroinvertebrate taxa were identified at the genus level from benthic samples collected during the open-water seasons of 2006, 2007, and 2008 at Camp, Sheardown NW, Sheardown SE, and Mary lakes. Macroinvertebrate density varied among lakes and was highest in Sheardown Lake SE (8,229 individuals/m^2), followed by Mary Lake (3,270 individuals/m^2), Sheardown Lake NW (2,488 individuals/m^2), and Camp Lake (2,122 individuals/m^2; Figure 4.3-9). Within each lake, except Camp Lake (euphotic/littoral zone was not sampled), the highest mean density occurred in lake areas falling within the euphotic/littoral zone. This is particularly evident for Sheardown Lake SE, as sampling occurred in a portion of the basin with aquatic macrophytes present. Areas with aquatic vegetation typically harbour the greatest density of macroinvertebrates, with invertebrates living on macrophyte surfaces as well as on and within the sediments. The higher densities of macroinvertebrates in the littoral zone generally reflects higher productivity (via photosynthetic and detrital foodweb pathways); the invertebrate community may further benefit from

the presence of aquatic macrophytes as they increase habitat diversity and provide protection from predators (invertebrate and fish). Taxonomic richness values were comparable with 29 taxa observed at the genus level in Sheardown Lake SE, 30 in Mary Lake, 34 in Sheardown NW, and 23 in Camp Lake (Table 4.3-8). All lakes are considered moderately diverse (mean diversity values ranged between 0.57 [Mary Lake] and 0.67 [Sheardown Lake NW]), with a variety of insect genera represented (Table 4.3-8). The higher the index (0 to 1), the greater the biodiversity and the less likely that two individuals would belong to the same species. Lake-wide mean evenness values ranged from 0.50 (Camp Lake) to 0.63 (Sheardown Lake NW and Mary Lake; Table 4.3-8). Evenness measures the similarity of population size of different species, with evenness values closer to 1 indicating that macroinvertebrates of different species are more similar in abundance.

Overall, macroinvertebrate density was dominated by Chironominae larvae (mainly *Micropsectra* and *Stictochironomus*) in lakes, but other types of macroinvertebrates, such as Ostracoda (seed shrimp), Orthocladiinae, and Tanypodinae, also notably contributed to the overall benthic density in lakes (Appendix 4.3-5).

The benthic communities of the Mine Area lakes are similar in many respects to the communities of other small lakes in the Canadian Arctic and subarctic (Table 4.3-9). In Arctic lakes, many larger invertebrates are typically absent and chironomids dominate the benthic invertebrate community in terms of density and biomass (Oliver 1968). Oliver (1964) reported that of 259 sediment dredges collected in Nettilling Lake, south-central Baffin Island, 95% of the total macroinvertebrates identified were chironomids. Of the remaining 5%, Oligochaeta (oligochaetes or aquatic earthworms) and Nemata (nematodes or roundworms) were most abundant. Preliminary data indicated that chironomids were dominated by Orthocladiinae, with smaller numbers of Tanypodinae and Chironominae present.

Benthic invertebrates in Contwoyto Lake, Nunavut, were low in density (1,689 individuals/m^2) and were dominated by chironomid taxa (53%), followed by Pisidiidae (fingernail clams; 22%) and Nemata (11%; Rescan 2007). The dominant chironomid in Contwoyto Lake was *Heterotrissocladius*.

Similar to the benthic invertebrate community in Contwoyto Lake, the communities observed in the lakes of the Doris Hinge Project, Nunavut, were low in density and comparable to the range of densities observed for Mine Area lakes (Table 4.3-9; R.L. & L. / Golder 2002). Chironomids, Nemata, Bivalvia (bivalves or clams), and oligochaetes dominated the lake benthic macroinvertebrate communities within the Doris Hinge Project area. The communities in deeper regions of the lakes appeared to be increasingly dominated by chironomids and occasionally

bivalves. With the exception of a few lakes and sample depths, chironomids tended to dominate (i.e., contributed more than 50% to total numbers) the benthic communities of the lakes.

Benthic macroinvertebrate groups encountered in the lakes of the Jericho Diamond Project (420 km northeast of Yellowknife) were similar in composition to those of the Doris Hinge Project area and included chironomids, nematodes, bivalves, and oligochaetes (Table 4.3-9; R.L. & L. 2000). As was observed for other Arctic and subarctic lakes, the communities were dominated by a few taxa and chironomids and nematodes were numerically abundant. The density of benthos at shallow water (littoral) sites ranged from 6,434 individuals/m^2 to 99,479 individuals/m^2 in a lake with a maximum depth of only 2.3 m; the density of benthos at deeper water (profundal) sites was considerably lower (550 individuals/m^2). The notably higher density observed in the shallow lake likely reflected the higher productivity of its littoral habitat due to increased water temperatures and light penetration in comparison to the deeper lake (R.L. & L. 2000).

The benthic invertebrate community of Meadowbank project lakes (near Baker Lake, Nunavut) was numerically dominated by aquatic insect larvae, especially chironomids, both in terms of density and species diversity, which is typical of most Arctic lakes (Table 4.3-9; Cumberland Resources 2005). The mean density of benthic invertebrates from project lakes ranged from 2,500 to 8,300 individuals/m^2, which is very similar to the range of densities observed in the Mine Area lakes. Chironomid larvae comprised between 50% and 86% of organisms in benthic samples from all study lakes and ponds between 1997 and 2003. The dominant genera in 2002 were *Procladius*, *Tanytarsus*, *Paratanytarsus*, *Tanytarsini*, and *Heterotrissocladius*. These results are consistent with data collected in August 1997 and 1998, where the genera *Procladius*, *Tanytarsus*, *Rheotanytarsus*, *Phaenospectra*, *Microspectra*, and *Heterotrissocladius* dominated abundance. Chironomids also dominated abundance in reference and regional lakes as is typical of Arctic lakes. Other important insect taxa such as Ephemeroptera (mayflies) and Plecoptera (stoneflies) are uncommon or absent in many Arctic lakes. The average number of genera identified from project lakes was between 11 and 20, slightly lower than what was observed in Mine Area lakes; chironomids were the most diverse taxon, with a total of 20 genera identified (Cumberland Resources 2005).

Benthic macroinvertebrate density, community composition, and taxonomic richness of Mine Area lakes are comparable in many aspects to data collected from lakes elsewhere in the Canadian Arctic (Table 4.3-9). The benthic communities of Mine Area lakes are also typical of oligotrophic Arctic lakes. Due to the variability and harshness of the Arctic environment, where air temperatures may range from -70˚C in winter to +15˚C in summer, fewer macroinvertebrate species are able to survive and adjust their metabolism to be active and complete their life cycles (Leoncini 2004). As a result, species richness and diversity are generally lower in the Arctic with relatively low rates of colonisation and speciation, and high rates of extinction. Benthic organisms have developed a

number of coping mechanisms that enable them to survive in cold environments. Such mechanisms include life history strategies whereby prolonged periods of rest or hibernation (diapause) conserve energy and limit the amount of food required for survival. Basking, cocoon building, preferential habitat selection, and parthenogenesis (reproduction without fertilization) are behavioural adaptations exhibited by benthic macroinvertebrates in cold environments (ACIA 2005). Chironomids are some of the most successfully adapted organisms to harsh Arctic environmental conditions, such as desiccation, anoxia, and temperature extremes (including freezing), thus they are often the dominant taxa in Arctic freshwaters (Oliver and Dillon 1997).

It should be noted that it is difficult to make direct comparisons in benthic macroinvertebrate density and community composition between data collected during the baseline studies and information presented for other projects due to a variety of differences among study areas and approaches, such as natural variability in physical habitat parameters (e.g., predominant substrate type, water depth, presence/absence of aquatic macrophytes, etc.), biological variables (e.g., presence/absence and species of fish, time of year, trophic status of water body, etc.), and differences in methods (e.g., sampling equipment used, size of mesh to sieve organisms, study design, level of taxonomy, data handling, etc.) associated with sampling programs. As such, comparisons made of density and community composition among Mine Area lakes and other Arctic lakes should be viewed with consideration given to the points outlined above.

4.3.5 Benthic Macroinvertebrates in Streams

4.3.5.1 Methods

Field Methods

Benthic macroinvertebrate sampling in streams was conducted in summer 2005 (August 6-17, 2005) and fall 2006-2008 (August 23 to September 1, 2006; August 31 to September 5, 2007; September 10-11, 2008) from the Mary (2005, 2006, 2007) and Tom (2006, 2007) rivers, and Camp Lake (2005, 2007) and Sheardown Lake (2005, 2007, 2008) tributaries. Locations of benthic macroinvertebrate sampling sites are presented in Table 4.3-7 and Figure 4.3-10.

As benthic samples were collected at or near habitat assessment sites in the Mine Area streams, site characteristics were noted extensively (see Section 4.1.2.2). Three replicate samples separated by approximately three wetted stream widths were collected at each sampling site in 2006 through 2008; only one replicate sample was collected at each sampling site in 2005. Within each replicate site, five sub-samples were combined into one large sample. Sub-samples were collected moving in an upstream direction and, whenever possible, they were collected from representative microhabitats across the stream.

Each sub-sample was collected by placing a Surber sampler on a flat area of the streambed, facing upstream. The surface area sampled by the Surber sampler was equivalent to 0.097 m^2. Macroinvertebrates were collected over a two minute time period by rubbing the rocks and disturbing the sediment in the substrate area framed by the Surber net. All sub-samples were rinsed from the netting into a 500 μm sieve; a 250 μm mesh size was used in 2005. Forceps were used to collect any macroinvertebrates remaining on the netting after rinsing. The sample was washed, transferred into a sample jar, and fixed as soon as possible in 10% formalin.

Data Analysis

Laboratory and data analysis methods for benthic macroinvertebrates in streams followed a similar approach as for lakes (see Section 4.3.4.1). Metrics were calculated for each replicate sample and summary statistics were generated for each stream reach and waterbody using pooled data collected in the open-water seasons of 2006, 2007, and 2008, where available. Data available for 2005 were analyzed separately due to the significant methodological changes between 2005 and subsequent years (i.e., samples were collected in summer and a 250 μm mesh size was used in 2005).

4.3.5.2 Results

Mary River

In 2005, a total of 17 benthic macroinvertebrate taxa were identified in Surber samples collected in the Mary River, with a total mean density of 398 individuals/m^2 ± 248 SE (Table 4.3-10). Benthic macroinvertebrate densities at the five reach sites ranged from 37 individuals/m^2 (DO-01) to 1,621 (CO-01), with taxa richness values ranging between 5 (GO[HO-01]) and 12 (EO-01a). Total diversity values ranged from 0.28 (CO-01) to 0.82 (DO-01; Table 4.3-10).With a mean diversity value of 0.60, the macroinvertebrate community of the Mary River is considered moderately diverse with a variety of insect genera represented. The mean evenness value was 0.55; evenness values were lowest in CO-01 (0.28) and highest in DO-01 (0.89; Table 4.3-10). Chironomidae (midges) dominated the sample, comprising 85% of the total macroinvertebrate density. The majority of the midges were in the subfamilies Diamesinae (64%; namely *Pseudokiefferiella*) and Orthocladiinae (15%; *Tvetenia*) (Appendix 4.3-5). Enchytraeidae (1%; Oligochaeta), *Acentrella* (1%; Ephemeroptera), Simuliidae (11%), and Tipulidae (1%) were also present, though at comparatively lower densities.

In 2006 and 2007, a total of 43 benthic macroinvertebrate taxa were identified from Surber samples collected in the Mary River, with a total mean density of 341 individuals/m^2 ± 65 SE (Table 4.3-10). Therefore, mean density was similar in 2006-2007 to the mean measured in 2005, but more taxa were present in 2006-2007. Benthic macroinvertebrate densities at six reach sites ranged from 58

(AO-01) to 800 (EO-01) individuals/m^2, with taxa richness values between 12 (AO-01 and CO-01) and 31 (EO-01). Total diversity values ranged from 0.53 (GO-3+GO-9) to 0.77 (AO-01; Table 4.3-10). With a mean diversity value of 0.64, this waterbody was considered moderately diverse with a variety of insect genera represented. The mean evenness value was 0.64; evenness values were lowest in GO-3+GO-9 (0.50) and highest in AO-01 (0.84; Table 4.3-10). As in 2005, Chironomidae dominated the sample, comprising 94% of the total macroinvertebrate density (Table 4.3-10). Orthocladiinae (mainly *Tokunagaia*), comprised 48% of the macroinvertebrate total and was the most abundant chironomid subfamily. Chironominae (20%), Diamesinae (21%), Podonominae (0.2%), and Tanypodindae (0.1%) were also present (Appendix 4.3-5). Also present in the Mary River samples were: Nemata (2%), Enchytraeidae (1%), Acari (1%), Ostrocoda (0.1%), Collembola (<0.1%), *Apatania* (1%), Simuliidae (0.2%), and Tipulidae (*Dicronata* 0.1% and *Tipula* 1%), which all contributed a comparatively small proportion to the overall macroinvertebrate density.

Tom River

In 2006 and 2007, a total of 30 benthic macroinvertebrate taxa were identified from Surber samples collected in the Tom River, with a total mean density of 346 individuals/m^2 ± 200 SE (Table 4.3-10). Benthic macroinvertebrate densities in the two reaches ranged from 161 individuals/m^2 at the upstream site (IO-04) to 531 individuals/m^2 at the downstream site (IO-01), with taxa richness ranging between 22 and 25. Total diversity values ranged from 0.59 (IO-04) to 0.61 (IO-01) (Table 4.3-10).With a mean diversity value of 0.60, this waterbody is considered moderately diverse with a variety of insect genera represented. The mean evenness value was 0.62 and evenness values were similar in both reach areas in the Tom River (Table 4.3-10). Chironomidae dominated the sample, comprising 94% of the total macroinvertebrate density (Table 4.3-10). Chironominae and Podonominae were the most abundant chironomid subfamilies (48% and 19% of macroinvertebrate total; Appendix 4.3-5). Within the Chironominae, *Micropsectra* dominated, accounting for 46% of the total macroinvertebrate density. Diamesinae and Orthocladiinae were also present and accounted for a small proportion of the total density. Nemata (0.5%), Enchytraeidae (1%), Acari (1%), *Agabus* (<0.1%; Coleoptera), Simuliidae (2%), and Tipulidae (*Dicronata* 0.5% and *Tipula* 1%) were also collected, though at comparatively lower densities.

Camp Lake Tributaries

In 2005, a total of 18 benthic macroinvertebrate taxa were collected in Surber samples from three reaches of the Camp Lake tributaries (Table 4.3-10). The total mean benthic macroinvertebrate density was 186 individuals/m^2 ± 116 SE. Benthic densities in the three reaches ranged from 39 individuals/m^2 (Lake Outlet Stream) to 414 individuals/m^2 (Tributary 1 Reach 1), with taxa richness ranging between 5 and 13. Total diversity values ranged from 0.50 (Trib1 Reach 1) to 0.86 (Trib2 Reach 2; Table 4.3-10).With a mean diversity value of 0.66, this waterbody is considered moderately

diverse with a variety of insect genera represented. The mean evenness value was 0.70; evenness values were lowest in Tributary 1 Reach 1 (0.47) and highest in Tributary 2 Reach 2 (0.90; Table 4.3-10). Chironomidae dominated the samples, comprising 77% of the total macroinvertebrate density. Orthocladiinae was the dominant subfamily, constituting 61% of the macroinvertebrate total and mainly consisted of *Tvetenia* (53%; Appendix 4.3-5). Other macroinvertebrate groups such as Enchytraeidae (1%; Oligochaeta), *Acentrella* (3%; Ephemeroptera), Capniidae (4%), Simuliidae (5%), and *Tipula* (9%; Tipulidae) were also present, though at comparatively lower densities.

In 2007, a total of 36 taxa were collected from two reaches of two Camp Lake tributaries (Table 4.3-10). The total mean benthic macroinvertebrate density was 515 individuals/m^2 ± 97 SE for all four reaches. Mean benthic densities ranged between 365 individuals/m^2 (Tributary 2 Reach 2) and 755 individuals/m^2 (Tributary 1 Reach 1), with taxa richness values between 17 and 29 (Tributary 1 Reach 1). Total diversity values ranged from 0.75 (Tributary 1 Reach 3) to 0.87 (Tributary 1 Reach 1 and Tributary 2 Reach 1) (Table 4.3-10). With a mean diversity value of 0.83, these waterbodies are considered relatively diverse in comparison to the Mine Area rivers also sampled in 2007, with a variety of insect genera represented. The mean evenness value was 0.77; evenness values were lowest in Tributary 1 Reach 3 (0.68) and highest in Tributary 2 Reach 1 (0.81) (Table 4.3-10). Chironomidae dominated the benthic samples comprising 87% of the mean total macroinvertebrate density (Table 4.3-10). Orthocladiinae was the most abundant (75% of mean total); Chironominae (7%), Diamesinae (5%), Podonominae (0.3%) were also present though to a lesser extent (Appendix 4.3-5). Other macroinvertebrate groups such as Nemata (1%), Enchytraeidae (3%; Oligochaeta), Acari (2%), *Tipula* (6%; Tipulidae) were identified; Empididae pupae, Simuliidae, and *Dicronata* (Tipulidae) were also were found in very low densities.

Sheardown Lake Tributaries

In 2005, a total of 10 benthic macroinvertebrate taxa were collected in a single sample from Sheardown Lake Tributary 1 Reach 2, which had a total density of 569 individuals/m^2 (Table 4.3-10). With a Simpson's Diversity Index value of 0.79 this waterbody is considered relatively diverse in comparison to the other Mine Area rivers and tributaries sampled in 2005, with a variety of insect genera represented; the evenness value was 0.77 (Table 4.3-10). Chironomidae dominated the sample, comprising 87% of the total macroinvertebrate density. The majority of the midges were within the subfamily Orthocladiinae (49%; namely *Tvetenia*); Diamesinae (14%; *Pseudokiefferiella*) and Tanypodinae (2%) were also present (Appendix 4.3-5). Enchytraeidae (3%; Oligochaeta), Simuliidae (1%), and *Tipula* (8%; Tipulidae) were also identified from this sample, though at comparatively lower densities.

In 2007 and 2008, a total of 47 taxa were collected in samples from four Sheardown Lake tributaries (Table 4.3-10). The total mean benthic macroinvertebrate density was 1,422 individuals/m^2 ± 406 SE. Mean benthic densities ranged between 300 individuals/m^2 (Tributary 1 Reach 1) and 3,786 (Tributary 1 Reach 4), with taxa richness values between 17 (Tributary 1 Reach 1) and 31 (Tributary 9 Reach 1). Total diversity values ranged from 0.57 (Tributary 12 Reach 1) to 0.87 (Tributary 9 Reach 1; Table 4.3-10).With a mean diversity value of 0.76, these waterbodies are considered relatively diverse in comparison to the Mine Area rivers sampled in 2007, with a variety of insect genera represented. The mean evenness value was 0.69; evenness values were lowest in Tributary 12 Reach 1 (0.49) and highest in Tributary 12 Reach 2 (0.82) (Table 4.3-10). Chironomidae dominated the sample, comprising 90% of the total macroinvertebrate density (Table 4.3-10). Diamesinae (mainly *Pseudokiefferiella*) and Orthocladiinae (mainly *Cricotopus* plus 21 other genera) were the most abundant chironomid subfamilies, accounting for 35% and 47% of the total benthic macroinvertebrates, respectively (Appendix 4.3-5). Other chironomid subfamilies identified from Sheardown Lake tributaries were Chironominae, Podonominae, and Tanypodinae. Macroinvertebrate groups Nemata (2%), Oligochaeta (Enchytraeidae 2%; Lumbriculidae 0.1%), Acari (1%), Ostracoda (0.5%), Collembola (<0.1%), *Hydroporus* (<0.1%; Coleoptera), *Acentrella* (<0.1%; Baetidae), Capniidae (<0.1%; Plecoptera), *Grensia* (<0.1%; Limnephilidae), *Atrichopogon* (<0.1%; Ceratopogonidae), Muscidae (<0.1%), Simuliidae (1%), and *Tipula* (3%; Tipulidae) were also collected, though in very low densities.

Summary and Regional Context

A total of 24 macroinvertebrate taxa were identified at the genus level from benthic samples collected during the open-water season of 2005 in the Mary River and Camp and Sheardown lake tributaries. Macroinvertebrate density varied among stream reaches and was highest in Sheardown Lake Tributary 1 Reach 2 (569 individuals/m^2), followed by the Mary River (398 individuals/m^2) and the Camp Lake tributaries (186 individuals/m^2; Figure 4.3-11). Taxonomic richness values at the genus level varied, with 10 taxa observed in Sheardown Lake tributaries, 17 in the Mary River, and 18 in Camp Lake tributaries (Table 4.3-10). The Mary River and Camp Lake tributaries sampled in 2005 were considered moderately diverse (mean diversity values of 0.60 and 0.66, respectively), with a variety of insect genera represented (Table 4.3-10); with a diversity index value of 0.79, Sheardown Lake Tributary 1 Reach 2 was considered relatively more diverse. The higher the index (0 to 1), the greater the biodiversity and the less likely that two individuals would belong to the same species. Stream-wide mean evenness values range from 0.55 (Mary River) to 0.77 (Sheardown Lake Tributary 1 Reach 2; Table 4.3-10). Evenness measures the similarity of population size of different species, with evenness values closer to 1 indicating that macroinvertebrates of different species are more similar in abundance.

Overall, macroinvertebrate density in 2005 samples was dominated by Diamesinae larvae (specifically *Pseudokiefferiella*) at stream sites. Other types of macroinvertebrates such as Enchytraeidae (an oligochaete family), Orthocladiinae, Simuliidae (black-flies), and *Tipula* (a type of crane-fly) also notably contributed to the overall benthic density at stream sites (Appendix 4.3-5).

A total of 62 macroinvertebrate taxa were identified at the genus level from benthic samples collected during the open-water seasons of 2006, 2007, and 2008 in the Mary and Tom rivers and Camp and Sheardown lake tributaries. Macroinvertebrate density varied among streams and was highest in Sheardown Lake tributaries (1,422 individuals/m^2); followed by Camp Lake tributaries (515 individuals/m^2), the Tom River (346 individuals/m^2), and the Mary River (341 individuals/m^2; Figure 4.3-12). Of the streams surveyed, Sheardown Lake Tributary 1 supported the highest density of benthic macroinvertebrates with notably higher densities at the most upstream sampling area (Reach 4), which is characterized as extremely shallow (<0.1 m deep) riffle/pool habitat over predominantly boulder (50%) and cobble (30%) substrate (Appendix 4.1-1). Periphyton is found to be more abundant at the most upstream sites in all streams except the Tom River (Section 4.2); however, periphyton biomass does not appear to be positively correlated with stream benthic macroinvertebrate density in all reaches sampled. Stream benthic macroinvertebrate density appeared to be somewhat higher in upstream reaches of the Mary River and Sheardown Lake Tributary 1, whereas the opposite is true in the Tom River, Camp Lake Tributaries 1 and 2, and Sheardown Lake Tributary 12 (Table 4.3-10). Numerous site-specific environmental factors influence the benthic macroinvertebrate community, such as water depth and flow regime, substrate composition, food availability and quality, and predation pressure, often making it difficult to predict or describe patterns in macroinvertebrate abundance. For example, Jones et al. (2003b) found that benthic invertebrate densities were positively correlated with bankfull depth among Barrenland, NWT, streams. Bankfull depth is generally greater in larger streams, which tend to carry more flow and are also less likely to freeze solid during the winter, thus invertebrates are able to find refuge and survive. However, this relationship does not hold true for Mine Area streams and rivers and may be due in part to the larger Tom and Mary rivers also freezing to the bottom in the winter (Volume 7, Appendix 7A).

Taxonomic richness values follow a similar spatial pattern as overall densities; 47 taxa were observed at the genus level in Sheardown Lake tributaries, 36 in Camp Lake tributaries, and 30 and 43 in the Tom and Mary rivers, respectively (Table 4.3-10). The Mary and Tom rivers sampled in 2006 and 2007 were considered moderately diverse (mean diversity values of 0.64 and 0.60, respectively), with a variety of insect genera represented (Table 4.3-10); the Camp Lake tributaries and Sheardown Lake tributaries were relatively more diverse, with mean diversity index values of 0.83 and 0.76, respectively. Stream-wide mean evenness values range from 0.62 (Tom River) to 0.77 (Camp Lake tributaries; Table 4.3-10).

Overall, macroinvertebrate density in 2006-2008 samples was dominated by Orthocladiinae larvae (mainly *Cricotopus*, *Tokunagaia*, and *Orthocladius* [*Euorthocladius*]) at all stream sites. Other types of macroinvertebrates such as Nemata, Enchytraeidae, Acari (water mites), Chironiminae, Diamesinae (specifically *Pseudokiefferiella*), Podonominae, and Tipula also notably contributed to the overall benthic density at stream sites (Appendix 4.3-5).

According to the classification of Beaufort Sea drainage streams by Craig and McCart (1975), the densities of macroinvertebrates in Mine Area streams are low to moderate (i.e., in the range of approximately 100 to 1,000 individuals/m^2). Densities of benthic macroinvertebrates in Mine Area streams are comparable to those found in northern Alaska (Miller and Stout 1989), somewhat lower than those reported for Nunavut streams sampled as part of the Bathhurst Inlet Port and Road Project (Rescan 2007) and the Doris Hinge Project (R.L. & L. / Golder 2002), and notably lower than those observed by Jones et al. (2003b) in the Barrenlands near Lac de Gras (NWT; Table 4.3-11).

The composition of the benthic macroinvertebrate community in Mine Area streams is typical of tundra streams found in other parts of the Arctic (Oswood 1989). Arctic stream invertebrate communities are generally dominated by a diverse group of dipterans, particularly Chironomidae, which may be as species-rich as the typical community observed in temperate streams (Oswood, 1989). Chironomids and black-flies were found to dominate the stream benthic communities in northern Alaska, with Plecoptera (stoneflies) and Ephemeroptera (mayflies) often abundant (Miller and Stout 1989). Dipteran larvae (mainly chironomids), black-flies, nematodes, stoneflies, mayflies, and oligochaetes have been observed to dominate or co-dominate in streams investigated in more southern parts of Nunavut (Rescan 2007; R.L. & L. / Golder 2002). Oswood (1989) has reported that chironomids and some types of stoneflies (Nemouridae) tend to increase in proportional abundance from south to north, while many other taxa decrease (e.g., mayflies, caddisflies, black-flies, bivalves).

As with benthic communities of Mine Area lakes, those of Mine Area streams are difficult to directly compare to other Arctic streams due to a variety of differences among study areas and methodological approaches (Table 4.3-11). Comparisons made above of density and community composition are qualitative and should be viewed with caution.

4.4 FISH POPULATIONS

Fish play a key role in ecosystem function and are generally considered important to stakeholders and regulatory agencies. Fish and fish habitat are protected by the *Fisheries Act*. This section provides a baseline description of fish populations within the Mine Area, including Camp, Sheardown, and Mary lakes, tributaries to these lakes, the Mary and Tom rivers, and Angajurjualuk Lake, based on field sampling conducted during the open-water seasons of 2005 to 2008 and 2010,

and winter 2007. There are two fish species in the Mine Area waterbodies: Arctic char (*Salvelinus alpinus*); and ninespine stickleback (*Pungitius pungitius*).

4.4.1 Lakes

4.4.1.1 Methods

Field Methods

Fish were sampled in lakes in the Mine Area using angling, minnow traps, backpack electrofishing, and standard gang index gill nets during the open-water periods of 2005 to 2008 and 2010 and using gill nets under the ice during May 2007 (Figure 4.4-1). Sampled lakes included Camp, Sheardown (northwest and southeast basins), Mary (north and south basins), and Angajurjualuk. Descriptions of fish sampling methods by gear type are provided below.

Minnow traps were primarily used as a means of assessing fish presence in streams during 2005 and 2006; however, two minnow traps were set in the nearshore environment of Angajurjualuk Lake during summer, 2006. Minnow traps were 41.9 cm long, 22.9 cm at their widest diameter, and were constructed of 6.4 mm metal mesh. Openings of approximately 2 cm diameter were located at each end of the trap. Traps were baited and typically set close to shore at depths from 0.3-1.0 m with the length of the trap oriented parallel to shore, and left in place for several days. Captured fish were sampled and released.

Angling was used to assess the presence of larger Arctic char from several lakes during 2005 and 2006. Captured fish were sampled and released.

A Smith-Root Model 11A or LR-24 backpack electrofisher was used during 2007 and 2008 to assess the use of wadeable nearshore lake habitat by small fish. During summer 2007, approximately 50-100 m long sections of shoreline with a variety of substrates (e.g., sand, cobble/boulder, gravel/cobble) were electrofished to assess habitat use by small fish in most Mine Area lakes. During spring 2008, electrofishing effort was focussed on substrate types (cobble/boulder) thought to be preferred Arctic char spawning habitat. The presence of recently hatched young-of-the-year (YOY) Arctic char in nearshore habitat during early spring would provide some evidence of nearby fall spawning. Captured fish were sampled and released.

During the open-water seasons of 2005-2008, standard gang index gill nets were used to sample fish at sites in Camp, Sheardown, Mary, and Angajurjualuk lakes. During 2005 and 2006, gillnet sites were selected opportunistically. In 2007, sites were selected to achieve good spatial coverage of Camp, Sheardown, and Mary lakes. In 2008, the focus of the gillnetting program was the identification of Arctic char spawning habitat. Gillnet gangs consisted of six 22.9 m long by 1.8 m

deep twisted nylon or monofilament panels of 1.5, 2.0, 3.0, 3.75, 4.25, and 5.0 inch (38, 51, 76, 95, 108, and 127 mm, respectively) stretched mesh. Nets were set on the bottom and left in place for short periods of time (less than 4 hours) to minimize fish mortality. During May 2007, gillnet gangs were set under the ice in Camp and Sheardown lakes. One site in Camp Lake and one site in each of the two Sheardown Lake basins were gillnetted with three replicate sets at each site. Winter gillnet gangs consisted of three 22.9 m long by 1.8 m deep twisted nylon panels of either 1.5, 2.0, and 3.0 inch twisted nylon mesh or 3.75, 4.25, and 5.0 inch twisted monofilament mesh. Nets were set on the bottom and left in place overnight. Captured fish were sampled and, if in good condition, released. Locations of all captured fish were recorded using a hand-held GPS.

Biological data were collected for most fish captured in all gear types; however, the amount of data collected varied by gear type, and size and condition (i.e., live or mortalities) of fish. Fish were identified to species, enumerated by location, and measured for fork length (± 1 mm). For fish less than 250 mm in length, round weight was measured to an accuracy of ± 1 g, while larger fish were weighed to an accuracy of ± 25 g. Fish longer than 250 mm, and in good condition, were marked with individually numbered Floy® FD-94 tags inserted at the base of the dorsal fin. When possible (i.e., during fall), live fish were examined for sex and maturity by gently massaging the abdomen and identifying any extruded gametes. Mortalities and fish in poor condition from all years were retained and examined internally to determine sex and state of sexual maturity (i.e., had never spawned, preparing to spawn in the current year, had just completed spawning in the current year, or had spawned in a previous year but would not be spawning in the current year), where possible. Ageing structures (otoliths) were collected from a length-stratified sub-sample of gillnet-caught fish from all Mine Area lakes and from a length-stratified sub-sample of electrofishing-caught fish from Mary River.

In 2006 and 2007, Arctic char mortalities were also examined for diet. Stomach contents were identified by taxonomic group (generally, class or family for invertebrates and species for fish) and enumerated on site. Due to large numbers of chironomids in the diet of Mine Area Arctic char, counts were estimated and categorized into one of five groups: none; few (< 10 individuals); some (10-25); several (26-100); and many (> 100). Liver and muscle tissues were collected from Arctic char in each of the lakes and from the Mary River for analysis of metals (see Section 4.5 for more details).

The movements of juvenile and adult Arctic char within the Mine Area were examined by enumerating fish entering and leaving selected tributary streams during spring and fall (Section 4.4.2.1), through Floy-tagging (as discussed above), with acoustic biotelemetry to monitor the movements of individual fish, and through strontium analysis. Fish selected for acoustic tagging were collected during experimental gillnetting programs conducted in Camp, Sheardown, Mary, and

Angajurjualuk lakes, had a minimum fork length of 375 mm, and were in good condition. Acoustic transmitters were surgically implanted into anaesthetized fish and fish were held until ready for release into the body of water from which they were captured (Appendix 4.4-1, NSC 2008a). To examine whether Arctic char in the Mine Area were anadromous, geochemical analysis of bony structures was undertaken. Otoliths were collected from a length-stratified sub-sample (n = 89 fish) of Arctic char mortalities during experimental gillnetting programs conducted in 2007 (Appendix 4.4-2, NSC 2008a).

Data Analysis

All fish catch and life history data were tabulated and reviewed for transcription errors as part of routine quality assurance/quality control (QA/QC) measures and, if warranted, outliers were eliminated from datasets. Fish catches were tabulated by lake, species, gear type, and year. Where possible, catch-per-unit-effort (CPUE) was calculated for electrofishing (#fish/minute of electrofishing), minnow traps (#fish/hour/trap), and gill nets (#fish/100 m of net/24 hrs).

For Arctic char, mean length, weight, and condition factor were calculated by lake, year, and gear type (electrofishing and gillnetting). Mean length of angled Arctic char was also calculated by lake. Length-frequency distributions were calculated for Arctic char by lake, year, and gear type (electrofishing and gillnetting). Age-length relationships were plotted for Arctic char by lake. Due to the fairly small sample size of Arctic char that were aged, age data from all Mine Area lakes, and for younger Arctic char captured in the Mary River, were combined and a logarithmic relationship between fork length and age was calculated. Regression equation-generated lengths at ages 2, 5, 10, 15, 20, and 25 were also plotted. Diet of gill net-caught Arctic char mortalities is presented by dietary item.

All lakes within the Mine Area were classified and mapped on their ability to support Arctic char as Present, Probable, Not Present, or Unknown. Designations were based on the results of aerial surveys, lake aquatic habitat surveys (Section 4.1.1), fish sampling, and professional judgement. Lakes where habitat was classified as Unknown were lakes where no fish habitat or fish community sampling was conducted. Lakes where Arctic char were determined to be Not Present were typically upstream of a barrier determined to be impassable. Lakes that were classified as Probable were accessible to fish, but had one or more characteristics (e.g., low water levels, little or no cover, large distances from overwintering habitat) that were unsuitable for extensive fish use, and where fish had not been captured. Arctic char were indicated as being Present in all the lakes where fish were captured, or the habitat was judged to be of suitable quality to support fish use.

Potential Arctic char spawning habitat within Camp Lake, Sheardown Lake, and Mary Lake was mapped using a combination of suitable water depth and substrate. Potential Arctic char spawning

habitat that was used for spawning by Arctic char was inferred using the location of fall caught adults, spring caught YOY, and professional judgement. Potential foraging and rearing habitat was defined as areas where Arctic char were present (as per previous paragraph) and mapped on the basis of catches of YOY and juvenile Arctic char during spring, summer, and fall, the presence of impassable barriers, and professional judgement. Overwintering habitat within Camp Lake, Sheardown Lake, and Mary Lake was mapped using suitable water depths. Potential overwintering habitat that was used for overwintering by Arctic char was validated based on Arctic char catches in May 2007.

4.4.1.2 Results

Camp Lake

The fish community of Camp Lake was sampled using angling (2005 and 2006), electrofishing (2007), and gillnetting (2005-2008). A total of 253 Arctic char (99.2% of the catch) and two ninespine stickleback (0.8% of the catch) were captured during 2005-2008 sampling (Table 4.4-1). Ninespine stickleback were likely more abundant than indicated as, among the three gear types used in Camp Lake, they were only susceptible to capture with backpack electrofishing. Overall, the open-water gill net CPUE was 32.2 Arctic char/24 hours/100 m of net, with annual values ranging from 10.1 in 2008 to 59.9 in 2005. A total of three Arctic char were captured in the one winter gill net set, indicating that Arctic char are capable of overwintering in Camp Lake.

Sheardown Lake

The fish community of Sheardown Lake has been separated into northwest and southeast basins due to the lack of connectivity that occurs between the two basins during winter

Northwest Basin

The fish community of the northwest basin of Sheardown Lake was sampled using angling (2005), electrofishing (2007 and 2008), and gillnetting (2006-2008). A total of 384 Arctic char were captured during 2005-2008 sampling (Table 4.4-2). Although they were not captured, ninespine stickleback likely occur within this basin as they were present in the southeast basin and were only susceptible to capture with backpack electrofishing. Overall, the open-water gill net CPUE was 51.4 Arctic char/24 hours/100 m of net, with annual values ranging from 10.1 in 2008 to 68.3 in 2007. A total of five Arctic char were captured in the one winter gill net set, indicating that they are capable of overwintering in the northwest basin of Sheardown Lake.

Southeast Basin

The fish community of the southeast basin of Sheardown Lake was sampled using angling (2005), electrofishing (2007 and 2008), and gillnetting (2007 and 2008). A total of 143 Arctic char (98.6% of the catch) and two ninespine stickleback (1.4% of the catch) were captured during the 2005-2008 sampling (Table 4.4-3). Ninespine stickleback were likely more abundant than indicated as, among the three gear types used in the Sheardown Lake, they were only susceptible to capture with backpack electrofishing. Overall, the open-water gill net CPUE was 150.9 Arctic char/24 hours/100 m of net, with annual values ranging from 105.7 in 2008 to 241.5 in 2007. A total of seven Arctic char were captured in the one winter gill net set, indicating that they are capable of overwintering in the southeast basin of Sheardown Lake.

Mary Lake

The fish community of Mary Lake has been separated into south and north basins due to the lack of connectivity that occurs between the two basins during winter and likely in extremely low water level conditions during ice-free periods.

South Basin

The fish community of the south basin of Mary Lake was sampled using angling (2005), electrofishing (2006 and 2008), and gillnetting (2006 and 2007). A total of 237 Arctic char were captured during 2005-2008 sampling (Table 4.4-4). Ninespine stickleback were not captured in the south basin of Mary Lake. Overall, the open-water gill net CPUE was 69.5 Arctic char/24 hours/100 m of net, with annual values ranging from 27.2 in 2006 to 73.0 in 2007. No winter gillnetting was conducted in the south basin of Mary Lake.

North Basin

The fish community of the north basin of Mary Lake was sampled using electrofishing (2008) and gillnetting (2007). A total of 102 Arctic char were captured during the 2007 and 2008 sampling (Table 4.4-5). Ninespine stickleback were not captured in the north basin of Mary Lake. The 2007 open-water gill net CPUE was 175.3 Arctic char/24 hours/100 m of net. No winter gillnetting was conducted in the north basin of Mary Lake.

Angajurjualuk Lake

The fish community of the northwestern portion of Angajurjualuk Lake (including the outlet of the Ravn River) was sampled using electrofishing (2006), gillnetting (2006 and 2007), and minnow traps (2006). A total of 264 Arctic char were captured during 2006 and 2007 sampling (Table 4.4-6).

Ninespine stickleback were not captured in Angajurjualuk Lake. Overall, the open-water gill net CPUE was 86.6 Arctic char/24 hours/100 m of net, with annual values ranging from 52.6 in 2006 to 91.1 in 2007. No winter gillnetting was conducted in Angajurjualuk Lake.

Miscellaneous Lakes

Fish community sampling was conducted in five other lakes in the Mine Area between 2005 and 2008 (Table 4.4-7). Mine Area Lake 1 was electrofished in 2007, Mine Area Lake 2 was angled in 2005, Mine Area Lake 3 was angled in 2005 and electrofished in 2007, Mine Area Lake 4 was gill netted in 2006, and the Candidate Reference Lake was gill netted in 2008. Small numbers of Arctic char were captured during all these sampling efforts, with a total of 23 Arctic char being captured among the five lakes.

4.4.2 Streams and Rivers

4.4.2.1 Methods

Field Methods

Fish were sampled in streams and rivers within the Mine Area using angling, minnow traps, backpack electrofishing, and hoop nets during the open-water periods of 2005 to 2008 (Figure 4.4-2). Sampled streams and rivers included inflows to Camp Lake, Sheardown Lake (northwest and southeast basins), and Mary Lake (north and south basins), as well as the Mary and Tom rivers. Descriptions of fish sampling methods by gear type are provided below.

Minnow traps (as per Section 4.4.1.1) were used as a means of assessing fish presence in streams and rivers during 2005 and 2006. Traps were typically set close to shore at depths from 0.3-1.0 m in areas with low velocity. Captured fish were sampled and released.

Angling was used to assess the presence of Arctic char from selected larger streams and rivers during 2005. Captured fish were sampled and released.

Backpack electrofishing was conducted from 2006-2008 using a Smith-Root Model 11A or LR-24 backpack electrofisher to assess the use of streams and rivers within the Mine Area by fish. Electrofishing surveys were primarily confined to reaches of streams and rivers where the results of aquatic habitat surveys (Section 4.1.2) suggested some potential to support fish. Stream reaches that either were ephemeral, or were cut off from lakes by impassable barriers typically were not fished. Streams and rivers electrofished in 2006 were confined to summer surveys, whereas most streams and rivers electrofished in 2007 were surveyed during spring, summer, and fall to document seasonal

use of the tributaries. During 2008, several tributaries that had not been electrofished previously (particularly tributaries to Mary Lake) were fished during spring and summer.

Streams were subdivided into reaches based primarily on changes in dominant habitat types. Sections of each reach (50 m long) were isolated with barrier nets, where possible, and electrofished to estimate total fish use and compare between habitat types. Three passes were made in a downstream direction along each reach and the number of fish captured during each pass was recorded. All captured fish were released back into the reach from which they were captured at the completion of sampling.

Additional information on the fish use of selected tributaries was collected using hoop nets. Hoop nets oriented to capture fish moving downstream were installed in Camp Lake Tributary 2 (CLT2) and Sheardown Lake Tributary 1 (SDLT1) during fall 2007 to assess downstream movements of fish out of these tributaries. During 2008, hoop nets were installed during spring and fall to identify timing and magnitude of movements of fish into and out of these same two streams after spring melt and prior to freeze-up. Upstream and downstream movements were monitored in CLT2 during spring and fall and in SDLT1 during spring, 2008. Fish movements in CLT2 could not be monitored during spring 2008 due to high flows. Low water levels during fall 2008 prevented monitoring of upstream movements in SDLT1. Hoop nets were constructed of fine-mesh beach seine material, were 0.6 m in diameter, and had 5 m long wings. Each hoop net was positioned as close to the confluences as possible at sufficient depths to remain submerged. Each wing and the cod end of the net were anchored so that it remained taut and spanned the width of the stream. Wings were lengthened with rock barriers, where necessary, to achieve 100% blockage of the channel in either upstream or downstream configurations. All captured fish were released into the stream on the opposite side of the hoop net in which they were caught at the completion of sampling.

Biological data were collected for most fish captured in all gear types; however, the amount of data collected varied by gear type and size of fish. Fish were identified to species, enumerated by location, and measured for fork length (± 1 mm). For hoopnet-caught fish, only the first 50 fish captured each day were measured for fork length. For fish less than 250 mm in length, round weight was measured to an accuracy of ± 1 g, while larger fish were weighed to an accuracy of ± 25 g. Fish longer than 250 mm, and in good condition, were marked with individually numbered Floy® FD-94 tags inserted at the base of the dorsal fin.

Methods to assess the movements of juvenile and adult Arctic char within the Mine Area are discussed in Section 4.4.1.1.

Data Analysis

All fish catch and life history data were entered and a QA/QC review of the data was conducted. Fish catches were tabulated by tributary, species, gear type, and year. Where possible, CPUE was calculated for electrofishing (#fish/minute of electrofishing), minnow traps (#fish/hour/trap), and hoop nets (#fish/net/24 hrs). For electrofishing, the estimated total number of fish using each survey stream was calculated by season and reach. The hoopnet catch frequency data from each tributary were plotted to illustrate daily downstream and/or upstream movements of fish in the streams.

For Arctic char, mean length, weight, and condition factor were calculated by tributary, reach, year, and gear type (electrofishing and hoopnetting). Mean length of Arctic char captured in minnow traps and during angling was also calculated by tributary and reach. Length-frequency distributions for Arctic char were calculated by stream, year, and gear type.

All streams and rivers within the Mine Area were classified and mapped according to their ability to support Arctic char as Present, Probable, Not Present, or Unknown. Designations were based on the results of aerial surveys, stream habitat surveys (Section 4.1.2), fish sampling, and professional judgement. Stream reaches where habitat was classified as Unknown were streams where no fish habitat or fish community sampling was conducted. For stream reaches receiving a Not Present designation the reason was typically the presence of an impassable barrier determined at the downstream end of that reach and, in some cases, supplemental electrofishing that did not yield any fish. Stream reaches that were classified as Probable were accessible to fish, but had one or more characteristics (e.g., low water levels, little or no cover, long distances from overwintering habitat) that were unsuitable for extensive Arctic char use, and where none were captured. Arctic char were indicated Present in all stream reaches where they were captured, or the habitat was judged to be of suitable quality to support Arctic char use.

Potential foraging and rearing habitat was designated for areas where Arctic char were present (as per previous paragraph) and mapped on the basis of catches of YOY and juvenile Arctic char during spring, summer, and fall, the presence of impassable barriers, and professional judgement.

4.4.2.2 Results

Camp Lake inflows

Five tributaries to Camp Lake were sampled between 2005 and 2008; Arctic char were captured in all five of these streams and ninespine stickleback were captured in four of the five (Table 4.4-8). Electrofishing was conducted in tributaries 1-4, but not 5. Mean CPUE for Arctic char ranged from a low of 1.11 fish/minute in Tributary 3 to a high of 3.11 fish/minute in Tributary 2. Mean CPUE for

ninespine stickleback ranged from a low of 0.04 fish/minute in Tributary 3 to a high of 0.08 fish/minute in Tributary 2. Hoop nets oriented to capture fish moving upstream and downstream were set at the mouth of Tributary 2 in fall 2007 and 2008. Hoop nets could not be deployed in spring 2008 due to high flows. During a 24 day period in fall 2007, 28 Arctic char were captured moving upstream and 2,779 Arctic char and four ninespine stickleback were captured moving downstream, while over a nine day period in fall 2008, 168 Arctic char and one ninespine stickleback were captured moving upstream and 342 Arctic char and six ninespine stickleback were captured moving downstream (Table 4.4-9). A small number of Arctic char and ninespine stickleback were captured in most of the five tributaries with minnow traps (Table 4.4-8).

Sheardown Lake inflows

The fish community of the tributary inflows to Sheardown Lake have been separated into inflows to the northwest and southeast basins due to the lack of connectivity that occurs between the two basins during winter and in extremely low water level conditions during ice-free periods.

Northwest Basin

Two tributaries to Sheardown Lake NW were sampled between 2005 and 2008; Arctic char were captured in both of these streams and ninespine stickleback were captured only in Tributary 1 (Table 4.4-10). Electrofishing was conducted in tributaries 1 and 12. Mean CPUE for Arctic char ranged from 0.10 fish/minute in Tributary 12 to 0.89 fish/minute in Tributary 1. Mean CPUE for ninespine stickleback was 0.05 fish/minute in Tributary 1. Hoop nets oriented to capture fish moving upstream and downstream were set at the mouth of Tributary 1 in fall 2007 and spring 2008. During fall 2008, hoop nets could only be set to capture fish moving downstream. During a 24 day period in fall 2007, 16 Arctic char were captured moving upstream and 1,240 Arctic char and 18 ninespine stickleback were captured moving downstream, while over a 17 day period in fall 2008, 418 Arctic char and eight ninespine stickleback were captured moving downstream (Table 4.4-9). During spring 2008, 354 Arctic char and six ninespine stickleback were captured moving upstream and 495 Arctic char and 42 ninespine stickleback were captured moving downstream. A small number of Arctic char were captured in Tributary 1 and Tributary 1b either angling or with minnow traps (Table 4.4-10).

Southeast Basin

Tributary 7 was electrofished in 2008 and Tributary 9 was electrofished in 2007. Mean CPUE for Arctic char was 1.08 fish/minute in Tributary 7 and 0.88 fish/minute in Tributary 9 (Table 4.4-11). Ninespine stickleback were only captured in Tributary 7, where the CPUE was 0.93 fish/minute.

Mary Lake Inflows

The fish communities of tributary inflows to Mary Lake have been separated into inflows to the north and south basins due to the lack of connectivity that occurs between the two basins during winter and in extremely low water level conditions during ice-free periods.

North Basin

Tributaries 1-4 were electrofished in 2008; Arctic char and ninespine stickleback were captured in all but Tributary 2. Mean CPUE for Arctic char ranged from 0.00 in Tributary 2 to 1.69 fish/minute in Tributary 1, while mean CPUE for ninespine stickleback ranged from 0.00 in Tributary 2 to 0.09 fish/minute in both tributaries 1 and 4 (Table 4.4-12).

South Basin

Tributaries 1-3 were electrofished in 2008; Arctic char were captured in tributaries 2 and 3, while ninespine stickleback were captured in all three tributaries. Mean CPUE for Arctic char ranged from 0.00 in Tributary 1 to 0.15 fish/minute in tributaries 2 and 3, while mean CPUE for ninespine stickleback ranged from 0.43 in Tributary 2 to 1.24 fish/minute in Tributary 1 (Table 4.4-13).

Mary River

Between 2005 and 2008, fish population sampling was conducted in several reaches of the Mary River, extending from upstream of Mary River Falls downstream to its outlet at Angajurjualuk Lake (Figure 4.4-2). Initially, sampling was conducted using angling (2005) and minnow traps (2006); however, the majority of sampling was conducted using electrofishing between 2006 and 2008. A total of 277 Arctic char and two ninespine stickleback were captured in the Mary River (Table 4.4-14). Mean CPUE for Arctic char captured using electrofishing was 0.50 fish/minute with fairly consistent values obtained in each of the three sampling years. Small numbers of Arctic char were captured angling and in minnow traps.

Tom River

Between 2005 and 2008, fish community sampling was conducted in several reaches of the Tom River, extending from Tom River Falls downstream to its outlet at Mary Lake (Figure 4.4-2). Initially, sampling was conducted using angling (2005) and minnow traps (2006); however, the majority of sampling was conducted using electrofishing between 2006 and 2008. A total of 55 Arctic char were captured in the Tom River; no ninespine stickleback were captured (Table 4.4-15). Mean CPUE for Arctic char captured using electrofishing was 0.40 fish/minute, with annual CPUE

ranging from 0.29 in 2006 to 1.05 in 2008. A small number of Arctic char were captured angling; none were captured in minnow traps.

Miscellaneous Streams and Rivers

Fish community sampling was conducted in two other streams in the Mine Area between 2005 and 2008 (Table 4.4-16). Candidate Reference streams 2 and 3 were electrofished in 2008. Two Arctic char were captured in Candidate Reference Stream 2; no other fish were captured.

4.4.3 Arctic Char

A generalized life history of Arctic char, with a focus on Baffin Island populations, is presented in Appendix 4.4-3.

4.4.3.1 Distribution and Abundance

Arctic char are widely distributed in Mine Area lakes and streams (Figure 4.1-11). The following provides an overview of Arctic char in Mine Area lakes and streams.

Lakes

Arctic char are present in all four Mine Area lakes. Catches of adults and larger juveniles varied among study years, but overall gillnet CPUE was highest in Mary Lake North Basin (175 Arctic char/100 m of net/24 hours), followed by Sheardown Lake SE (151), Angajurjualuk Lake (87), Mary Lake South Basin (70), Sheardown Lake NW (51), and Camp Lake (32; Figure 4.4-3). Catches of juveniles also varied among study years, but overall electrofishing CPUE was highest in Sheardown Lake NW (2.05 Arctic char/minute of electrofishing), followed by Sheardown Lake SE (0.98), Angajurjualuk (0.76), Camp Lake (0.53), Mary Lake North Basin (0.38), and Mary Lake South Basin (0.09) (Figure 4.4-4).

Using similar gillnet gangs, but longer (one to three day long) sets as compared to short (< 4 hours long) sets used in the present study, Stewart and MacDonald (1981) obtained CPUEs of 5.8 Arctic char/100 m of net/24 hrs at an Unnamed Lake that appears to be the Candidate Reference Lake, 11.7 Arctic char/100 m of net/24 hrs at Angajurjualuk Lake, and 20.6 Arctic char/100 m of net/24 hrs at Erichsen Lake. Stewart and MacDonald (1981) reported obtaining a CPUE of 69.1 Arctic char/100 m of net/24 hrs at an Unnamed Lake within the Jungerson River of northern Baffin Island and stated that fish in this lake were abundant relative to other Baffin Island populations.

Streams

Arctic char were captured with electrofishing gear in all four of the Camp Lake tributaries that were sampled (Table 4.4-8), both of the Sheardown Lake NW tributaries (Table 4.4-10), both of the Sheardown Lake SE tributaries (Table 4.4-11), three of the four tributaries to the north basin of Mary Lake (Table 4.4-12), and two of the three tributaries to the south basin of Mary Lake (Table 4.4-13). In the Mary River, Arctic char were captured in six of the eight reaches sampled (Table 4.4-17), with no Arctic char being captured in the reach immediately upstream of Mary Lake or upstream of Mary River Falls (Figure 4.4-5). Although Arctic char were not captured in the reach of the Mary River immediately upstream of Mary Lake, it is used by Arctic char as a movement corridor (Section 4.4.3.4). In the Tom River, Arctic char were captured between Tom River Falls and Mary Lake but were not captured upstream of Tom River Falls (Table 4.4-17; Figure 4.4-6).

4.4.3.2 Biological Data

Lakes

Length and Weight

The mean fork length of gillnet-caught Arctic char was fairly comparable among lakes, ranging from 336 mm in Camp Lake to 384 mm in the south basin of Mary Lake (Figure 4.4-7). The maximum length of gillnet-caught Arctic char in a given water body ranged from 458 mm in the north basin of Mary Lake to 751 mm in Camp Lake (Table 4.4-18). Length-frequency distributions for gillnet-caught Arctic char in Camp Lake, northwest and southeast basins of Sheardown Lake, south and north basins of Mary Lake, and Angajurjualuk Lake are presented in Figures 4.4-8 – 4.4-13, respectively. Mean condition factors ranged from 0.85 in the northwest basin of Sheardown Lake to 0.99 in Camp Lake and the southeast basin of Sheardown Lake (Table 4.4-18). Fork length-weight relationships for gillnet-caught Arctic char in Mine Area lakes are presented in Table 4.4-19. The overall length-weight relationship for Arctic char from all study lakes and all years combined was:

$$\text{Log10Weight} = -4.80 + 2.90\ (\text{Log10Fork Length}) \qquad (n=876;\ r^2=0.95)$$

The mean fork length of electrofishing-caught Arctic char ranged from 52 mm in the southeast basin of Sheardown Lake to 81 mm in the north basin of Mary Lake (Table 4.4-20). For all lakes combined, Arctic char ranged in length from 33-180 mm. A length-frequency distribution for electrofishing-caught Arctic char in the northwest and southeast basins of Sheardown Lake is presented in Figure 4.4-14. The modal length interval for each basin was 70-79 mm.

Age and Growth

Age-length relationships for Arctic char captured in Camp, Sheardown (both basins combined), Mary (both basins combined), and Angajurjualuk lakes are presented in Figures 4.4-15 to 4.4-18, respectively. The youngest age represented in the gillnet catch ranged from five to eight years with a maximum age ranging from 17 to 25 years. Arctic char in the Mine Area (Arctic char from all four lakes and smaller Arctic char from the Mary River [data from the Mary River are presented in the next section] pooled) are approximately 73 mm long at age 2, 162 mm long at age 5, 295 mm long at age 10, 423 mm long at age 15, 538 mm long at age 20, and 657 mm long at age 25 (Figure 4.4-19).

Sex and Maturity

Sex and state of maturity information for Arctic char collected for Mine Area lakes is presented in Table 4.4-21. Data collected in 2006 and 2007 was collected during summer while data collected in 2008 was collected during fall. When all lakes and years combined are considered, the overall ratio of males to females was 0.96:1. The proportion of fish that were maturing to spawn in the current year ranged from 12.7% in 2007 to 93.9% in 2008. Again, it should be noted that the 2008 program was conducted during fall and was targeted to capture spawning fish. The smallest male and female Arctic char identified as preparing to spawn in the current year were 165 mm (approximately five years old) and 181 mm (approximately six years old), respectively (Table 4.4-18).

Diet

Diet of Arctic char captured in Mine Area lakes in 2006 and 2007 was primarily chironomid larvae, pupae, and adults with other invertebrates (Trichoptera, Ephemeroptera, Amphipoda) and small Arctic char consumed at lower frequencies (Figures 4.4-20 through 4.4-24). Detailed dietary analyses conducted in 2006 showed that most Arctic char stomachs contained at least 10 chironomids, with more than 100 chironomids being the most frequently occurring concentration in most lakes (Table 4.4-22).

Streams

Length and Weight

The mean fork length of electrofishing-caught Arctic char ranged from 60 mm in Sheardown Lake Tributary 9 to 115 mm in Mary Lake North Tributary 3 (Table 4.4-23). For all streams combined, Arctic char ranged in length from 34-295 mm. Length-frequency distributions for electrofishing-caught Arctic char in Camp Lake Tributary 2 and Sheardown Lake Tributary 1 are presented in Figures 4.4-25 and 4.4-26, respectively. The modal length intervals for Arctic char captured in Camp Lake Tributary 2 and Sheardown Lake Tributary 1 were each 60-69 mm.

Overall mean fork lengths of upstream and downstream moving hoopnet-caught Arctic char were comparable in both Camp Lake Tributary 2 (103 mm) and Sheardown Lake Tributary 1 (102 mm) (Table 4.4-24). For both streams combined, Arctic char ranged in length from 28-415 mm. Length-frequency distributions for Arctic char captured in upstream and downstream oriented hoop nets in Camp Lake Tributary 2 and Sheardown Lake Tributary 1 in 2007 and 2008 are presented in Figures 4.4-27 to 4.4-29. Fall downstream migrants tended to be larger in 2007 than in 2008 in both tributaries. The modal length intervals for Arctic char captured moving downstream in Camp Lake Tributary 2 during fall 2007 and fall 2008 were 80-89 and 120-129 mm, respectively (Figure 4.4-27). The modal length intervals for Arctic char captured moving downstream in Sheardown Lake Tributary 1 during fall 2007 and fall 2008 were 80-89 and 120-129 mm, respectively (Figure 4.4-28). The modal length intervals for Arctic char captured moving upstream and downstream in Sheardown Lake Tributary 1 during spring 2008 were 100-109 and 70-79 mm, respectively (Figure 4.4-29).

Age and Growth

An age-length relationship for Arctic char captured in the Mary River is presented in Figure 4.4-30. Arctic char ranged from approximately 60 to 150 mm in length and were 2 – 5 years old. Arctic char in the Mine Area (Arctic char from the four Mine Area lakes and these Arctic char from the Mary River pooled) are approximately 73 mm long at age 2, 162 mm long at age 5, 295 mm long at age 10, 423 mm long at age 15, 538 mm long at age 20, and 657 mm long at age 25 (Figure 4.4-19).

4.4.3.3 Habitat Use

Spawning Habitat

As in most Arctic populations (see Appendix 4.4-3) Arctic char in the Mine Area are believed to restrict their spawning to lakes. The streams (including the Mary and Tom rivers) are not believed to be used for spawning as they freeze to the bottom during winter (Volume 7, Appendix 7A) and, therefore, eggs are not able to incubate and hatch in the spring. Information collected during field studies suggested that Arctic char spawn in Sheardown and Camp lakes and may spawn in Mary and Angajurjualuk lakes.

Potential spawning habitat was assessed on the basis of preferred depth and substrate. The upper elevation of potential spawning in each lake was considered to be 2 m below the sill elevation (note: sill elevation is used as a surrogate for the approximate minimum open-water level and 2 m is considered as the maximum ice thickness) to 10 m below the sill elevation (Appendix 4.4-3). Suitable substrates were those classified as either cobble/boulder or gravel/pebble for Camp and Sheardown lakes and boulder, cobble/boulder for Mary Lake. The combination of suitable depth and

substrate was then considered as potential spawning habitat. Where available, catches of adults in spawning condition in fall 2008, and/or the presence of YOY in nearshore habitats in early spring 2008 were used to supplement the habitat preference data.

Camp Lake

Camp Lake bathymetry and substrate mapping shows that approximately 24.2 ha of suitable spawning habitat exists (Table 4.4-25, Figure 4.4-31). The majority of this is located along the periphery of the lake, particularly along the eastern shore and in the northwest corner of the lake, although a small shoal towards the northeastern corner of the lake may also provide suitable conditions. In fall 2008, all Arctic char captured in Camp Lake that were maturing to spawn in the current year were captured along the eastern shore of the lake, particularly in the northeastern corner.

Sheardown Lake

Sheardown Lake bathymetry and substrate mapping shows that approximately 19.7 ha of suitable spawning habitat exists (Table 4.4-25, Figures 4.4-32 and 4.4-33). There is a large amount of this habitat available in the eastern portion of the northwestern basin and a large amount in the eastern half of the southeastern basin. The data from spring shoreline electrofishing surveys and fall gillnetting surveys conducted in Sheardown Lake strongly suggest that spawning is occurring primarily, if not exclusively, in the southeast basin of the lake, most likely in the immediate vicinity of Tributary 9. Large concentrations of pre-spawning fish were captured in the southeast corner of the southeast basin near the same location where recently hatched YOY were captured during spring 2008 electrofishing surveys. Gillnet and electrofishing data also suggest that Arctic char may spawn in the vicinity of Tributary 7, although the substrate in this area is largely sand, and not preferred spawning substrate.

Mary Lake

Mary Lake bathymetry and substrate mapping shows that approximately 4.1 ha of preferred spawning habitat exists (Table 4.4-25, Figure 4.4-34). Spawning habitat in Mary Lake is limited by a scarcity of preferred substrates under winter water level conditions. The entire north basin is composed of sand, while the south basin is largely fine sand and silt/clay in the central deeper areas, with sand and gravel along much of the shoreline. Where suitable substrates are found, it was typically in less than 2 m of water. There are only a few small patches along the southern shore of the south basin, and possibly a small reef near the narrows of the south basin, that would appear to provide ideal spawning habitat.

Although adults maturing to spawn in the current year were captured in the south basin of Mary Lake in summer of 2006 and 2007, no YOY Arctic char were captured in shoreline electrofishing surveys conducted in the north and south basins of Mary Lake during spring 2008. As water temperatures were still relatively low at the time of the spring survey relative to the other lakes that were surveyed, it is possible that movement to nearshore habitat from overwintering habitat had not yet occurred. A single YOY was captured in Mary Lake North Tributary 1 during summer 2008. If spawning is not occurring in Mary Lake, it is possible that any or all life stages of Arctic char move into Mary Lake from Camp, Sheardown, and/or Angajurjualuk lakes (see Section 4.4.3.4). Although the evidence for spawning in Mary Lake is not strong, given that adults maturing to spawn in the current year were captured in summer, and that marginal spawning habitat (sand/gravel substrate) does occur in the north basin and to a minimal extent in the south basin, the precautionary principle must be applied and, therefore, it is assumed that Mary Lake does provide some spawning habitat for Arctic char.

Rearing and Foraging Habitat

Gillnetting and electrofishing data indicate that Arctic char use all the major lakes, many of the tributaries to these lakes, and the Mary and Tom rivers for rearing and foraging during the open-water period.

Lakes

Among the lakes, gillnet catches of adults and larger juveniles were highest in the southeast basin of Sheardown Lake and lowest in Camp Lake (Figure 4.4-3). The largest gillnet catch was actually obtained from the north basin of Mary Lake but this was based on a fairly limited sample size in one season. Electrofishing catches of smaller juveniles and YOY were highest in Sheardown Lake NW and lowest in the south basin of Mary Lake (Figure 4.4-4). In Sheardown Lake, CPUE was highest in nearshore areas that were dominated by cobble and boulder substrate and/or near tributary confluences and lowest in areas dominated by fine substrate sizes. Substrate information from Camp Lake and the northwest and southeast basins of Sheardown Lake illustrate that much of the nearshore zone is dominated by cobble/boulder and gravel/pebble substrates (Table 4.4-25, Figures 4.4-31 to 4.4-33). Much of the shoreline of Mary Lake consists of sand and gravel with little cover (Table 4.4-25, Figure 4.4-34). Young-of-the-year and juveniles in these habitats would be highly susceptible to predation from larger Arctic char or piscivorous birds. Small Arctic char in Mary Lake may either remain in deeper habitat or may move into tributary streams as soon as water temperatures reach preferred levels. Though relatively small and shallow compared with other surveyed areas, average CPUE in the north basin of Mary Lake in 2007 was almost twice as high as in any other lake/basin. Sheardown Lake, particularly the southeast basin, also had a relatively high CPUE in 2007. These

data suggest either proportionally larger population sizes or important summer feeding areas for large juvenile and adult Arctic char.

Streams

All the streams and rivers within the Mine Area (including the Mary and Tom rivers) freeze solid during winter (Volume 7, Appendix 7A). Juvenile, YOY and, to a lesser extent, adult Arctic char move upstream into the smaller tributaries to access rearing and foraging habitat in spring. Stream habitat where Arctic char were captured in the Mary River, Tom River, Camp Lake inflows, Sheardown Lake inflows, and Mary Lake inflows is illustrated in Figures 4.4-5, 4.4-6, 4.4-35, 4.4-36, and 4.4-37, respectively. All streams marked in green are reaches in which Arctic char were captured. Streams and lakes marked in yellow are reaches where Arctic char were not captured but habitat use of these areas is Probable. Streams marked in red are reaches where Arctic char were not captured and where a potential or known barrier to fish passage was identified.

Based on electrofishing catches, some of the more productive tributaries in terms of rearing and foraging habitat for Arctic char included Camp Lake Tributary 1, Camp Lake Tributary 2, Sheardown Lake Tributary 1, Sheardown Lake Tributary 7, Mary Lake North Tributary 1, Mary River, and Tom River. In most of these tributaries, Arctic char use the entire reach between the lake into which the tributary flows and an upstream impassable barrier and are found primarily in cobble and boulder habitat where cover is available. Arctic char were not captured in the reach of the Mary River immediately upstream of Mary Lake, a reach characterized by sand substrate with very little cover available. Although Arctic char were not captured in this reach, it is known that Arctic char move through this reach (Section 4.4.3.4).

Overwintering Habitat

Overwintering habitat within the Mine Area appears to be restricted to Camp Lake, Sheardown Lake (northwest and southeast basins), Mary Lake (north and south basins) and Angajurjualuk lakes. Based on a maximum ice thickness of 2 m, available overwintering habitat is herein defined as being 2 m below the sill elevation of the lake outlet to the bottom. Abundant overwintering habitat is available in the four aforementioned lakes (Figures 4.4-31 to 4.4-34), with the possible exception of the generally shallower north basin of Mary Lake. Winter sampling in Camp and Sheardown lakes conducted in May, 2007 was limited to three sites and captured only 15 Arctic char, but confirmed the presence of overwintering adults in both lakes, including both basins of Sheardown Lake. None of the streams or rivers in the Mine Area are considered to provide overwintering habitat for Arctic char, as all freeze solid (Volume 7, Appendix 7A).

4.4.3.4 Movements

The movements of juvenile and adult Arctic char within the Mine Area were examined through Floy-tagging, with acoustic biotelemetry to monitor the movements of individual fish, through strontium analysis, and by enumerating fish entering and leaving selected tributary streams during spring and fall.

Movements within and between lakes

A total of 532 Arctic char were marked with Floy® tags in five Mine Area lakes/basins from 2006-2008 (Table 2.4-26). Of these tagged fish, only two were recaptured between 2006 and 2008, partially due to limited fish sampling in 2008. One fish tagged in Camp Lake during summer 2007 was recaptured in a hoop net set in Camp Lake Tributary 1 during fall 2007 moving back into Camp Lake. The second tag return was originally marked in the southeast basin of Sheardown Lake during summer 2007 and was recaptured in almost the exact same location during fall 2008.

A total of 31 fish from Camp (n = 9), Mary (n = 14; both basins combined), and Sheardown (n = 8) lakes were implanted with acoustic tags in summer 2007. Generally, there was limited movement of acoustic tagged fish. Interlake/basin movements were confirmed for only one fish in 2007 and six in 2008, most of which were a relatively short distance (Figure 4.4-38, Appendix 4.4-1). One fish tagged in Camp Lake moved to the north basin of Mary Lake during late summer 2007 and then returned to Camp Lake in early July, 2008. The remaining confirmed interlake/basin movements in 2008 were all recorded for fish tagged in either the north or south basin of Mary Lake that had moved to the opposite basin during the summer of 2008. These fish stayed in the opposite basin usually only for a few weeks of the summer and all returned to their basin of origin prior to removal of the receivers during fall 2008. Due to the timing and duration of the events, these short distance movements were most likely related to feeding and not spawning. Movements of fish between the receivers in the south basin of Mary Lake were relatively frequent suggesting that intra lake/basin movements are more common. An Arctic char tagged in Sheardown Lake was detected several times over a single day in July 2007 by a receiver in Mary Lake at the inlet of the Mary River. Approximately one month later this fish was detected back in Sheardown Lake. It is suspected that this fish spent part of the summer of 2007 in the Mary River, moving far enough downstream to be briefly detected by a Mary Lake receiver. Several fish tagged in the northwest basin of Sheardown Lake were recorded from the southeast basin in mid-late August and early September, 2007 and 2008. These acoustic data provide additional support that adult Arctic char may be using the southeast basin for spawning, but spend the remainder of the open-water season either in the northwest basin or in the Mary River.

Detailed results of strontium analyses from otoliths of Arctic char captured in 2007 are presented in Appendix 4.4-2 and in NSC (2008a). Of the 15 Arctic char sampled from Sheardown Lake, only one showed a substantial change in strontium concentration (from < 100 to approximately 250 ppm) throughout its life. This change was of short duration and may have resulted from brief movements between water bodies. The remaining 14 fish showed little or no change in strontium concentrations in otoliths, which suggests that they likely remained in Sheardown Lake throughout their entire life. The outflow of Sheardown Lake into the Mary River is relatively shallow (approximately 10 cm deep) throughout most of the open-water season, which may limit the potential for immigration of larger adult Arctic char into Sheardown Lake.

Six of the 15 Arctic char analysed from the south basin of Mary Lake showed little to no change in strontium concentrations, suggesting that these fish have remained in or near Mary Lake throughout their lives. Five Mary Lake Arctic char all showed small, short-lived spikes in strontium concentration. It is unknown if these peaks represent a short duration visit to another body of water or an increase in the background levels of strontium within Mary Lake during a particular time period. The remaining four Mary Lake Arctic char all showed much higher strontium concentration peaks of varying duration. These strontium concentrations suggest that these fish have spent at least a portion of their life cycle in a different waterbody. Observed peak concentrations are consistent with those detected in Angajurjualuk Lake Arctic char, which is located approximately 6 km downstream. These data suggest that movements of fish between the two lakes may be relatively common.

Average concentrations of strontium in otoliths of Arctic char from Angajurjualuk Lake were much higher than those observed in Mary Lake. In addition, there was more variation in the concentrations in individual fish. The relatively consistent strontium concentration peaks and valleys among individual fish suggest some regular or periodic movement of most fish between different water bodies or perhaps between different areas of this large lake. The lower strontium concentration of one Arctic char early in its life suggests that it probably spent this time in Mary Lake. Four Arctic char from Angajurjualuk Lake had peak concentrations (> 1000 ppm) that were much higher than other sampled fish. These peaks typically occurred early in life and, therefore, do not indicate anadromy. It is unknown where these fish spent their early life.

Movements within streams

During spring, juvenile Arctic char typically begin to move into the small tributaries to the Mine Area lakes at temperatures of about 5-7°C. Typically, the number of Arctic char moving upstream will increase until water temperatures reach about 15°C. Although the general pattern is upstream movement during spring, Arctic char may also move downstream out of the tributary in spring,

likely in response to changes in flow or reductions in water temperature. Juvenile Arctic char are thought to move into these tributaries to access warmer water and foraging habitat and to avoid predators. Most of the habitat available within the accessible streams is used by juvenile Arctic char.

During fall, juvenile Arctic char typically return downstream out of the small tributaries. Data from Camp Lake Tributary 2 and Sheardown Lake Tributary 1 suggest that these movements are generally triggered by a drop in water temperature to about 7°C. The number of fish moving back down to Camp and Sheardown lakes increased until water temperature in the tributary had reached about 2°C and then declined to almost no movement.

Patterns of Arctic char movement within the Tom and Mary rivers are somewhat different than those of the smaller tributaries. While the smaller tributaries are typically inhabited by fish from the downstream lake, juvenile Arctic char using the Tom River and the Camp Lake outflow likely originate from both Camp and Mary Lake. Although the majority of the Arctic char using the Mary River were juveniles, adults are also known to use selected reaches of the Mary River. Arctic char using the most downstream reach of the Mary River likely have overwintered in either Mary or Angajurjualuk lakes while Arctic char captured in the Mary River upstream of Mary Lake have likely moved into this reach from either Mary Lake or Sheardown Lake.

Anadromy

In general, patterns of strontium concentration in the otoliths of sampled fish do not suggest anadromy given that none of the fish displayed seasonally elevated spikes later in their life. Stewart and MacDonald (1981) sampled Erichsen Lake, below Angajurjualuk Lake on the Ravn River, and found that the Arctic char in that lake did not appear to be anadromous. Length at age data for Arctic char in Mine Area lakes were plotted against those for a known anadromous population of Arctic char from the Ravn River (data from Kroeker 1987). Lengths at age for the Ravn River population are much larger than those for the Mine Area lakes (Figure 4.4-39), providing additional information to suggest that Arctic char from the Mine Area are not anadromous.

Summary and Regional Context

Arctic char and ninespine stickleback are the only two fish species found in waterbodies within the Mine LSA and surrounding area. Arctic char were the dominant species, accounting for a minimum of 98.6% of the catch (gill nets, electrofishing, angling, and minnow traps combined) in all surveyed Mine Area lakes (Tables 4.4-1 to 4.4-7). The results of electrofishing, hoopnetting, angling, and minnow trap surveys in tributaries to the surveyed lakes, and the Mary and Tom rivers, indicated that Arctic char are also the dominant species in most sampled streams (Tables 4.4-8 to 4.4-16).

Arctic char were found to be widely distributed in Mine Area lakes and streams (Figure 4.1-11). Catches of adults and larger juveniles varied among study years, but overall gillnet catch-per-unit-effort (CPUE) was highest in Mary Lake N (175 Arctic char/100 m of net/24 hours), followed by Sheardown Lake SE (151), Angajurjualuk Lake (86.6), Mary Lake S (69.5), Sheardown Lake NW (51.4), and Camp Lake (32.2; Figure 4.4-3). Catches of juveniles also varied among study years, but overall electrofishing CPUE was highest in Sheardown Lake NW (2.05 Arctic char/minute of electrofishing), followed by Sheardown Lake SE (0.98), Angajurjualuk (0.76), Camp Lake (0.53), Mary Lake N (0.38), and Mary Lake S (0.09; Figure 4.4-4).

Using similar gillnet gangs, but longer (one to three day long) sets as compared to short (< 4 hours long) sets used in the present study, Stewart and MacDonald (1981) obtained CPUEs of 5.8 Arctic char/100 m of net/24 hrs at an Unnamed Lake that appears to be the Candidate Reference Lake, 11.7 Arctic char/100 m of net/24 hrs at Angajurjualuk Lake, and 20.6 Arctic char/100 m of net/24 hrs at Erichsen Lake. Stewart and MacDonald (1981) reported obtaining a CPUE of 69.1 Arctic char/100 m of net/24 hrs at an Unnamed Lake within the Jungerson River of northern Baffin Island and stated that fish in this lake were abundant relative to other Baffin Island populations.

Arctic char were captured with electrofishing gear in all four of the Camp Lake tributaries that were sampled, both of the Sheardown Lake NW tributaries, both of the Sheardown Lake SE tributaries, three of the four tributaries to Mary Lake N, and two of the three tributaries to Mary Lake S (Tables 4.4-8 to 4.4-13). In the Mary River, Arctic char were captured in six of the eight reaches sampled (Table 4.4-14), with no Arctic char being captured upstream of Mary River Falls (Figure 4.4-5). In the Tom River, Arctic char were captured between Tom River Falls and Mary Lake but were not captured upstream of Tom River Falls (Table 4.4-15; Figure 4.4-6).

Among lakes, the mean length of gillnet-caught Arctic char was fairly comparable, ranging from 336 mm in Camp Lake to 384 mm in the south basin of Mary Lake (Figure 4.4-7), with maximum lengths ranging from 458 mm in the north basin of Mary Lake to 751 mm in Camp Lake. The mean length of electrofishing-caught Arctic char ranged from 52 mm in the southeast basin of Sheardown Lake to 81 mm in the south basin of Mary Lake (Table 4.4-20). For all lakes combined, Arctic char ranged in length from 26-180 mm. Among streams, the mean length of electrofishing-caught Arctic char ranged from 60 mm in Sheardown Lake Tributary 9 to 115 mm in Mary Lake North Tributary 3 (Table 4.4-23). For all streams combined, Arctic char ranged in length from 34-295 mm.

The youngest gillnet-caught Arctic char from lakes in the Mine Area ranged from five to eight years with maximum age ranging from 17 to 25 years. When younger Arctic char captured in the Mary River are pooled with the lake-caught fish, and a length-age relationship is generated, Arctic char in the Mine Area are approximately 73 mm long at age 2, 162 mm long at age 5, 295 mm long at age

10, 423 mm long at age 15, 538 mm long at age 20, and 657 mm long at age 25 (Figure 4.4-19). The overall ratio of male to female gillnet-caught Arctic char was 0.96:1. The proportion of fish that were maturing to spawn in the current year ranged from 12.7% in 2007 to 93.9% in 2008 (it should be noted that the 2008 program was conducted during fall and was targeted to capture spawning fish; this info may not be that useful). The smallest male and female Arctic char identified as preparing to spawn in the current year were 165 mm (approximately five years old) and 181 mm (approximately six years old), respectively. Diet of Arctic char captured in Mine Area lakes in 2006 and 2007 was primarily chironomid larvae, pupae, and adults with other invertebrates (Trichoptera, Ephemeroptera, and Amphipoda) and small Arctic char consumed at lower frequencies.

As in most high Arctic populations, Arctic char in the Mine Area are believed to restrict their spawning to lakes. The streams (including the Mary and Tom rivers) freeze to the bottom during winter (Volume 7, Appendix 7A) and, therefore, eggs are not able to incubate and hatch in the spring. Information collected during field studies suggested that Arctic char spawn in Sheardown and Camp lakes and may spawn in Mary and Angajurjualuk lakes.

Gillnetting and electrofishing data indicate that Arctic char use all the major lakes, many of the tributaries to these lakes, and the Mary and Tom rivers for rearing and foraging during the open-water period. Among the lakes, gillnet catches of adults and larger juveniles were highest in the southeast basin of Sheardown Lake and lowest in Camp Lake (Figure 4.4-3). Electrofishing catches of smaller juveniles and YOY were highest in Sheardown Lake NW and lowest in the south basin of Mary Lake (Figure 4.4-4).

All the streams and rivers within the Mine Area (including the Mary and Tom rivers) freeze solid during winter (Volume 7, Appendix 7A). Juvenile, YOY and, to a lesser extent, adult Arctic char move upstream into the smaller tributaries to access rearing and foraging habitat in spring. Stream habitat where Arctic char were captured in the Mary River, Tom River, Camp Lake inflows, Sheardown Lake inflows, and Mary Lake inflows is illustrated in Figure 4.4-15. Based on electrofishing catches, some of the more productive tributaries in terms of rearing and foraging habitat for Arctic char included Camp Lake Tributary 1, Camp Lake Tributary 2, Sheardown Lake Tributary 1, Sheardown Lake Tributary 7, Mary Lake North Tributary 1, Mary River, and Tom River. In most of these tributaries, Arctic char use the entire reach between the lake into which the tributary flows and the first impassable barrier and are found primarily in cobble and boulder habitat where cover is available.

Overwintering habitat within the Mine Area appears to be restricted to Camp Lake, Sheardown Lake (northwest and southeast basins), Mary Lake (north and south basins) and Angajurjualuk lakes. None of the streams or rivers in the Mine Area are considered to provide overwintering habitat for Arctic

char, as all freeze solid (Volume 7, Appendix 7A). It should be noted that one IQ respondent thought that Arctic char might overwinter in the Mary River. Abundant overwintering habitat is available in the four aforementioned lakes, with the possible exception of the generally shallower Mary Lake N. Winter sampling in Camp and Sheardown lakes confirmed the presence of overwintering adults in both lakes, including both basins of Sheardown Lake.

In general, movement data collected from Mine Area lakes and streams suggest that Arctic char larger than approximately 250 mm do not move large distances, preferring to spend the majority of their life within a particular lake, although some movement of Arctic char between lakes via larger rivers during summer has been documented. Juvenile Arctic char overwinter in lakes and move either to the nearshore zones of lakes or into the smaller tributaries during spring and move back into the lakes during summer or fall. Arctic char within the Mine Area may be classified as freshwater resident and are not anadromous. Stewart and MacDonald (1981) sampled Erichsen Lake, below Angajurjualuk Lake on the Ravn River, and found that the Arctic char in that lake did not appear to be anadromous.

4.5 METALS IN FISH

Arctic char tissues were collected and analysed for concentrations of metals in the Mine Area during the conduct of the baseline studies program. Arctic char were collected from four lakes (Angajurjualuk, Mary, Sheardown, and Camp lakes) and from the Mary River from 2006-2008 (Table 4.5-1). Fish collected from the Mary River were juveniles, while larger, older fish were collected from the lakes.

4.5.1 Methods

4.5.1.1 Field Methods

Arctic char were collected from the Mary River and several lakes in the Mine Area from 2006-2008 for the analysis of metals in muscle and liver tissues (Table 4.5-1). Fish were captured in lakes opportunistically (i.e., mortalities) during gillnetting surveys; targeted sampling of juvenile char from the Mary River was conducted by electrofishing in order to provide baseline information for this waterbody and fish life history stage. Fish were weighed, measured for fork length, examined externally for deformities, erosion, lesions, and tumours (DELTs) and tissue samples were collected for metals analysis.

A sample of dorsal skeletal muscle of approximately 2 g was first collected with a pre-cleaned scalpel and the sample was placed in a labelled whirlpac bag. The abdominal cavity was then opened with a scalpel and the entire liver was excised and placed in a labelled whirlpac bag.

Samples were kept frozen until submission to the analytical laboratory. Dorsal skeletal muscle and liver samples were submitted to ALS Laboratories (Vancouver, BC) for analysis of total metals by inductively coupled mass spectrometry/optical emission spectrophotometry and mercury by cold vapour atomic fluorescence spectrophotometry.

4.5.1.2 Data Analysis

Tissue and liver samples from each fish sampled were analyzed individually for metals and mercury. Means, standard deviations (SD), ranges, and percent detections were calculated for each metal and waterbody for each year of sampling, as well as for all pooled data. All statistics were calculated using a value of one half the analytical detection limit (DL) where values were reported below the (DL). Means±SD were only derived where a metal was detected in ≥ 75% of samples. For a number of metals, the laboratory DLs varied between samples, most notably for liver samples, due to variability in tissue weights and matrix interference issues.

As mercury concentrations in fish tissues are typically positively correlated to fish age or size (e.g., Bodaly et al. 1984, Gantner et al. 2010), mercury data were regressed against Artic char fork lengths. Regression of Artic char fork length versus age was also conducted to evaluate the overall relationships between mercury in Artic char and length/age. This analysis was done for each waterbody, sampling year, and for pooled data collectively. Length-standardized mercury concentrations in muscle were also derived for the approximate (i.e., rounded) mean fork lengths of Artic char captured in the study area lakes (i.e., 400 mm) to facilitate comparison between waterbodies. Length-standardization was accomplished by applying the linear regression equation derived for a given set of data.

Concentrations of mercury in Artic char muscle were compared to the Health Canada guideline for commercial marketing of fish in Canada (0.5 µg/g wet weight [w.w.]; Health Canada 2007) and the Health Canada guideline for subsistence consumption (0.2 µg/g w.w.; Wheatley 1984). Concentrations of arsenic and lead were also compared to the Canadian Food Inspection Agency's fish and seafood consumption guidelines (http://www.inspection.gc.ca/english/fssa/fispoi/man/samnem/app3e.shtml; last accessed August 11, 2010).

4.5.2 Results

The following is an overview of the results of the analysis of metals in Arctic char tissues for the period of 2006-2008.

4.5.2.1 Camp Lake

Arctic char tissues were collected in 2006 from Camp Lake; muscle samples were analysed for mercury and liver samples were analysed for a suite of metals. Artic char captured in Camp Lake for metals analysis in 2006 ranged from 170 to 751 mm fork length and from 6 to 19 years in age (Table 4.5-2).

Summary statistics for metals in liver and mercury in muscle tissues are provided in Tables 4.5-3 and 4.5-4, respectively. Aluminum, arsenic, barium, cadmium, calcium, cobalt, copper, iron, magnesium, manganese, molybdenum, potassium, selenium, sodium, thallium, and zinc were detected in all liver samples. Antimony, beryllium, bismuth, lithium, and tin were not detected in any liver samples. The remaining metals were detected from between 20 and 90% of liver samples.

Mercury ranged from 0.059 to 0.449 µg/g (w.w.) in Arctic char muscle tissue. All samples were therefore below the guideline for the commercial sale of fish (0.5 µg/g w.w.); 20% of samples exceeded the subsistence guideline of 0.2 µg/g (w.w.). Linear regression between fork length and mercury concentrations in muscle were significant ($p < 0.02$) with a correlation coefficient (R^2) of 0.54 (Figure 4.5-1). The mean length-standardized concentration of mercury in Artic char muscle was 0.162 µg/g (w.w.).

4.5.2.2 Sheardown Lake NW

Arctic char tissues were collected in 2006 and 2007 from Sheardown Lake. Char captured for metals analysis in 2006 ranged from 180 to 572 mm fork length and from 6 to 19 years in age; Artic char of similar size and age ranges (fork lengths ranging from 240 to 508 mm and an age span of 5 to 22 years) were analysed for metals in 2007 (Table 4.5-2).

Summary statistics for metals (excluding mercury) in liver and muscle tissues are provided in Tables 4.5-5 and 4.5-6, respectively. Mercury in muscle and liver are presented in Tables 4.5-4 and 4.5-7, respectively. Similar to the Artic char captured in Camp Lake, cadmium, calcium, cobalt, copper, iron, magnesium, manganese, molybdenum, potassium, selenium, sodium, thallium, and zinc were detected in all liver samples. Antimony, beryllium, bismuth, chromium, lithium, and tin were not detected in any liver samples. Other metals were detected at a frequency ranging from 4 to 89%.

Excluding mercury, only calcium, copper, iron, magnesium, manganese, potassium, selenium, sodium, and zinc – all of which are essential elements - were consistently detected in muscle samples. Like liver samples, a number of metals were not detected in char muscle.

Mercury ranged from 0.030 to 0.769 µg/g (w.w.) in Arctic char muscle tissue; three samples (11% of samples) were above the guideline for the commercial sale of fish (0.5 µg/g w.w.) and 18% of samples exceeded the subsistence guideline (0.2 µg/g w.w.). Linear regression between fork length and mercury concentrations in muscle (2006 and 2007 combined) were significant ($p < 0.0001$) with a correlation coefficient (R^2) of 0.47 (Figure 4.5-1). The mean length-standardized concentration of mercury in Artic char muscle was 0.137 µg/g (w.w.).

Mercury ranged from 0.082 to 1.5 µg/g (w.w.) in char liver (Table 4.5-7). Like muscle mercury, concentrations of mercury in liver were significantly correlated to fish fork length ($R^2 = 0.44$, $p < 0.002$; Figure 4.5-2). Mean concentrations of mercury were higher in Artic char liver than muscle.

4.5.2.3 Mary Lake

Arctic char tissues were collected in 2006 and 2007 from Mary Lake. Char captured for metals analysis in 2006 ranged from 165 to 685 mm fork length and from 9 to 24 years in age; Artic char of similar size (fork lengths of 266 to 548 mm) and age ranges (8 to 23 years) were analysed for metals in 2007 (Table 4.5-2).

Summary statistics for metals in liver and muscle tissues are provided in Tables 4.5-8 and 4.5-9, respectively. Mercury in muscle and liver are presented in Tables 4.5-4 and 4.5-7, respectively. The same metals consistently detected in Sheardown Lake Artic char liver and muscle samples were consistently detected in Mary Lake fish. In addition, strontium and aluminum were detected in all Mary Lake liver samples and strontium was detected in 100% of Mary Lake Artic char muscle samples.

Mercury ranged from 0.056 to 2.13 µg/g (w.w.) in Arctic char muscle tissue; four samples (11% of samples) were above the guideline for the commercial sale of fish (0.5 µg/g w.w.) and 25% exceeded the subsistence guideline. The highest mercury concentration measured in Artic char muscle from the study area (2.13 µg/g w.w.) occurred in an Artic char captured in Mary Lake. Linear regression between fork length and mercury concentrations in muscle were significant ($p < 0.0001$) with a correlation coefficient (R^2) of 0.44 (Figure 4.5-1). The mean length-standardized concentration of mercury in Artic char muscle was 0.166 µg/g (w.w.).

Mercury ranged from 0.142 to 1.47 µg/g (w.w.) in Artic char liver and as observed for Sheardown Lake, the mean concentration in liver (2007 mean = 0.385 µg/g w.w.) was higher than in muscle (2007 mean = 0.134 µg/g w.w.). Like muscle mercury, concentrations of mercury in liver were significantly correlated to fish fork length ($R^2 = 0.57$, $p < 0.0001$; Figure 4.5-2).

4.5.2.4 Angajurjualuk Lake

Arctic char tissues were collected in 2006 and 2007 from Angajurjualuk Lake. Artic char captured for metals analysis in 2006 ranged from 323 to 566 mm fork length and from 11 to 25 years in age; Artic char of similar size (228-636 mm fork lengths) and age ranges (8-24 years) were analysed for metals in 2007 (Table 4.5-2).

Summary statistics for metals in liver and muscle tissues are provided in Tables 4.5-10 and 4.5-11, respectively. Mercury in muscle and liver are presented in Tables 4.5-4 and 4.5-7, respectively. Metals consistently detected in Camp, Sheardown and Mary Lake liver samples and in Sheardown and Mary lake Artic char muscle samples were generally also detected in all Angajurjualuk Lake fish.

Mercury ranged from 0.067 to1.46 µg/g (w.w.) in Arctic char muscle tissue; seven samples (25% of samples) were above the guideline for commercial sale of fish (0.5 µg/g w.w.) and 50% exceeded the subsistence guideline. Linear regression between fork length and mercury concentrations in muscle were significant ($p < 0.0001$) with a correlation coefficient (R^2) of 0.59 (Figure 4.5-1). The mean length-standardized concentration of mercury in Artic char muscle was 0.211 µg/g (w.w.). Mercury ranged from 0.122 to1.92 µg/g (w.w.) in Artic char liver. Like muscle mercury, concentrations of mercury in liver were significantly correlated to fish fork length ($R^2 = 0.73$, $p < 0.0001$; Figure 4.5-2).

4.5.2.5 Mary River

Juvenile Artic char captured from the Mary River for metals analysis ranged in length from 63 to 150 mm and from 2 to 5 years in age. In general, a similar list of metals was detected in all liver and muscle samples as observed in Artic char captured from the study area lakes (Table 4.5-12 and 4.5-13). Concentrations of mercury were however, notably lower in Artic char muscle and liver in juveniles captured from the Mary River; mercury ranged from 0.016 to 0.054 µg/g (w.w.) in muscle and from 0.0437 to 0.183 µg/g (w.w.) in liver. Lower concentrations in smaller younger Artic char are typically observed due to the positive relationship between fish age/size and mercury concentrations. Due to the relatively small length and age ranges sampled in the Mary River, mercury in muscle or liver of juvenile Artic char were not correlated to fish fork lengths. Mercury was consistently below the guideline for commercial sale of fish and the subsistence guideline.

4.5.2.6 Summary and Regional Context

A total of 102 Arctic char ranging from 5 to 25 years and 165 to 751 mm in length were captured and analysed for metals in liver and muscle from 2006-2007 (Table 4.5-2). Thirty juvenile Artic

char ranging from 2-5 years and from 63-150 mm in length were captured from the Mary River and analysed for metals in liver and muscle in 2008 (Table 4.5-2).

In general, results were similar across lakes and the Mary River in terms of metals consistently detected or consistently not detected in liver and muscle samples. Considering the results as a whole, metals consistently detected in Artic char muscle samples included calcium, copper, magnesium, manganese, mercury, potassium, selenium, sodium and zinc. Strontium and aluminum were also detected at high frequencies across sites. Metals that were not detected in any Artic char muscle samples were antimony, beryllium, bismuth, cadmium, lead, tin, uranium, and vanadium.

Metals consistently detected in Artic char livers included calcium, copper, iron, magnesium, manganese, mercury, potassium, and zinc. In addition, several metals were detected in all liver samples of fish captured from lakes (cadmium, cobalt, molybdenum, selenium, sodium, and thallium) but not in juvenile fish captured from the Mary River. This apparent difference may reflect actual differences in accumulation of metals in Artic char liver due to age, size, or other biological or environmental factors or may reflect the differences in the analytical detection limits between the livers of larger fish and smaller juveniles; due to the smaller weights of the juvenile fish livers, analytical detection limits varied notably between individuals and relative to the older fish that were analysed.

All concentrations of lead and arsenic measured in Artic char muscle were below the CFIA guidelines (0.5 µg/g w.w. for lead; 3.5 µg/g w.w. for arsenic) in the Mine Area.

As mercury bioaccumulates and biomagnifies, it is generally highest in larger, older fish and in species that occupy a higher trophic position (i.e., top predators). Mercury concentrations in muscle and liver of Artic char (excluding juvenile fish) were positively correlated to fish fork length (Figures 4.5-1 to 4.5-4). As Artic char age was also positively correlated to fork length (Figure 4.5-5), a similar correlation between mercury concentrations and age can be inferred. No relationship between length and mercury concentrations in juvenile Artic char muscle and liver were found; this is not unexpected due to the relatively small age/length range sampled and because juvenile Artic char have not been accumulating mercury for a long period of time.

Arithmetic and length-standardized mean concentrations of mercury in Artic char muscle were relatively similar across lakes (Table 4.5-4), but both values were highest in Angajurjualuk Lake. Concentrations of mercury in juvenile Artic char muscle were notably lower than in larger fish captured from the lakes. Collectively, of the fish captured in lakes (age range of 5 to 25 years),14% of Artic char muscle samples exceeded the Health Canada guideline for the commercial sale of fish (0.5 µg/g w.w.) and 29% of samples exceeded the Health Canada subsistence guideline (0.2 µg/g

w.w.). Arithmetic mean mercury concentrations in muscle of Artic char from Mary and Angajurjualuk lakes exceeded the subsistence guideline, while only fish from Angajurjualuk Lake contained a mean length-standardized mercury concentration (0.211 µg/g w.w.) above the subsistence guideline.

Mercury concentrations are commonly higher in landlocked Artic char relative to anadromous populations (Lockhart et al. 2005) and frequently above the Health Canada subsistence guideline of 0.2 µg/g (w.w.) in Arctic fish (e.g., Gantner et al. 2010). Concentrations of mercury in muscle of char collected in the Mine Area fall within the ranges observed in 27 populations of land-locked char sampled across remote lakes of the Canadian Arctic (Gantner et al. 2010) and from land-locked char collected from 6 lakes in the Canadian Arctic archipelago (Muir et al. 2005). The arithmetic mean concentrations of mercury in muscle of Artic char from the Study Area lakes was lower than the mean reported by Gantner et al. (2010) for Radar Lake, Baffin Island, despite similarity in mean fork lengths between these populations.

5.0 RAILWAY/ACCESS ROAD AREA: BASELINE STUDIES

The proposed Project includes a railway that stretches 143 km from the Mine Site to the southern terminus at the proposed port site at Steensby Inlet (Figure 5-1). The railway corridor, which will include a construction access road, several spur roads to access aggregate source sites (borrow pits/quarries) and four construction camps, will traverse three major watersheds. From the mine site to approximately km 69 the line will traverse numerous watercourses that drain generally westward as part of the Ravn River watershed. From km 69 to approximately km 127 the line will pass through the Cockburn River watershed that flows southward to Steensby Inlet. The remainder of the line will lie within the Ikpikitturjuaq River watershed that drains southwestwardly and empties into Ikpikitturjuaq Bay, north of the Steensby Port site.

The access road will run adjacent to the railway for most of its length, with several minor deviations and two major deviations, one at Cockburn Lake and one to the north of the Ravn River crossing (Figure 5-1). Construction camps will be located north of the Ravn River crossing (Ravn River Camp), at Mid-Rail Camp Lake (Mid-Rail Camp), on the east side of the middle basin of Cockburn Lake (Cockburn Tunnels Camp), and near the southern end of Cockburn Lake (Cockburn South Camp; Figure 5-1).

Field studies were initiated within the Railway/Access Road study area in 2007. Potential stream crossing, lake encroachment and aggregate source sites were initially identified by Canarail Consultants Inc., who also provided UTM coordinates for each location. Additional field studies were conducted in 2008 and 2010 to assess sites that could not be completed in 2007, as well as sites that were added due to alignment adjustments that were made in 2008. A summary of site assessments is provided in Table 5-1.

5.1 RAILWAY/ACCESS ROAD STREAM CROSSINGS

The following provides an overview of the methods and results of field surveys of stream crossings for the railway and access road.

5.1.1 Methods

Descriptions of field studies and survey methods used are described in Section 5.1.1.1., including all stream crossing surveys for the railway and construction access road, and studies conducted on Cockburn Lake. Where survey methods differed between years, these differences are discussed.

5.1.1.1 Field Methods

Railway/Access Road Stream Crossing field studies were initiated in 2007. Fish habitat surveys were conducted from August 1-14 at all watercourse crossings along the proposed railway alignment and along sections of the proposed construction access road. Access to all sites was provided by helicopter.

A watercourse crossing assessment protocol specific to the Mary River Project was developed in 2007 by North/South Consultants Inc. (NSC) and Knight Piésold Ltd. to ensure that crossings were assessed in a standardized manner. The protocol was based upon protocols described in DFO and BCMOE (1989) and NSC (2006), but tailored to better describe conditions occurring along the railway alignment (Appendix 5.1-1). The 2007 assessment protocol was intended to provide preliminary information regarding the observed/potential fish habitat at each site, and identify locations at which additional and more detailed assessments could be required. Due to time constraints, electrofishing surveys were conducted only at sites that were considered most likely to provide habitat for fish. At all other locations, visual observation surveys were conducted along sections of shoreline near the crossing, all fish observations were recorded, and all sites that appeared to have suitable fish habitat were noted for future evaluation.

Fish were collected along a 100 m reach (50 m upstream and 50 m downstream of the centre line) using a Smith-Root Model 11A electrofisher. All captured fish were enumerated by species and, once electrofishing at that site was completed, were released alive back into the water from which they were captured. No additional biological measurements were collected from captured fish, although an estimated length was noted for each fish.

Species identification was usually, but not always, possible when fish were observed but not captured, depending on a number of environmental factors (time of day, water depth, etc.) and the size of the observed fish. Observed fish were identified to species and sizes were estimated whenever possible.

Physical habitat characteristics measured at each crossing site included: floodplain width; wetted and bankfull widths; bank height, shape and stability; maximum water depth; and, where appropriate, a profile of water depth across the stream (at 25, 50 and 75% of the width). Channel profile, confinement, gradient, and morphology, as well as substrate composition, the amount of available stream cover, and the flow regime were also evaluated at each water-crossing. Photographs were taken of representative habitat at each crossing and a schematic of the crossing was drawn.

Barriers to fish movement, specifically for juvenile Arctic char, were identified on all streams within the Railway/Access Road study area. The most common barrier types were high velocity and/or

vertical drop barriers that prevent upstream, but not necessarily downstream movements. Fish distribution and passage surveys in Mine Area waterbodies demonstrated that water velocities in excess of 2.5 m/s and vertical drops greater than 0.5 m effectively prevent upstream movements of all juvenile Arctic char. A combination of low water levels and steep gradient (> 10°) can also act as a complete barrier at lower water velocities. Insufficient depths prevent access by larger juveniles (> 100 mm FL) and smaller Arctic char can be obstructed by consistent velocities reaching 1.5-2.0 m/s. Other barrier types observed include subsurface flow, boulder piles, and a lack of channelization allowing water to spread out in a thin layer over terrestrial vegetation. These barrier types all prevent movement of fish in both directions. Fish movement information and barrier characteristics derived from Mine Area and Milne Inlet Tote Road surveys were used to identify probable barriers in other study areas (e.g. Railway/Access Road, Steensby Port, and Milne Port areas).

Reaches immediately upstream and downstream of each crossing (within 100-200 m in each direction) were examined to identify any potential barriers to fish movement, and any larger bodies of water that may provide additional habitat (e.g., overwintering habitat). When important changes in habitat type or substantial barriers to upstream fish passage were present in watercourse reaches upstream or downstream of the crossing, those reaches were evaluated at the same level of detail as the crossing itself. At sites where it was not possible to land the helicopter, aerial photographs were taken and observations were recorded. Habitat assessments at those sites were based on photograph interpretation and recorded observations.

Construction access road sites examined in 2007 were located on a plateau above and to the east of Cockburn Lake. Due to time constraints and difficulty accessing these sites from the ground, all were qualitatively assessed by flying over the site in a helicopter.

Railway/Access Road Stream Crossing field studies were resumed in 2008, from July – September. The 2008 field studies conducted along the railway and access road alignments included:

- surveying sites that could not be completed in 2007;
- confirmation of fish presence or absence at sites that were designated as potential fish habitat in 2007; and,
- surveys of new sites resulting from railway or access road re-alignments that occurred subsequent to the 2007 surveys.

Physical habitat characteristics were measured in greater detail in 2008. At proposed culvert sites, detailed information was collected at 20 m intervals, starting at 100 m downstream and ending at 100 m upstream. For proposed bridge crossing sites information was collected at 20 m intervals from 40 m downstream to 40 m upstream of each crossing site. Wetted and bankfull widths, substrate

composition, channel morphology, and at least three representative velocities were recorded at 10-20 m intervals, depending on uniformity of habitat (Appendix 5.1-1). Additional physical data collected included: floodplain width; bank height range, shape and stability of the shore; channel profile; confinement; gradient; available stream cover; and maximum water depth. Photographs were taken of representative habitat at each 10-20 m wide assessment site, and a schematic of the crossing was drawn.

Crossings that appeared to provide suitable habitat for Arctic char and/or ninespine stickleback (the only fish species present in the area) were first examined visually (usually during habitat assessment data collection) and then electrofished to confirm the presence of fish. Electrofishing was typically conducted over the same 100 m of stream assessed for habitat. All captured fish were enumerated, identified to species, measured for fork length (mm), and returned to the section of stream from which they were collected. If fish were not present, but habitat appeared otherwise suitable, the section of a stream between the crossing and the nearest potential overwintering site (generally lakes with maximum depth > 3.0 m) was surveyed to locate any potential barriers to fish movement. Additional electrofishing was conducted downstream of some barriers to determine fish presence or absence, and UTM coordinates were recorded for identified barriers.

Based on the results of habitat and fish surveys, aquatic habitat quality at each crossing was classified as No Fish Habitat (non fish-bearing), Marginal (provides limited quantity or quality of habitat for either species), or Important (easily accessible to fish and provides abundant, suitable habitat).

A final round of stream crossing surveys was conducted from August 26-27, 2010, to incorporate new sites subsequent to final railway/access road alignment adjustments that were made in late 2008. Field survey methods to describe habitats and determine fish presence/absence were the same as those used in 2007. The surveys conducted in 2008 and 2010 included upstream and downstream searches to locate potential fish barriers.

Data collected at railway and access road crossings were recorded on standardized field data sheets (Appendix 5.1-1).

Cockburn Lake

The proposed railway alignment runs roughly parallel to the west side of Cockburn Lake's north basin, crosses the lake at the second narrows and then follows along the east side of the middle and south basins (Figure 5-1). Given the railway's proximity to this large lake and the possibility of project interactions (e.g., lake crossing, construction camps and lake encroachments) a field program

was implemented to map the lake's bathymetry and substrate characteristics, with the objective of determining fish habitat types and distribution.

Acoustic data collections were conducted on the north and middle basins on August 13 and 14, 2007, using a single beam sonar system operated from a 4.3 m Zodiac MKII inflatable boat. The sonar system included a Quester Tangent (QTC; Sidney, British Columbia; www.questertangent.com) sounder interface module (SIM) and QTC VIEW Series V acquisition software operated in conjunction with a Suzuki echo sounder (Model ES-2035; operating at 50 Hz) and a Trimble Pro XRS differential GPS set to record location every five seconds. Sounder parameters within QTC VIEW V were configured to record the first wave of each acoustic echo.

Cockburn Lake is deep and narrow, with rapidly increasing water depth from shore. The operating parameters for the sonar system normally require some adjustment when moving between shallow and deep water to account for alteration in signal characteristics. However, to avoid acquiring an overly complicated dataset and recognizing that quality fish habitat and potential project interactions generally would be limited to shallower water, the field crew maintained shallow water settings for the duration of the survey.

Data were collected by boating along transects, generally arranged in broad zig-zag patterns across the lake. Additional transects were laid out approximately perpendicular to the zig-zag pattern to ensure acoustic signal types were similar at intersecting points. In selected areas of interest, additional closely spaced transects were completed to provide more detailed information. Additional sampling effort was focused along the west shore of the north basin of the lake, adjacent to the proposed railway alignment. Similarly, the east shore of the middle basin was targeted for additional effort. Acoustic surveying could not be completed in the south basin in 2007, so this work was conducted in August of 2010. The 2010 survey of the south basin also included a search for potential Arctic char spawning habitat, particularly in the vicinity of the proposed Cockburn South Camp.

Substrate samples were collected at various locations using a Ponar benthic grab, and qualitatively described to provide validation for substrate classification provided during the processing of QTC VIEW V data.

Gillnetting was conducted in the north basin of Cockburn lake in the fall of 2008 (September 5-6) to collect information on fish presence and habitat utilization with the additional objective of identifying Arctic char congregations and potential spawning areas. The survey included five net sets in the vicinity of the channel separating the north and middle basins (i.e., the vicinity of proposed railway crossing) (Figure 5.1-1). The fall gillnetting survey was curtailed due to the lateness of the season and equipment issues.

5.1.1.2 Data Analysis

The *Fisheries Act* defines 'fish habitat' as 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. In 2007, determination of fish habitat at watercourse crossings was based on physical characteristics (primarily water depth, but also substrate and flow characteristics), fish accessibility to the site, the extent of suitable habitat upstream of the crossing, and the presence of and distance to a suitable overwintering waterbody. Lake encroachment sites were assessed on the basis of lake depth (measured or assumed) and suitability of habitat characteristics, particularly at the encroachment site.

At sites that appeared to be suitable fish habitat but where it was not possible to definitively determine habitat importance, these sites were assumed to be fish habitat and noted as requiring further investigation.

At sites where fish habitat was confirmed (i.e., fish were observed) or could reasonably be assumed, habitat quality was classified as Marginal or Important. In general, habitat was considered to be Marginal if it was accessible to fish, but had one or more characteristics that were unsuitable for extensive fish use (e.g., limited access, low water levels, little or no cover, large distances from overwintering habitat). Important fish habitat was determined to be easily accessible from overwintering habitat, had abundant suitable substrate (cobble and/or boulder, deep pools) and stream morphology (riffle/pool), and was in all respects suitable for fish rearing, and/or spawning. Where possible, the numbers of fish observed or captured were used to assist in categorizing habitat quality. Only Arctic char and ninespine stickleback have been documented in freshwater lakes and streams in the vicinity of the Project. Consequently, only habitat requirements specific to those species were considered when ranking habitat quality at watercourse crossings and lake encroachment sites.

The railway and access road alignments run roughly parallel and adjacent for most of their lengths. To avoid duplication, separate access road crossing assessments were conducted only at sites where crossing locations were further than 100 m apart (i.e., divergent alignments). Also, numerous streams or specific sites were visited on more than one occasion (i.e., in 2007, 2008 or 2010) to gather additional information, confirm fish presence/absence, or to account for alignment adjustments. To simplify data presentation and the assessment process, site summary sheets were prepared for each individual site only once where crossings are considered to be adjacent. Separate summary sheets were prepared for access road sites where the alignments are considered to be divergent (i.e., distance between railway and access road sites >100 m) or where the access road will

cross a watercourse that will not be crossed by the railway. Tabulated site information and detailed site assessment sheets are provided in Appendix 5.1-2 (railway) and Appendix 5.1-3 (access road).

Cockburn Lake

Analysis of the QTC VIEW V data was conducted using the software IMPACT, provided by QTC. The software linked the acoustic survey data and the GPS files to produce geo-referenced depth data. Geo-referenced depth values were imported into a geographic information system (ESRI ArcGIS 9.2) for mapping.

Once the geo-referenced depth values were generated, a digital shoreline was created from vector topographic data derived from high-resolution ortho-imagery. The shoreline was assigned a depth value of 0 and was then merged with the QTC data. A kriging algorithm was used in ArcGIS® Spatial Analyst to create the contour lines from the geo-referenced depth data. A tolerance distance was set so that the value of each interpolated raster cell was derived from a minimum of 5 measured depth points. The kriging process produced a continuous depth raster dataset which was then converted to a vector depth contour data set. Once the contours were created, they were inspected for anomalies, and a smoothing algorithm was applied (which does not change the data) to produce final contour lines for final cartographic outputs.

To facilitate substrate characterization and mapping all acoustic data collected from waters deeper than 55 m were removed, since operating parameters on the sonar system were set for use in shallow water as discussed previously. The remaining acoustic data set was examined prior to analysis using the full features vector (FFV) editor in IMPACT, and anomalous data were removed.

Once the raw data were in satisfactory condition, IMPACT was used to generate full feature vectors (FFV) of the data. IMPACT uses principal components analysis (PCA) to transform or reduce dimensionality within multivariate data sets into three primary indices that account for a large proportion of the total variation within the data set being analyzed. This process allows for easier interpretation of substrate classes. The Automatic Cluster Engine (ACE) was used to classify the PCA-transformed sonar signatures into 7 natural clusters depicting varying sizes of lake-bottom substrate. Observation data collected during the survey were used to validate the classes obtained from the unsupervised classification analysis. Once classification was completed, the data set was exported from IMPACT as an ASCII text file complete with geographic coordinates and lake-bed classification information.

ESRI's ArcGIS® ArcMap was used to map the classified substrate track files. ArcGIS® Spatial Analyst was used to create a raster file, which interpolated a continuous surface of values between the discrete substrate class data points. The raster data set was smoothed using a boundary cleaning

algorithm to remove noise relics created by the interpolation tool. The interpolated raster substrate map was then converted to a vector polygon file. Data were mapped over a 100 m wide swath along the shoreline of Cockburn Lake where railway construction is expected to take place.

5.1.2 Results

Railway Crossings

Table 5.1-1 provides a summary of fish habitat assessments for all railway stream crossings, by major watershed and fish species. A total of 230 potential crossing sites were surveyed, including 68 sites (30%) that were confirmed or suspected to be Arctic char habitat. Ninespine stickleback habitat was confirmed or suspected at 63 streams (27%). A total of 54 streams (23%) were assessed as fish habitat for both species, and 152 streams (66%) were designated as having no fish habitat.

Excluding the Mary and Ravn river crossings, Arctic char habitat was limited to summer rearing and feeding habitat for young-of-the-year (YOY) and juveniles. Of the 230 sites surveyed, forty-eight sites (21%) were assessed as Important, most of them in the Ravn and Cockburn river watersheds (Table 5.1-2). Twenty sites (9%) were considered to provide Marginal habitat for Arctic char, most in the Ikpikitturjuaq and Ravn river watersheds.

An overview map of the railway alignment and sites surveyed in 2007, 2008 and 2010 is presented in Figure 5.1-2. More than half of the streams surveyed are in the Ravn River watershed. Streams crossed from the Mine Site to approximately km 4.6 down the railway drain into the Mary River, and eventually to Angajurjualuk Lake (Figure 5.1-3). South of the Mary River the railway alignment runs between the base of an escarpment to the east and a Mary River tributary that connects a string of small lakes to the west. Most of the streams along this section are small, short and relatively steep, with mostly cobble and boulder substrates. Arctic char using these streams were juveniles and the downstream lakes are likely used for spawning, overwintering and adult foraging. The larger lakes in the area (i.e., Sheardown, Mary, Camp and Angajurjualuk lakes) may also serve as spawning and overwintering areas for these Arctic char, because all would be accessible.

From km 4.6 to km 30.9, the railway continues along the base of the escarpment and stream characteristics are similar to those described above (Figures 5.1-3 to 5.1-5). Although there are a few small lakes to the west of the railway along this section, most of the streams are longer and eventually empty directly into Angajurjualuk Lake. Several of the larger lakes adjacent to the railway likely serve as overwintering and spawning habitat, but most of the observed juvenile Arctic char probably migrated from larger lakes downstream, including Angajurjualuk Lake.

From km 30.9 to km 37.6, streams crossed by the railway flow into Ravn Camp Lake or directly into the Ravn River, which is crossed by the railway at km 37.6 (Figures 5.1-5 and 5.1-6). The first part of this section continues along the same steep escarpment and is confined between it and the north shore of Ravn Camp Lake. Stream characteristics generally are similar to those described above. Potential overwintering and spawning lakes along this section include Ravn Camp Lake and possibly the Ravn River, although it is more likely that Arctic char would continue downstream to Angajurjualuk Lake, rather than overwinter in the Ravn River.

South of the Ravn River, from approximately km 37.6 to km 62.1, the railway alignment follows a relatively large and unnamed tributary of the Ravn River (Figures 5.1-6 and 5.1-7). The terrain throughout this area has very low relief and complex drainage patterns, with numerous small but shallow lakes. Mid-Rail Camp Lake is the largest and likely the deepest lake along this section. The lack of deep lakes in the area likely means that juvenile Arctic char using stream habitats in this area return to the Ravn River or Angajurjualuk Lake to overwinter. Most of the streams crossed in this section are small, low gradient streams flowing through hummocky to flat, usually saturated sedge/moss meadow vegetation. With few exceptions, stream habitat is of low quality for Arctic char, although numerous streams provide adequate habitat for ninespine stickleback, provided that access to overwintering habitat is available.

The railway enters the Cockburn Lake watershed at approximately km 68.8, following a relatively large but unnamed tributary to Cockburn Lake to about km 88.3 (Figures 5.1-8 to 5.1-11). The terrain in this section is more diverse and the relief more pronounced. The streams crossed by the railway alignment are consequently better defined, generally with higher flows and gradients. Cobble and rock substrates dominate in most stream channels. These features are typical of good to high quality Arctic char habitat in the region, but no Arctic char were captured or observed in any of the streams surveyed in this section. A notable feature of the entire sub-catchment that is drained by this Cockburn Lake tributary is the nearly total absence of lakes that could serve as overwintering and spawning habitat for Arctic char, and access from Cockburn Lake is precluded by several cataracts and high waterfalls. The implication is that Arctic char are absent from this sub-catchment, despite the presence of an abundance of suitable stream habitat. The only potential overwintering refuge and spawning area is a 37 ha lake located along the tributary mainstem between km 79 and km 82. This lake was surveyed in 2008 and it was determined that much of the lake is shallow, although the central basin has depths in excess of 20 m. This would be adequate to support overwintering Arctic char, so it is likely that a lack of some other critical habitat requirement has prevented establishment of an Arctic char population. The absence of this species was confirmed in 2010 when an extensive shoreline electrofishing survey failed to produce any Arctic char. Ninespine stickleback were captured in the lake, as well as at various stream locations along the railway.

From km 88.3 to km 130.5 the railway follows the shore of Cockburn Lake; initially the west shore, then crossing over to the east shore at km 95.5 (Figures 5.1-9 to 5.1-11). Cockburn lake lies within a deep and very steep-sided glacially carved valley, and the streams flowing into it are typically too small and the gradient too high to provide Arctic char habitat. A few exceptions exist, primarily where streams level out before entering the lake. The most important exception, however, occurs near the south end of the lake in the vicinity of the Cockburn South Camp. Here two larger streams descend through long, narrow canyons before levelling out as they approach the lake. At this point each divides into several channels as it transects thick cobble/gravel alluvial deposits, before converging again just before entering the lake. These braided channels vary in size from small to relatively large, and all provide high quality rearing habitat for juvenile Arctic char. Cockburn Lake supports both freshwater resident and anadromous Arctic char populations (see Appendix 4.4-3), as well as ninespine stickleback.

South of Cockburn Lake, at approximately km 130.5, the railway crosses into the Ikpikitturjuaq watershed and remains within this watershed to its terminus at the proposed Steensby Port Site (Figures 5.1-11 and 5.1-12). Several large lakes, including 10 km Lake (ST-352), dominate the Ikpikitturjuaq system and support both freshwater resident and anadromous Arctic char populations. The Ikpikitturjuaq River empties into the sea at Ikpikitturjuaq Bay, north of Steensby Port site. The hilly terrain in this area consists of numerous smaller sub-catchments with streams that flow into the Ikpikitturjuaq River. These tributaries are generally small but connect numerous small to medium sized lakes with depth and other habitat features that are suitable for both Arctic char and ninespine stickleback. Many of these tributaries provide suitable Arctic char rearing habitat, but poor connectivity and other natural barriers have effectively isolated many populations. As a general statement, the area includes numerous lakes that support distinct Arctic char populations, many with inflowing or outflowing streams that provide rearing habitat for juvenile Arctic char.

Arctic char is a fall spawning salmonid species requiring relatively high winter dissolved oxygen concentrations for overwintering of juveniles and adults, as well as winter egg incubation (Appendix 4.4-3). All of the streams to be crossed by the railway and access road are likely to freeze to the bottom during winter and the potential for overwintering or spawning habitat is therefore precluded. Where Arctic char are present, habitat use is for YOY and juvenile summer rearing almost exclusively. The few exceptions would be the largest streams (i.e., Mary and Ravn rivers) which may also be used by adults for summer foraging or movement between lakes. Although it is possible that sections of the Ravn River are deep enough support some Arctic char overwintering, no such habitat was found in the vicinity of either alignment and overwintering potential is considered to be low. The railway and access road will also cross Cockburn Lake at a narrow section between the north and middle basins. This would be the only site with potential to provide year-round habitat for a number of Arctic char life stages.

Ninespine stickleback spawn during late spring/early summer in shallow water with little to no flow (Appendix 4.4-3), so streams that freeze to the bottom in winter may still be able to support spawning provided that other overwintering habitat is available. This species is also more tolerant of low dissolved oxygen levels and it is likely that a number of the larger streams may also support some level overwintering. In general, however, the primary importance of streams along the railway and access road alignment where ninespine stickleback are present is as summer feeding and rearing habitat for adults, juveniles and YOY.

Access Road Crossings

Table 5.1-3 provides a summary of fish habitat assessments for all access road stream crossings, by major watershed and fish species, excluding those sites where railway and access road crossings will be adjacent. A total of 93 potential crossing sites were surveyed, including 19 (20%) that were confirmed or suspected to be Arctic char habitat. Ninespine stickleback habitat was confirmed or suspected at 23 streams (25%). A total of 19 streams (20%) were assessed as fish habitat for both species, and 70 streams (75%) were designated as having no fish habitat.

Excluding the Mary and Ravn river crossings, Arctic char habitat was limited to summer rearing and feeding habitat for YOY and juveniles. Twelve sites (13%) were assessed as Important, most of them in the Ravn River watershed (Table 5.1-4). Seven sites (8%) were considered to provide Marginal habitat for Arctic char, most in the Ravn River watershed.

Fish habitat use and habitat limitations at access road stream crossings are the same as discussed for railway stream crossings.

An overview map of the access road alignment and sites surveyed in 2007, 2008 and 2010 is presented in Figures 5.1-13, and detailed maps of the alignment are provided in Figures 5.1-14 to 5.1-24.

The access road alignment generally parallels the railway alignment, the major deviations being along the east side of the south and middle basins of Cockburn Lake, as well as the west side of the north basin (Figures 5.1-20 to 5.1-23), and the vicinity of Ravn River Camp (Figures 5.1-16 and 5-17). The Cockburn Lake deviation is necessitated by the lack of space between the lake shore and valley wall. The access road ascends to the plateau above Cockburn Lake just north of Cockburn South Camp and re-joins the railway alignment at the Cockburn Lake crossing. Streams on the high plateau are all small and the lakes are small and shallow. No Arctic char or ninespine stickleback habitat was identified anywhere along this portion of the route, although several Arctic char were captured at the outlet of the largest lake in the area in the vicinity of AR-039 (Figure 5.1-22). The outlet stream for this lake eventually flows to Cockburn Lake but a natural barrier precludes any fish

movement beyond the lake outlet area. The access road will cross five streams that empty into this lake or its outlet stream (AR-038 – AR-042), but all of these tributaries are ephemeral or too small to provide fish habitat.

Similarly, the access road will ascend out of the valley to bypass the north basin. The section of road from Cockburn Lake to its convergence with the railway at km 88.4 crosses several small, mostly ephemeral streams that provide no habitat for fish. The largest lake along this section of road is located approximately 1 km upstream of crossing AR-051. This lake was found to have Arctic char in September, 2008, but impassable cataracts and waterfalls upstream and downstream of crossing AR-051 prevent fish passage between the lake and the crossing site or Cockburn Lake.

The Ravn access road deviation begins at the eastern end of Ravn River Camp, where it runs along the south shore of the lake while the railway follows the north shore, and ends south of the Ravn River. The section north of the Ravn River has very few stream crossings, two of which were identified as Important habitat while the remaining sites were identified as No Fish Habitat. The section south of the Ravn River runs more or less parallel to the railway but at a variable distance to it. Streams crossed along this section of the access road are similar to those described for the corresponding section of the railway alignment.

Cockburn Lake

Cockburn Lake is a narrow lake, approximately 37 km long, confined within a steep-sided valley. It comprises three basins separated by two narrow and relatively shallow channels (Figure 5-1). A bathymetric map of the lake is provided in Appendix 5.1-4. The middle basin is by far the largest (approximately 18.6 km long and 394.4 km^2), while the south basin (approximately 7.8 km long and 10.5 km^2) and north basin (approximately 5.7 km long and 9.5 km^2) are substantially smaller. The precipitous nature of the surrounding valley is reflected in the lake's subsurface topography, with depth increasing rapidly from shore to depths in excess of 190 m. The north basin has maximum and mean depths of 192 m and 29.8 m, respectively. The middle has a maximum depth of 195 m and a mean depth of 34.7 m. The south basin has maximum and mean depths of 61.4 m and 21.5 m, respectively. The north and middle basins are connected by a channel approximately 1 km in length. The channel is shallow and at the time of the survey was fast flowing. Two channels separate the middle and south basins, although the shallower west channel may become dewatered during exceptionally low water periods. The wider and deeper east channel is approximately 2.5 km long and approximately 5 m deep, based on the 2010 survey. This channel is dominated by boulder/cobble substrate across its width and for most of its length.

In the north and middle basins, acoustic data collection was focused along shorelines adjacent to the proposed railway and access road alignments. Substrate interpretation was therefore conducted for a swath of habitat extending offshore for a distance of 100 m along the corresponding shorelines. Shoreline surveys were also conducted adjacent to the proposed railway alignment in the south basin, focusing on habitat extending offshore to depths of 10+ m to determine char spawning habitat potential. Substrate distribution maps are provided in Appendix 5.1-4.

Six substrate classes were determined by principle components analyses completed using IMPACT. These included:

- boulders;
- a mixed substrate of cobble with a clay matrix;
- a mixed substrate of cobble and pebbles;
- a mixed substrate of gravel and coarse sand;
- sand; and,
- silt/clay.

Substrate classifications based on the 2007 data were validated from 59 visual observations and Ponar grabs collected along the shore. The south basin substrate was validated with 28 Ponar grabs and visual interpretation of the Suzuki depth sounder's echo display. The validation data are presented in Appendix 5.1-4.

Substrate composition was mapped for about 3 km^2 of shoreline along the north and middle basins of Cockburn Lake. Boulder and cobble substrates with clay or pebble matrices comprised about 94% of the habitat mapped in these basins. Gravel and sand substrates comprised only 6% of the area mapped. Most soft substrates occurred at shallow areas such as near the constriction between the north and south basins, and at the inlet and outlet of the lake. Small patches of gravel or sand occur sporadically along the shoreline, often where small streams enter the lake, or at the periphery of scree slopes.

The area of the south basin of Cockburn Lake surveyed in 2010 had substrates dominated by fines (i.e., sand, silt, and clay). Coarser rock substrates (i.e., boulder, cobble, gravel) were generally confined to nearshore areas and did not occur in water greater than 3 m deep. The only exception to this occurred in the narrows between the south and the middle basin, which had cobble/boulder dominated substrate occurring in water more than 5 m deep. Nearshore substrate composed of boulder and cobble would provide cover and feeding habitat for juvenile char and possibly ninespine stickleback.

Gillnetting was conducted at Cockburn Lake in the fall of 2008, at five sites located in the vicinity of the Cockburn Lake railway crossing. Of the five sites fished in Cockburn Lake, CPUE was highest (85-86 fish/100 m/24 hrs) at two nearshore sites (4-5 m depths). These two sites were on the east and west shore of the channel separating the north and south basins. All other sites were further offshore or in deeper water. Average CPUE at these three sites was less than 15 fish/100 m/24 hrs. In addition, average fork lengths (468-473 mm) and weights (1100-1500 g) were higher at nearshore sites (offshore mean length < 400 mm), suggesting a potentially greater proportion of large, mature char in these areas during fall of 2008 (Table 5.1-5).

5.2 RAILWAY/ACCESS ROAD LAKE ENCROACHMENTS

5.2.1 Methods

Descriptions of field studies and survey methods used are described in Section 5.2.1.1., below. Where survey methods differed between years, these differences are discussed.

5.2.1.1 Field Methods

Railway/Access Road Lake Encroachment field studies were initiated in 2007 and were conducted from August 1-14. Fish habitat assessments were conducted at all lake encroachment sites along the proposed railway alignment and along sections of the proposed construction access road. Access to all sites was provided by helicopter. At all sites where the railway or access road could potentially encroach on lake shorelines, aquatic habitat was qualitatively described in the context of its potential importance as fish habitat, and site photographs were taken. Lakes that appeared to be suitable fish habitat (i.e., based on fish observations or professional judgment) were noted for future evaluation. No fishing was done at lake encroachment sites in 2007, but all fish observations were recorded.

Railway/Access Road Lake Encroachment field studies were resumed in 2008 from July 18 – September 7. The 2008 field studies conducted along the railway and access road alignments included:

- surveying sites that could not be completed in 2007;
- confirmation of fish presence or absence (using an electrofisher) at sites that were designated as potential fish habitat in 2007; and,
- surveys of new sites resulting from railway and/or access road re-alignments that occurred subsequent to the 2007 surveys.

Additional habitat information was collected at all encroachment sites to supplement information collected in 2007, and at new sites resulting from changes to the railway and/or access road

alignment. Back-pack electrofishing was conducted at all sites that appeared to be suitable for fish habitat. Electrofishing was conducted over suitable substrates, along shorelines at potential encroachment sites. Electrofishing methods were the same as described in Section 5.1.1.1 and Appendix 5.1-1.

A final round of lake encroachment surveys was conducted from August 26-27, 2010, to incorporate new sites subsequent to final railway/access road alignment adjustments that were made in late 2008. Field survey methods to describe habitats and determine fish presence/absence were the same as those used in 2007 and 2008.

Data collected at potential railway and access road lake encroachments sites were recorded on standardized field data sheets (Appendix 5.1-1).

5.2.1.2 Data Analysis

Lake encroachment site habitat assessments were based on fish presence/absence where it could be confirmed, or on professional judgment where it could not. Lakes or ponds were considered to be fish habitat if it could be confirmed or reasonably assumed that fish utilize a waterbody for overwintering or spawning, or for feeding or rearing, either seasonally or year-round. Habitat classifications were the same as those described in Section 5.1.1.2 and Appendix 5.1-1. Tabulated site information and detailed site assessment sheets are provided in Appendix 5.2-1.

5.2.2 Results

Table 5.2-1 provides a summary of fish habitat assessments for all lake encroachment sites, by major watershed and fish species. A total of 46 potential encroachment sites were surveyed, including 19 (41%) that were confirmed or suspected to be Arctic char habitat. Ninespine stickleback habitat was confirmed or suspected at 25 sites (54%). A total of 17 sites (37%) were confirmed or suspected to provide habitat for both species, and 18 sites (39%) were designated as having no fish habitat.

Encroachment sites identified as Arctic char habitat (Table 5.2-2) generally are shallow nearshore sites with habitat that is suitable for Arctic char feeding and rearing. No sites were identified as potential spawning or overwintering sites, and no sites were identified where this type of habitat is limited in a given waterbody (i.e., critical). Eleven sites (24%) were assessed as Important, most of them in the Cockburn and Ikpikitturjuaq watersheds. Eight sites (17%) were considered to provide Marginal habitat for Arctic char, all in the Ravn and Ikpikitturjuaq watersheds.

An overview map of potential lake encroachment sites for the railway and access road and sites surveyed in 2007, 2008 and 2010 is presented in Figure 5.2-1, and detailed maps of the alignment

are provided in Figures 5.2-2 to 5.2-6. Tabulated site information and detailed site assessment sheets are provided in Appendix 5.2-1.

5.3 QUARRY LOCATIONS

5.3.1 Methods

Descriptions of field studies and survey methods used are described in Section 5.3.1.1., below. Where survey methods differed between years, these differences are discussed.

5.3.1.1 Field Methods

Fish habitat assessments at proposed quarry locations, and along proposed access roads to those locations, were initiated in 2007 (August 1-14), were resumed in 2008 (July 18 – September 7), and continued in 2010 (August 26-27). Only sites where quarry development could potentially interact with surface waters were investigated and only sites that appeared to have some fish habitat potential were surveyed in detail. Field survey methods for quarry sites were the same as described in Section 5.1.1.1, Appendix 5.1-1 (stream crossings), and Section 5.2.1.1 (lake encroachments). In 2007, habitat assessments at quarry sites were based on photograph interpretation and recorded observations. Access to all sites was provided by helicopter.

5.3.1.2 Data Analysis

Data analysis for potential quarry sites was the same as described in Section 5.1.1.2 and Appendix 5.1-1 (stream crossings) and Section 5.2.1.2 (lake encroachments).

5.3.2 Results

Quarry sites were initially examined on maps and aerial photos to determine if there were potential project interactions with fish-bearing waterbodies, or if relevant sites had already been assessed as railway/access road crossing sites or lake encroachment sites. Assessments were then conducted only on those sites that had not already been assessed and where the potential for effects on fish habitat existed. Table 5.3-1 provides a summary of fish habitat assessments for surveyed quarry locations, by major watershed and fish species. A total of three potential quarry sites were surveyed, including one (33%) that was confirmed or suspected to be Arctic char habitat. Ninespine stickleback habitat was confirmed or suspected at one site (33%). Only one site (33%) was confirmed or suspected to provide habitat for both species, and two sites (67%) were designated as having no fish habitat.

The potential quarry site identified as Arctic char habitat (Table 5.3-2) is a shallow nearshore site with habitat that is suitable for Arctic char feeding and rearing only. It was classified as Important Arctic char habitat.

An overview map showing the railway and access road alignments and potential stream crossing sites surveyed in 2007, 2008 and 2010 is presented in Figure 5.3-1, and detailed maps of the alignment are provided in Figures 5.3-2 to 5.3-6. Tabulated site information and detailed site assessment sheets are provided in Appendix 5.3-1.

5.4 RAVN RIVER CAMP

Ravn Camp (Figure 5.4-1), located approximately 40 km southeast of the Mine Site (Figure 5-1), is being proposed as a site for a railway construction camp. A number of field studies were conducted in August, 2010, to support an assessment of potential project effects to the fish and fish habitat of this lake. These included:

- collection of water quality and chlorophyll *a* samples;
- bathymetric and substrate classification surveys of the entire lake, with emphasis on areas in the vicinity of potential water intake locations;
- a survey to identify fish presence/absence (i.e., to confirm fish presence) in the vicinity of the proposed camp location; and,
- an assessment of fish habitat in the vicinity of the proposed camp location.

5.4.1 Methods

5.4.1.1 Field Methods

Chlorophyll *a* Sampling

Chlorophyll *a* samples were collected as a component of the water quality sampling program at Ravn River Camp Lake. A detailed description of water quality sampling methods is provided in (Volume 7, Appendix 7B). In brief, water samples were collected 1 m from the water surface and 1 m from the sediments and submitted to Exova Laboratories, Ottawa, ON for analysis.

Bathymetry/Substrate Survey

Bathymetry and substrate information was collected using the QTC sonar system (see Section 5.1.1.1 for detailed system setup and methodology). Data were collected along transect lines generally spaced at intervals of 200 m or less. More detailed data (i.e., transects less than 100 m apart) were collected in west end of the lake in the vicinity of the proposed camp location.

At selected locations along the bathymetric survey, bottom types were characterized using a Ponar dredge. These descriptions were used to validate the collected acoustic data used for bottom typing.

Local survey control was unavailable at Ravn Camp Lake; therefore, a temporary benchmark was established for determining relative water level elevations during the bathymetric survey. The temporary benchmark was the top surface of a boulder on shore. A line and level was then used to measure the water elevation to the boulder surface. This temporary benchmark was spray painted for future identification and a GPS location and photographs were taken to document its location. An estimate of the high water mark was also taken to provide an estimate of the maximum water level.

At selected locations along the bathymetric survey, bottom types were characterized using a Ponar dredge. These descriptions were used to validate the collected acoustic data used for bottom typing.

Fish Presence/Absence

Backpack electrofishing was used to determine fish presence along shorelines in the west end of the lake in the vicinity of the proposed camp location. A minimum of 100 m of shoreline was fished at each site. Captured fish were identified to species, enumerated, measured for fork length, weighed, and returned to the lake alive near their captured location.

Chlorophyll *a*

Chlorophyll *a* measured in Ravn Camp Lake was low (1.1 µg/L in August 2010) indicating low primary productivity in the area.

5.4.1.2 Data Analysis

Analysis for the bathymetric and substrate survey data was conducted as described for Cockburn Lake in Section 5.1.1.2. Analysis of fish survey data was conducted as described for lake encroachments in Section 5.2.1.2.

5.4.2 Results

Ravn Camp Lake has a surface area of 1.9 km^2 and at the time of the 2010 survey had a maximum and mean depth of 50.0 m and 14.5 m, respectively (Figure 5.4-2). The lake volume was calculated to be 27.5 million m^3. The east basin, which includes both potential water withdrawal sites, is both the largest and the deepest. The lake substrate is dominated by sand and silt/clay/sand complexes with only isolated pockets of boulders, cobble, and sand in nearshore areas. No potential Arctic char spawning areas were identified. A bathymetric map is provided (Figure 5.4-2) and a substrate distribution map is presented in Figure 5.4-3.

5.5 MID-RAIL CAMP

Mid-Rail Camp (Figure 5.5-1) is located near the railway alignment, approximately 60 km from the Mine Site and 20 km south of the Ravn River Camp site (Figure 5-1). A number of field studies were in the Mid-Rail Camp Area between 2007 and 2010, including:

- collection of water quality samples and field data (2008 by Knight Piésold; and 2010 by North/South Consultants Inc.);
- determination of fish presence/absence and collection of fish habitat information (2008 and 2010);
- collection of lake bathymetry data from several lakes (2008 and 2010); and,
- determination of local drainage basins and surface water flow patterns (2010)

Several options are being considered in this area for disposal of sewage from the Mid-Rail and Ravn River camps. To support a decision process for disposal site selection the drainages around Mid-Rail Camp were surveyed with the following objectives:

- to identify the water flow in these drainages, i.e., to assess the ultimate fate of sewage effluent from potential treated sewage discharge sites in relation to Mid-Rail Camp Lake; and,
- to confirm whether these waterbodies support fish habitat.

The field program for this study component consisted of the following at potential effluent receiving lakes:

- collection of water quality, phytoplankton, and zooplankton samples;
- bathymetric surveys;
- a survey to identify fish presence/absence (i.e., to confirm fish presence); and,
- an assessment of fish habitat.

5.5.1 Methods

5.5.1.1 Field Methods

Chlorophyll *a* Sampling

Chlorophyll *a* samples were collected as a component of the water quality sampling program from Lake MRC-7. A detailed description of water quality sampling methods is provided in (Volume 7, Appendix 7B). In brief, water samples were collected 1 m from the water surface and 1 m from the sediments and submitted to Exova Laboratories, Ottawa, ON for analysis.

Bathymetry/Substrate Survey

Bathymetric surveys were conducted in a number of local lakes to identify suitable water withdrawal and sewage disposal options, and to help identify lakes with potential fish habitat. A coarse bathymetric survey of Mid-Rail Camp Lake was conducted by EBA Engineering Consultants Ltd. (EBA 2008) in 2008, based on the DFO protocol for assessing lakes intended for winter water withdrawals (DFO 2002). The survey, conducted on April 26, 2008, utilized a Ground Penetrating Radar (GPR) system.

A more detailed bathymetric survey of Mid-Rail Camp Lake was conducted in August, 2010. This survey was focused on the north bay in the vicinity of the proposed camp location. Survey techniques were similar to those described for the Ravn River Camp Lake survey, and the equipment used was as described in Section 5.1.1.1. Bathymetric data were collected along transects perpendicular to shore, spaced less than 100 m apart.

Detailed bathymetric data were collected on three smaller lakes to the south of Mid-Rail Camp Lake in 2008, using a Humminbird side-scanning depth sounder and a handheld Garmin GPS to record position. These lakes included MRC-3, MRC-4 and MRC-5 lakes (Figure 5.5-1). Additional bathymetric surveys were conducted on MRC-1and MRC-7 in 2010, using QTC equipment and survey methods described in Section 5.1.1.1.

At selected locations along the bathymetric survey where the QTC survey equipment was used, bottom types were characterized using a Ponar dredge. These descriptions were used to validate the collected acoustic data used for bottom typing.

Local survey control was unavailable at MRC-1and MRC-7 lakes in 2010; therefore, a temporary benchmark was established for determining relative water level elevations during the bathymetric survey. The temporary benchmark was the top surface of a boulder on shore. A line and level was then used to measure the water elevation to the boulder surface. This temporary benchmark was spray painted for future identification and a GPS location and photographs were taken to document its location. An estimate of the high water mark was also taken to provide an estimate of the maximum water level.

Fish Presence/Absence

A brief gillnetting survey was conducted on Mid-Rail Camp Lake on August 8, 2008. A single gillnet gang consisting of six 22.9 m long by 1.8 m deep twisted nylon or monofilament panels of 1.5, 2.0, 3.0, 3.75, 4.25, and 5.0 inch (38, 51, 76, 95, 108, and 127 mm, respectively) stretched mesh was set on the bottom and left in place for 1.5 hours to minimize fish mortality. A 4.3 m Zodiac MKII inflatable boat was used to set and retrieve the net.

Fish presence/absence in other lakes in the region was identified during opportunistic observational surveys conducted in conjunction with bathymetry surveys in 2008. All captured/observed fish were identified to species. Captured fish were measured for fork length (mm) and returned to the waterbody from which they were captured.

Backpack electrofishing was conducted on Mid-Rail Camp, MRC-1, and MRC-7 lakes in 2010. In Mid-Rail Camp Lake electrofishing was conducted along the north bay shoreline in the vicinity of the proposed camp location to determine fish utilization.

Hydrology

Waterbody connectivity and flow patterns were determined by aerial observations from a helicopter and by ground surveys at key locations. Water flow direction was noted from outlets of water bodies if evident. If flow between two adjacent waterbodies was not evident, the surface elevations for each lake were estimated using the helicopter's altimeter (i.e., the helicopter was landed at the waters edge), and direction of flow was determined accordingly.

5.5.1.2 Data Analysis

For the 2008 surveys the methods used to convert Humminbird depth data into a map were similar to QTC data analysis methods, but less detailed and did not require the use of QTC IMPACT software. Analysis for the bathymetric and substrate survey data collected in 2010 was conducted as described for Cockburn Lake in Section 5.1.1.2. Analysis of fish survey data was conducted as described for lake encroachments in Section 5.2.1.2.

5.5.2 Results

Bathymetry/Substrate Survey

Mid-Rail Camp (Figure 5.5-1) is located near the railway alignment, approximately 60 km from the Mine Site and 20 km south of the Ravn River Camp site (Figure 5-1). Mid-Rail Camp Lake has a surface area of 1.8 km^2 and a maximum and mean depth of 14.4 m and 4.2 m, respectively, for the portion of the lake that was surveyed in 2010 (Figure 5.5-2). The lake volume was estimated to be 7.6 million m^3.

Bathymetric maps for MRC-1, MRC-3, MRC-4, MRC-5 and MRC-7 are provided in Figures 5.5-3 through 5.5-7, respectively.

The Mid-Rail Camp area is relatively flat and local surface water flow patterns are complex and in places indefinite. The general flow pattern in the south is from MRC-5 to MRC-1. During the 2010

survey the surface elevations of Mid-Rail Camp Lake and MRC-1 were virtually identical and no flow between these lakes was detectable, although there was standing water in the short connection between the two lakes. It is anticipated that direction of flow may vary, depending on the relative elevation of both lakes at any given time. At times MRC-1 may flow into Mid-Rail Camp Lake, but general flow pattern appears to be to the west, eventually to Angajurjualuk Lake. Mid-Rail Camp Lake appears to have two potential outlets, south to MRC-1 and northeast to MRC-7.

Fish Presence/Absence

A total of four Arctic char ranging in size from 180-359 mm were captured in a gill net set in Mid-Rail Camp Lake in 2008. Juvenile Arctic char were observed in nearshore areas of this lake, but were generally absent from the shallow lakes to the south of Mid-Rail Camp Lake, several of which did however have ninespine stickleback. Intermittent connectivity and low water levels in these other lakes limit fish use to occasional rearing of small numbers of juveniles. Ninespine stickleback were also observed in MRC-7 to the northeast.

Chlorophyll *a*

Chlorophyll *a* measured in Lake MRC-7 was low (mean of a triplicate sample collected 1 m below the surface was 1.2 µg/L in August 2010) indicating low primary productivity in the area.

5.6 COCKBURN TUNNELS CAMP

The Cockburn Tunnels Camp is located on the east side of Cockburn Lake, approximately midway down the middle basin (Figure 5-1).

5.6.1 Methods

5.6.1.1 Field Methods

Bathymetry and substrate mapping surveys were conducted along the east shore of Cockburn Lake in 2007, including the area adjacent to the Cockburn Tunnels Camp and the proposed water withdrawal area (Figure 5.6-1; see Section 5.1.1.1 for survey methods). A single access road crossing (AR-037b; Figure 5.1-22) that lies within the camp's footprint was assessed in late August, 2010. Assessment equipment and methods are described in Section 5.1.1.1.

5.6.1.2 Data Analysis

Data analysis for information collected at this single access road site is described in Section 5.1.1.2.

5.6.2 Results

Bathymetry and substrate mapping surveys were conducted along the east shore of Cockburn Lake in 2007, including the area adjacent to the Cockburn Tunnels Camp and in the vicinity of the proposed water withdrawal (Appendix 5.1-4). A single access road crossing (AR-037b) that lies within the camp's footprint was assessed in late August, 2010. The stream crossed at AR-037b was dry when surveyed in August 2010 with a steep gradient separating the area near Tunnels Camp from Cockburn Lake downstream. This stream was, therefore, classified as No Fish Habitat.

5.7 COCKBURN SOUTH CAMP

The Cockburn South Camp is located on the east side of Cockburn Lake, near the south end of the lake and approximately 20 km from Steensby Inlet (Figure 5-1). A number of field studies were conducted in August, 2010, primarily to support decisions regarding the location of potential water withdrawal and sewage disposal facilities. These studies included:

- a detailed bathymetric survey of the south basin, with emphasis in the vicinity of the proposed camp location;
- an assessment of fish habitat in the vicinity of the proposed camp location; and
- a general assessment of fish spawning habitat in the south basin of Cockburn Lake.

Though not directly associated with the camp, two access road crossings within the camp footprint (AR-021 and AR-021a) were assessed (Figure 5.1-23); one in 2008 and one in 2010.

5.7.1 Methods

5.7.1.1 Field Methods

Equipment and methods used to assess access road crossings for aquatic habitat are described in Section 5.1.1.1.

Bathymetry/Substrate Survey

Bathymetry and substrate information was collected using the QTC sonar system (see Section 5.1.1.1 for detailed system setup and methods) in the southern basin of Cockburn Lake adjacent to the Cockburn Lake Camp location. Data were collected along transect lines generally spaced at intervals of 300 m or less. More detailed data (i.e., transects less than 100 m apart) were collected in the vicinity of the proposed camp location. Survey techniques were similar to those described for the Ravn River Camp Lake survey and the equipment used was as described in Section 5.1.1.1.

At selected locations along the bathymetric survey, bottom types were characterized using a Ponar dredge. These descriptions were used to validate the collected acoustic data used for bottom typing.

Local survey control was unavailable at Cockburn Lake; therefore, a temporary benchmark was established for determining relative water level elevations during the bathymetric survey as described for Ravn River Camp Lake (in Section 5.4.1.1). An estimate of the high water mark was also taken to provide an estimate of the maximum water level.

5.7.1.2 Data Analysis

Data analysis for information collected at the two access road sites in 2008 are described in Section 5.1.1.2. Analysis for the bathymetric and substrate survey data was conducted as described for Cockburn Lake in Section 5.1.1.2.

5.7.2 Results

A bathymetric map is provided (Appendix 5.1-4).Substrates in the south basin of Cockburn Lake are dominated by fines (i.e., sand, silt, and clay), with coarser rock substrates (i.e., boulder, cobble, gravel) generally confined to nearshore areas at depths less than 3 m. No potential Arctic char spawning areas were located in the vicinity of Cockburn South Camp, although nearshore habitats composed of boulder and cobble would provide cover and feeding habitat for juvenile Arctic char and possibly ninespine stickleback.

Though not directly associated with the camp, two access road crossings within the camp footprint (AR-021 and AR-021a) were assessed (Figure 5.1-23); one in 2008 and one in 2010. Habitat in the stream crossed by AR-021 is primarily low velocity riffle/pool with cobble substrate. It has been classified as Marginal char habitat with no evidence of use by ninespine stickleback. The stream at crossing AR-021a was dry when assessed in fall 2010 and is believed to provide No Fish Habitat.

6.0 STEENSBY PORT AREA: BASELINE STUDIES

The Steensby Port Area consists of numerous lakes and streams in small, coastal watersheds and various components of larger catchments such as the watersheds of the Cockburn and Ikpikitturjuaq rivers (Figure 6-1). Most of the fresh water in this region lies in areas of relatively low relief with permanent or intermittent outflows to the sea.

Aquatic biota and habitat baseline studies at the Steensby Port Area were largely conducted in 2008 and 2010 once the Project description was advanced, although limited work was also conducted in 2007. Studies included surveys to determine fish presence/absence and distribution, fish barriers, interconnectivity of waterbodies, and habitat assessments. Information on primary production (i.e., phytoplankton) was obtained in 2008 at selected lakes in conjunction with the water quality sampling program

In 2007, fish and fish habitat assessments were conducted at several isolated ponds on the offshore island and in streams in the vicinity of the initial location of the proposed airstrip and access road. More extensive fish and fish habitat surveys were conducted in 2008 and 2010 to include additional lakes and streams throughout the Steensby Port Area that could be affected by existing and proposed Project infrastructure and Project effects (e.g., dust deposition). The main objective of these surveys was to identify fish distribution in the study area. In addition, bathymetric surveys were conducted by EBA Engineering Consultants Ltd. in winter 2008 at four lakes in the Steensby Port Area (EBA Engineering Consultants Ltd. 2008). Bathymetric and substrate surveys were also conducted at lakes ST-353 and ST-352 in the vicinity of potential water intake locations during the open-water season in 2008.

Unlike for the Mine Area (Section 4.0) for which multiple trophic levels were studied, the emphasis of habitat surveys in the Steensby Port Area were on requirements specific to local fish populations. Therefore, habitat, as discussed in this section, refers exclusively to fish habitat.

6.1 METHODS

The following provides a description of methods used to describe aquatic habitat in streams in the Steensby Port Area from 2007-2010.

6.1.1 Fish Habitat

6.1.1.1 Field Methods

Methods for fish habitat assessment surveys were relatively consistent between years for Steensby Port Area waterbodies. In lakes and ponds, physical data collected included: estimated or, where

possible, actual maximum water depth; shoreline substrate composition; and *in situ* water quality parameters (additional water quality data were collected in 2008 and are discussed in Volume 7, Appendix 7B). Protocols for habitat assessments in the Steensby Port Area were based on protocols outlined in DFO and BCMOE (1989) and NSC (2006) and were similar to those applied for the Mine Area, Milne Port Area, and Milne Inlet Tote Road (see sections 4.0, 7.0, and 8.0, respectively). Physical stream data collected included: connectivity with overwintering lakes/marine habitat; channel gradient; water depths and velocities; bank characteristics; vegetation; channel morphology; substrate composition; *in situ* water quality measurements; and, identification and description of potential barriers to fish movements. Photographs were taken of representative habitat at each site.

In 2010, an initial desktop screening of potential sites in the Steensby Port Area was conducted to identify waterbodies that may provide fish habitat and were most likely to be affected by Project activities. Following identification of the area affected by existing and proposed Project infrastructure and potential Project effects (e.g., dust deposition), detailed air photographs were consulted to identify potential fish habitat. Waterbodies that provided no potential fish habitat were eliminated from further studies. Lakes and streams that appeared to offer at least some potential for habitat were then assessed using aerial and/or ground-based surveys by a field crew.

Subsequent to the desktop screening, aerial surveys of waterbodies in the Steensby Port Area were conducted in 2010 to assist with identification of waterbody connectivity, fish barriers, and assessment of potential fish presence. Determinations of typical fish and non fish-bearing habitats established for the Steensby Port and Mary River Mine study areas in previous years assisted with the efficiency and accuracy of desktop and aerial surveys in 2010.

EBA Engineering Consultants Ltd. (2008) conducted bathymetry surveys in lakes ST-028, ST-029, ST-092, and ST-353 during winter 2008 (Figure 6-1). Detailed survey methods are described in EBA Engineering Consultants Ltd. (2008). Generally, surveys were conducted with a Ground Penetrating Radar (GPR) system (Geophysical Survey Systems Inc. SIR-8 radar with 120 MHz antenna) linked to a Trimble Ag132 GPS system for real-time positioning. An ice thickness of 2.0 m was assumed for all lakes.

Bathymetry conducted on lakes ST-353 and ST-352 during the open-water season in 2008 used a side-scanning sonar and GPS. Methods and equipment were similar to those employed in the Milne Inlet Tote Road, Mine, and Railway/Access Road areas.

Lake primary productivity was measured through analysis of chlorophyll *a* at 12 Steensby Port Area lakes where water quality sampling was conducted. Ten lakes were sampled twice during the open-

water season of 2008 (i.e., summer and fall); two additional lakes were sampled on one occasion (one in summer and one in fall). Sampling sites are indicated in Figure 6-2.

Generally, samples of water for chlorophyll *a* analysis were collected 1 m from the surface and 1 m from the sediments. However, for logistical reasons samples were collected from shore at four of the lakes (ST81, ST88, ST92, and ST-353 lakes) and only near surface grab samples were collected. All samples were shipped to Exova Laboratories, Ottawa, ON for analysis.

6.1.1.2 Data Analysis

Fish habitat data collected during pond, lake, and stream assessments were summarized and tabulated on standardized data sheets (Appendix 6-1) and the quality of available habitat relative to fish was determined for each waterbody. Bathymetry data were analysed and converted into maps.

6.1.2 Fish Populations

6.1.2.1 Field Methods

Several fish collection methods were employed to determine fish presence in Steensby Port Area streams and lakes from 2007 to 2010, including: observational surveys; backpack electrofishing; angling; and, gillnetting (Figure 6-3).

Observational Surveys and Backpack Electrofishing

Shallow areas of streams and lakes were visually inspected for fish movement in all study years. The number (approximated if large numbers present) and species of fish observed were recorded. Backpack electrofishing was conducted from 2007 to 2010 with a Smith-Root Model 11A or Model LR-24 backpack electrofisher. Voltage and frequency were typically set at 500V and 30 Hz; however, adjustments were frequently necessary in the Steensby Port Area due to highly variable water chemistry between sites. Fished sections of streams and lakes measured approximately 100 m.

All captured fish were measured for fork length (± 1 mm) using a ruler and, where possible, a sub-sample was measured for weight (±1 g) with a digital scale. Fish were released back into the waterbody from which they were captured at the completion of sampling.

Experimental Gillnetting and Angling

Experimental gillnet gangs were used to sample fish in a subsample of lakes within the Steensby Port Area in 2008. Gillnet gangs used in summer consisted of four 22.9 m long by 1.8 m deep twisted nylon panels of 2.0, 3.0, 3.75 and 4.25 inch (51, 76, 95 and 108 mm, respectively) stretched mesh. Nets were set on the bottom and left in place for short periods of time (less than 4 hours) to

minimize fish mortality. A 4.3 m long Zodiac MKII inflatable boat was used to set and retrieve the nets. Angling was conducted opportunistically in lakes within the area during summer, 2008.

All Arctic char captured during gillnetting and angling surveys were enumerated and measured for fork length (± 1 mm) and round weight (± 25 g). Live fish in good condition were released back into the water. Mortalities and fish in poor condition were retained and examined internally to determine sex and state of sexual maturity (i.e., had never spawned, pre-spawning condition, post-spawning condition) and stomach contents.

6.1.2.2 Data Analysis

Catch composition and catch-per-unit-effort (CPUE; #fish/minute) were calculated for electrofishing surveys. For gillnetting, CPUE was standardized for each net set as the number of fish caught in 100 m of net in 24 hours (# fish/100 m/24 hrs).

6.2 RESULTS

The following provides an overview of fish habitat and fish distribution and habitat use for the Steensby Port Area as a whole. Detailed information with respect to stream crossings and lake encroachment sites along the railway and access road are described in Section 5.0.

6.2.1 Fish Habitat

Detailed fish habitat assessments for Steensby Port Area waterbodies are presented in Appendix 6-1 and a summary of key characteristics is provided in Tables 6-1 and 6-2. Generally, the majority of available fish habitat in the Steensby Port Area is lacustrine (Figure 6-1). There are relatively few large streams (Figure 6-1), in particular those with a predominance of cobble/riffle habitat, relative to the Mine Area (see Section 4.0). Most of the available fish habitat in the surveyed area can be found in catchments ST-02, 04, 05, and 06 (Figures 6-1 and 6-4). Lake ST-22 was discovered to be a probable tidal pool (based on *in situ* water chemistry results) and is, therefore, not considered freshwater habitat.

Nearshore substrates in a large number of the lakes in the surveyed area, particularly those found in catchments ST-01, ST-05, and ST-14 to ST-27, are predominantly gravel or smaller in size (Table 6-1). The number of lakes with significant proportions of cobble or larger substrates is contrastingly smaller. Most catchments on the mainland have at least one lake with apparently sufficient depth to provide overwintering habitat for both species (Table 6-2). However, none of the freshwater waterbodies on the proposed port facility island (i.e., catchments ST-23 to 27) have sufficient depth to provide overwintering habitat (Table 6-2) and lack connections to any freshwater areas with such potential. Therefore, freshwater waterbodies on Steensby Island do not provide suitable fish habitat.

A large proportion of surveyed streams were identified as not having fish habitat based on a lack of sufficient flows and/or connectivity with probable overwintering locations. Of the remaining streams with suitable fish habitat, most are characterized by mainly fine substrates. Barriers are present throughout most catchments, but are more common in smaller drainages along the coast (Table 6-1, Figure 6-4). Barriers to fish movement in the area typically consist of steep gradients and/or areas with little to no surface water (Table 6-1). The distribution of these barriers and the presence of a large number of streams with limited flow, suggest that fish movements between lakes may be somewhat limited, particularly for Arctic char, in many of the catchments. In addition, there appears to be a general lack of connectivity with the marine environment (i.e., barriers to movement or insufficient flows/water levels in streams flowing into Milne Inlet) in surveyed catchments within the Steensby Port Area. In contrast, some nearby catchments within the Rail Route Area do include habitat with significant marine connections (e.g. Cockburn River).

Results of bathymetry surveys conducted during winter 2008 can be found in EBA Engineering Consultants Ltd. (2008). Bathymetry data collected on lakes ST-353 and ST-352 are presented in Figures 6-5 and 6-6. Ten km Lake has maximum and mean depths of over 50 and 20 m, respectively (Figure 6-5). Nearshore habitat in this section of ST-352 transitions from 100% cobble/boulder in the southwest to primarily sand in the southeast. Habitat in offshore regions (> 4-5 m depth) of the south end of ST-352 is almost exclusively sand.

Maximum and mean depths for the surveyed (western half) region of ST-353 are approximately 25 and 12 m, respectively (Figure 6-6). Depths rapidly increase with distance from shore. Nearshore habitat in the vicinity of a potential water intake on this lake (i.e., the western shore) is an approximately equal mixture of sand and cobble/boulder.

In general, chlorophyll *a* concentrations in lakes in the Steensby Port Area were low, but varied between lakes (Table 6-3). Typically, open-water season chlorophyll *a* ranged from <0.2 µg/L to 5.5 µg/L at the surface, and from <0.2 µg/L to 4.2 µg/L near the bottom. Excluding one anomalous result, lakes ST-024, ST-081, ST-088, and ST-195 had the lowest primary productivity and lakes ST-028 and ST-006 had the highest primary productivity. Chlorophyll *a* was generally higher in fall than summer, as observed at the Mine Area lakes. Conversely, the available data suggest that at least some Steensby Port Area lakes are somewhat more productive than lakes in the Mine Area. Based on generic trophic level categorization criteria using chlorophyll *a*, Steensby Port Area lakes range from ultra-oligotrophic to borderline oligotrophic/mesotrophic. As discussed in Section 4.2.1.2, the range of chlorophyll *a* concentrations in Steensby Port lakes, while somewhat higher than Mine Area lakes, are within the general ranges reported for other Artic lakes.

6.2.2 Fish Populations

Arctic char and ninespine stickleback were captured/observed throughout the Steensby Port Area (Table 6-4, Figure 6-4). However, ninespine stickleback were more widespread and abundant in many catchments. Both species were captured or observed more commonly in lakes than in streams in most watersheds. However, fish were absent from surveyed waterbodies in four small (≤ 0.30 km^2), coastal, mainland catchments (ST-14, 17, 20, and 22) and from small, freshwater catchments (ST-23 to 27) on the proposed port facility island (Table 6-4, Figure 6-4). Consequently, waterbodies in these catchments were designated as Not Fish-bearing for both species (Table 6-5). Some of these waterbodies (e.g., Lake ST-007 in catchment ST-17) appear to provide suitable habitat for spawning, overwintering, and rearing for one or both species, but fish are not present (Appendix 6-1).

Three additional coastal watersheds (ST-03, 18, and 19) support populations of ninespine stickleback, but not char (Table 6-4). These catchments range in size from approximately 0.4 to 1.0 km^2 (Figure 6-4). Several waterbodies in these three catchments are classified as important for ninespine stickleback, providing suitable habitat for spawning, overwintering, and rearing (Table 6-5). Ninespine stickleback were also more abundant and widespread than Arctic char in catchments ST-02 and 05 (Table 6-4), two of the largest watersheds in the surveyed area. However, important habitat for all life history stages of both species was common in these regions (Table 6-5), suggesting they are relatively important for the overall fish populations of the Steensby Port Area in general.

Only catchments ST-01 and, in particular, ST-04 produced greater catches/observations of Arctic char than ninespine stickleback within the surveyed area (Table 6-4, Figure 6-4). Despite a large number of potential fish-bearing waterbodies in catchment ST-11, both species were confirmed from only one lake and one stream each (Table 6-4). Barriers and a lack of sufficient flow in most streams likely contribute to the abbreviated distribution within this watershed.

The broader distribution of ninespine stickleback relative to Arctic char in many Steensby watersheds can probably be attributed to the predominance of fine substrates, low flow/lack of connectivity, and, in some areas, low DO levels. Many of these areas are suitable for multiple life history stages of ninespine stickleback, but limit movements and survival of Arctic char, which prefer larger substrate sizes (see Section 4.0). The general lack of connectivity to the marine environment in the surveyed catchments of the Steensby Port Area suggests there are likely no local anadromous populations of Arctic char outside of the Ikpikitturjuaq River system. In contrast, anadromous populations are likely present in nearby catchments (e.g., Cockburn River) within the Railway/Access Road Area (Section 5.0).

Although dietary information was not collected from fish captured in the Steensby Port Area, Arctic char likely consume similar prey items as in the Mine Area (Section 4.0). Midges (Chironomidae) are likely the main prey item, but the increased abundance and availability of ninespine stickleback may result in an increased proportion of this species in the diet.

Habitat in the vicinity of a potential water intake and dock on Lake ST-352 is not ideal for Arctic char spawning. Fine substrate sizes are increasingly abundant at depths over which spawning is likely to occur (3-10 m) with larger, more suitable substrates (i.e., cobbles) uncommon at these depths. With depths rapidly increasing from shore and a uniform distribution of larger substrates, suitable spawning habitat appears to be abundant in ST-353. It is unknown if Arctic char spawn in the vicinity of this potential water intake or in similar regions in other parts of the lake, but the possibility exists.

Waterbodies which could potentially be affected by the construction of a proposed airstrip are primarily in catchment ST-11 and include lakes ST-080 and 081 and streams SPS-011h and 011j (Figure 6-4). In addition, the associated access road from camp would likely cross streams SPS-019, 024, and 029. None of the waterbodies within the proposed airstrip footprint were identified as Arctic char habitat (Table 6-5, Figure 6-4). Ninespine stickleback were not captured in ST-081, despite the availability of suitable habitat. Streams SPS-019 and 029 provide suitable rearing habitat for Arctic char from upstream lakes within their respective catchments and are considered important fish habitat (Table 6-5, Figure 6-4, Appendix 6-1).

7.0 MILNE PORT AREA: BASELINE STUDIES

The Milne Port Area includes a major coastal watershed (Phillips Creek), several small coastal streams that drain directly into Milne Inlet, small and shallow headwater ponds near the coast, and deeper headwater lakes in the highlands to the southeast (Figure 1.1-4). Most of the freshwater streams in this region provide drainage for mountainous terrain to the east and west of Phillips Creek. Coastal areas within the footprint of existing and proposed port infrastructure are of relatively low relief with most streams having direct connections to Milne Inlet.

Existing facilities at the Milne Port Site were constructed in 2007-2008 to support the shipping of a bulk sample of iron ore from the Mine Area (see Section 8.0 for a description of the Bulk Sample Program and Milne Inlet Tote Road) and for sea lift shipments of supplies. Streams in the area crossed by the Milne Inlet Tote Road were assessed for fish and fish habitat during construction and monitoring phases of the Bulk Sample Program from 2006-2010 (see Section 8.0 for more details regarding methods and results). The current Project includes proposed expansion of port facilities to support year round trucking of ore from the Mine Area and subsequent loading to ships during the open-water season.

Additional aquatic baseline studies were conducted in 2010 to supplement data collected during Milne Inlet Tote Road studies (Section 8.0) and support potential expansion of Milne Port Area infrastructure and operations. Baseline studies focused primarily on aquatic habitat and fish presence/absence in streams and lakes throughout the region. The emphasis of habitat surveys in the Milne Port Area were on requirements specific to local fish populations. Therefore, habitat, as discussed in this section, refers exclusively to fish habitat.

7.1 METHODS

The following provides a description of methods used to describe aquatic habitat in streams in the Milne Port Area in 2010.

7.1.1 Fish Habitat

7.1.1.1 Field Methods

A total of 18 lake and 33 stream sites within the Milne Port Area were targeted for assessments of habitat and fish presence/absence in 2010 (Figure 1.1-4). The main objective of the 2010 survey was to establish fish distribution (or absence) and provide supporting aquatic habitat information for the general area surrounding the Milne Port Area. All waterbodies were initially surveyed aerially by helicopter during summer 2010 to determine connectivity with Milne Inlet and/or headwater lakes that may provide overwintering habitat. Streams were flown from their outflow into Milne Inlet

upstream to potential overwintering lakes and all barriers identified were recorded with a hand-held GPS.

Sites identified as potentially fish-bearing from the aerial surveys were then assessed on the ground during summer 2010 for detailed habitat characteristics. Protocols for habitat assessments in the Milne Port Area were based on protocols outlined in DFO and BCMOE (1989) and NSC (2006) and were similar to those applied for the Mine Area, Steensby Port Area, and Milne Inlet Tote Road (see sections 4.0, 6.0, and 8.0, respectively) including assessment of substrate composition, stream morphology, velocities, and depths (where applicable), and measurement of basic *in situ* water quality. Representative photographs were taken of available habitat.

In addition, chlorophyll *a* was measured from six waterbodies in the area in August 2010 as a component of the water quality sampling program. Samples were collected as near surface grabs and submitted to Exova Laboratories, Ottawa, ON for analysis. Chlorophyll *a* is used as an indicator of phytoplankton biomass.

Primary production was measured at selected sites through analysis of chlorophyll *a*. Samples of surface water were collected from six sites (Figure 7-1) in August 2010 in conjunction with water quality sampling and submitted to Exova Laboratories, Ottawa for analysis.

7.1.1.2 Data Analysis

Fish habitat data collected during Tote Road surveys were summarized and tabulated on standardized data sheets (Appendix 7-1) and the quality of available habitat relative to fish was determined for each waterbody. All sites were sorted by fish use (presence/absence) and suitability (preferred substrate composition, stream gradient, level of accessibility) of available habitat into the following categories:

- Not fish-bearing (i.e., no fish habitat);
- Marginal (limited fish use); and,
- Important (significant use by one or more life history stages of fish).

7.1.2 Fish Populations

7.1.2.1 Field Methods

Fish presence/absence in streams and lakes surveyed for detailed habitat characteristics in 2010 was determined through visual observation, backpack electrofishing and, in Phillips Creek, hoopnetting (Figure 7-2). A single pass of approximately 50-100 m with a Smith-Root Model LR-24 backpack

electrofisher was conducted in each stream or nearshore lacustrine habitat. To identify potential use of Phillips Creek by spawning anadromous Arctic char, two hoop nets were set at the same location near the confluence with Milne Inlet oriented to catch fish moving upstream in late August, 2010. The hoop nets were constructed of 6.45 cm^2 nylon mesh, with openings measuring 1.2 m in diameter and wings of variable length. Hoop nets were checked one to two times daily from 25-31 August, 2010. All sampled fish were measured for fork length (mm) using a ruler and subsequently released into the area from which they were captured.

7.1.2.2 Data Analysis

Catch-per-unit-effort (CPUE) was calculated for each site where fish were captured and recorded as the number of fish captured per minute of electrofishing or the number of fish caught per day in each hoop net. Mean length of Arctic char was calculated by waterbody and gear type.

7.2 RESULTS

7.2.1 Fish Habitat

Detailed habitat assessment data are provided in Appendix 7-1. The majority of streams in the Milne Port Area were eliminated as potential fish-bearing streams because aerial surveys showed they had no flow, no existing connections to potential upstream or downstream overwintering habitat (i.e., no access to fish coming from overwintering lakes/marine habitat), and/or were located on steep slopes (Figure 7-3). Additional ground surveys were not conducted at these sites.

The headwater lakes (ML-015, ML-016, ML-018, ML-019, ML-020) for the two main coastal streams (M11-1, M13-1) east of Phillips Creek are located at relatively high elevation to the south of the Port Site (Figure 7-3). The nearshore areas of most of these lakes largely comprise fines with overlying cobble and gravel (Appendix 7-1). Depths in ML-015, ML-016, 0ML-18, and ML-020 are likely suitable for overwintering and ML-019 is connected to ML-018.

Of the coastal streams to the east of Phillips Creek, only M11-1, M13-1, and M18-1 have sufficient water depths and flows to provide a persistent connection with Milne Inlet. However, ML-18-1 is not connected to a headwater lake and there are significant barriers (falls 50 m or more in height) between the coastal reaches of M11-1 and M13-1 and upstream headwater/overwintering lakes (Figure 7-3). A lack of access to upstream overwintering areas suggests that fish use of the coastal reaches of these streams is limited to fish moving upstream from Milne Inlet. All remaining watercourses in the coastal area are small, isolated, spring runoff streams that drain snowmelt from the highlands to the south and provide no fish habitat (Table 7-1, Figures 1.1-4 and 7-3). Habitat in

these coastal streams consists primarily of cobble/gravel substrate and riffle morphology with relatively shallow depths and low to moderate velocities (Appendix 7-1).

Waterbodies ML-01 to ML-13 are shallow ponds with substrates consisting almost exclusively of fines that are only intermittently connected to other watercourses, and provide no overwintering habitat (Table 7-1, Appendix 7-1). These ponds likely do not provide suitable fish habitat even during periods of peak flow (Table 7-1).

Phillips Creek (M03-1) is a large river that drains into Milne Inlet. Upper reaches of the river, in particular the run-of-the-river lakes, are known to be used extensively by Arctic char (see the discussion for the Milne Inlet Tote Road; Section 8.0). However, there are impassable falls approximately 15 km upstream from Milne Inlet and only minimal potential for overwintering or spawning in this lower reach downstream of the falls. Depths throughout most of the reach downstream of the falls are shallow (< 2.0 m), likely freezing solid during winter. Therefore, fish use of the lower 15 km is likely primarily restricted to short term excursions by anadromous Arctic char that eventually return to other river systems to overwinter. Habitat in the lower reach is dominated by gravel/cobble substrate and run morphology (Appendix 7-1). Small tributaries of the lower reach of Phillips Creek (e.g., M03-3) typically provide similar substrates, but insufficient flows for fish use. Some may have sufficient flows in early spring to allow intermittent use.

Of the streams surveyed to the west of Phillips Creek, only M02-1 has the potential to provide fish habitat (Table 7-1, Appendix 7-1), although an impassable waterfall between the coastal reach and a potential headwater overwintering lake precludes migrations between the lake and Milne Inlet. Potential habitat below the barrier is similar to that found in Phillips Creek and the large streams to the east.

Productivity (as indicated by chlorophyll *a*) within lakes in the Milne Port Area was low. Chlorophyll *a* concentrations ranged from <0.2 µg/L to 4.0 µg/L at sites sampled in August 2010 (Figure 7-1).

7.2.2 Fish Populations

Despite the availability of suitable habitat in all headwater lakes in the Milne Inlet Port Area, fish were captured in only the largest lake, ML-20 (Table 7-2). Juvenile Arctic char were abundant in nearshore areas of ML-20, suggesting this lake provides important habitat (Tables 7-1 and 7-2). Although ninespine stickleback were not captured, their presence in the lake cannot be definitively ruled out.

Small numbers of Arctic char were captured in the coastal reaches of M13-1 and M18-1 (Table 7-2). The colouration of these fish (silvery) is different from those captured in streams along the Milne Inlet Tote Road, Phillips Creek upstream of the falls, and the waterbodies in the vicinity of the Mine Area (bronze, brown, or reddish), which support known or probable land-locked populations. The colouration, combined with a lack of access to upstream overwintering sites suggests the char in the coastal reaches are entering the streams from Milne Inlet. There are other large streams flowing into Milne Inlet further to the east and on the north shore (e.g., Tugaat and Robertson rivers), that likely support anadromous populations of Arctic char. Although fish were not captured in M11-1 (Table 7-2), it is accessible from Milne Inlet and may, therefore, experience intermittent use by anadromous Arctic char. M13-1 has the greatest potential of these streams to support fish, but all three were classified as Marginal habitat (Table 7-1).

All other coastal waterbodies east of Phillips Creek and its tributaries were identified as non fish-bearing based on available habitat and/or fish community surveys (Tables 7-1 and 7-2). Although fish were not captured in Phillips Creek (i.e., M03-1) through electrofishing and hoopnetting (Table 7-2), or its tributaries (M03-2 and M03-3), and overwintering potential downstream of the falls may be limited, the presence of fish in nearby coastal drainages suggests that anadromous char use, for at least foraging purposes, is probable. Quotas for anadromous Arctic char were set in Phillips Creek on two occasions in the 1970s (Yaremchuk et al. 1989), but fish were never harvested, which further suggests a limited use of this river by anadromous adults. Similarly, fish use of M02-1 is probable based on its connection with Milne Inlet despite the lack of fish captures in the 2010 survey (Table 7-2). Phillips Creek, due primarily to its size and the potential for more extensive use by anadromous Arctic char, was classified as Important Arctic char habitat while the other potentially fish-bearing streams to the west were classified as Marginal habitat.

Ninespine stickleback were not captured or observed in any of the coastal drainages from the Milne Port Area and may not be present. A single ninespine stickleback was captured in a small stream in the Robertson River catchment flowing into Koluktoo Bay to the north of the Milne Port Area (Stewart and MacDonald 1981) indicating that this species, though apparently uncommon, is at least present in neighbouring drainages of Milne Inlet.

8.0 MILNE INLET TOTE ROAD AREA: BASELINE STUDIES

As a component of advanced exploration at the Project site, BIM proposed baseline environmental and monitoring studies concerning the completion of a Bulk Sampling Program. The purpose of the Bulk Sampling Program, which was completed in 2007-2008, was to confirm the quality and marketability of the Mary River iron ore. As part of the Bulk Sampling Program initiative, upgrades to the original Milne Inlet Tote Road (Tote Road) were necessary to facilitate the transport of the ore to the coast at Milne Inlet, where the iron ore was transported via sealift to Europe for testing.

The Tote Road, which was first established in the 1960s, runs approximately 105 km from the Mine Area near Mary River to Milne Inlet (Figure 8-1). It was designated as a public use road during the Nunavut Land Claims Agreement process and is defined as such in the North Baffin Land Use Plan. The completed road upgrades included adjustments to the road alignment to facilitate haul road travel, roadbed improvements, road widening and installation of drainage crossings along the route. Most of the existing drainage crossings from the 1960s were in very poor condition; many were built with makeshift fuel barrel culverts which had collapsed or had been washed out. The Tote Road upgrades were designed to enhance the flow conditions of the waterways, reduce potential erosion related effects and improve the opportunity for fish to access approximately 53,000 m^2 of mainly upstream habitat. A more detailed description of the Bulk Sampling Program can be found in annual reports submitted to DFO and the NNLP (Knight Piésold 2006, 2008, Baffinland Iron Mines Corporation 2009). As part of the NNLP, potential habitat compensation sites were identified as mitigation for HADD sites. Habitat compensation works are described in detail in Knight Piésold (2006, 2008) and Baffinland Iron Mines Corporation (2009).

Monitoring studies were conducted following completion of road upgrades and the Bulk Sampling Program to enhance and compare with information collected during baseline studies conducted in 2006 and from 2008 to 2010. Monitoring studies were also designed to identify potential issues that may arise during the upgrading and maintenance phases of the Tote Road and to determine the effectiveness of habitat compensation works. The purposes of Tote Road environmental baseline studies were to identify and describe fish habitat in watercourses crossed by the Tote Road and determine the extent of fish use of available habitat.

8.1 METHODS

The following provides a description of methods used to describe aquatic habitat in streams in the Milne Port Area in 2010.

8.1.1 Fish Habitat

8.1.1.1 Field Methods

Engineering field investigations of all watercourse crossings were conducted by Knight Piésold Ltd. in spring 2006, including both aerial and ground inspections, prior to construction of the Tote Road upgrades. Aerial reviews involved mapping and photographic documentation of the sites. Ground inspections involved hydrological surveys for the purposes of sizing watercourse crossings. From these data, crossing streams were grouped by catchment area, geometry, and estimated peak flows into the following categories:

- Extra-small (XS): < 0.5 km^2 catchment;
- Small (S): 0.5-2.5 km^2 catchment;
- Medium (M): 2.5-7.5 km^2 catchment;
- Large (L): 7.5-30.0 km^2 catchment; and
- Extra-large (XL): > 30.0 km^2 catchment.

Following initial watercourse classification, a representative subsample of streams was selected for detailed fish and fish habitat investigations that were conducted in summer 2006. Fish habitat was surveyed for key characteristics such as wetted and high-water widths, water depths and velocities, channel gradient, riparian and aquatic vegetation, stream cover, stream morphology, and substrate composition. Protocols for habitat assessments along the Milne Inlet Tote Road were based on protocols outlined in DFO and BCMOE (1989) and NSC (2006). Photographs were taken facing upstream, downstream, and across the streams at each assessment site from consistent locations and angles to document available habitat and for comparison during the subsequent monitoring period.

The remaining crossings were assessed remotely using aerial and ground-based photographs, topographic maps, and comparative information collected from the representative subsample sites.

Habitat compensation sites were selected based on data collected during the 2006 field and remote studies. In addition, two lakes (at km 27 and 32 along the Tote Road) were surveyed for bathymetry in summer 2007 as potential water sources for construction and/or long-term camps at the Milne Port Area and along the Tote Road. A 4.3 m Zodiac MKII inflatable boat was used to follow straight-line transects in a zig-zag pattern across the lakes. Transects were at approximately 45 to 90˚ angles to each other. Approximately every 20-30 m along each transect, geographic location was recorded using a hand-held global positioning system and depth was measured using a Humminbird Piranha MAX15 depth sounder. These lakes were revisited in summer 2010 during the monitoring phase of

the program to assess shoreline habitat along the road and determine fish presence with observational surveys.

Subsequent habitat surveys from 2008-2010 were designed to monitor the Tote Road during the post-construction (i.e., operation) phase at a variety of water levels. During this period, all potentially fish-bearing streams were surveyed at least once, including several that were only assessed remotely during 2006. Fish habitat quality during the monitoring period was assessed using the same key characteristics identified during 2006 surveys with the additional measurement of some *in situ* water quality parameters. All crossings subject to an Authorization under the *Fisheries Act* and the *Navigable Waters Act* (Figure 8-2), were surveyed at least once over the course of habitat investigations from 2006-2010. A detailed description of habitat monitoring methods is provided in Section 4.1.

In order to minimize and mitigate the potential impact that changes to existing drainage crossings or the creation of new crossings have on fish and fish habitat, Baffinland developed a Bulk Sampling NNLP. The NNLP document identified 25 sites where habitat alteration, disruption, or destruction would occur (HADD; 8 medium, 13 large, 4 extra-large crossing) as a result of the upgrade. A *Fisheries Act* Authorization (NU-06-0084, dated August 3, 2007) was issued for these 25 locations.

8.1.1.2 Data Analysis

Fish habitat data collected during Tote Road surveys were summarized and tabulated on standardized data sheets (Appendix 8-1) and the quality of available habitat relative to fish was determined for each waterbody. All sites were sorted by fish use (presence/absence) and suitability (preferred substrate composition, stream gradient, level of accessibility) of available habitat into the following categories:

- Not fish-bearing (i.e., no fish habitat);
- Marginal (limited fish use); and
- Important (significant use by one or more life history stages of fish).

8.1.2 Fish Populations

8.1.2.1 Field Methods

Fish presence/absence in 2006 was assessed by visual observation and use of minnow traps and backpack electrofishing. Assessments conducted during 2008-2010 included observational and electrofishing surveys of fish use with an emphasis on monitoring fish passage through upgraded road crossing structures and use of upstream habitat.

Minnow traps used during the 2006 study were 41.9 cm (16.5 inches) long, 22.9 cm (9 inches) at their widest diameter, and were constructed of 6.4 mm (0.25 inch) metal mesh. Openings of approximately 2 cm diameter were located at each end of the trap. Traps were baited and typically set close to shore at depths from 0.3-1.0 m with the openings facing the direction of current, and left in place for several days.

Backpack electrofishing along the Tote Road was conducted with a Smith-Root Model 11A or Model LR-24 backpack electrofisher. Voltage and frequency were typically set at 500V and 30 Hz; however, adjustments were sometimes necessary depending on differences in conductivity between streams. Fished sections of streams measured approximately 100 m with the distance split to 50 m upstream and 50 m downstream of road crossings during the monitoring phase to confirm fish passage. Date, time of day, and UTM coordinates at the upstream and downstream end of each survey reach were recorded.

All captured fish were measured for fork length (± 1 mm) using a ruler and a subsample was measured for weight (± 1.0 g). Mean fork lengths were calculated by reach, stream, and sampling period. Fish were released back into the reach (upstream or downstream) from which they were captured at the completion of sampling.

8.1.2.2 Data Analysis

The catch-per-unit-effort (CPUE) was calculated for Tote Road electrofishing and minnow trap catches during each sampling period. Electrofishing CPUE was measured as the number of fish captured per minute of electrofishing. Minnow trap CPUE was calculated as the number of fish captured per hour per trap.

8.2 RESULTS

8.2.1 Fish Habitat

Surveys from 2006-2010 identified a total of 248 watercourse crossings along the Milne Inlet Tote Road (Table 8-1, Figure 8-1). There were 5 extra-large, 13 large, 13 medium, 43 small, and 174 extra-small crossings. Detailed habitat assessments conducted at selected crossings are provided in Appendix 8-1. Summaries of key habitat characteristics important for identifying and quantifying fish use are presented in Tables 8-2 and 8-3. Crossings subject to an Authorization under the Fisheries Act and the Navigable Waters Act are illustrated in Figure 8-2. Although 25 crossings were initially identified as HADD sites in the Bulk Sampling NNLP, additional surveys from 2008-2010 determined that two (CV-048 and CV-94) and possibly a third (CV-040) crossing are not fish-bearing due to the presence of downstream barriers. Habitat types prevalent along the Tote Road can

be broadly classified into several zones according to general locations along the road. These general locations are discussed below.

Streams within the first km of the Tote Road (running from Milne Inlet to the Mine Area) were removed as potential crossing sites when the location of the Milne Port Area infrastructure was moved (Figure 8-3a). Two sites (CV-183 and CV-181) were subsequently examined for potential habitat compensation and will be discussed in more detail in Section 8.2.3. Streams in this area vary in size from extra-small to extra-large and drain directly into Milne Inlet (Table 8-1). There is a lack of connectivity with upstream headwater lakes (i.e., potential overwintering locations) for all streams in this area due to the presence of natural fish barriers (i.e., not related to construction; Table 8-2). Streams in this region are characterized by gravel, sand, and cobble substrates, predominantly riffle habitat and water velocities less than 1.5 m/s (Tables 8-2 and 8-3). These streams were no longer considered as potential upgraded crossing sites when the location of the Bulk Sampling Program infrastructure at Milne Inlet was moved.

Watercourses between km 1 and km 15 along the Tote Road (CV-179 to CV-130) are small or extra-small streams (Table 8-1, Figures 8-3a and 8-3b) that primarily transport run-off from the highlands to the east downstream to Phillips Creek. These streams are characterized mainly by cobble substrate, riffle/cascade morphology, low to moderate water velocities and shallow depths (Tables 8-2 and 8-3). Many of these streams do not have persistent flows throughout the open-water season and have steep gradients that act as potential barriers to fish movements.

Crossings between km 15 and km 50 along the Tote Road (CV-129 to CV-080) range from extra-small to extra-large, most of which are in relatively close proximity to Phillips Creek (Table 8-1, Figures 8-3b to 8-3f) and drain flatter terrain than those along the previous 14 km of the road alignment. As a result, smaller substrate sizes (e.g., gravel) are more prevalent, stream morphology is characterized by a greater abundance of riffle/pool habitat, and natural water velocities are typically less than 1.0 m/s (Tables 8-2 and 8-3). There are fewer barriers to fish movements and barrier types are more variable in this area. Falls and steep gradients occur in some drainages, but others are simply disconnected from Phillips Creek due to insufficient flows.

Lakes at km 27 and km 32 are part of the Phillips Creek system. The lake at km 27 ("km 27 Lake") is characterized by mean and maximum depths of approximately 20 and 59 m, respectively (Figures 8-4a and 8-4b). The lake at km 32 ("km 32 Lake") is larger in terms of surface area and depth/volume; the maximum depth is greater than 100 m (Figures 8-4a and 8-4b). Substrates along the eastern shorelines of km 27 and km 32 lakes are dominated by cobble and gravel, respectively.

Watercourses crossed between km 50 and km 61 (CV-079 to CV-057) are primarily meandering, highly braided streams with large floodplains that eventually flow into Phillips Creek (Table 8-1, Figures 8-3f to 8-3h). The extra-small streams are typically dry throughout most of the year, but many of the small and larger-sized streams provide, at a minimum, seasonal fish habitat. Cobble is still present in most watercourses in this road section, but sand and gravel compose a greater proportion of the available substrate relative to other areas along the Tote Road (Table 8-2). Although natural water velocities in these streams are typically low (i.e., < 0.50 m/s) throughout most of the year (Table 8-3), snow melt and significant rain events can greatly and rapidly increase flows and discharges.

The zone between km 61 and km 75 (CV-056 to CV-033) is part of the upper Ravn River catchment and consists of highland terrain with relatively few watercourse crossings (Table 8-1, Figures 8-3h to 8-3j). The majority of crossings in this area are extra-small spring run-off drainages that are dry most of the year. The remainder provide primarily shallow, cobble/riffle habitat with typically moderate (0.50 – 1.00 m/s) water velocities (Tables 8-2 and 8-3). All but one perennial watercourse in this segment (CV-049) have at least partial (limited passage for smaller size classes of fish) downstream barriers to fish movements. Barriers consist of steep gradients and/or flows that become subsurface for several hundred metres during summer and fall. Many of the crossings in this zone are also several kilometres from the nearest potential overwintering habitat. As a result of all these factors, suitable fish habitat is uncommon in this zone.

The area between km 75 and km 83 (BG-33 to CV-023) is a relatively broad, flat terrain characterized by watercourses that transport large amounts of fine substrates (i.e., sand) during spring snow melt and periods of heavy rain, most of which flow into or out of Muriel Lake (Table 8-1, Figure 8-3j). Sandy pool/flat habitat dominates watercourses in this zone (Table 8-2). Water velocities are typically low, but depths range from < 0.1 m to > 2.0 m between streams (Table 8-3). Natural barriers to fish movement are uncommon.

Terrain between km 83 and km 90 (BG-30 and BG-18) is characterized by a large number of small drainages (Table 8-1, Figure 8-3k), most of which do not provide fish habitat. Cobble/gravel substrates dominate with riffle/pool morphology and variable water velocities (Tables 8-2 and 8-3).

The remainder of the area crossed by the Tote Road consists of a large number of spring run-off drainages, but also includes several large watercourses that are in close proximity to overwintering lakes in the Mine Area (e.g., Mary Lake, Camp Lake) and provide abundant suitable fish habitat (Table 8-1, Figures 8-3k to 8-3m). Cobble/sand, riffle/pool habitat dominates and natural water velocities in several streams in this zone can exceed 1.0 m/s (Tables 8-2 and 8-3). Few of the streams in this area have barriers between the crossings and downstream overwintering sites, but frequently

contain upstream barriers (typically falls) within a kilometre or two preventing further upstream movements.

8.2.2 Fish Populations

Two species of fish are present in the Tote Road Area: Arctic char and ninespine stickleback. Detailed fish community data are provided in Appendix 8-2 and summarized in Table 8-4. Potential use of available habitat for specific life history stages for both fish species is presented in Table 8-5, highlighted in Figures 8-3a to 8-3m and summarized, by habitat zones along the Tote Road, below. Because ninespine stickleback were relatively uncommon in watercourses along the Tote Road, the discussion focuses primarily on Arctic char.

Of the streams that drain directly into Milne Inlet within the first kilometre along the road, Arctic char were only captured in the largest (CV-183; Table 8-4, Figure 8-3a). A single fish was captured in 2006 and four additional fish were captured in 2010 (see Section 7.0). All fish were juveniles, but were more silvery in colour than similarly sized Arctic char captured in other streams along the Tote Road. The colouration, in addition to the presence of barriers between Milne Inlet and upstream headwater overwintering lakes (see Section 7.0 for a description of these lakes), suggest these fish likely originate from Milne Inlet and are therefore anadromous. Spawning of this population likely occurs in some other drainage along the Milne Inlet coast that provides access to suitable spawning and overwintering habitat. Although fish have never been captured in CV-181, the connection with Milne Inlet suggests the potential for char use of this stream. Both of the above streams are categorized as Marginal fish habitat, providing only occasional rearing habitat for Arctic char (Table 8-5).

No fish were captured in watercourses between km 1 and km 15 (Table 8-4, Figures 8-3a and 8-3b). Barriers prevent fish use of most of these streams and, consequently, they were classified as Not Fish-bearing streams (Table 8-5).

Arctic char were captured at a total of nine crossings between km 15 and km 50 along the Tote Road, with CPUE ranging up to 2.46 fish/minute in CV-112 (Table 8-4, Figures 8-3b to 8-3f). One watercourse in this section of the Tote Road (CV-094) supports juvenile Arctic char, but only below the falls located approximately 30 m downstream of the crossing. Most of the streams in this area support a variety of juvenile Arctic char size classes; however, CV-102 (a small drainage) appears to support only young-of-the-year (YOY) Arctic char suggesting its downstream confluence may be in close proximity to lacustrine spawning habitat. A single ninespine stickleback was captured during summer 2010 in CV-129, representing the only evidence of this species presence in watercourses in the Phillips Creek and Milne Inlet catchments (Table 8-4). Overall population sizes of ninespine stickleback may be lower in these drainages compared with those further to the south or perhaps

habitat is less suitable for this species. Ninespine stickleback have been reported from other Milne Inlet watersheds (Stewart and MacDonald 1981) and observed similarities between many habitats in this catchment and those with ninespine stickleback further to the south along the Tote Road provide evidence to support the latter. Five streams were categorized as Marginal fish habitat, six as Important, and the remainder as Not Fish-bearing with potential uses restricted mainly to rearing and some migration (Table 8-5).

Both of the lakes at km 27 and km 32 along the Tote Road support Arctic char populations; large numbers of juveniles of all sizes were observed using nearshore habitat. The presence of YOY Arctic char in both lakes suggests that each supports a spawning population.

Many of the small and larger watercourses between km 50 and km 61 of the Tote Road support fish (Table 8-4, Figures 8-3f to 8-3h). The only non fish-bearing streams in this section are those extra-small drainages that do not persist beyond the initial snow melt period. Electrofishing CPUE in fish-bearing streams often exceeded 2.0 fish/minute and juveniles up to approximately 150 mm fork length were represented in the catches (Table 8-4). Of the nine streams in this segment known to support fish, four were classified as Marginal and five as Important habitat (Table 8-5). Use was primarily restricted to juvenile Arctic char rearing.

Only two streams in the zone between km 61 and km 75 (BG-50 and CV-049) support substantial Arctic char use near the crossings (Tables 8-4 and 8-5, Figures 8-3h to 8-3j). A third watercourse (CV-040) supports fish downstream of a subsurface flow barrier, but it appears that fish access to the crossing area is limited. Surface flows were observed along the entire length of this stream during spring freshet in 2010. However, due to the large distance between the crossing and the nearest probable overwintering location (Muriel Lake), it is likely difficult for juvenile char to reach the crossing in the brief period in which flows may be adequate for fish passage (i.e., snow melt period).

Both species of fish were observed at several crossings between km 75 and km 83 (Table 8-4, Figure 8-3j). The low velocities and small substrate sizes in many of these streams appears to be particularly attractive to ninespine stickleback and YOY Arctic char. Three watercourses were identified as Marginal fish habitat and two as Important (Table 8-5). In addition to rearing habitat, BG-32 was identified as providing potential stickleback spawning habitat and CV-217 as a potential movement corridor between Muriel Lake and several downstream waterbodies.

Only three watercourses between km 83 and km 90 appear to support fish. Only one stream (BG-24) was identified as providing Important fish habitat (Tables 8-4 and 8-5, Figure 8-3k), likely due to its size and close proximity to a potential overwintering lake. Ninespine stickleback were less prevalent in this segment than in the nearest upstream and downstream segments of the Tote Road.

There are nine additional watercourses along the remainder of the Tote Road that provide fish habitat, with eight of these classified as Important (Tables 8-4 and 8-5, Figures 8-3k to 8-3m). Several of these streams are tributaries to large lakes and appear to support large numbers of rearing YOY and juvenile Arctic char. For example, electrofishing CPUE was nearly 40.0 fish/minute in BG-01 during summer 2010 (Table 8-4). Fish use is mainly restricted to char rearing, but there is also potential for ninespine stickleback spawning in some streams (e.g., CV-001), and small-scale foraging movements of both species (Table 8-5).

8.2.3 Habitat Compensation

Table 8-6 provides a description of habitat compensation measures undertaken along the Tote Road, including their status and available information regarding their monitoring. Nine of the 13 sites originally selected based on remote 2006 habitat surveys were subsequently determined to be non fish-bearing when investigated in detail during the monitoring phase. Downstream barriers that were not detectable remotely affect most of these watercourses. Habitat compensation measures at the remaining four crossings were successful and six additional potential compensation projects have been proposed.

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TABLES AND FIGURES

Table 4.1-1. Classification of lacustrine habitats in the Mine Area.

Classification of Lacustrine Habitats			
Zone	**Substrata Type/ Aquatic Macrophytes**		**Type**
Shoreline	Cobble/Boulder		1
	Gravel/Pebble		2
	Sand		3
	Fine Sand, Silt/Clay	Macrophytes Absent	4
		Macrophytes Present	5
Littoral/Euphotic	Cobble/Boulder		6
	Gravel/Pebble		7
	Sand		8
	Fine Sand, Silt/Clay	Macrophytes Absent	9
		Macrophytes Present	10
Profundal	Cobble/Boulder		11
	Gravel/Pebble		12
	Sand		13
	Fine Sand, Silt/Clay	Macrophytes Absent	14

Table 4.1-2. Summary of aquatic habitat information for lakes in the Mine Area.

Waterbody/Zone	Zone Area			Substrata Type									
				Cobble/Boulder		Gravel/Pebble		Sand		Fine Sand and Silt/Clay		Sand/Gravel	
Lake / Zone [1]	m^2	ha	% of Area	Area (m^2)	% Composition	Area (m^2)	% Composition	Area (m^2)	% Composition	Area (m^2)	% Composition	Area (m^2)	% Composition
Camp Lake													
Shoreline Zone (<2 m)	163,248	16.32	7.7	16,931	0.8	26,499	1.3	118,797	5.6	1,020	0.0	-	-
Euphotic Zone (2 m-12 m)	1,169,719	116.97	55.4	86,523	4.1	386,720	18.3	681,810	32.3	14,667	0.7	-	-
Profundal Zone (>12 m)	779,394	77.94	36.9	4,555	0.2	182,590	8.6	489,191	23.2	103,058	4.9	-	-
Camp Lake Total	**2,112,361**	**211.24**	**100.0**	**108,009**	**5.1**	**595,809**	**28.2**	**1,289,798**	**61.1**	**118,745**	**5.6**	**0**	**0.0**
Sheardown Lake NW													
Shoreline Zone (<2 m)	79,011	7.90	11.6	3,302	0.5	13,625	2.0	62,085	9.2	0	0.0	-	-
Euphotic Zone (2 m-12 m)	282,340	28.23	41.6	36,848	5.4	128,720	19.0	116,547	17.2	225	0.0	-	-
Profundal Zone (>12 m)	316,999	31.70	46.7	28,687	4.2	141,415	20.8	133,483	19.7	13,413	2.0	-	-
Sheardown Lake NW Total	**678,350**	**67.84**	**100.0**	**68,837**	**10.1**	**283,760**	**41.8**	**312,115**	**46.0**	**13,638**	**2.0**	**0**	**0.0**
Sheardown Lake SE													
Shoreline Zone (<2 m)	46,678	4.67	19.4	7,437	3.1	8,007	3.3	31,234	13.0	-	-	-	-
Euphotic Zone (2 m-12 m)	156,810	15.68	65.2	29,292	12.2	56,827	23.6	70,690	29.4	-	-	-	-
Profundal Zone (>12 m)	36,905	3.69	15.4	5,309	2.2	22,498	9.4	9,097	3.8	-	-	-	-
Sheardown Lake SE Total	**240,393**	**24.04**	**100.0**	**42,038**	**17.5**	**87,332**	**36.3**	**111,021**	**46.2**	**0**	**0.0**	**0**	**0.0**
Mary Lake													
Shoreline Zone (<2 m)	4,932,421	493.24	35.7	543,125	3.9	-	-	3,351,253	24	447,757	3	590,286	4.3
Euphotic Zone (2 m-12 m)	3,647,614	364.76	26.4	40,061	0.3	-	-	1,806,061	13	1,794,092	13	7,401	0.1
Profundal Zone (>12 m)	5,219,125	521.91	37.8	1,753	0.0	-	-	414,426	3	4,802,947	35	0	0.0
Mary Lake Total	**13,799,160**	**1,379.92**	**100.0**	**584,939**	**4.2**	**0**	**0.0**	**5,571,741**	**40.4**	**7,044,795**	**51.1**	**597,688**	**4.3**
Candidate Reference Lake													
Shoreline Zone (<2 m)	245,330	24.53	21.1	23,281	2.0	-	-	27,782	2.4	194,267	16.7	-	-
Euphotic Zone (2 m-12 m)	918,697	91.87	78.9	0	0.0	-	-	117	0.0	918,580	78.9	-	-
Profundal Zone (>12 m)	0	0.00	0.0	0	0.0	-	-	0	0.0	0	0.0	-	-
Candidate Reference Lake Total	**1,164,027**	**116.40**	**100.0**	**23,281**	**2.0**	**0**	**0.0**	**27,899**	**2.4**	**1,112,847**	**95.6**	**0**	**0.0**

[1] Zone boundaries adjusted for water level variation at time of bathymetric survey: Camp Lake +0.43 m; Sheardown NW +0.35 m; Sheardown SE +0.40 m; Mary Lake +0.82 m (south basin); and Mary Lake +0.93 (North Basin). No corrections were available for the Candidate Reference Lake.

Table 4.2-1. Trophic status classification schemes for lakes based on phytoplankton.

Chlorophyll *a* (µg/L)					Reference
Ultra-oligotrophic	**Oligotrophic**	**Mesotrophic**	**Eutrophic**	**Hyper-eutrophic**	
-	<2.5	2.5 - 8	8 - 25	> 25	OECD (1982)
0.01 - 0.5	0.3 - 3	2 - 15	10 - 500	-	Wetzel (1983)
-	<3.5	3.5 - 9	9.1 - 25	> 25	Nürnberg (1996)

Table 4.2-2. Trophic status classification schemes for streams based on phytoplankton and periphyton.

Parameter	Unit	Oligotrophic	Mesotrophic	Eutrophic	Reference
Mean phytoplankton chlorophyll *a*	(µg/L)	<10	10-30	>30	Dodds et al. (1998)
Mean benthic chlorophyll *a*	(mg/m^2)	<20	20-70	>70	
Maximum benthic chlorophyll *a*	(mg/m^2)	<60	60-200	>200	

Table 4.2-3. Water sampling locations where phytoplankton and/or chlorophyll samples were collected and periods sampled for the Mine Area.

		UTM			2007				2008			
Waterbody	**Site ID**	**Zone**	**Easting**	**Northing**	**May**	**June**	**July/Aug**	**Sept**	**May**	**June**	**July/Aug**	**Aug/Sept**
Mary River												
	G0-09	17 W	571546	7916317	-	x	x	x	-	-	x	-
	G0-03	17 W	567204	7912587	-	x	x	x	-	-	x	-
	E0-03	17 W	562974	7912472	-	x	x	-	-	-	x	-
	E0-01	17 W	560949	7911531	-	x	x	x	-	-	x	-
	C0-10	17 W	560669	7911633	-	x	x	x	-	-	x	-
	C0-05	17 W	558352	7909170	-	x	x	x	-	x	x	x
	C0-01	17 W	556305	7906894	-	x	x	x	-	-	x	-
	A0-10	17 W	557391	7903368	-	-	-	-	-	x	-	-
	A0-01	17 W	559019	7900094	-	-	x	x	-	x	x	x
Tom River												
	I0-04	17 W	557152	7918991	-	x	x	x	-	x	-	x
	I0-01	17 W	555470	7914139	-	x	x	x	-	x	-	-
Sheardown Lake Tributaries												
	D1-05	17 W	561397	7913558	-	-	-	-	-	x	x	-
	D1-01	17 W	560753	7913507	-	x	x	x	-	x	x	x
	D1-00	17 W	560329	7913512	-	-	-	-	-	x	x	x
	D-Stream-1	17 W	560964	7912998	-	x	x	x	-	x	x	x
	D-Stream-2	17 W	560777	7912867	-	x	-	-	-	x	-	-
	D-Stream-3	17 W	561770	7911809	-	-	-	x	-	x	x	x
	D-Stream-4	17 W	560629	7912638	-	-	-	-	-	x	-	x
	D-Stream-5	17 W	560719	7912501	-	-	-	-	-	-	-	x
	D-Stream-6	17 W	560893	7912263	-	-	-	-	-	x	-	x
Mary Lake Tributary 2												
	MLST2	17W	552111	7905088	-	-	-	-	-	x	x	x
Camp Lake												
	JL0-01	17W	557108	7914369	x	-	x	x	x	-	x	-
	JL0-02	17W	557615	7914750	x	-	x	x	-	-	x	-
	JL0-09	17W	556335	7913955	x	-	x	x	-	-	x	-

Table 4.2-3. - Continued -

		UTM			2007				2008			
Waterbody	**Site ID**	**Zone**	**Easting**	**Northing**	**May**	**June**	**July/Aug**	**Sept**	**May**	**June**	**July/Aug**	**Aug/Sept**
Sheardown Lake Northwest Basin												
	DL0-01-1	17W	560080	7913128	x	-	x	x	x	-	x	x
	DL0-01-2	17W	560353	7912924	-	-	x	x	-	-	x	x
	DL0-01-3	17W	560474	7912833	x	-	-	-	-	-	-	-
	DL0-01-4	17W	560695	7913043	-	-	x	x	-	-	x	x
	DL0-01-5	17W	559798	7913356	x	-	x	x	-	-	x	x
	DL0-01-7	17W	560525	7912609	-	-	x	x	-	-	x	x
Sheardown Lake NW Nearshore												
	SDL1	17W	560347	7913430	-	-	-	-	-	x	x	x
	SDL2	17W	560310	7913469	-	-	-	-	-	x	x	x
	SDL3	17W	560264	7913482	-	-	-	-	-	x	x	x
	SDL4	17W	559941	7913085	-	-	-	-	-	x	x	x
	SDL5	17W	559960	7913039	-	-	-	-	-	x	x	x
	SDL6	17W	559991	7912998	-	-	-	-	-	x	x	x
Sheardown Lake Southeast Basin												
	DL0-02-1	17W	560814	7912116	x	-	x	x	-	-	x	x
	DL0-02-3	17W	561046	7911915	-	-	x	-	x	-	x	x
	DL0-02-3b	17W	560950	7911917	-	-	-	x	-	-	-	-
	DL0-02-4	17W	561512	7911832	-	-	x	x	-	-	x	x
	DL0-02-6	17W	560756	7912167	x	-	-	-	-	-	-	-
Mary Lake												
	BL0-01	17W	554562	7913234	x	-	x	x	x	-	x	-
	BL0-03	17W	552680	7906651	x	-	x	x	-	-	x	-
	BL0-04	17W	553817	7904886	x	-	x	x	x	-	x	-
	BL0-05	17W	554632	7906031	x	-	x	x	-	-	x	-
	BL0-06	17W	555924	7903760	-	-	x	x	-	-	-	-
Candidate Reference Lake												
	CRL-3	17W	565703	7904839	-	-	-	-	-	-	x	-

Table 4.2-4. Chlorophyll *a* concentrations (µg/L) measured in water samples collected from lakes in the Mine Area, 2007-2008.

	Site	Sampling	Surface					Bottom				
Waterbody	**ID**	**Period**	**Mean**	**Min**	**Max**	**SE**	**n**	**Mean**	**Min**	**Max**	**SE**	**n**
OPEN-WATER SEASON												
Camp Lake												
	JL0-01	2007	0.2	<0.2	0.2	0.1	2	0.3	<0.2	0.4	0.2	2
	JL0-01	2008	1.5	-	-	-	1	0.3	-	-	-	1
	JL0-02	2007	0.2	<0.2	0.3	0.1	2	0.6	0.3	0.9	0.3	2
	JL0-02	2008	0.5	-	-	-	1	0.5	-	-	-	1
	JL0-09	2007	0.2	<0.2	0.3	0.1	2	0.9	<0.2	1.7	0.8	2
	JL0-09	2008	<0.2	-	-	-	1	<0.2	-	-	-	1
	All Sites	Summer 2007	<0.2	<0.2	0.2	0.0	3	0.9	<0.2	1.7	0.5	3
	All Sites	Fall 2007	0.2	<0.2	0.3	0.1	3	0.3	<0.2	0.4	0.1	3
	All Sites	2007	0.2	<0.2	0.3	0.0	6	0.6	<0.2	1.7	0.3	6
	All Sites	Summer 2008	0.7	<0.2	1.5	0.4	3	0.3	<0.2	0.5	0.1	3
	All Sites	Fall 2008	n/s	n/s	n/s	n/s	0	n/s	n/s	n/s	n/s	0
	All Sites	2008	0.7	<0.2	1.5	0.4	3	0.3	<0.2	0.5	0.1	3
Sheardown Lake NW												
	DL0-01-1	2007	<0.2	<0.2	<0.2	0.0	2	<0.2	<0.2	<0.2	0.0	2
	DL0-01-1	2008	<0.2	<0.2	<0.2	0.0	2	0.6	<0.2	1.0	0.5	2
	DL0-01-2	2007	0.4	0.2	0.5	0.2	2	1.0	0.7	1.3	0.3	2
	DL0-01-2	2008	<0.2	<0.2	<0.2	0.0	2	<0.2	<0.2	<0.2	0.0	2
	DL0-01-4	2007	0.9	0.9	0.9	0.0	2	0.3	<0.2	0.5	0.2	2
	DL0-01-4	2008	<0.2	<0.2	<0.2	0.0	2	<0.2	<0.2	<0.2	0.0	2
	DL0-01-5	2007	0.2	<0.2	0.3	0.1	2	0.4	<0.2	0.7	0.3	2
	DL0-01-5	2008	<0.2	<0.2	<0.2	0.0	2	<0.2	<0.2	<0.2	0.0	2

Table 4.2-4. - Continued -

Waterbody	Site ID	Sampling Period	Surface					Bottom				
			Mean	Min	Max	SE	n	Mean	Min	Max	SE	n
	DL0-01-7	2007	0.2	<0.2	0.2	0.1	2	0.7	0.2	1.1	0.5	2
	DL0-01-7	2008	<0.2	<0.2	<0.2	0.0	2	1.4	<0.2	2.7	1.3	2
	All Sites	Summer 2007	0.3	<0.2	0.9	0.2	5	0.4	<0.2	1.3	0.2	5
	All Sites	Fall 2007	0.4	<0.2	0.9	0.1	5	0.6	<0.2	1.1	0.2	5
	All Sites	2007	0.3	<0.2	0.9	0.1	10	0.5	<0.2	1.3	0.1	10
	All Sites	Summer 2008	<0.2	<0.2	<0.2	0.0	5	0.6	<0.2	2.7	0.5	5
	All Sites	Fall 2008	<0.2	<0.2	<0.2	0.0	5	0.3	<0.2	1.0	0.2	5
	All Sites	2008	<0.2	<0.2	<0.2	0.0	10	0.5	<0.2	2.7	0.3	10
Sheardown Lake - Nearshore												
	SDL1	2008	1.2	<0.2	4.4	1.1	4	-	-	-	-	-
	SDL2	2008	0.9	<0.2	3.1	0.8	4	-	-	-	-	-
	SDL3	2008	0.7	<0.2	2.6	0.6	4	-	-	-	-	-
	SDL4	2008	1.2	<0.2	4.4	1.1	4	-	-	-	-	-
	SDL5	2008	<0.2	<0.2	<0.2	0.0	4	-	-	-	-	-
	SDL6	2008	1.1	<0.2	4.0	1.0	4	-	-	-	-	-
	All Sites	25-Jun-08	<0.2	<0.2	<0.2	0.0	6	-	-	-	-	-
	All Sites	31-Jul-08	<0.2	<0.2	<0.2	0.0	6	-	-	-	-	-
	All Sites	7-Aug-08	<0.2	<0.2	<0.2	0.0	6	-	-	-	-	-
	All Sites	14-Sep-08	3.1	<0.2	4.4	0.7	6	-	-	-	-	-
	All Sites	2008	0.9	<0.2	4.4	0.3	24	-	-	-	-	-
Sheardown Lake SE												
	DL0-02-1	2007	<0.2	<0.2	<0.2	0.0	2	<0.2	<0.2	<0.2	0.0	2
	DL0-02-1	2008	<0.2	<0.2	<0.2	0.0	2	<0.2	<0.2	<0.2	0.0	2
	DL0-02-3	2007	<0.2	<0.2	<0.2	0.0	2	0.2	<0.2	0.2	0.1	2
	DL0-02-3	2008	1.6	1.1	2.1	0.5	2	5.0	2.3	7.6	2.7	2
	DL0-02-4	2007	<0.2	<0.2	<0.2	0.0	2	<0.2	<0.2	<0.2	0.0	2

Table 4.2-4. - Continued -

	Site	Sampling	Surface					Bottom				
Waterbody	**ID**	**Period**	**Mean**	**Min**	**Max**	**SE**	**n**	**Mean**	**Min**	**Max**	**SE**	**n**
	DL0-02-4	2008	<0.2	<0.2	<0.2	0.0	2	<0.2	<0.2	<0.2	0.0	2
	All Sites	Summer 2007	<0.2	<0.2	<0.2	0.0	3	<0.2	<0.2	0.2	0.0	3
	All Sites	Fall 2007	<0.2	<0.2	<0.2	0.0	2	<0.2	<0.2	<0.2	0.0	3
	All Sites	2007	<0.2	<0.2	<0.2	0.0	6	0.1	<0.2	0.2	0.0	6
	All Sites	Summer 2008	0.8	<0.2	2.1	0.7	3	0.8	<0.2	2.3	0.7	3
	All Sites	Fall 2008	0.4	<0.2	1.1	0.3	3	2.6	<0.2	7.6	2.5	3
	All Sites	2008	0.6	<0.2	2.1	0.3	6	1.7	<0.2	7.6	1.2	6
Mary Lake												
	BL0-01	2007	<0.2	<0.2	<0.2	0.0	2	<0.2	<0.2	<0.2	0.0	2
	BL0-01	2008	-	-	-	-	0	0.3	-	-	-	1
	BL0-03	2007	<0.2	<0.2	<0.2	0.0	2	0.5	0.3	0.7	0.2	2
	BL0-03	2008	1.8	-	-	-	1	0.4	-	-	-	1
	BL0-04	2007	0.7	<0.2	1.2	0.6	2	1.6	<0.2	3.0	1.5	2
	BL0-04	2008	1.4	-	-	-	1	<0.2	-	-	-	1
	BL0-05	2007	0.5	0.3	0.7	0.2	2	1.5	1.3	1.7	0.2	2
	BL0-05	2008	1.8	-	-	-	1	1.1	-	-	-	1
	All Sites	Summer 2007	0.2	<0.2	0.3	0.1	4	0.5	<0.2	1.3	0.3	4
	All Sites	Fall 2007	0.5	<0.2	1.2	0.3	4	1.4	<0.2	3.0	0.6	4
	All Sites	2007	0.3	<0.2	1.2	0.1	8	0.9	<0.2	3.0	0.4	8
	All Sites	Summer 2008	1.7	1.4	1.8	0.1	3	0.5	<0.2	1.1	0.2	4
	All Sites	Fall 2008	n/s	n/s	n/s	n/s	0	n/s	n/s	n/s	n/s	0
	All Sites	2008	1.7	1.4	1.8	0.1	3	0.5	<0.2	1.1	0.2	4
Candidate Reference Lake												
	CRL-3	2007	n/s	n/s	n/s	n/s	0	n/s	n/s	n/s	n/s	0

Table 4.2-4. - Continued -

Waterbody	Site ID	Sampling Period	Surface					Bottom				
			Mean	Min	Max	SE	n	Mean	Min	Max	SE	n
	CRL-3	2008	<0.2	-	-	-	1	<0.2	-	-	-	1
ICE-COVER SEASON												
Camp Lake												
	All Sites	May 2007	0.2	<0.2	0.5	0.1	3	n/s	n/s	n/s	n/s	0
	All Sites	May 2008	1.5	-	-	-	1	3.0	-	-	-	1
Sheardown Lake NW												
	All Sites	May 2007	0.5	0.4	0.6	0.1	3	-	-	-	-	0
	All Sites	May 2008	1.2	-	-	-	1	2.2	-	-	-	1
Sheardown Lake - Nearshore												
	All Sites	May 2007	n/s	n/s	n/s	n/s	0	n/s	n/s	n/s	n/s	0
	All Sites	May 2008	n/s	n/s	n/s	n/s	0	n/s	n/s	n/s	n/s	0
Sheardown Lake SE												
	All Sites	May 2007	<0.2	<0.2	<0.2	0.0	2	n/s	n/s	n/s	n/s	0
	All Sites	May 2008	<0.2	-	-	-	1	1.9	-	-	-	1
Mary Lake												
	All Sites	May 2007	<0.2	<0.2	<0.2	0.0	4	n/s	n/s	n/s	n/s	0
	All Sites	May 2008	0.3	<0.2	0.4	0.2	2	<0.2	<0.2	<0.2	0.0	2
Candidate Reference Lake												
	CRL-3	May 2007	n/s	n/s	n/s	n/s	0	n/s	n/s	n/s	n/s	0
	CRL-3	May 2008	n/s	n/s	n/s	n/s	0	n/s	n/s	n/s	n/s	0

Table 4.2-5. Trophic status classification for lakes in the Mine Area based on mean open-water season chlorophyll *a* concentrations (µg/L).

Waterbody	Year	Lake Trophic Status					Reference
		Ultra-oligotrophic	Oligotrophic	Mesotrophic	Eutrophic	Hyper-eutrophic	
		-	<2.5	2.5 - 8	8 - 25	> 25	OECD (1982)
		0.01 - 0.5	0.3 - 3	2 - 15	10 - 500	-	Wetzel (1983)
		-	<3.5	3.5 - 9	9.1 - 25	> 25	Nürnberg (1996)
Camp Lake							
	2007	0.2					
	2008		0.7				
	2007-2008		0.4				
Sheardown Lake NW							
	2007		0.3				
	2008	<0.2					
	2007-2008	0.2					
Sheardown Lake SE							
	2007	<0.2					
	2008		0.6				
	2007-2008	0.2					
Mary Lake							
	2007		0.3				
	2008		1.7				
	2007-2008		0.7				
Candidate Reference Lake[1]							
	2008	<0.2					

[1]This lake was only sampled in 2008.

Table 4.2-6. Mean phytoplankton biomass and relative abundance for lakes in the Mine Area, 2007-2008.

Waterbody	Sampling Period	Number of Samples	Total Biomass (mg/m^3)	Relative Abundance (%)						
				Bacillariophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Euglenophyceae	Cyanophyceae	Peridineae
Camp Lake										
	2007	6	80.28	81.70	8.74	1.55	2.52	1.86	0.30	3.33
	2008	3	204.64	56.20	3.25	1.51	7.95	0.00	17.14	13.95
	2007-08	9	121.74	73.20	6.91	1.54	4.33	1.24	5.91	6.87
Sheardown Lake NW										
	2007	10	86.65	81.61	7.99	2.15	1.44	3.41	1.48	1.92
	2008	10	321.00	71.18	13.96	2.39	1.64	0.00	6.53	4.31
	2007-08	20	203.82	76.39	10.97	2.27	1.54	1.71	4.00	3.12
Sheardown Lake SE										
	2007	6	58.64	67.03	15.97	1.16	2.11	4.51	1.16	8.05
	2008	6	191.79	67.00	17.39	0.97	2.49	0.06	9.44	2.66
	2007-08	12	125.22	67.02	16.68	1.06	2.30	2.29	5.30	5.36
Mary Lake										
	2007	10	166.10	84.44	8.12	0.86	2.78	0.97	2.53	1.12
	2008	4	105.55	87.92	2.32	3.56	3.02	1.91	1.27	0.00
	2007-08	14	148.80	85.43	6.33	1.63	2.85	1.23	2.17	0.80

Table 4.2-7. Comparison of phytoplankton chlorophyll *a* concentrations and biomass measured in Mine Area lakes and streams to other Arctic waterbodies.

Project/Study	General Location	Stream/Lake	Years	Chlorophyll *a* (µg/L)	Biomass (mg/m^3)	Reference
Mary River Project	Mine Area lakes	Lakes	2007-2008	Lake Means: 0.2 - 0.7	Lake Means: 122-204	This Study
		Streams	2007-2008	Stream Means: 0.2 - 3.5	-	
High Lake Project	Western Nunavut, approximately 200 km east of Kugluktuk	Lakes	1994	<0.001 - 3.01	-	Wolfden Resources (2007)
		Kennarctic River	1994	0.022 (based on 1 value)	-	
Meadowbank Gold Project	75 north of hamlet of Baker Lake, Nunavut; sub-Arctic barrengrounds	11 lakes	1998, 2002	-	Lake Means: 5.1-360.8	Cumberland Resources Ltd. (2005)
Limnological survey of subarctic lakes	South-central and southwestern Yukon	19 lakes	1982	0.62 - 3.76 (mean June-Sept)	-	Shortreed and Stockner (1986)
Stream and Lake Survey	Lakes near Yellowknife, NWT area	Great Slave Lake	1983	1.2-3.9	-	Fee et al. (1985)
		3 nearby lakes	1983	1.1-2.8	-	
Bathhurst Inlet Port and Road Project	west side of Bathhurst Inlet, NU	Contwoyto Lake	2001	0.2	-	Rescan Environmental Services Ltd.(2007)
Jericho Diamond Project	Near Contwoyto Lake, NU	Lake C4	2000	0.75 (mean of 3 samples in July)	-	RL&L (2000)
Nutrient addition study	Saqvaqjuac lakes, NT	4 lakes	1977-1981	0.98 - 3.14	-	Welch et al. (1989)
Whole Lake Nutrient fertilization Experiment	Toolik Lake, Alaska	Lake N-2 (reference condition)	Reference Condition: Pre-fertilization	1.2: photic zone average	-	O'Brien et al. (2005)
Survey of northern Baffin Island	3 lakes on Northern Baffin Island	Nina Bang Lake	Aug-80	0.42	-	Stewart and MacDonald (1981)
		Unnamed Lake, Milne Inlet	Aug-80	0.80	-	
		Erichsen Lake	Aug-80	1.22	-	

Table 4.2-7. - Continued -

Project/Study	General Location	Stream/Lake	Years	Chlorophyll *a* (µg/L)	Biomass (mg/m^3)	Reference
Whole Lake P fertilization study	Lakes at Saqvaqjuac, NT	Reference lakes	June-Sept 1977-81	1 - 2.4 (mean open-water)	<1000 maximum summer	Welch et al. (1989)
Surveys of lakes and rivers, Alaska	North Slope, Alaska	16 lakes	month of July over period of 1986-1990	Range (excluding 1 lake): 0.3 - 7.6	-	Kling et al. (1992)
		7 rivers	month of July over period of 1988-1990	Range: 0.1 - 9.4; 6 of 7 rivers <1	-	
Stream benthic algal study	Tributaries to the Tanana River, Alaska	15 streams	summer 1979; summer 1983	Means: 0.18 - 1.12	-	LaPerriere et al. (1989)
Diaviak Diamond Mines Inc. EIS	Lac de Gras, NT	Lac de Gras	Aug and Sept 1998	0.431 - 0.474	-	DDMI (1998)
		Lac du Sauvage	Aug and Sept 1998	0.603 - 0.716	-	

Table 4.2-8. Comparison of phytoplankton taxonomic composition (relative abundance) and biomass measured in Mine Area lakes to other Arctic lakes.

Project/Study	Location	Stream/Lake	Years	Relative Abundance (%)							Typical Dominant Group	Total Biomass (mg/m^3)	Reference
				Bacillariophyceae	Chlorophyceae	Chrysophyceae	Cryptophyceae	Euglenophyceae	Cyanophyceae	Peridinae			
Mary River Project	Mine Area lakes	Camp Lake	2007-2008	73.20	6.91	1.54	4.33	1.24	5.91	6.87	Bacillophyceae	121.74	This Study
		Sheardown Lake NW	2007-2008	76.39	10.97	2.27	1.54	1.71	4.00	3.12	Bacillophyceae	203.82	
		Sheardown Lake SE	2007-2008	67.02	16.68	1.06	2.30	2.29	5.30	5.36	Bacillophyceae	125.22	
		Mary Lake	2007-2008	85.43	6.33	1.63	2.85	1.23	2.17	0.80	Bacillophyceae	148.80	
Meadowbank Gold Project	75 km north of hamlet of Baker Lake, Nunavut	11 lakes	1998, 2002	0.3-70.8	0.9-36.3	2.2-313.4	0.2-7.4	-	0.2-13.4	0.6-61.8	Chrysophyceae	5.1-360.8	Cumberland Resources Ltd. (2005)
General	Lakes near Yellowknift, NWT area	Great Slave Lake	1983	4-48	1-5	11-58	21-37	0	0-1	3-20	Chyrosophytes (4 sites); Diatoms (1 site)	135-656	Fee et al. (1985)
		4 nearby lakes	1983	1-26	0-10	15-64	7-22	0-1	0-39	2-16	Chrysophytes (3 lakes); Cyanophytes (1 lake)	345-2412	
Snap Lake Project	Snap Lake Project	Snap Lake, NU	1999	46.8	3.5	10.2	4.2	1.9	9.5	23.8	Diatoms	266	De Beers 2002 (In Cumberland Resources Ltd. 2005)
Diaviak Diamond Mines Inc. EIS	Lac de Gras, NT	Lac de Gras	Jul-98	1.7	13.8	68.7	4	0	11.7	0.1	Chrysophyceae	-	DDMI (1998)
			Aug-98	1.9	11.7	69.5	5	0	11.8	0.1		-	
			Sep-98	2	17.5	67.8	5.5	0.1	7	0.1		-	
			Mean	1.9	14.3	68.7	4.8	0.0	10.2	0.1		-	
		Lac du Sauvage	Jul-98	4.8	6.8	83.6	4.2	0	0.4	0.2	Chrysophyceae	-	
			Aug-98	12.3	15.4	52.1	18.9	0	1.3	0		-	
			Sep-98	59.7	2.6	32.5	4.4	0.3	0.2	0.3		-	
			Mean	25.6	8.3	56.1	9.2	0.1	0.6	0.2		-	

Table 4.2-9. Summary statistics for chlorophyll *a* concentrations in water samples from rivers and streams in the Mine Area: 2007 and 2008.

Waterbody	Site ID	Sampling Date	Chlorophyll *a* (µg/L)				
			Mean	Mininum	Maximum	SE	n
Mary River							
	G0-09	2007	0.2	<0.2	0.4	0.1	3
	G0-09	2008	2.9	-	-	-	1
	G0-03	2007	0.2	<0.2	0.4	0.1	3
	G0-03	2008	3.3	-	-	-	1
	E0-03	2007	0.3	<0.2	0.4	0.2	2
	E0-03	2008	3.1	-	-	-	1
	E0-01	2007	0.2	<0.2	0.3	0.1	3
	E0-01	2008	<0.2	-	-	-	1
	C0-10	2007	0.6	<0.2	1.5	0.5	3
	C0-10	2008	1.2	-	-	-	1
	C0-05	2007	0.2	<0.2	0.4	0.1	3
	C0-05	2008	0.9	<0.2	2.4	0.8	3
	C0-01	2007	0.2	<0.2	0.4	0.1	3
	C0-01	2008	4.0	-	-	-	1
	A0-10	2007	-	-	-	-	0
	A0-10	2008	<0.2	-	-	-	1
	A0-01	2007	0.2	<0.2	0.3	0.1	2
	A0-01	2008	1.2	0.3	1.7	0.4	3
	All Sites	Spring 2007	<0.2	<0.2	<0.2	0.0	7
	All Sites	Summer 2007	0.3	<0.2	0.4	0.1	8
	All Sites	Fall 2007	0.4	<0.2	1.5	0.2	7
	All Sites	2007	0.3	<0.2	1.5	0.1	22
	All Sites	Spring 2008	0.2	<0.2	0.3	0.1	3
	All Sites	Summer 2008	2.0	<0.2	4.0	0.5	8
	All Sites	Fall 2008	2.1	1.7	2.4	0.3	2
	All Sites	2008	1.6	<0.2	4.0	0.4	12
	All Sites	2007-08	0.8	<0.2	4.0	0.2	35
Tom River							
	I0-04	2007	<0.2	<0.2	0.2	0.0	3
	I0-04	2008	<0.2	<0.2	<0.2	0.0	2

Table 4.2-9. - Continued -

Waterbody	Site ID	Sampling Date	Chlorophyll *a* (µg/L)				
			Mean	Mininum	Maximum	SE	n
	I0-01	2007	0.2	<0.2	0.3	0.1	3
	I0-01	2008	<0.2	-	-	-	1
	All Sites	Spring 2007	0.3	0.2	0.3	0.1	2
	All Sites	Summer 2007	0.2	<0.2	0.3	0.1	2
	All Sites	Fall 2007	<0.2	<0.2	<0.2	0.0	2
	All Sites	2007	0.2	<0.2	0.3	0.0	6
	All Sites	Spring 2008	<0.2	<0.2	<0.2	0.0	2
	All Sites	Summer 2008	-	-	-	-	0
	All Sites	Fall 2008	<0.2	-	-	-	1
	All Sites	2008	<0.2	<0.2	<0.2	0.0	3
	All Sites	2007-08	0.2	<0.2	0.3	0.0	9
Sheardown Lake Tributaries							
	D1-05	2007	-	-	-	-	0
	D1-05	2008	3.9	<0.2	7.7	3.8	2
	D1-01	2007	0.2	<0.2	0.4	0.1	3
	D1-01	2008	<0.2	<0.2	<0.2	-	3
	D1-00	2007	-	-	-	-	0
	D1-00	2008	1.2	<0.2	3.3	1.1	3
	D-Stream 1	2007	<0.2	<0.2	<0.2	0.0	3
	D-Stream 1	2008	<0.2	<0.2	<0.2	0.0	3
	D-Stream 2	2007	<0.2	-	-	-	1
	D-Stream 2	2008	<0.2	-	-	-	1
	D-Stream 3	2007	<0.2	-	-	-	1
	D-Stream 3	2008	0.6	<0.2	1.6	0.5	3
	D-Stream 5	2007	-	-	-	-	0
	D-Stream 5	2008	<0.2	-	-	-	1
	D-Stream 6	2007	-	-	-	-	0
	D-Stream 6	2008	<0.2	<0.2	<0.2	0.0	2
	All Sites	Spring 2007	0.2	<0.2	0.4	0.1	3
	All Sites	Summer 2007	<0.2	<0.2	<0.2	0.0	2
	All Sites	Fall 2007	<0.2	<0.2	<0.2	0.0	3
	All Sites	2007	<0.2	<0.2	0.4	0.0	8

Table 4.2-9. - Continued -

Waterbody	Site ID	Sampling Date	Chlorophyll *a* (µg/L)				
			Mean	Mininum	Maximum	SE	n
	All Sites	Spring 2008	<0.2	<0.2	<0.2	0.0	8
	All Sites	Summer 2008	1.6	<0.2	7.7	1.5	5
	All Sites	Fall 2008	0.8	<0.2	3.3	0.5	7
	All Sites	2008	0.7	<0.2	7.7	0.4	20
	All Sites	2007-08	0.6	<0.2	7.7	0.3	28
Mary Lake Tributary 2							
	MLST2	Spring 2008	8.9	-	-	-	1
	MLST2	Summer 2008	<0.2	-	-	-	1
	MLST2	Fall 2008	1.6	-	-	-	1
	MLST2	2008	3.5	<0.2	8.9	2.7	3

Table 4.2-10. Periphyton sampling locations and dates: open-water season 2007 and 2008.

Waterbody	Site ID	UTM			Sampling Dates	
		Zone	Easting	Northing	2007	2008
Mary River						
	G0-09	17W	571546	7916317	3-Aug; 5-Sep	-
	G0-03	17W	567204	7912587	3-Aug; 5-Sep	-
	E0-01	17W	560949	7911532	2-Aug; 4-Sep	-
	C0-10	17W	560669	7911633	2-Aug; 4-Sep	-
	C0-01	17W	556305	7906894	2-Aug; 3-Sep	-
Tom River						
	I0-04	17W	557152	7918991	31-Jul; 5-Sep	-
	I0-01	17W	555470	7914139	1-Aug; 5-Sep	-
Sheardown Lake Tributaries						
	SDLT-1 R4	17W	561501	7913538	27-Jun; 29-Jul; 31-Aug	26-Jun; 25-Jul; 28-Aug
	SDLT-1 R2	17W	560753	7913507	28-Jun; 29-Jul; 31-Aug	26-Jun; 25-Jul; 28-Aug
	SDLT-1 R1	17W	560324	7913498	-	26-Jun; 25-Jul; 28-Aug
	SDLT-9 US	17W	561788	7911790	28-Jun; 31-Jul; 1-Sep	-
	SDLT-9 DS	17W	561739	7911801	28-Jun	-
	SDLT-12 US	17W	561102	7912835	27-Jun; 28-Jul; 1-Sep	-
	SDLT-12 DS	17W	561022	7912971	27-Jun; 28-Jul; 1-Sep	-
Mary Lake Tributaries						
	MLST-2	17W	552111	7905088	-	25-Jun; 25-Jul
Camp Lake Tributaries						
	CLT-1 US	17W	558529	7915065	5-Aug, 4-Sep	-
	CLT-1 DS	17W	557598	7914857	5-Aug; 2-Sep	-
	CLT-2 US	17W	557491	7915427	4-Aug, 2-Sep	-
	CLT-2 DS	17W	557466	7914969	4-Aug, 2-Sep	-

Table 4.2-11. Periphyton density measured in streams in the Mine Area.

Watershed	Site ID	Sampling Date	Ash-free dry weight (g/m^2)						Chlorophyll *a* (mg/m^2)					
			Mean	Min	Max	SD	SE	n	Mean	Min	Max	SD	SE	n
Camp Lake Tributaries: 2007														
	CLT-1 US	5-Aug-07	11.6	4.7	15.1	6.0	3.5	3	5.2	1.4	8.5	3.6	2.1	3
	CLT-1 US	4-Sep-07	67.8	45.6	109.5	36.2	20.9	3	49.0	18.4	108.3	51.4	29.7	3
	CLT-1 US	2007	39.7	4.7	109.5	38.5	15.7	6	27.1	1.4	108.3	40.5	16.5	6
	CLT-1 DS	5-Aug-07	28.7	15.4	51.7	19.9	11.5	3	8.9	3.3	15.1	5.9	3.4	3
	CLT-1 DS	2-Sep-07	30.3	22.6	44.5	12.4	7.1	3	20.9	15.5	25.4	5.0	2.9	3
	CLT-1 DS	2007	29.5	15.4	51.7	14.9	6.1	6	14.9	3.3	25.4	8.2	3.3	6
	CLT-2 US	4-Aug-07	21.3	20.6	22.6	1.1	0.6	3	43.9	18.4	94.2	43.5	25.1	3
	CLT-2 US	2-Sep-07	45.5	15.6	101.3	48.4	27.9	3	61.1	17.9	136.6	65.6	37.9	3
	CLT-2 US	2007	33.4	15.6	101.3	33.3	13.6	6	52.5	17.9	136.6	50.7	20.7	6
	CLT-2 DS	4-Aug-07	26.5	15.1	47.9	18.6	10.7	3	11.0	4.7	16.5	5.9	3.4	3
	CLT-2 DS	2-Sep-07	28.7	9.4	57.7	25.6	14.8	3	30.8	8.9	51.8	21.4	12.4	3
	CLT-2 DS	2007	27.6	9.4	57.7	20.0	8.2	6	20.9	4.7	51.8	17.8	7.2	6
	All Sites	Summer	22.1	4.7	51.7	13.8	4.0	12	17.3	1.4	94.2	25.0	7.2	12
	All Sites	Fall	43.1	9.4	109.5	32.9	9.5	12	40.4	8.9	136.6	40.2	11.6	12
	All Sites	2007	32.6	4.7	109.5	26.9	5.5	24	28.8	1.4	136.6	34.8	7.1	24
Mary River: 2007														
	GO-09	3-Aug-07	4.8	1.6	9.4	4.1	2.4	3	1.6	0.9	1.9	0.5	0.3	3
	GO-09	5-Sep-07	88.7	71.1	104.1	16.6	9.6	3	32.2	16.0	47.1	15.6	9.0	3
	GO-09	2007	46.7	1.6	104.1	47.3	19.3	6	16.9	0.9	47.1	19.4	7.9	6
	GO-03	3-Aug-07	0.5	0.2	0.6	0.2	0.1	3	<0.5	<0.5	<0.5	0.0	0.0	3
	GO-03	5-Sep-07	13.2	9.7	16.1	3.2	1.9	3	7.8	4.7	9.9	2.8	1.6	3
	GO-03	2007	6.8	0.2	16.1	7.2	3.0	6	4.0	0.3	9.9	4.5	1.8	6
	EO-01	2-Aug-07	5.4	3.0	8.0	2.5	1.5	3	<0.5	<0.5	<0.5	0.0	0.0	3

Table 4.2-11. - Continued -

Watershed	Site ID	Sampling Date	Ash-free dry weight (g/m^2)						Chlorophyll *a* (mg/m^2)					
			Mean	Min	Max	SD	SE	n	Mean	Min	Max	SD	SE	n
	EO-01	4-Sep-07	8.1	6.0	9.5	1.8	1.1	3	8.3	7.1	9.9	1.4	0.8	3
	EO-01	2007	6.7	3.0	9.5	2.5	1.0	6	4.3	0.3	9.9	4.5	1.8	6
	CO-10	2-Aug-07	<0.05	<0.05	0.05	0.01	0.01	3	1.0	<0.5	2.4	1.2	0.7	3
	CO-10	4-Sep-07	24.5	21.8	27.6	2.9	1.7	3	4.7	4.2	5.2	0.5	0.3	3
	CO-10	2007	12.3	0.0	27.6	13.5	5.5	6	2.8	0.3	5.2	2.2	0.9	6
	CO-01	2-Aug-07	17.2	13.9	21.5	3.9	2.3	3	7.4	1.9	10.4	4.8	2.8	3
	CO-01	3-Sep-07	52.8	23.1	99.4	40.9	23.6	3	10.4	6.1	18.4	6.9	4.0	3
	CO-01	2007	35.0	13.9	99.4	32.5	13.3	6	8.9	1.9	18.4	5.6	2.3	6
	All Sites	Summer	5.6	<0.05	21.5	6.8	1.8	15	2.1	<0.5	10.4	3.4	0.9	15
	All Sites	Fall	37.5	6.0	104.1	35.2	9.1	15	12.7	4.2	47.1	12.2	3.1	15
	All Sites	2007	21.5	<0.05	104.1	29.7	5.4	30	7.4	<0.5	47.1	10.3	1.9	30
Tom River: 2007														
	IO-04	31-Jul-07	14.9	7.0	23.3	8.2	4.7	3	5.6	<0.5	13.2	6.8	3.9	3
	IO-04	5-Sep-07	6.8	4.6	9.1	2.3	1.3	3	2.9	<0.5	5.2	2.5	1.4	3
	IO-04	2007	10.8	4.6	23.3	7.0	2.8	6	4.2	0.3	13.2	4.8	2.0	6
	IO-01	1-Aug-07	11.4	4.7	18.0	6.7	3.8	3	9.4	6.6	13.2	3.4	2.0	3
	IO-01	5-Sep-07	14.7	6.5	19.8	7.2	4.1	3	15.2	5.7	29.7	12.7	7.3	3
	IO-01	2007	13.0	4.7	19.8	6.5	2.6	6	12.3	5.7	29.7	8.9	3.6	6
	All Sites	Summer	13.1	4.7	23.3	6.9	2.8	6	7.5	<0.5	13.2	5.2	2.1	6
	All Sites	Fall	10.8	4.6	19.8	6.4	2.6	6	9.1	<0.5	29.7	10.6	4.3	6
	All Sites	2007	11.9	4.6	23.3	6.5	1.9	12	8.3	<0.5	29.7	8.0	2.3	12
Sheardown Lake Tributaries: 2007														
	SDLT-1 R4	27-Jun-07	18.6	16.0	21.2	3.7	2.6	2	4.2	2.4	6.1	2.7	1.9	2
	SDLT-1 R4	29-Jul-07	36.3	22.4	54.0	16.1	9.3	3	17.7	5.7	25.0	10.5	6.1	3
	SDLT-1 R4	31-Aug-07	38.9	24.6	48.1	12.6	7.3	3	39.4	33.0	46.6	6.9	4.0	3
	SDLT-1 R4	2007	32.8	16.0	54.0	14.1	5.0	8	22.5	2.4	46.6	16.5	5.8	8

Table 4.2-11. - Continued -

Watershed	Site ID	Sampling Date	Ash-free dry weight (g/m^2)						Chlorophyll *a* (mg/m^2)					
			Mean	Min	Max	SD	SE	n	Mean	Min	Max	SD	SE	n
	SDLT-1 R2	28-Jun-07	13.5	6.8	23.2	8.6	5.0	3	1.4	0.9	1.9	0.5	0.3	3
	SDLT-1 R2	29-Jul-07	19.0	12.2	25.3	6.6	3.8	3	6.0	2.4	12.2	5.5	3.2	3
	SDLT-1 R2	31-Aug-07	46.1	27.5	78.6	28.3	16.3	3	10.4	5.2	14.6	4.8	2.8	3
	SDLT-1 R2	2007	26.2	6.8	78.6	21.4	7.1	9	5.9	0.9	14.6	5.3	1.8	9
	SDLT-12 US	27-Jun-07	70.3	7.5	176.3	92.4	53.3	3	9.9	1.9	18.4	8.3	4.8	3
	SDLT-12 US	28-Jul-07	238.3	149.4	342.5	97.4	56.3	3	47.2	7.5	108.3	53.7	31.0	3
	SDLT-12 US	1-Sep-07	244.2	207.7	268.2	32.2	18.6	3	62.8	61.2	65.9	2.7	1.6	3
	SDLT-12 US	2007	184.2	7.5	342.5	109.9	36.6	9	40.0	1.9	108.3	36.0	12.0	9
	SDLT-12 DS	27-Jun-07	43.2	13.8	76.7	31.6	18.3	3	8.3	3.3	10.8	4.3	2.5	3
	SDLT-12 DS	28-Jul-07	5.5	2.0	7.9	3.1	1.8	3	3.3	0.9	4.7	2.1	1.2	3
	SDLT-12 DS	1-Sep-07	19.9	10.4	36.0	14.0	8.1	3	11.9	7.1	20.7	7.6	4.4	3
	SDLT-12 DS	2007	22.8	2.0	76.7	23.9	8.0	9	7.8	0.9	20.7	5.9	2.0	9
	SDLT-9 US	28-Jun-07	2.7	1.4	5.1	2.1	1.2	3	0.7	<0.5	1.4	0.6	0.4	3
	SDLT-9 US	31-Jul-07	91.3	49.3	152.9	54.5	31.5	3	45.2	33.0	65.9	18.0	10.4	3
	SDLT-9 US	1-Sep-07	55.8	39.3	68.6	15.0	8.7	3	21.8	11.8	37.7	13.9	8.0	3
	SDLT-9 US	2007	49.9	1.4	152.9	47.9	16.0	9	22.6	<0.5	65.9	22.4	7.5	9
	SDLT-9 DS	28-Jun-07	14.9	7.3	27.0	10.6	6.1	3	7.4	4.2	13.2	5.0	2.9	3
	SDLT-9 DS	2007	14.9	7.3	27.0	10.6	6.1	3	7.4	4.2	13.2	5.0	2.9	3
	All Sites	Spring	27.7	1.4	176.3	42.4	10.3	17	5.4	<0.5	18.4	5.3	1.3	17
	All Sites	Summer	78.1	2.0	342.5	98.0	25.3	15	23.9	0.9	108.3	29.3	7.6	15
	All Sites	Fall	81.0	10.4	268.2	87.3	22.6	15	29.3	5.2	65.9	21.5	5.6	15
	All Sites	2007	60.8	1.4	342.5	80.7	11.8	47	18.9	<0.5	108.3	22.9	3.3	47
Sheardown Lake Tributaries: 2008														
	SDLT-1 R4	26-Jun-08	26.3	22.9	28.6	3.0	1.7	3	7.4	3.5	12.0	4.3	2	3
	SDLT-1 R4	25-Jul-08	15.2	8.1	26.8	10.1	5.8	3	5.8	1.8	9.2	3.7	2	6
	SDLT-1 R4	28-Aug-08	31.5	28.2	38.3	5.9	3.4	3	19.1	9.5	26.7	8.8	5	6

Table 4.2-11. - Continued -

Watershed	Site ID	Sampling Date	Ash-free dry weight (g/m^2)						Chlorophyll *a* (mg/m^2)					
			Mean	Min	Max	SD	SE	n	Mean	Min	Max	SD	SE	n
	SDLT-1 R4	2008	24.4	8.1	38.3	9.4	3.1	9	10.8	1.8	26.7	8.2	2.7	9
	SDLT-1 R2	26-Jun-08	53.9	12.9	131.7	67.4	38.9	3	3.8	1.1	8.5	4.1	2	3
	SDLT-1 R2	25-Jul-08	12.4	4.9	22.2	8.9	5.1	3	2.2	0.8	3.6	1.4	1	6
	SDLT-1 R2	28-Aug-08	17.4	8.1	30.3	11.5	6.7	3	2.6	0.8	3.8	1.6	1	6
	SDLT-1 R2	2008	27.9	4.9	131.7	39.7	13.2	9	2.9	0.8	8.5	2.4	0.8	9
	SDLT-1 R1	26-Jun-08	18.6	17.6	19.1	0.8	0.5	3	3.7	1.6	7.2	3.1	2	3
	SDLT-1 R1	25-Jul-08	6.2	3.9	9.7	3.0	1.7	3	2.5	1.5	4.4	1.6	1	3
	SDLT-1 R1	28-Aug-08	27.2	10.9	41.6	15.4	8.9	3	7.9	4.9	13.5	4.8	3	3
	SDLT-1 R1	2008	17.3	3.9	41.6	12.1	4.0	9	4.7	1.5	13.5	3.9	1.3	9
	SDLT-1 All sites	Spring 2008	32.9	12.9	131.7	37.4	12.5	9	5.0	1.1	12.0	3.8	1.3	9
	SDLT-1 All sites	Summer 2008	11.3	3.9	26.8	8.0	2.7	9	3.5	0.8	9.2	2.7	0.9	9
	SDLT-1 All sites	Fall 2008	25.4	8.1	41.6	11.9	4.0	9	9.9	0.8	26.7	8.9	3.0	9
	SDLT-1 All sites	2008	23.2	3.9	131.7	24.0	4.6	27	6.1	0.8	26.7	6.2	1.2	27
Mary Lake South Tributaries														
	MLST-2	25-Jun-08	35.8	0.3	65.8	33.1	19.1	3	11.5	<0.5	17.1	9.7	6	3
	MLST-2	25-Jul-08	40.8	13.1	66.9	26.9	15.6	3	5.3	<0.5	14.1	7.6	4	3
	MLST-2	2008	38.3	0.3	66.9	27.1	11.1	6	8.4	<0.5	17.1	8.5	3.5	6
Study Area: 2007														
	All Sites	Spring 2007	27.7	1.37	176.3	42.4	10.3	17	5.4	<0.5	18.4	5.3	1.3	17
	All Sites	Summer 2007	33.3	<0.05	342.5	62.4	9.0	48	13.4	<0.5	108.3	22.2	3.2	48
	All Sites	Fall 2007	49.1	4.61	268.2	58.9	8.5	48	24.3	<0.5	136.6	26.8	3.9	48
	All Sites	2007	39.2	<0.05	342.5	58.5	5.5	113	16.8	<0.5	136.6	23.7	2.2	113
Study Area: 2008														
	All sites	Spring 2008	33.7	0.3	131.7	34.9	10.1	12	6.6	<0.5	17.1	6.0	1.7	12
	All sites	Summer 2008	18.7	3.9	66.9	18.9	5.4	12	4.0	<0.5	14.1	4.1	1.2	12
	All sites	Fall 2008	25.4	8.1	41.6	11.9	4.0	9	9.9	0.8	26.7	8.9	3.0	9
	All sites	2008	26.0	0.3	131.7	24.9	4.3	33	6.5	<0.5	26.7	6.6	6.5	33

Table 4.2-11. - Continued -

Watershed	Site ID	Sampling Date	Pheophytin *a* (mg/m^2)						Total chlorophyll *a* (mg/m^2)					
			Mean	Min	Max	SD	SE	n	Mean	Min	Max	SD	SE	n
Camp Lake Tributaries: 2007														
	CLT-1 US	5-Aug-07	20.6	4.7	33.9	14.8	8.5	3	25.7	6.1	39.6	17.5	10.1	3
	CLT-1 US	4-Sep-07	97.3	51.8	169.5	63.2	36.5	3	146.3	72.0	277.8	114.2	65.9	3
	CLT-1 US	2007	58.9	4.7	169.5	58.8	24.0	6	86.0	6.1	277.8	98.5	40.2	6
	CLT-1 DS	5-Aug-07	24.5	19.8	33.4	7.8	4.5	3	33.4	23.1	48.5	13.4	7.7	3
	CLT-1 DS	2-Sep-07	45.4	35.3	56.5	10.6	6.1	3	66.2	50.9	78.2	14.0	8.1	3
	CLT-1 DS	2007	34.9	19.8	56.5	14.1	5.8	6	49.8	23.1	78.2	21.7	8.9	6
	CLT-2 US	4-Aug-07	3.5	<0.5	8.0	4.0	2.3	3	47.5	18.6	96.5	42.7	24.7	3
	CLT-2 US	2-Sep-07	6.7	4.2	9.4	2.6	1.5	3	67.8	24.5	146.0	67.8	39.2	3
	CLT-2 US	2007	5.1	0.3	9.4	3.5	1.4	6	57.6	18.6	146.0	51.9	21.2	6
	CLT-2 DS	4-Aug-07	24.3	9.4	33.4	13.0	7.5	3	35.3	14.1	46.6	18.4	10.6	3
	CLT-2 DS	2-Sep-07	30.8	7.1	65.9	31.1	17.9	3	61.5	16.0	117.7	51.7	29.8	3
	CLT-2 DS	2007	27.5	7.1	65.9	21.6	8.8	6	48.4	14.1	117.7	37.5	15.3	6
	All Sites	Summer	18.2	0.3	33.9	12.9	3.7	12	35.5	6.1	96.5	23.4	6.8	12
	All Sites	Fall	45.0	4.2	169.5	46.1	13.3	12	85.5	16.0	277.8	71.3	20.6	12
	All Sites	2007	31.6	0.3	169.5	35.8	7.3	24	60.5	6.1	277.8	57.8	11.8	24
Mary River: 2007														
	GO-09	3-Aug-07	1.9	0.9	2.8	0.9	0.5	3	3.5	1.9	4.7	1.4	0.8	3
	GO-09	5-Sep-07	18.5	10.4	33.0	12.5	7.2	3	50.7	28.3	80.0	26.6	15.3	3
	GO-09	2007	10.2	0.9	33.0	12.1	4.9	6	27.1	1.9	80.0	30.9	12.6	6
	GO-03	3-Aug-07	<0.5	<0.5	0.5	0.1	0.1	3	0.6	<1	0.7	0.1	0.1	3
	GO-03	5-Sep-07	3.8	0.9	8.5	4.1	2.4	3	11.6	5.7	18.4	6.4	3.7	3
	GO-03	2007	2.0	0.3	8.5	3.2	1.3	6	6.1	<1	18.4	7.3	3.0	6
	EO-01	2-Aug-07	<0.5	<0.5	<0.5	0.0	0.0	3	<1	<1	<1	0.0	0.0	3

Table 4.2-11. - Continued -

Watershed	Site ID	Sampling Date	Pheophytin *a* (mg/m^2)						Total chlorophyll *a* (mg/m^2)					
			Mean	Min	Max	SD	SE	n	Mean	Min	Max	SD	SE	n
	EO-01	4-Sep-07	6.1	3.8	8.5	2.4	1.4	3	14.4	13.2	16.5	1.8	1.0	3
	EO-01	2007	3.2	0.3	8.5	3.5	1.4	6	7.5	<1	16.5	7.7	3.2	6
	CO-10	2-Aug-07	0.8	<0.5	1.9	0.9	0.5	3	1.7	<1	4.2	2.2	1.2	3
	CO-10	4-Sep-07	5.7	2.4	7.5	2.9	1.7	3	10.4	6.6	12.2	3.3	1.9	3
	CO-10	2007	3.2	0.3	7.5	3.3	1.3	6	6.1	<1	12.2	5.3	2.2	6
	CO-01	2-Aug-07	8.5	6.1	13.2	4.1	2.4	3	15.9	8.0	23.5	7.8	4.5	3
	CO-01	3-Sep-07	10.4	5.7	13.7	4.2	2.4	3	20.7	17.9	24.0	3.1	1.8	3
	CO-01	2007	9.4	5.7	13.7	3.8	1.6	6	18.3	8.0	24.0	5.9	2.4	6
	All Sites	Summer	2.3	<0.5	13.2	3.6	0.9	15	4.4	<1.0	23.5	6.8	1.7	15
	All Sites	Fall	8.9	0.9	33.0	7.7	2.0	15	21.6	5.7	80.0	18.7	4.8	15
	All Sites	2007	5.6	<0.5	33.0	6.8	1.2	30	13.0	<1.0	80.0	16.4	3.0	30
Tom River: 2007														
	IO-04	31-Jul-07	7.5	<0.5	19.3	10.3	6.0	3	13.0	<1.0	32.5	17.1	9.9	3
	IO-04	5-Sep-07	3.2	<0.5	7.1	3.5	2.0	3	6.1	<1.0	12.2	5.9	3.4	3
	IO-04	2007	5.3	0.3	19.3	7.3	3.0	6	9.6	<1.0	32.5	12.0	4.9	6
	IO-01	1-Aug-07	12.7	10.4	16.5	3.3	1.9	3	22.1	17.0	29.7	6.7	3.9	3
	IO-01	5-Sep-07	8.0	2.4	18.8	9.4	5.4	3	23.2	8.5	32.0	12.9	7.4	3
	IO-01	2007	10.4	2.4	18.8	6.8	2.8	6	22.7	8.5	32.0	9.2	3.7	6
	All Sites	Summer	10.1	<0.5	19.3	7.4	3.0	6	17.6	<1.0	32.5	12.6	5.2	6
	All Sites	Fall	5.6	<0.5	18.8	6.9	2.8	6	14.7	<1.0	32.0	12.9	5.3	6
	All Sites	2007	7.9	<0.5	19.3	7.2	2.1	12	16.1	<1.0	32.5	12.3	3.5	12
Sheardown Lake Tributaries: 2007														
	SDLT-1 R4	27-Jun-07	11.8	4.2	19.3	10.7	7.5	2	16.0	10.4	21.7	8.0	5.7	2
	SDLT-1 R4	29-Jul-07	17.1	9.4	28.3	9.9	5.7	3	34.8	15.1	50.9	18.2	10.5	3
	SDLT-1 R4	31-Aug-07	28.1	3.8	56.5	26.6	15.4	3	67.5	42.4	103.1	31.7	18.3	3
	SDLT-1 R4	2007	19.9	3.8	56.5	17.2	6.1	8	42.4	10.4	103.1	29.7	10.5	8

Table 4.2-11. - Continued -

Watershed	Site ID	Sampling Date	Pheophytin *a* (mg/m^2)						Total chlorophyll *a* (mg/m^2)					
			Mean	Min	Max	SD	SE	n	Mean	Min	Max	SD	SE	n
	SDLT-1 R2	28-Jun-07	19.3	11.8	27.3	7.8	4.5	3	20.7	12.7	29.2	8.3	4.8	3
	SDLT-1 R2	29-Jul-07	24.2	17.4	32.0	7.4	4.2	3	30.1	19.8	44.3	12.7	7.3	3
	SDLT-1 R2	31-Aug-07	57.3	35.3	70.6	19.2	11.1	3	67.6	40.5	85.2	23.9	13.8	3
	SDLT-1 R2	2007	33.6	11.8	70.6	21.0	7.0	9	39.5	12.7	85.2	25.7	8.6	9
	SDLT-12 US	27-Jun-07	43.5	8.0	65.9	31.1	17.9	3	53.4	9.9	75.3	37.7	21.7	3
	SDLT-12 US	28-Jul-07	42.2	8.9	61.2	28.9	16.7	3	89.5	16.5	164.8	74.2	42.8	3
	SDLT-12 US	1-Sep-07	20.7	17.4	26.4	4.9	2.8	3	83.5	79.6	87.6	4.0	2.3	3
	SDLT-12 US	2007	35.5	8.0	65.9	24.1	8.0	9	75.4	9.9	164.8	44.9	15.0	9
	SDLT-12 DS	27-Jun-07	8.9	4.2	12.2	4.2	2.4	3	17.3	7.5	23.1	8.5	4.9	3
	SDLT-12 DS	28-Jul-07	4.6	0.9	6.6	3.1	1.8	3	7.8	1.9	10.8	5.2	3.0	3
	SDLT-12 DS	1-Sep-07	6.3	3.3	12.2	5.2	3.0	3	18.2	10.4	33.0	12.8	7.4	3
	SDLT-12 DS	2007	6.6	0.9	12.2	4.1	1.4	9	14.4	1.9	33.0	9.5	3.2	9
	SDLT-9 US	28-Jun-07	2.3	<0.5	4.2	2.0	1.2	3	3.0	<1.0	5.7	2.6	1.5	3
	SDLT-9 US	31-Jul-07	45.5	4.7	70.6	35.7	20.6	3	90.7	70.6	107.4	18.6	10.7	3
	SDLT-9 US	1-Sep-07	69.8	7.1	127.1	60.2	34.8	3	91.7	18.8	164.8	73.0	42.1	3
	SDLT-9 US	2007	39.2	<0.5	127.1	45.9	15.3	9	61.8	<1	164.8	58.0	19.3	9
	SDLT-9 DS	28-Jun-07	12.4	8.5	20.2	6.8	3.9	3	19.8	12.7	33.4	11.8	6.8	3
	SDLT-9 DS	2007	12.4	8.5	20.2	6.8	3.9	3	19.8	12.7	33.4	11.8	6.8	3
	All Sites	Spring	16.6	<0.5	65.9	18.3	4.4	17	22.0	<1.0	75.3	21.9	5.3	17
	All Sites	Summer	26.7	0.9	70.6	24.0	6.2	15	50.6	1.9	164.8	46.0	11.9	15
	All Sites	Fall	36.4	3.3	127.1	35.7	9.2	15	65.7	10.4	164.8	41.3	10.7	15
	All Sites	2007	26.2	<0.5	127.1	27.4	4.0	47	45.1	<1.0	164.8	40.9	6.0	47
Sheardown Lake Tributaries: 2008														
	SDLT-1 R4	26-Jun-08	17.6	3.4	28.0	12.7	7	3	25.0	15.4	34.7	9.7	6	3
	SDLT-1 R4	25-Jul-08	16.9	10.5	22.1	5.9	3	6	22.7	12.3	31.3	9.6	6	6
	SDLT-1 R4	28-Aug-08	36.9	24.3	48.0	11.9	7	6	56.0	33.8	74.7	20.7	12	6

Table 4.2-11. - Continued -

Watershed	Site ID	Sampling Date	Pheophytin *a* (mg/m^2)						Total chlorophyll *a* (mg/m^2)					
			Mean	Min	Max	SD	SE	n	Mean	Min	Max	SD	SE	n
	SDLT-1 R4	2008	23.8	3.4	48.0	13.5	4.5	9	34.6	12.3	74.7	20.3	6.8	9
	SDLT-1 R2	26-Jun-08	25.2	14.9	42.9	15.5	9	3	29.0	16.7	51.5	19.5	11	3
	SDLT-1 R2	25-Jul-08	20.5	9.7	26.1	9.4	5	6	22.7	10.5	29.1	10.6	6	6
	SDLT-1 R2	28-Aug-08	23.2	9.8	36.5	13.4	8	6	25.8	10.5	39.6	14.6	8	6
	SDLT-1 R2	2008	22.9	9.7	42.9	11.4	3.8	9	25.8	10.5	51.5	13.6	4.5	9
	SDLT-1 R1	26-Jun-08	16.2	12.3	20.3	4.0	2	3	19.9	14.6	27.5	6.8	4	3
	SDLT-1 R1	25-Jul-08	17.2	6.9	29.4	11.4	7	3	19.8	8.3	31.1	11.4	7	3
	SDLT-1 R1	28-Aug-08	39.5	31.7	45.0	7.0	4	3	47.5	37.1	55.4	9.4	5	3
	SDLT-1 R1	2008	24.3	6.9	45.0	13.4	4.5	9	29.0	8.3	55.4	16.0	5.3	9
	SDLT1 All sites	Spring 2008	19.6	3.4	42.9	11.0	3.7	9	24.6	14.6	51.5	12.1	4.0	9
	SDLT1 All sites	Summer 2008	18.2	6.9	29.4	8.1	2.7	9	21.7	8.3	31.3	9.3	3.1	9
	SDLT1 All sites	Fall 2008	33.2	9.8	48.0	12.2	4.1	9	43.1	10.5	74.7	19.1	6.4	9
	SDLT1 All sites	2008	23.7	3.4	48.0	12.3	2.4	27	29.8	8.3	74.7	16.6	3.2	27
Mary Lake South Tributaries														
	MLST-2	25-Jun-08	31.9	2.7	49.0	25.4	15	3	43.4	3.0	66.1	35.1	20	3
	MLST-2	25-Jul-08	48.6	34.6	58.9	12.6	7	3	53.9	34.8	72.9	19.1	11	3
	MLST-2	2008	40.2	2.7	58.9	20.1	8.2	6	48.6	3.0	72.9	25.9	10.6	6
Study Area: 2007														
	All Sites	Spring 2007	16.6	<0.5	65.9	18.3	4.4	17	22.0	<1.0	75.3	21.9	5.3	17
	All Sites	Summer 2007	14.9	<0.5	70.6	17.9	2.6	48	28.3	<1.0	164.8	34.0	4.9	48
	All Sites	Fall 2007	26.1	<0.5	169.5	34.3	4.9	48	50.5	<1.0	277.8	51.4	7.4	48
	All Sites	2007	19.9	<0.5	169.5	26.5	2.5	113	36.8	<1.0	277.8	42.5	4.0	113
Study Area: 2008														
	All sites	Spring 2008	22.7	2.7	49.0	15.4	4.4	12	29.3	3.0	66.1	20.1	5.8	12
	All sites	Summer 2008	25.8	6.9	58.9	16.3	4.7	12	29.8	8.3	72.9	18.4	5.3	12
	All sites	Fall 2008	33.2	9.8	48.0	12.2	4.1	9	43.1	10.5	74.7	19.1	6.4	9
	All sites	2008	26.7	2.7	58.9	15.1	26.7	33	33.2	3.0	74.7	19.6	33.2	33

Table 4.2-12. Comparison of chlorophyll *a* and ash free dry weight (AFDW) of periphyton measured in Mine Area streams and to other Arctic streams.

Project/Study	Location	Stream/Lake	Years	Chlorophyll a (mg/m^2)	AFDW (g/m^2)	Reference
Mary River Project	Mine Area streams	Streams	2007-2008	2.8-52.5	6.7-184.2	This Study
Bathhurst Inlet Port and Road Project	west side of Bathhurst Inlet, NU	6 streams	2001	130-2730	-	Rescan Environmental Services Ltd. (2007.)
Jericho Diamond Project	Near Contwoyto Lake, NU	Means for 2 streams	2000	20-98	-	RL&L (2000)
Arctic stream surveys	Streams in the vicinity of Lac de Gras, NT	9 natural streams	1998-2000	-	Means (1998-2000): 17 - 20	Jones et al. (2003a)
Arctic stream nutrient addition study	Kuparuk River, Alaska	Control Reaches - Riffles	1989	<10	-	Bowden et al. (1992)
		Control Reaches - Pools	1989	approx. 20-150	-	
Stream fertilization study	Hershey Creek, Alaska	Reference area	Jul-02	<100	-	Benstead et al. (2005)
Stream benthic algal study	Tributaries to the Tanana River, Alaska	2 creeks	May 1982-May 1983	Ranged from <0.1-approx. 9 over the year	-	LaPerriere et al. (1989)
		Delta Clearwater Creek	March 1978-May1979	Ranged from approx. 2 - 22 over the year	-	
Carbon study Kuparuk River	Kuparuk River, Alaska	Riffles	July 1978 and 1980	Range: 1.3-3.6	-	Peterson et al. (1986)
		Pools	July 1978 and 1980	Range: 1.2-21.9	-	
Doris North Project	East of Bathurst Inlet, NU	7 streams	1997	Range: 275-6800	-	RL&L/Golder (2002)
			2000	Range: 3.1-6.0	-	
Macroinvertebrate stream study	Imnavait Creek (arctic stream) and Caribou-Poker Creek (sub-arctic stream), Alaska	Imnavait Creek	1981-1983	3.4-348	-	Miller and Stout (1989)
		Caribou-Poker Creek	1981-1983	2.5-146	-	

Table 4.3-1. Crustacean zooplankton survey information for vertical net tows from waterbodies in the Mine Area: 2007 and 2008.

Waterbody	Site ID	UTM Coordinates			Sample Date	Season	No. of Vertical Tows	Sample Depth (m)	Volume Filtered (m^3)
		Zone	Easting	Northing					
Camp Lake									
	JLO-01	17W	557101	7914386	10-Aug-07	summer	1	16.8	0.82
					30-Jul-08	summer	1	17.5	0.86
					17-Sep-07	fall	1	18.9	0.93
	JLO-02	17W	557615	7914750	10-Aug-07	summer	1	11.5	0.56
					30-Jul-08	summer	1	12.6	0.62
					17-Sep-07	fall	1	13.4	0.66
	JLO-09	17W	556335	7913955	10-Aug-07	summer	1	18.6	0.91
					30-Jul-08	summer	1	12.8	0.63
					17-Sep-07	fall	1	15.9	0.78
Sheardown Lake NW									
	DLO-01-1	17W	560080	7913128	7-Aug-07	summer	1	22.8	1.12
					31-Jul-08	summer	1	21.5	1.06
					17-Sep-07	fall	1	22.4	1.10
					2-Sep-08	fall	1	20.6	1.01
	DLO-01-2	17W	560353	7912924	7-Aug-07	summer	1	13.0	0.64
					31-Jul-08	summer	1	17.2	0.84
					17-Sep-07	fall	1	19.9	0.98
					2-Sep-08	fall	1	14.7	0.72
	DLO-01-4	17W	560695	7913043	7-Aug-07	summer	1	6.6	0.32
					31-Jul-08	summer	1	6.4	0.31
					17-Sep-07	fall	1	7.0	0.34
					2-Sep-08	fall	1	6.6	0.32
	DLO-01-5	17W	559798	7913356	7-Aug-07	summer	1	22.5	1.10
					31-Jul-08	summer	1	23.8	1.17
					17-Sep-07	fall	1	25.4	1.25
					2-Sep-08	fall	1	21.2	1.04
	DLO-01-7	17W	560525	7912609	7-Aug-07	summer	1	10.8	0.53
					31-Jul-08	summer	1	11.9	0.58
					17-Sep-07	fall	1	10.6	0.52
					2-Sep-08	fall	1	11.6	0.57
Sheardown Lake SE									
	DLO-02-1	17W	560814	7912116	7-Aug-07	summer	1	12.0	0.59
					31-Jul-08	summer	1	12.8	0.63
					13-Sep-07	fall	1	12.4	0.61
					2-Sep-08	fall	1	11.5	0.56
	DLO-02-3	17W	561046	7911915	7-Aug-07	summer	1	13.7	0.67
					31-Jul-08	summer	1	14.6	0.72
					13-Sep-07	fall	1	1.8 [1]	0.09
					2-Sep-08	fall	1	15.0	0.74

Table 4.3-1. - Continued -

Waterbody	Site ID	UTM Coordinates			Sample Date	Season	No. of Vertical Tows	Sample Depth (m)	Volume Filtered (m^3)
		Zone	Easting	Northing					
	DLO-02-4	17W	561512	7911832	7-Aug-07	summer	1	7.5	0.37
					31-Jul-08	summer	1	8.4	0.41
					13-Sep-07	fall	1	7.2	0.35
					2-Sep-08	fall	1	9.0	0.44
Mary Lake									
	BLO-01	17W	554695	7913212	9-Aug-07	summer	1	10.5	0.52
					6-Aug-08	summer	1	10.6	0.52
					19-Sep-07	fall	1	11.2	0.55
	BLO-03	17W	552680	7906651	14-Aug-07	summer	1	19.2	0.94
					5-Aug-08	summer	1	17.5	0.86
					20-Sep-07	fall	1	14.1	0.69
	BLO-04	17W	553817	7904886	14-Aug-07	summer	1	21.6	1.06
					5-Aug-08	summer	1	20.3	1.00
					18-Sep-07	fall	1	20.3	1.00
	BLO-05	17W	554771	7906033	14-Aug-07	summer	1	18.4	0.90
					5-Aug-08	summer	1	20.8	1.02
					18-Sep-07	fall	1	11.9	0.58
	BLO-06	17W	555924	7903760	14-Aug-07	summer	1	9.4	0.46
					18-Sep-07	fall	1	8.8	0.43

[1] 17W 560950 7911917

Table 4.3-2. Summary statisitics for total crustacean zooplankton density (individuals/m^3) by waterbody (seasonally and overall) for the Mary River Mine Area: 2007 and 2008.

Waterbody	Season	n [1]	Mean	Median	SD	SE	Min	Max	Taxonomic Richness [2]
Camp Lake									
	Summer	6	11,772	11,077	8,442	3,447	3,244	22,619	4
	Fall	3	9,829	6,901	6,269	3,620	5,561	17,027	5
	Overall	9	11,125	6,901	7,437	2,479	3,244	22,619	5
Sheardown Lake Northwest									
	Summer	10	11,878	10,770	8,335	2,636	2,637	26,211	7
	Fall	10	19,966	13,979	17,352	5,487	3,753	53,307	6
	Overall	20	15,922	12,706	13,883	3,104	2,637	53,307	7
Sheardown Lake Southeast									
	Summer	6	13,127	9,290	10,132	4,136	3,303	31,074	6
	Fall	6	10,578	10,834	5,707	2,330	4,776	16,854	6
	Overall	12	11,852	9,290	7,952	2,296	3,303	31,074	7
Mary Lake									
	Summer	9	2,713	2,208	2,246	749	750	7,811	9
	Fall	5	6,147	5,588	5,159	2,307	1,528	13,832	5
	Overall	14	3,939	2,281	3,769	1,007	750	13,832	9

1 number of samples collected in 2007 and 2008

2 total number of taxa observed to species-level, not the average number of taxa

Table 4.3-3. Comparison of zooplankton densities and community structure observed in Mine Area lakes to other northern Canada waterbodies.

Project/Study	General Location	Lake	Years	Crustacean Zooplankton Density (individuals/m^3)	Dominant Crustacean Zooplankton Taxa	Number of Crustacean Zooplankton Species	Comments	Reference
Mary River Project	Mine Area lakes, Baffin Island	Camp Lake	2007	11,125	Copopeda dominant (most abundant copepods *Cyclops scutifer* and *Diaptomus minutus*; most abundant cladocerans *Daphnia longiremis* and *Bosmina longirostris*)	9 (all combined)	depth-integrated; 63 um	This Study
		Sheardown Lake NW	2007, 2008	15,922				
		Sheardown Lake SE	2007	11,852				
		Mary Lake	2007	3,939				
Limnological investigation of Nettilling Lake	south-central Baffin Island	Nettilling Lake	1956	-	*C. scutifer*, *D. minutus*, and *D. longiremus* predominant	10	densities not provided; species list very similar to Mine Area lakes	Oliver (1964)
Distribution of aquatic invertebrates	Frobisher Bay and Cumberland Peninsula, Baffin Island	18 pools, ponds, and lakes	1969, 1975	-	Copepods dominant (*D. minutus* most abundant copepod; *Daphnia pulex* most abundant cladoceran)	8 (all combined)	collected near shore; 76 um; densities not provided; species list somewhat dissimilar to Mine Area lakes, but different types of habitat sampled	Bushnell and Byron (1979)

Table 4.3-3. – Continued -

Project/Study	General Location	Lake	Years	Crustacean Zooplankton Density (individuals/m^3)	Dominant Crustacean Zooplankton Taxa	Number of Crustacean Zooplankton Species	Comments	Reference
Aquatic resource survey of northern Baffin Island	northern Baffin Island	Nina Bang Lake	1980	11,870	Copepods dominant (*C. scutifer* most abundant copepod; *D. longiremis* most abundant cladoceran)	8 (all combined)	depth-integrated; 73 um	Stewart and MacDonald (1981)
		Unnamed Lake, Milne Inlet	1980	280				
		Erichsen Lake	1980	24,700				
Limnological survey of subarctic lakes	south-central and south-western Yukon (Yukon River drainage basin)	19 lakes	1982 (summer); 1983 (March)	-	*C. scutifer*, *D. longiremis*, *Diaptomus pribilofensis* (calanoid copepod) predominant	species list not provided	depth-integrated; 100 um; densities not provided	Shortreed and Stockner (1986)
Zoogeography of lakes and rivers in arctic Alaska	Toolik Lake area in Arctic Alaska	42 lakes	1988, 1990	-	Based on presence/absence across lakes, copepods dominant (*D. pribilofensis* most abundant copepod; *Daphnia middendorphiana* most abundant cladoceran)	8 (all combined)	vertical or oblique hauls; 100 or 335 um; densities not provided, only presence/absence	Kling et al. (1992)

Table 4.3-3. – Continued -

Project/Study	General Location	Lake	Years	Crustacean Zooplankton Density (individuals/m^3)	Dominant Crustacean Zooplankton Taxa	Number of Crustacean Zooplankton Species	Comments	Reference
Physical, chemical, and biotic effects on Arctic zooplankton communities	Toolik Lake area in Arctic Alaska	104 lakes	1996-1999	-	Species list: *B. longirostris*, *D. longiremis*, *D. pribilofensis*, *C. scutifer*; *Holopedium gibberum*, *D. middendorffiana*, *Heterocope septentrionalis*, *Polyphemus pedunculus*	8 (all combined)	depth-integrated; 335 um (adult crustacean zooplankton); densities not provided; species list somewhat dissimilar to Mine Area lakes	O'Brien et al. (2004)
Response and recovery to nutrient addition of a partitioned Arctic lake	Toolik Lake, Alaska	oligotrophic Lake N-2 (reference condition)	reference condition: pre-fertilization (<1985)	10,000-30,000	Four species commonly present pre-fertilization: *D. longiremis*, *B. longirostris*, *D. pribilofensis*, and *C. scutifer*	complete species list not provided	pre-fertilization methods not indicated; during experiment, depth-integrated, 335 um (adult crustacean zooplankton)	O'Brien et al. (2005)
Doris Hinge Project	Doris Hinge Area: east of Bathurst Inlet (Nunavut)	8 lakes	1996, 1997, and 2000	235-34,634	Crustacean zooplankton typically dominated by copepods (usually cyclopoids); *C. scutifer* and *D. longiremis* were common	complete species list not provided	depth-integrated; 118 um; rotifers enumerated, although likely underestimated due to inappropriate mesh size; total density in report includes rotifers	R.L. & L. / Golder (2002)

Table 4.3-3. – Continued -

Project/Study	General Location	Lake	Years	Crustacean Zooplankton Density (individuals/m^3)	Dominant Crustacean Zooplankton Taxa	Number of Crustacean Zooplankton Species	Comments	Reference
Jericho Diamond Project	420 km northeast of Yellowknife	2 lakes	2000	1,743-5,941	Calanoid copepods were the dominant taxonomic group; within this group, *Leptodiaptomus minutus* and *Leptodiaptomus sicilis* were the most important species; *Daphnia pulex* was the dominant cladoceran	7 (combined)	depth-integrated; 64 um; rotifers enumerated; total density in report includes rotifers	R.L. & L. (2000)
Meadowbank Gold Project	75 km north of the hamlet of Baker Lake, Nunavut	9 lakes and 3 ponds	1997, 1998, 2002, 2003	1,202-19,702	Calanoid copepods were the dominant taxonomic group, except in small ponds (cladocerans or cyclopoid copepods predominant); *Leptodiaptomus ashlandi* (calanoid) was the most abundant species in most lakes	20 (all combined); 7 cladocerans, 7 calanoids, 6 cyclopoids	depth-integrated; 64 um and 250 um	Cumberland Resources (2005)

Table 4.3-4. Drifting invertebrate survey information from streams in the Mine Area: 2007 and 2008.

Waterbody	Site ID	UTM Coordinates			Sample Date	
		Zone	Easting	Northing	2007	2008
Stream Sites						
Camp Lake Tributaries	CLT-1	17W	557597	7914863	summer (3/4 Aug); fall (2/3 Sep)	-
	CLT-2	17W	557452	7914955	summer (3/4 Aug); fall (2/3 Sep)	-
Sheardown Lake Tributaries	SDLT-1	17W	560324	7913498	spring (25/26 Jun); summer (28/29 Jul); fall (31 Aug/1 Sep)	spring (25 Jun); summer (25 Jul); fall (11 Sep)
	SDLT-9	17W	561739	7911801	spring (28/29 Jun)	-
	SDLT-12	17W	560951	7912996	spring (25/26 Jun); summer (28/29 Jul); fall (31 Aug/1 Sep)	-
Mary Lake - South Tributary	MLST-2	17W	552111	7905088	-	spring (24/25 Jun); summer (25/26 Jul)

Table 4.3-5. Summary statisitics for total drifting invertebrate density (individuals/100m^3) by stream (seasonally and overall) for the Mine Area: 2007 and 2008.

Water-body	Season	Study Year	n [1]	Mean	Median	SD	SE	Min	Max	Taxonomic Richness [2]	Dominant Taxon
Camp Lake Tributaries Combined [3]											
	Spring	-	-	-	-	-	-	-	-	-	-
	Summer	2007	6	66.30	52.06	66.79	27.27	0.00	196.11	4	Orthocladiinae
	Fall	2007	6	67.91	54.76	42.13	17.20	26.87	127.76	4	Orthocladiinae
	Overall	2007	12	67.11	52.06	53.25	15.37	0.00	196.11	7	Orthocladiinae
Sheardown Lake Tributaries Combined [4]											
	Spring	2007, 2008	12	185.52	39.72	217.26	62.72	3.85	606.69	9	Orthocladiinae
	Summer	2007, 2008	9	16.33	16.60	19.06	6.35	0.00	62.10	7	unidentified Chironomidae adult
	Fall	2007, 2008	8	18.94	12.18	19.03	6.73	0.00	59.09	6	Orthocladiinae
	Overall	2007, 2008	29	87.06	17.80	160.70	29.84	0.00	606.69	16	Orthocladiinae
Mary Lake South Tributary 2 [5]											
	Spring	2008	3	7.10	3.87	9.14	5.28	0.00	17.42	3	Orthocladiinae
	Summer	2008	3	13.30	11.40	10.58	6.11	3.80	24.69	5	other Annelida
	Fall	-	-	-	-	-	-	-	-	-	-
	Overall	2008	6	10.20	7.63	9.47	3.87	0.00	24.69	6	Orthocladiinae

[1] number of samples collected in 2007 and 2008

[2] total number of taxa observed to family-level, not the average number of taxa

[3] site ID: CLT-1, CLT-2

[4] site ID: SDLT-1, SDLT-9, SDLT-12

[5] site ID: MLST-2

Table 4.3-6. Comparison of drifting invertebrate densities and community structure observed in Mine Area streams to other northern Canada waterbodies.

Project/Study	General Location	Stream	Years	Drift Density (individuals/ 100m^3)	Dominant Drifting Invertebrate Taxa	Number of Drifting Invertebrate Taxa	Comments	Reference
Mary River Project	Mine LSA streams, Baffin Island	two tributaries to Camp Lake	2007	overal mean (seasonal range): 67 (66-68)	Orthocladiinae (Chironimidae)	7 families	standard drift trap (0.225 m^2); 500 um mesh net	This Study
		three tributaries to Sheardown Lake	2007, 2008	overal mean (seasonal range): 87 (16-186)	Orthocladiinae	16 families		
		one tributary to Mary Lake	2008	overal mean (seasonal range): 10 (7-13)	Orthocladiinae dominated with 'other types of annelids', hymenopterans, and Chironominae larvae occaisionally abundant	6 families		
Macroinvertebrate community composition in an Arctic and subarctic stream	northern Alaska	Imnavait Creek (arctic; first order)	1981, 1982, 1983	seasonal means: 2-350	chironomids dominated with stoneflies (Nemouridae) often abundant for all sample types combined; complete species list by sampling method not provided	number of species a composite of drift, Hess, and rock basket samples; 112 species	drift nets; 363 um mesh net	Miller and Stout (1989)

Table 4.3-6. – Continued -

Project/Study	General Location	Stream	Years	Drift Density (individuals/ 100m^3)	Dominant Drifting Invertebrate Taxa	Number of Drifting Invertebrate Taxa	Comments	Reference
		Caribou-Poker Creek (sub-arctic; fourth order)		seasonal means: 26-94	chironomids and black-flies (Simuliidae) dominated with mayflies and stoneflies (Perlodidae) often abundant for all sample types combined; complete species list by sampling method not provided	number of species a composite of drift, Hess, and rock basket samples; 138 species		
Ecological characteristics of streams in Canadian Arctic	Barrenlands near Lac de Gras, NWT	Polar-Vulture, Pigeon: two lake outlet streams	summer 1999 (Polar-Vulture only), summer 2000	overall mean estimated: 1152 (micro-crustaceans removed)	composed mainly of microcrustaceans (cladocerans, copepods, ostracods); remaining organisms consited primarily of dipterans (Chironomidae, Simuliidae)	complete species list not provided	Field-Dodgson tri-net samplers; 250 um nets; enumerated micro-crustaceans (cladocerans, copepods, ostracods) and included in drift density calculations	Jones et al. (2003b)
Doris Hinge Project	Doris Hinge Area: east of Bathurst Inlet (Nunavut)	7 lake outlet streams	1997 (twice), 2000 (once)	overall mean and seasonal range estimated: 202 (136-302) (cladoercans and copepods removed)	Chironomidae, Simuliidae, Ostracoda, and Cladocera dominated	raw data available in appendix, but not summarized	cone-shaped net; 500 um mesh	R.L. & L. / Golder (2002)

Table 4.3-7. Locations of benthic invertebrate lake and stream sampling sites in the Mine Area: 2005 to 2008.

Waterbody	Site ID	Habitat Type	UTM			Sample Date
			Zone	Easting	Northing	
Lake Sites						
Camp Lake						
	JLO-10-B1	4	17W	556085	7913755	02-Sep-07
	JLO-10-B2	4	17W	556085	7913753	02-Sep-07
	JLO-10-B3	4	17W	556087	7913757	02-Sep-07
	JLO-01-B1	14	17W	557099	7914360	01-Sep-07
	JLO-01-B2	14	17W	557105	7914375	01-Sep-07
	JLO-01-B3	14	17W	557104	7914374	01-Sep-07
	JLO-02-B1	14	17W	557617	7914749	31-Aug-07
	JLO-02-B2	14	17W	557621	7914750	31-Aug-07
	JLO-02-B3	14	17W	557624	7914747	31-Aug-07
	JLO-07-B1	14	17W	556705	7914182	02-Sep-07
	JLO-07-B2	14	17W	556715	7914157	02-Sep-07
	JLO-07-B3	14	17W	556719	7914170	02-Sep-07
	JLO-09-B1	14	17W	556332	7913948	02-Sep-07
	JLO-09-B2	14	17W	556342	7913946	02-Sep-07
	JLO-09-B3	14	17W	556324	7913946	02-Sep-07
Sheardown Lake NW						
	SDL-Hab4-Stn1	4	17W	560401	7912573	8-Sep-08
	SDL-Hab4-Stn2	4	17W	560503	7912526	8-Sep-08
	SDL-Hab4-Stn3	4	17W	560605	7912654	8-Sep-08
	SDL-Hab4-Stn4	4	17W	560582	7912730	8-Sep-08
	SDL-Hab4-Stn5	4	17W	560561	7912801	8-Sep-08
	DD-Hab4-Stn-1	4	17W	560420	7913355	12-Sep-08
	DD-Hab4-Stn-2	4	17W	560374	7913391	12-Sep-08
	DD-Hab4-Stn-3	4	17W	560351	7913426	12-Sep-08
	DD-Hab9-Stn-1	9	17W	560259	7913455	12-Sep-08
	DD-Hab9-Stn-2	9	17W	560323	7913402	12-Sep-08
	DD-Hab9-Stn-3	9	17W	560354	7913358	12-Sep-08
	DLO-01-3-B1	9	17W	560466	7912837	15-Sep-07
	DLO-01-3-B2	9	17W	560485	7912833	15-Sep-07
	DLO-01-3-B3	9	17W	560496	7912815	15-Sep-07
	DLO-01-3-B1	9	17W	560474	7912833	12-Sep-08
	DLO-01-4-B1	9	17W	560690	7913045	07-Sep-07
	DLO-01-4-B2	9	17W	560678	7913055	07-Sep-07
	DLO-01-4-B3	9	17W	560683	7913060	07-Sep-07
	DLO-01-4-B1	9	17W	560695	7913043	9-Sep-08
	DLO-01-4-B2	9	17W	560775	7913069	9-Sep-08
	DLO-01-6-B1	9	17W	559705	7913525	14-Sep-07
	DLO-01-6-B2	9	17W	559721	7913526	14-Sep-07
	DLO-01-6-B3	9	17W	559705	7913506	14-Sep-07
	DLO-01-6-B1	9	17W	559685	7913509	11-Sep-08
	DLO-01-6-B2	9	17W	559680	7913564	11-Sep-08

Table 4.3-7. - Continued -

Waterbody	Site ID	Habitat Type	UTM			Sample Date
			Zone	Easting	Northing	
Lake Sites conitinued						
Sheardown Lake NW continued						
	DLO-01-7-B1	9	17W	560520	7912616	07-Sep-07
	DLO-01-7-B2	9	17W	560509	7912603	07-Sep-07
	DLO-01-7-B3	9	17W	560481	7912619	07-Sep-07
	DLO-01-7-B1	9	17W	560525	7912609	9-Sep-08
	DLO-01-7-B2	9	17W	560572	7912619	9-Sep-08
	DLO-01-2-B1	14	17W	560337	7912913	15-Sep-07
	DLO-01-2-B2	14	17W	560342	7912915	15-Sep-07
	DLO-01-2-B3	14	17W	560357	7912917	15-Sep-07
	DLO-01-2-B1	14	17W	560353	7912924	12-Sep-08
	DLO-01-2-B2	14	17W	560326	7912854	12-Sep-08
	DLO-01-5-B1	14	17W	559775	7913350	15-Sep-07
	DLO-01-5-B2	14	17W	559788	7913335	15-Sep-07
	DLO-01-5-B3	14	17W	559800	7913340	15-Sep-07
	DLO-01-5-B1	14	17W	559798	7913356	9-Sep-08
Sheardown Lake SE						
	DLO-02-3-B1	4	17W	560950	7911919	04-Sep-07
	DLO-02-3-B2	4	17W	560947	7911926	04-Sep-07
	DLO-02-3-B3	4	17W	560958	7911925	04-Sep-07
	DLO-02-4-B1	10	17W	561127	7911708	04-Sep-07
	DLO-02-4-B2	10	17W	561133	7911717	04-Sep-07
	DLO-02-4-B3	10	17W	561145	7911699	04-Sep-07
	DLO-02-1-B1	14	17W	560816	7912124	06-Sep-07
	DLO-02-1-B2	14	17W	560824	7912125	06-Sep-07
	DLO-02-1-B3	14	17W	560818	7912111	06-Sep-07
	DLO-02-2-B1	14	17W	561161	7911866	06-Sep-07
	DLO-02-2-B2	14	17W	561170	7911872	06-Sep-07
	DLO-02-2-B3	14	17W	561164	7911864	06-Sep-07

Table 4.3-7. - Continued -

Waterbody	Site ID	Habitat Type	UTM			Sample Date
			Zone	Easting	Northing	
Lake Sites conitinued						
Mary Lake						
	BLO-01 B1	9	17W	554695	7913212	19-Sep-07
	BLO-01 B2	9	17W	554695	7913212	19-Sep-07
	BLO-01 B3	9	17W	554695	7913212	19-Sep-07
	BLO-05-B1	9	17W	554780	7906047	20-Sep-07
	BLO-05-B2	9	17W	554769	7906066	20-Sep-07
	BLO-05-B3	9	17W	554785	7906078	20-Sep-07
	BLO-06-B1	9	17W	555912	7903757	20-Sep-07
	BLO-06-B2	9	17W	555913	7903734	20-Sep-07
	BLO-06-B3	9	17W	555890	7903721	20-Sep-07
	BLO-01 B1	14	17W	554695	7913212	31-Aug-06
	BLO-01 B2	14	17W	554695	7913212	31-Aug-06
	BLO-01 B3	14	17W	554695	7913212	31-Aug-06
	BLO-05-B1	14	17W	554771	7906033	05-Sep-06
	BLO-05-B2	14	17W	554771	7906033	05-Sep-06
	BLO-05-B3	14	17W	554771	7906033	05-Sep-06
	BLO-03-B1	14	17W	552387	7906645	20-Sep-07
	BLO-03-B2	14	17W	552360	7906630	20-Sep-07
	BLO-03-B3	14	17W	552356	7906635	20-Sep-07
	BLO-04-B1	14	17W	553799	7904897	20-Sep-07
	BLO-04-B3	14	17W	553824	7904871	20-Sep-07

Table 4.3-7. - Continued -

Waterbody	Site ID	UTM			Sample Date
		Zone	Easting	Northing	
Stream Sites					
Mary River					
	AO-01	17W	559019	7900094	14-Aug-05
	CO-01	17W	556305	7906894	09-Aug-05
	DO-01	17W	560765	7911692	11-Aug-05
	EO-01a (E2-01)	17W	562348	7911310	15-Aug-05
	EO-01a (E0-03)	17W	562974	7912472	15-Aug-05
	HO-01	17W	571409	7917611	12-Aug-05
	AO-01 B1	17W	559034	7900064	05-Sep-07
	AO-01 B2	17W	558997	7900112	05-Sep-07
	AO-01 B3	17W	558994	7900151	05-Sep-07
	CO-01 B1	17W	556291	7906919	03-Sep-07
	CO-01 B2	17W	-	-	03-Sep-07
	CO-01 B3	17W	556323	7906925	03-Sep-07
	CO-05 B1	17W	558364	7909231	03-Sep-07
	CO-05 B2	17W	558389	7909248	03-Sep-07
	CO-05 B3	17W	558411	7909298	03-Sep-07
	CO-10 B1	17W	560490	7911370	30-Aug-06
	CO-10 B2	17W	560490	7911370	30-Aug-06
	CO-10 B3	17W	560490	7911370	30-Aug-06
	CO-10 B1	17W	560616	7911666	04-Sep-07
	CO-10 B2	17W	560661	7911687	04-Sep-07
	CO-10 B3	17W	560708	7911701	04-Sep-07
	EO-01 B1	17W	560926	7911488	04-Sep-07
	EO-01 B2	17W	560940	7911429	04-Sep-07
	EO-01 B3	17W	560906	7911533	04-Sep-07
	GO-03 B1	17W	567194	7912596	05-Sep-07
	GO-03 B2	17W	567220	7912598	05-Sep-07
	GO-03 B3	17W	567247	7912602	05-Sep-07
	GO-09 B1	17W	571665	7916111	01-Sep-06
	GO-09 B2	17W	571665	7916111	01-Sep-06
	GO-09 B3	17W	571665	7916111	01-Sep-06
	GO-09 B1	17W	571572	7916367	05-Sep-07
	GO-09 B2	17W	571577	7916330	05-Sep-07
	GO-09 B3	17W	571566	7916302	05-Sep-07

Table 4.3-7. - Continued -

Waterbody	Site ID	UTM			Sample Date
		Zone	Easting	Northing	
Stream Sites continued					
Tom River					
	IO-01 B1	17W	555441	7914175	25-Aug-06
	IO-01 B2	17W	555441	7914175	25-Aug-06
	IO-01 B3	17W	555441	7914175	25-Aug-06
	IO-01 B1	17W	555407	7914291	05-Sep-07
	IO-01 B2	17W	555449	7914160	05-Sep-07
	IO-01 B3	17W	555496	7914154	05-Sep-07
	IO-04 B1	17W	557136	7918889	23-Aug-06
	IO-04 B2	17W	557136	7918889	23-Aug-06
	IO-04 B3	17W	557136	7918889	23-Aug-06
	IO-04 B1	17W	557132	7918928	05-Sep-07
	IO-04 B2	17W	557153	7918972	05-Sep-07
	IO-04 B3	17W	557155	7918994	05-Sep-07
Camp Lake Tributaries					
	FS-01 (Trib.1, Reach 1)	17W	558264	7914877	10-Aug-05
	KO-01 (Trib.2, Reach 2)	17W	557390	7915030	09-Aug-05
	JO-01 (lake outlet stream)	17W	555701	7913773	09-Aug-05
	CLT-1 DS B1	17W	557641	7914880	02-Sep-07
	CLT-1 DS B2	17W	557648	7914888	02-Sep-07
	CLT-1 DS B3	17W	557653	7914898	02-Sep-07
	CLT-1 US B1	17W	558515	7915032	04-Sep-07
	CLT-1 US B2	17W	558509	7915020	04-Sep-07
	CLT-1 US B3	17W	558497	7914999	04-Sep-07
	CLT-2 DS B1	17W	557466	7914969	02-Sep-07
	CLT-2 DS B2	17W	557465	7914977	02-Sep-07
	CLT-2 DS B3	17W	557449	7914956	02-Sep-07
	CLT-2 US B1	17W	557448	7915324	02-Sep-07
	CLT-2 US B2	17W	557450	7915287	02-Sep-07
	CLT-2 US B3	17W	557464	7915251	02-Sep-07

Table 4.3-7. - Continued -

Waterbody	Site ID	UTM			Sample Date
		Zone	Easting	Northing	
Stream Sites continued					
Sheardown Lake Tributary 1					
	SDLT-1 Reach 2a	17W	560753	7913507	08-Aug-05
	SDLT-1 Reach 1 B1	17W	560320	7913504	10-Sep-08
	SDLT-1 Reach 1 B2	17W	560337	7913512	10-Sep-08
	SDLT-1 Reach 1 B3	17W	560346	7913525	10-Sep-08
	SDLT-1 DS Reach 2 B1	17W	560710	7913504	31-Aug-07
	SDLT-1 DS Reach 2 B2	17W	560716	7913506	31-Aug-07
	SDLT-1 DS Reach 2 B3	17W	560722	7913504	31-Aug-07
	SDLT-1 Reach 2 B1	17W	560739	7913502	10-Sep-08
	SDLT-1 Reach 2 B2	17W	560756	7913502	10-Sep-08
	SDLT-1 Reach 2 B3	17W	560774	7913598	10-Sep-08
	SDLT-1 US Reach 4 B1	17W	561503	7913541	31-Aug-07
	SDLT-1 US Reach 4 B2	17W	-	-	31-Aug-07
	SDLT-1 US Reach 4 B3	17W	561521	7913524	31-Aug-07
	SDLT-1 Reach 4 B1	17W	561490	7913533	11-Sep-08
	SDLT-1 Reach 4 B2	17W	561506	7913538	11-Sep-08
	SDLT-1 Reach 4 B3	17W	561511	7913536	11-Sep-08
Sheardown Lake Tributary 9					
	SDLT-9 US B1	17W	561771	7911813	01-Sep-07
	SDLT-9 US B2	17W	561774	7911814	01-Sep-07
	SDLT-9 US B3	17W	561784	7911819	01-Sep-07
Sheardown Lake Tributary 12					
	SDLT-12 DS B1	17W	561000	7942973	01-Sep-07
	SDLT-12 DS B2	17W	561011	7912970	01-Sep-07
	SDLT-12 DS B3	17W	561027	7912966	01-Sep-07
	SDLT-12 US B1	17W	561091	7912833	01-Sep-07
	SDLT-12 US B2	17W	561092	7912848	01-Sep-07
	SDLT-12 US B3	17W	561097	7912837	01-Sep-07

Table 4.3-8. Summary statistics for benthic invertebrate community descriptors for lake sites in the Mine Area, 2006 to 2008.

Waterbody	Habitat Type	Sample Year(s)	No. of Replicates Stations/ Habitat	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Lake Sites										
Camp Lake	4	2007	3	inds/m^2	14	0	25	14	0	43
				Taxonomic Richness[1]	2	--	--	--	0	2
				Simpson's Diversity Index (1-D)	0.78	--	0.39	0.22	--	--
				Evenness (Shannon's Equitability, E_H)	0.24	--	0.34	0.20	--	--
				Chironomidae Proportion (%)	20	--	--	--	--	--
	14	2007	12	inds/m^2	2649	1978	1497	432	730	6226
				Taxonomic Richness[1]	23	--	--	--	6	14
				Simpson's Diversity Index (1-D)	0.60	--	0.12	0.03	--	--
				Evenness (Shannon's Equitability, E_H)	0.56	--	0.13	0.04	--	--
				Chironomidae Proportion (%)	96	--	--	--	--	--
Camp Lake										
Overall	4, 14	2007	15	inds/m^2	2122	1843	1717	443	0	6226
				Taxonomic Richness[1]	23	--	--	--	0	14
				Simpson's Diversity Index (1-D)	0.64	--	0.19	0.05	--	--
				Evenness (Shannon's Equitability, E_H)	0.50	--	0.24	0.06	--	--
				Chironomidae Proportion (%)	96	--	--	--	--	--

Table 4.3-8. - Continued -

Waterbody	Habitat Type	Sample Year(s)	No. of Replicates Stations/ Habitat	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Sheardown Lake NW										
	4	2008	8	inds/m^2	829	507	783	277	162	2129
				Taxonomic Richness[1]	26	--	--	--	13	16
				Simpson's Diversity Index (1-D)	0.73	--	0.09	0.03	--	--
				Evenness (Shannon's Equitability, E_H)	0.65	--	0.10	0.03	--	--
				Chironomidae Proportion (%)	79	--	--	--	--	--
	9	2007	12	inds/m^2	6026	5887	2970	858	2026	10470
				Taxonomic Richness[1]	27	--	--	--	8	15
				Simpson's Diversity Index (1-D)	0.77	--	0.07	0.02	--	--
				Evenness (Shannon's Equitability, E_H)	0.73	--	0.08	0.02	--	--
				Chironomidae Proportion (%)	81	--	--	--	--	--
	9	2008	10	inds/m^2	817	798	448	142	250	1677
				Taxonomic Richness[1]	26	--	--	--	11	20
				Simpson's Diversity Index (1-D)	0.76	--	0.09	0.03	--	--
				Evenness (Shannon's Equitability, E_H)	0.70	--	0.08	0.03	--	--
				Chironomidae Proportion (%)	83	--	--	--	--	--
	9	2007, 2008	22	inds/m^2	3658	2165	3429	731	250	10470
				Taxonomic Richness[1]	31	--	--	--	8	20
				Simpson's Diversity Index (1-D)	0.76	--	0.08	0.02	--	--
				Evenness (Shannon's Equitability, E_H)	0.72	--	0.08	0.02	--	--
				Chironomidae Proportion (%)	81	--	--	--	--	--

Table 4.3-8. - Continued -

Waterbody	Habitat Type	Sample Year(s)	No. of Replicates Stations/ Habitat	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Sheardown Lake NW continued										
	14	2007	6	inds/m^2	1577	1665	219	89	1226	1783
				Taxonomic Richness[1]	13	--	--	--	4	9
				Simpson's Diversity Index (1-D)	0.32	--	0.13	0.05	--	--
				Evenness (Shannon's Equitability, E_H)	0.36	--	0.10	0.04	--	--
				Chironomidae Proportion (%)	95	--	--	--	--	--
	14	2008	3	inds/m^2	149	158	43	25	102	446
				Taxonomic Richness[1]	10	--	--	--	7	8
				Simpson's Diversity Index (1-D)	0.50	--	0.12	0.07	--	--
				Evenness (Shannon's Equitability, E_H)	0.52	--	0.08	0.05	--	--
				Chironomidae Proportion (%)	93	--	--	--	--	--
	14	2007, 2008	9	inds/m^2	1101	1391	735	245	102	1783
				Taxonomic Richness[1]	14	--	--	--	4	9
				Simpson's Diversity Index (1-D)	0.38	--	0.15	0.05	--	--
				Evenness (Shannon's Equitability, E_H)	0.41	--	0.12	0.04	--	--
				Chironomidae Proportion (%)	95	--	--	--	--	--
Sheardown Lake NW										
Overall	4, 9, 14	2007, 2008	39	inds/m^2	2488	1391	2924	468	102	10470
				Taxonomic Richness[1]	34	--	--	--	4	20
				Simpson's Diversity Index (1-D)	0.67	--	0.19	0.03	--	--
				Evenness (Shannon's Equitability, E_H)	0.63	--	0.15	0.02	--	--
				Chironomidae Proportion (%)	82	--	--	--	--	--

Table 4.3-8. - Continued -

Waterbody	Habitat Type	Sample Year(s)	No. of Replicates Stations/ Habitat	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Sheardown Lake SE										
	4	2007	3	inds/m^2	4270	1026	6137	3543	435	11348
				Taxonomic Richness[1]	23	--	--	--	14	17
				Simpson's Diversity Index (1-D)	0.73	--	0.12	0.07	--	--
				Evenness (Shannon's Equitability, E_H)	0.67	--	0.16	0.09	--	--
				Chironomidae Proportion (%)	88	--	--	--	--	--
	10	2007	3	inds/m^2	18562	15235	11312	6531	9287	31165
				Taxonomic Richness[1]	19	--	--	--	12	15
				Simpson's Diversity Index (1-D)	0.71	--	0.12	0.07	--	--
				Evenness (Shannon's Equitability, E_H)	0.65	--	0.09	0.05	--	--
				Chironomidae Proportion (%)	72	--	--	--	--	--
	14	2007	6	inds/m^2	5042	4674	1350	551	3548	6730
				Taxonomic Richness[1]	15	--	--	--	4	12
				Simpson's Diversity Index (1-D)	0.61	--	0.15	0.06	--	--
				Evenness (Shannon's Equitability, E_H)	0.59	--	0.09	0.05	--	--
				Chironomidae Proportion (%)	97	--	--	--	--	--
Sheardown Lake SE										
Overall	4, 10, 14	2007	12	inds/m^2	8229	5822	8359	2413	435	31165
				Taxonomic Richness[1]	29	--	--	--	4	17
				Simpson's Diversity Index (1-D)	0.66	--	0.14	0.04	--	--
				Evenness (Shannon's Equitability, E_H)	0.62	--	0.11	0.03	--	--
				Chironomidae Proportion (%)	82	--	--	--	--	--

Table 4.3-8. - Continued -

Waterbody	Habitat Type	Sample Year(s)	No. of Replicates Stations/ Habitat	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Mary Lake	9	2007	9	inds/m^2	4005	3957	2879	960	783	8870
				Taxonomic Richness*	19	--	--	--	5	10
				Simpson's Diversity Index (1-D)	0.67	--	0.12	0.04	--	--
				Evenness (Shannon's Equitability, E_H)	0.70	--	0.16	0.05	--	--
				Chironomidae Proportion (%)	95	--	--	--	--	--
	14	2006	6	inds/m^2	4159	3730	1594	651	2670	7017
				Taxonomic Richness*	25	--	--	--	8	18
				Simpson's Diversity Index (1-D)	0.62	--	0.06	0.03	--	--
				Evenness (Shannon's Equitability, E_H)	0.57	--	0.06	0.02	--	--
				Chironomidae Proportion (%)	93	--	--	--	--	--
	14	2007	5	inds/m^2	878	826	249	111	609	1261
				Taxonomic Richness*	8	--	--	--	1	6
				Simpson's Diversity Index (1-D)	0.36	--	0.29	0.13	--	--
				Evenness (Shannon's Equitability, E_H)	0.47	--	0.31	0.14	--	--
				Chironomidae Proportion (%)	99	--	--	--	--	--
	14	2006, 2007	11	inds/m^2	2668	2670	2057	620	609	7017
				Taxonomic Richness*	26	--	--	--	1	18
				Simpson's Diversity Index (1-D)	0.50	--	0.23	0.07	--	--
				Evenness (Shannon's Equitability, E_H)	0.52	--	0.21	0.06	--	--
				Chironomidae Proportion (%)	94	--	--	--	--	--
Mary Lake Overall	9, 14	2006, 2007	20	inds/m^2	3270	2974	2487	556	609	8870
				Taxonomic Richness*	30	--	--	--	1	18
				Simpson's Diversity Index (1-D)	0.57	--	0.20	0.05	--	--
				Evenness (Shannon's Equitability, E_H)	0.63	--	0.15	0.03	--	--
				Chironomidae Proportion (%)	95	--	--	--	--	--

[1] number of taxa reported at Genus level. If group identified to higher level it was assumed that only one Genus was represented; this possibly resulted in a conservative estimate of number of taxa. For the mean, the total number of taxa observed to specified-level, not the average number of taxa, is presented; the minimum and the maximum are for individual replicates.

Table 4.3-9. Comparison of benthic macroinvertebrate densities and community structure observed in Mine Area lakes to other northern Canada waterbodies.

Project/Study	General Location	Lake	Years	Benthic Invertebrate Density (individuals/m^2)	Dominant Benthic Invertebrate Taxa	Number of Benthic Invertebrate Taxa	Comments	Reference
Mary River Project	Mine LSA lakes, Baffin Island	Camp Lake	2007	overall lake mean: 2,122	Chironomidae (96%)	23 genera	Ekman used in 2006, petit Ponar in 2007, 2008; sampling area of 0.023 m^2; 500 um mesh	This Study
		Sheardown Lake NW	2007, 2008	overall lake mean: 2,488	Chironomidae (82%)	34 genera		
		Sheardown Lake SE	2007	overall lake mean: 8,229	Chironomidae (82%)	29 genera		
		Mary Lake	2006, 2007	overall lake mean: 3,270	Chironomidae (95%)	30 genera		
Limnological investigation of Nettilling Lake	south-central Baffin Island	Nettilling Lake	1956	-	Chironomidae larvae > 95% of total benthos (Orthocladiinae predominated); next most important were oligochaetes and nematodes	complete species list not provided	dredgings taken with small Ekman and Petersen dredges; samples not quantitative	Oliver (1964)
Zoogeography of lakes and rivers in Arctic Alaska	Toolik Lake area in Arctic Alaska	20 lakes	1988, 1990	-	Based on presence/absence across lakes, *Stictochironomus rosenschoeldi* (Chironominae), *Heterotrissocladius* spp. (Orthocladiinae), and *Procladius* spp. (Tanypodinae) were the most widely distributed chironomid species	genus/ species list provided for chironomids only; 33 chironomid genera	one benthic sample taken with Ekman dredge in subset of lakes; 200 um mesh; only chironomids sorted and identified	Kling et al. (1992)

Table 4.3-9. – Continued -

Project/Study	General Location	Lake	Years	Benthic Invertebrate Density (individuals/m^2)	Dominant Benthic Invertebrate Taxa	Number of Benthic Invertebrate Taxa	Comments	Reference
Response and recovery to nutrient addition of a partitioned Arctic lake	Toolik Lake, Alaska	oligotrophic Lake N-2 (reference condition)	reference condition: pre-fertilization (<1985)	-	Benthic community dominated by the snail *Lymnaea elodes* (thought to be food limited) and a sparse community of chironomids (thought to be limited due to sculpin predation)	complete species list not provided	chironomids by Ekman dredge; snails by SCUBA divers counts	O'Brien et al. (2005)
Bathurst Inlet Port and Road Project	Kitikmeot region, Nunavut	Contwoyto Lake	2001	1,689	Chironomids (53%) dominated the community followed by fingernail clams (22%) and nematodes (11%)	raw data available in appendix, but not summarized	Ekman used; 595 um mesh	Rescan (2007)
Doris Hinge Project	Doris Hinge Area: east of Bathurst Inlet (Nunavut)	8 lakes	1996, 1997, and 2000	overall lake means: 1,959; 2,778; 3,311; 1,541; 3,066; 371; 19,176; 1,929	Chironomids, nematodes, bivalves, and oligochaetes dominated the community; communities in deeper parts of lakes increasingly dominated by chironomids; chironomids contributed between 32% and 100% to total numbers	raw data available in appendix, but not summarized	Ekman used; sampling area of 0.023 m^2; 493 um mesh	R.L. & L. / Golder (2002)

Table 4.3-9. - Continued -

Project/Study	General Location	Lake	Years	Benthic Invertebrate Density (individuals/m^2)	Dominant Benthic Invertebrate Taxa	Number of Benthic Invertebrate Taxa	Comments	Reference
Jericho Diamond Project	420 km northeast of Yellowknife	2 lakes	2000	lake with max depth 2.3m: 99,479 (chironomids, nematodes); lake with littoral (6434: chironomids) and produndal (550: chironomids)	Groups included chironomids, nematodes, bilvalves, oligochaetes, and ostracods; communities dominated by few taxa with chironomids and nematodes numerically abundant	9 (profundal) -17 (littoral) taxa	Ekman used; sampling area of 0.023 m^2; 243 um mesh	R.L. & L. (2000)
Meadowbank Gold Project	75 km north of the hamlet of Baker Lake, Nunavut	9 lakes and 3 ponds	1997, 1998, 2002, 2003	overall project lakes mean: 2,500-8,300; small isolated ponds: 2,279-6,228	Project lakes and ponds were numerically dominated by aquatic insect larvae, especially chironomids (50%-86%), both in terms of density and species diversity	average number of genera: 11-20; average number of chironomid genera: 10-12; total number of chironomid genera: 20	standard Ekman or Ponar used; 250 um mesh; nematodes and ostracods not included in density calculations due to small size; planktonic copepods and adult insects not included in density calculations	Cumberland Resources (2005)

Table 4.3-10. Summary statistics for benthic invertebrate community descriptors for stream sites in the Mine Area: 2005 to 2008.

Waterbody	Reach	Sample Year(s)	No. of Replicates Stations/ Reach	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Mary River										
	GO (HO-01)	2005	1	inds/m^2	307	--	--	--	--	--
				Taxonomic Richness*	5	--	--	--	--	--
				Simpson's Diversity Index (1-D)	0.51	--	--	--	--	--
				Evenness (Shannon's Equitability, E_H)	0.60	--	--	--	--	--
				Chironomidae Proportion (%)	86	--	--	--	--	--
	EO-01a	2005	2	inds/m^2	135	135	141	100	35	235
				Taxonomic Richness*	12	--	--	--	6	10
				Simpson's Diversity Index (1-D)	0.78	--	0.01	0.00	--	--
				Evenness (Shannon's Equitability, E_H)	0.83	--	0.07	0.05	--	--
				Chironomidae Proportion (%)	63	--	--	--	--	--
	CO-01	2005	1	inds/m^2	1621	--	--	--	--	--
				Taxonomic Richness*	11	--	--	--	--	--
				Simpson's Diversity Index (1-D)	0.28	--	--	--	--	--
				Evenness (Shannon's Equitability, E_H)	0.28	--	--	--	--	--
				Chironomidae Proportion (%)	95	--	--	--	--	--
	DO-01	2005	1	inds/m^2	37	--	--	--	--	--
				Taxonomic Richness*	7	--	--	--	--	--
				Simpson's Diversity Index (1-D)	0.82	--	--	--	--	--
				Evenness (Shannon's Equitability, E_H)	0.89	--	--	--	--	--
				Chironomidae Proportion (%)	44	--	--	--	--	--
	AO-01	2005	1	inds/m^2	155	--	--	--	--	--
				Taxonomic Richness*	7	--	--	--	--	--
				Simpson's Diversity Index (1-D)	0.42	--	--	--	--	--
				Evenness (Shannon's Equitability, E_H)	0.45	--	--	--	--	--
				Chironomidae Proportion (%)	29	--	--	--	--	--
Mary River Overall	All	2005	6	inds/m^2	398	195	608	248	35	1621
				Taxonomic Richness*	17	--	--	--	5	11
				Simpson's Diversity Index (1-D)	0.60	--	0.23	0.09	--	--
				Evenness (Shannon's Equitability, E_H)	0.55	--	0.26	0.13	--	--
				Chironomidae Proportion (%)	85	--	--	--	--	--

Table 4.3-10. - Continued -

Waterbody	Reach	Sample Year(s)	No. of Replicates Stations/ Reach	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Mary River										
	GO-09	2006	3	inds/m^2	404	381	149	86	268	563
				Taxonomic Richness*	14	--	--	--	4	10
				Simpson's Diversity Index (1-D)	0.28	--	0.07	0.04	--	--
				Evenness (Shannon's Equitability, E_H)	0.34	--	0.07	0.04	--	--
				Chironomidae Proportion (%)	99	--	--	--	--	--
	GO-3+GO-9	2007	6	inds/m^2	438	403	336	137	103	810
				Taxonomic Richness*	22	--	--	--	5	15
				Simpson's Diversity Index (1-D)	0.64	--	0.04	0.02	--	--
				Evenness (Shannon's Equitability, E_H)	0.57	--	0.07	0.03	--	--
				Chironomidae Proportion (%)	97	--	--	--	--	--
	GO-3+GO-9	2006, 2007	9	inds/m^2	427	381	276	92	103	810
				Taxonomic Richness*	24	--	--	--	5	15
				Simpson's Diversity Index (1-D)	0.53	--	0.18	0.06	--	--
				Evenness (Shannon's Equitability, E_H)	0.50	--	0.13	0.04	--	--
				Chironomidae Proportion (%)	98	--	--	--	--	--
	EO-01	2007	3	inds/m^2	800	1019	649	375	70	1311
				Taxonomic Richness*	31	--	--	--	8	25
				Simpson's Diversity Index (1-D)	0.72	--	0.07	0.04	--	--
				Evenness (Shannon's Equitability, E_H)	0.69	--	0.14	0.08	--	--
				Chironomidae Proportion (%)	90	--	--	--	--	--
	CO-10	2006	3	inds/m^2	348	301	260	150	115	629
				Taxonomic Richness*	19	--	--	--	10	14
				Simpson's Diversity Index (1-D)	0.74	--	0.13	0.08	--	--
				Evenness (Shannon's Equitability, E_H)	0.71	--	0.16	0.09	--	--
				Chironomidae Proportion (%)	92	--	--	--	--	--
	CO-10	2007	3	inds/m^2	91	89	17	10	76	109
				Taxonomic Richness*	13	--	--	--	7	10
				Simpson's Diversity Index (1-D)	0.73	--	0.06	0.03	--	--
				Evenness (Shannon's Equitability, E_H)	0.76	--	0.10	0.06	--	--
				Chironomidae Proportion (%)	90	--	--	--	--	--

Table 4.3-10. - Continued -

Waterbody	Reach	Sample Year(s)	No. of Replicates Stations/ Reach	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Mary River continued										
	CO-10	2006, 2007	6	inds/m^2	220	112	217	88	76	629
				Taxonomic Richness*	23	--	--	--	10	14
				Simpson's Diversity Index (1-D)	0.73	--	0.09	0.04	--	--
				Evenness (Shannon's Equitability, E_H)	0.73	--	0.12	0.05	--	--
				Chironomidae Proportion (%)	92	--	--	--	--	--
	CO-05	2007	3	inds/m^2	307	278	223	129	99	542
				Taxonomic Richness*	18	--	--	--	8	15
				Simpson's Diversity Index (1-D)	0.67	--	0.02	0.01	--	--
				Evenness (Shannon's Equitability, E_H)	0.64	--	0.05	0.03	--	--
				Chironomidae Proportion (%)	99	--	--	--	--	--
	CO-01	2007	3	inds/m^2	184	140	138	80	72	338
				Taxonomic Richness*	12	--	--	--	4	9
				Simpson's Diversity Index (1-D)	0.60	--	0.13	0.07	--	--
				Evenness (Shannon's Equitability, E_H)	0.65	--	0.11	0.06	--	--
				Chironomidae Proportion (%)	95	--	--	--	--	--
	AO-01	2007	3	inds/m^2	58	62	10	6	47	66
				Taxonomic Richness*	12	--	--	--	7	8
				Simpson's Diversity Index (1-D)	0.77	--	0.11	0.07	--	--
				Evenness (Shannon's Equitability, E_H)	0.84	--	0.12	0.07	--	--
				Chironomidae Proportion (%)	76	--	--	--	--	--
Mary River Overall	All	2006, 2007	27	inds/m^2	341	159	336	65	47	1311
				Taxonomic Richness*	43	--	--	--	4	25
				Simpson's Diversity Index (1-D)	0.64	--	0.16	0.03	--	--
				Evenness (Shannon's Equitability, E_H)	0.64	--	0.16	0.03	--	--
				Chironomidae Proportion (%)	94	--	--	--	--	--

Table 4.3-10. - Continued -

Waterbody	Reach	Sample Year(s)	No. of Replicates Stations/ Reach	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Tom River										
	IO-04	2006	3	inds/m^2	265	272	35	20	227	295
				Taxonomic Richness*	15	--	--	--	6	11
				Simpson's Diversity Index (1-D)	0.45	--	0.20	0.12	--	--
				Evenness (Shannon's Equitability, E_H)	0.47	--	0.16	0.09	--	--
				Chironomidae Proportion (%)	81	--	--	--	--	--
	IO-04	2007	3	inds/m^2	58	56	20	11	39	78
				Taxonomic Richness*	16	--	--	--	7	10
				Simpson's Diversity Index (1-D)	0.73	--	0.08	0.05	--	--
				Evenness (Shannon's Equitability, E_H)	0.76	--	0.10	0.06	--	--
				Chironomidae Proportion (%)	90	--	--	--	--	--
	IO-04	2006, 2007	6	inds/m^2	161	153	116	47	39	295
				Taxonomic Richness*	22	--	--	--	6	11
				Simpson's Diversity Index (1-D)	0.59	--	0.21	0.08	--	--
				Evenness (Shannon's Equitability, E_H)	0.61	--	0.20	0.08	--	--
				Chironomidae Proportion (%)	83	--	--	--	--	--
	IO-01	2006	3	inds/m^2	117	107	46	27	76	167
				Taxonomic Richness*	15	--	--	--	5	9
				Simpson's Diversity Index (1-D)	0.69	--	0.02	0.01	--	--
				Evenness (Shannon's Equitability, E_H)	0.74	--	0.08	0.05	--	--
				Chironomidae Proportion (%)	91	--	--	--	--	--

Table 4.3-10. - Continued -

Waterbody	Reach	Sample Year(s)	No. of Replicates Stations/ Reach	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Tom River continued										
	IO-01	2007	3	inds/m^2	945	190	1375	794	113	2532
				Taxonomic Richness*	19	--	--	--	9	14
				Simpson's Diversity Index (1-D)	0.53	--	0.23	0.13	--	--
				Evenness (Shannon's Equitability, E_H)	0.51	--	0.22	0.12	--	--
				Chironomidae Proportion (%)	98	--	--	--	--	--
	IO-01	2006, 2007	6	inds/m^2	531	140	981	401	76	2532
				Taxonomic Richness*	25	--	--	--	5	14
				Simpson's Diversity Index (1-D)	0.61	--	0.17	0.07	--	--
				Evenness (Shannon's Equitability, E_H)	0.63	--	0.19	0.08	--	--
				Chironomidae Proportion (%)	97	--	--	--	--	--
Tom River										
Overall	All	2006, 2007	12	inds/m^2	346	140	694	200	39	2532
				Taxonomic Richness*	30	--	--	--	5	11
				Simpson's Diversity Index (1-D)	0.60	--	0.18	0.05	--	--
				Evenness (Shannon's Equitability, E_H)	0.62	--	0.19	0.05	--	--
				Chironomidae Proportion (%)	94	--	--	--	--	--

Table 4.3-10. - Continued -

Waterbody	Reach	Sample Year(s)	No. of Replicates Stations/ Reach	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Stream Sites										
Camp Lake Tributary										
	Trib 1 Reach 1	2005	1	inds/m^2	414	--	--	--	--	--
				Taxonomic Richness*	13	--	--	--	--	--
				Simpson's Diversity Index (1-D)	0.50	--	--	--	--	--
				Evenness (Shannon's Equitability, E_H)	0.47	--	--	--	--	--
				Chironomidae Proportion (%)	86	--	--	--	--	--
	Trib 2 Reach 2	2005	1	inds/m^2	103	--	--	--	--	--
				Taxonomic Richness*	10	--	--	--	--	--
				Simpson's Diversity Index (1-D)	0.86	--	--	--	--	--
				Evenness (Shannon's Equitability, E_H)	0.90	--	--	--	--	--
				Chironomidae Proportion (%)	36	--	--	--	--	--
	Lake Outlet Stream	2005	1	inds/m^2	39	--	--	--	--	--
				Taxonomic Richness*	5	--	--	--	--	--
				Simpson's Diversity Index (1-D)	0.61	--	--	--	--	--
				Evenness (Shannon's Equitability, E_H)	0.73	--	--	--	--	--
				Chironomidae Proportion (%)	89	--	--	--	--	--
Camp Lake Tributary										
Overall	All	2005	3	inds/m^2	186	103	201	116	39	414
				Taxonomic Richness*	18				5	13
				Simpson's Diversity Index (1-D)	0.66	--	0.19	0.11	--	--
				Evenness (Shannon's Equitability, E_H)	0.70	--	0.22	0.13	--	--
				Chironomidae Proportion (%)	77	--	--	--	--	--

Table 4.3-10. - Continued -

Waterbody	Reach	Sample Year(s)	No. of Replicates Stations/ Reach	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Camp Lake Tributary										
	Trib 1 Reach 1	2007	3	inds/m^2	755	798	572	330	163	1305
				Taxonomic Richness*	29	--	--	--	14	25
				Simpson's Diversity Index (1-D)	0.87	--	0.04	0.02	--	--
				Evenness (Shannon's Equitability, E_H)	0.75	--	0.04	0.02	--	--
				Chironomidae Proportion (%)	83	--	--	--	--	--
	Trib 1 Reach 3	2007	3	inds/m^2	506	452	330	191	206	860
				Taxonomic Richness*	24	--	--	--	11	16
				Simpson's Diversity Index (1-D)	0.75	--	0.08	0.05	--	--
				Evenness (Shannon's Equitability, E_H)	0.68	--	0.07	0.04	--	--
				Chironomidae Proportion (%)	90	--	--	--	--	--
	Trib 2 Reach 1	2007	3	inds/m^2	432	482	109	63	307	507
				Taxonomic Richness*	22	--	--	--	16	20
				Simpson's Diversity Index (1-D)	0.87	--	0.02	0.01	--	--
				Evenness (Shannon's Equitability, E_H)	0.81	--	0.01	0.00	--	--
				Chironomidae Proportion (%)	89	--	--	--	--	--
	Trib 2 Reach 2	2007	3	inds/m^2	365	423	204	118	138	534
				Taxonomic Richness*	17	--	--	--	11	15
				Simpson's Diversity Index (1-D)	0.83	--	0.01	0.00	--	--
				Evenness (Shannon's Equitability, E_H)	0.79	--	0.04	0.02	--	--
				Chironomidae Proportion (%)	89	--	--	--	--	--
Camp Lake Tributary Overall	All	2007	12	inds/m^2	515	467	336	97	138	1305
				Taxonomic Richness*	36	--	--	--	11	25
				Simpson's Diversity Index (1-D)	0.83	--	0.06	0.02	--	--
				Evenness (Shannon's Equitability, E_H)	0.77	--	0.07	0.02	--	--
				Chironomidae Proportion (%)	87	--	--	--	--	--

Table 4.3-10. - Continued -

Waterbody	Reach	Sample Year(s)	No. of Replicates Stations/ Reach	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Sheardown Lake Tributaries										
	Trib 1 Reach 2	2005	1	inds/m^2	569	--	--	--	--	--
				Taxonomic Richness*	10	--	--	--	--	--
				Simpson's Diversity Index (1-D)	0.79	--	--	--	--	--
				Evenness (Shannon's Equitability, E_H)	0.77	--	--	--	--	--
				Chironomidae Proportion (%)	87	--	--	--	--	--
Sheardown Lake Tributaries										
	Trib 1 Reach 1	2008	3	inds/m^2	300	315	52	30	241	342
				Taxonomic Richness*	17	--	--	--	11	13
				Simpson's Diversity Index (1-D)	0.82	--	0.04	0.02	--	--
				Evenness (Shannon's Equitability, E_H)	0.77	--	0.06	0.03	--	--
				Chironomidae Proportion (%)	69	--	--	--	--	--
	Trib 1 Reach 2	2007	3	inds/m^2	441	421	111	64	342	561
				Taxonomic Richness*	21	--	--	--	14	16
				Simpson's Diversity Index (1-D)	0.77	--	0.03	0.02	--	--
				Evenness (Shannon's Equitability, E_H)	0.70	--	0.03	0.02	--	--
				Chironomidae Proportion (%)	67	--	--	--	--	--
	Trib1 Reach 2	2008	3	inds/m^2	649	431	464	268	334	1181
				Taxonomic Richness*	18	--	--	--	13	14
				Simpson's Diversity Index (1-D)	0.76	--	0.03	0.02	--	--
				Evenness (Shannon's Equitability, E_H)	0.71	--	0.03	0.01	--	--
				Chironomidae Proportion (%)	80	--	--	--	--	--
	Trib 1 Reach 2	2007, 2008	6	inds/m^2	545	426	322	132	334	1181
				Taxonomic Richness*	27	--	--	--	13	16
				Simpson's Diversity Index (1-D)	0.76	--	0.03	0.01	--	--
				Evenness (Shannon's Equitability, E_H)	0.71	--	0.03	0.01	--	--
				Chironomidae Proportion (%)	75	--	--	--	--	--

Table 4.3-10. - Continued -

Waterbody	Reach	Sample Year(s)	No. of Replicates Stations/ Reach	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Sheardown Lake Tributaries continued										
	Trib 1 Reach 4	2007	3	inds/m^2	4526	2052	4368	2522	1957	9569
				Taxonomic Richness*	22	--	--	--	14	19
				Simpson's Diversity Index (1-D)	0.69	--	0.21	0.12	--	--
				Evenness (Shannon's Equitability, E_H)	0.62	--	0.18	0.10	--	--
				Chironomidae Proportion (%)	94	--	--	--	--	--
	Trib 1 Reach 4	2008	3	inds/m^2	3046	3233	701	405	2270	3635
				Taxonomic Richness*	24	--	--	--	11	20
				Simpson's Diversity Index (1-D)	0.74	--	0.12	0.07	--	--
				Evenness (Shannon's Equitability, E_H)	0.66	--	0.08	0.05	--	--
				Chironomidae Proportion (%)	94	--	--	--	--	--
	Trib 1 Reach 4	2007, 2008	6	inds/m^2	3786	2752	2913	1189	1957	9569
				Taxonomic Richness*	30	--	--	--	11	20
				Simpson's Diversity Index (1-D)	0.71	--	0.16	0.06	--	--
				Evenness (Shannon's Equitability, E_H)	0.64	--	0.13	0.05	--	--
				Chironomidae Proportion (%)	94	--	--	--	--	--

Table 4.3-10. - Continued -

Waterbody	Reach	Sample Year(s)	No. of Replicates Stations/ Reach	Community Descriptors	Summary Statistics					
					Mean	Median	SD	SE	Minimum	Maximum
Sheardown Lake Tributaries continued										
	Trib 9 Reach 1	2007	3	inds/m^2	715	705	42	24	678	761
				Taxonomic Richness*	31	--	--	--	21	26
				Simpson's Diversity Index (1-D)	0.87	--	0.05	0.03	--	--
				Evenness (Shannon's Equitability, E_H)	0.79	--	0.05	0.03	--	--
				Chironomidae Proportion (%)	78	--	--	--	--	--
	Trib 12 Reach 1	2007	3	inds/m^2	864	526	1072	619	2	2064
				Taxonomic Richness*	25	--	--	--	1	23
				Simpson's Diversity Index (1-D)	0.57	--	0.49	0.28	--	--
				Evenness (Shannon's Equitability, E_H)	0.49	--	0.43	0.25	--	--
				Chironomidae Proportion (%)	96	--	--	--	--	--
	Trib 12 Reach 2	2007	3	inds/m^2	833	1031	416	240	355	1113
				Taxonomic Richness*	24	--	--	--	16	20
				Simpson's Diversity Index (1-D)	0.86	--	0.02	0.01	--	--
				Evenness (Shannon's Equitability, E_H)	0.82	--	0.05	0.03	--	--
				Chironomidae Proportion (%)	81	--	--	--	--	--
Sheardown Lake Tributaries										
Overall	All	2007, 2008	24	inds/m^2	1422	692	1989	406	2	9569
				Taxonomic Richness*	47	--	--	--	1	26
				Simpson's Diversity Index (1-D)	0.76	--	0.19	0.04	--	--
				Evenness (Shannon's Equitability, E_H)	0.69	--	0.17	0.04	--	--
				Chironomidae Proportion (%)	90	--	--	--	--	--

[1] number of taxa reported at Genus level. If group identified to higher level it was assumed that only one Genus was represented; this possibly resulted in a conservative estimate of number of taxa. For the mean, the total number of taxa observed to specified-level, not the average number of taxa, is presented; the minimum and the maximum are for individual replicates.

Table 4.3-11. Comparison of benthic macroinvertebrate densities and community structure observed in Mine Area streams to other northern Canada waterbodies.

Project/Study	General Location	Stream	Years	Benthic Invertebrate Density (individuals/m^2)	Dominant Benthic Invertebrate Taxa	Number of Benthic Invertebrate Taxa	Comments	Reference
Mary River Project	Mine LSA streams, Baffin Island	Mary River	2005	398	Chironomidae (85%)	17 genera	Surber; sampling area 0.097 m^2; 250 um mesh; summer sampling period	This Study
		Mary River	2006, 2007	341	Chironomidae (94%)	43 genera	Surber; sampling area 0.097 m^2; 500 um mesh; fall sampling period	
		Tom River	2006, 2007	346	Chironomidae (94%)	30 genera	Surber; sampling area 0.097 m^2; 500 um mesh; fall sampling period	
		two tributaries to Camp Lake and outlet stream	2005	186	Chironomidae (77%)	18 genera	Surber; sampling area 0.097 m^2; 250 um mesh; summer sampling period	
		two tributaries to Camp Lake	2007	515	Chironomidae (87%)	36 genera	Surber; sampling area 0.097 m^2; 500 um mesh; fall sampling period	
		one tributary to Sheardown Lake	2005	569	Chironomidae (87%)	10 genera	Surber; sampling area 0.097 m^2; 250 um mesh; summer sampling period	
		three tributaries to Sheardown Lake	2007, 2008	1,422	Chironomidae (90%)	47 genera	Surber; sampling area 0.097 m^2; 500 um mesh; fall sampling period	
Classification of stream types in Beaufort Sea drainages	Arctic streams from Prudhoe Bay, Alaska, to the Mackenzie River delta	55 locations in 17 Beaufort Sea drainages	1971, 1972, 1973	montain: 293; tundra: 1,025; spring: 22,011	Most frequently occurred: caddisflies (spring streams only); stoneflies; mayflies; oligochaetes	22 taxa in spring streams; 18 in each of tundra and mountain streams	Surber; sampling area 0.09 m^2; 9 threads/cm; summer sampling period	Craig and McCart (1975)

Table 4.3-11. – Continued -

Project/Study	General Location	Stream	Years	Benthic Invertebrate Density (individuals/m^2)	Dominant Benthic Invertebrate Taxa	Number of Benthic Invertebrate Taxa	Comments	Reference
Macroinvertebrate community composition in an Arctic and subarctic stream	northern Alaska	Imnavait Creek (Arctic; first order)	1981, 1982, 1983	seasonal means: 334-917	chironomids dominated with stoneflies (Nemouridae) often abundant for all sample types combined; complete species list by sampling method not provided	number of species a composite of drift, Hess, and rock basket samples; 112 species	Hess; sampling area 0.86 m^2; mesh size not reported	Miller and Stout (1989)
		Caribou-Poker Creek (subarctic; fourth order)		seasonal means: 394-799	chironomids and black-flies (Simuliidae) dominated with mayflies and stoneflies (Perlodidae) often abundant for all sample types combined; complete species list by sampling method not provided	number of species a composite of drift, Hess, and rock basket samples; 138 species		
Community structure of benthic invertebrates in interior Alaska	interior Alaska streams and rivers	listed in Appendix 1 of manuscript	114 data sets	-	dipterans dominated with stoneflies, caddisflies, and mayflies collectively accounting for < 25%; dipterans represented by 13 families, but chironoimds accounted for nearly 90%; chironomids and plecopterans increase in proportional contribution from south to north, while many other taxa decrease	-	data summary based on literature search; sampling methods, schedules, and taxonomic level of identifications varied widely between studies reviewed	Oswood (1989)

Table 4.3-11. – Continued -

Project/Study	General Location	Stream	Years	Benthic Invertebrate Density (individuals/m^2)	Dominant Benthic Invertebrate Taxa	Number of Benthic Invertebrate Taxa	Comments	Reference
Ecological characteristics of streams in Canadian Arctic	Barrenlands near Lac de Gras, NWT	9 streams	1998-2000 (summer)	23,485	dipterans contributed 43% of all individuals; chironomids were numerically dominant	complete species list not provided; 10 families of dipeterans; 29 genera of chironomids	Surber; sampling area 0.093 m^2; 250 um mesh; fall sampling period	Jones et al. (2003b)
Bathurst Inlet Port and Road Project	Kitikmeot region, Nunavut	6 streams	2001	404-7,181 (5 of the streams sampled were <3,500)	dipteran larvae (mainly chironomids) dominated in 3 streams; nematodes dominated in 1; dipterans and stoneflies shared dominance with mayflies and oligochaetes in 2 streams	90 taxa in total; number of taxa in individual streams ranged from 16 to 48	Surber; sampling area 0.097 m^2; 500 um mesh	Rescan (2007)
Doris Hinge Project	Doris Hinge Area: east of Bathurst Inlet (Nunavut)	7 lake outlet streams	1996, 1997, 2000	349-53,162 (more than half the streams sampled were <3,000)	chironomids and black-flies dominated	raw data available in appendix, but not summarized	artificial substrate samplers; mesh size not reported	R.L. & L. / Golder (2002)

Table 4.4-1. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in Camp Lake, by gear type, year, and species.

Gear Type	Year[1]	Effort[2]	Arctic char			Ninespine stickleback		
			n	%	Mean CPUE[3]	n	%	Mean CPUE[3]
Angling	2005	4	12	100.0	-	0	0.0	0.00
	2006	1	4	100.0	-	0	0.0	0.00
	Total	5	16	100.0	-	0	0.0	0.00
Electrofishing	2007	1	8	80.0	0.53	2	20.0	0.13
	Total	1	8	80.0	0.53	2	20.0	0.13
Gill nets	2005(O)	4	92	100.0	59.86	0	0.0	0.00
	2006(O)	2	21	100.0	13.40	0	0.0	0.00
	2007(O)	20	94	100.0	43.96	0	0.0	0.00
	2008(O)	14	22	100.0	10.08	0	0.0	0.00
	Total(O)	40	229	100.0	32.16	0	0.0	0.00
	2007(W)	1	3	100.0	2.25	0	0.0	0.00
Total		N/A	256	99.2	-	2	0.8	-

[1] 2007 winter (W) sample results are kept separate from open water (O) gillnet calculations (but are included in overall n for the lake) due to sampling and fish behaviour differences (char mobility is reduced during winter)
[2] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets)
[3] Gill net CPUE = #fish/100m of net/24 hrs; electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap

Table 4.4-2. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in the northwest basin of Sheardown Lake, by gear type, year, and species.

Gear Type	Year[1]	Effort[2]	Arctic char			Ninespine stickleback		
			n	%	Mean CPUE[3]	n	%	Mean CPUE[3]
Angling	2005	3	9	100.0	-	0	0.0	-
	Total	3	9	100.0	-	0	0.0	-
Electrofishing	2007	5	220	100.0	2.86	0	0.0	0.00
	2008	10	36	100.0	0.75	0	0.0	0.00
	Total	15	256	100.0	2.05	0	0.0	0.00
Gill nets	2006(O)	1	17	100.0	13.84	0	0.0	0.00
	2007(O)	12	92	100.0	68.25	0	0.0	0.00
	2008(O)	4	5	100.0	10.06	0	0.0	0.00
	Total(O)	17	114	100.0	51.36	0	0.0	0.00
	2007(W)	1	5	100.0	3.85	0	0.0	0.00
Total		N/A	384	100.0	-	0	0.0	-

[1] 2007 winter (W) sample results are kept separate from open water (O) gillnet calculations (but are included in overall n for the lake) due to sampling and fish behaviour differences (char mobility is reduced during winter)
[2] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets)
[3] Gill net CPUE = #fish/100m of net/24 hrs; electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap

Table 4.4-3. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in the southeast basin of Sheardown Lake, by gear type, year, and species.

Gear Type	Year[1]	Effort[2]	Arctic char			Ninespine stickleback		
			n	%	Mean CPUE[3]	n	%	Mean CPUE[3]
Angling	2005	1	7	100.0	-	0	0.0	-
	Total	1	7	100.0	-	0	0.0	-
Electrofishing	2007	2	32	97.0	1.78	1	3.0	0.06
	2008	4	4	80.0	0.21	1	20.0	0.05
	Total	6	36	94.7	0.98	2	5.3	0.05
Gill nets	2007(O)	2	30	100.0	241.47	0	0.0	0.00
	2008(O)	4	63	100.0	105.65	0	0.0	0.00
	Total(O)	6	93	100.0	150.93	0	0.0	0.00
	2007(W)	1	7	100.0	6.02	0	0.0	0.00
Total		N/A	143	98.6	-	2	1.4	-

[1] 2007 winter (W) sample results are kept separate from open water (O) gillnet calculations (but are included in overall n for the lake) due to sampling and fish behaviour differences (char mobility is reduced during winter)
[2] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets)
[3] Gill net CPUE = #fish/100m of net/24 hrs; electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap

Table 4.4-4. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in the south basin of Mary Lake, by gear type, year, and species.

Gear Type	Year	Effort[1]	Arctic char			Ninespine stickleback		
			n	%	Mean CPUE[2]	n	%	Mean CPUE[2]
Angling	2005	1	5	100.0	-	0	0.0	-
	Total	1	5	100.0	-	0	0.0	-
Electrofishing	2006	1	0	0.0	0.00	0	0.0	0.00
	2008	7	2	100.0	0.12	0	0.0	0.00
	Total	8	2	100.0	0.09	0	0.0	0.00
Gill nets	2006	2	62	100.0	27.16	0	0.0	0.00
	2007	24	168	100.0	72.98	0	0.0	0.00
	Total	26	230	100.0	69.46	0	0.0	0.00
Total		N/A	237	100.0	-	0	0.0	-

[1] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets)
[2] Gill net CPUE = #fish/100m of net/24 hrs; electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap

Table 4.4-5. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in the north basin of Mary Lake, by gear type, year, and species.

Gear Type	Year	Effort[1]	Arctic char			Ninespine stickleback		
			n	%	Mean CPUE[2]	n	%	Mean CPUE[2]
Electrofishing	2008	3	4	100.0	0.38	0	0.0	0.00
Total								
Gill nets	2007	8	98	100.0	175.27	0	0.0	0.00
Total		8	98	100.0	175.27	0	0.0	0.00
Total		N/A	102	100.0	-	0	0.0	-

[1] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets)
[2] Gill net CPUE = #fish/100m of net/24 hrs; electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap

Table 4.4-6. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in Angajurjualuk Lake, by gear type, year, and species.

Gear Type	Year	Effort[1]	Arctic char			Ninespine stickleback		
			n	%	Mean CPUE[2]	n	%	Mean CPUE[2]
Electrofishing	2006	1	15	100.0	0.76	0	0.0	0.00
Total		1	15	100.0	0.76	0	0.0	0.00
Gill nets	2006	2	103	100.0	52.62	0	0.0	0.00
	2007	15	146	100.0	91.14	0	0.0	0.00
Total		17	249	100.0	86.61	0	0.0	0.00
Minnow traps	2006	2	0	0.0	0.00	0	0.0	0.00
Total		2	0	0.0	0.00	0	0.0	0.00
Total		N/A	264	100	-	0	0	-

[1] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets)
[2] Gill net CPUE = #fish/100m of net/24 hrs; electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap

Table 4.4-7. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in other lakes in the Mine Area, by gear type, year, and species.

Gear Type	Lake	Year	Effort[1]	Arctic char			Ninespine stickleback		
				n	%	Mean CPUE[2]	n	%	Mean CPUE[2]
Angling	Mary River Study Area Lake 2	2005	1	2	100.0	-	0	0.0	-
	Mary River Study Area Lake 3	2005	1	4	100.0	-	0	0.0	-
Electrofishing	Mary River Study Area Lake 1	2007	1	11	100.0	0.92	0	0.0	0.00
	Mary River Study Area Lake 3	2007	1	2	100.0	0.20	0	0.0	0.00
Gill nets	Candidate Reference Lake 3	2008	1	3	100.0	16.15	0	0.0	0.00
	Mary River Study Area Lake 4	2006	1	1	100.0	1.07	0	0.0	0.00
Total			N/A	23	100	-	0	0.0	-

[1] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets)
[2] Gill net CPUE = #fish/100m of net/24 hrs; electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap

Table 4.4-8. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in Camp Lake tributaries, by tributary, gear type, year, and species.

Tributary	Gear Type	Year	Effort[1]	Arctic char			Ninespine stickleback		
				n	%	Mean CPUE[2]	n	%	Mean CPUE[2]
Trib 1	Electrofishing	2006	3	8	100.0	0.23	0	0.0	0.00
		2007	6	407	97.4	2.38	11	2.6	0.06
		2008	4	29	100.0	1.45	0	0.0	0.00
		Total	13	444	97.6	1.96	11	2.4	0.05
	Minnow traps	2005	2	29	100.0	-	0	0.0	-
		2006	3	4	100.0	0.01	0	0.0	0.00
		Total	5	33	100.0	-	0	0.0	-
	Total		N/A	477	97.7	-	11	2.3	-
Trib 1b	Angling	2005	1	0	0.0	-	0	0.0	-
	Minnow traps	2005	1	1	7.7	-	12	92.3	-
	Total		N/A	1	7.7	-	12	92.3	-
Trib 2	Electrofishing	2006	1	1	100.0	0.14	0	0.0	0.00
		2007	4	409	97.4	3.50	11	2.6	0.09
		2008	4	41	97.6	1.97	1	2.4	0.05
		Total	9	451	97.4	3.11	12	2.6	0.08
	Hoop nets	2007	24	2807	99.9	116.96	4	0.1	0.17
		2008	9	510	98.6	28.33	7	1.4	0.39
		Total	33	3317	99.7	58.88	11	0.3	0.31
	Minnow traps	2006	2	0	0.0	0.00	0	0.0	0.00
	Total		N/A	3768	99.4	-	23	0.6	-
Trib 3	Electrofishing	2006	1	11	100.0	0.87	0	0.0	0.00
		2008	4	71	95.9	1.15	3	4.1	0.05
	Total		5	82	96.5	1.11	3	3.5	0.04
Trib 4	Electrofishing	2006	1	0	0.0	0.00	0	0.0	0.00
		2008	6	104	94.5	1.49	6	5.5	0.09
		Total	7	104	94.5	1.27	6	5.5	0.07
	Minnow traps	2005	5	37	100.0	-	0	0.0	-
		2006	1	0	0.0	0.00	0	0.0	0.00
		Total	6	37	100.0	-	0	0.0	-
	Total		N/A	141	95.9	-	6	4.1	-
Trib 5	Minnow traps	2005	2	9	100.0	-	0	0.0	-

[1] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets); hoop nets (number of days)
[2] Electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap (not calculated for 2005); hoop net CPUE = #fish/day/trap

Table 4.4-9. The number of fish captured in upstream and downstream oriented hoop nets set in tributaries in the Mine Area, 2007-2008.

Waterbody	Year	Season	No. Days Sampled	Temperature Range (°C)	Arctic Char		Ninespine Stickleback	
					DS	US	DS	US
CLT2	2007	Fall	24	0.0-8.0	2779	28	4	0
	2008	Fall	9	3.0-4.8	342	168	6	1
SDLT1	2007	Fall	24	0.2-8.7	1240	16	18	0
	2008	Spring	18	5.3-14.1	495	354	42	6
	2008	Fall[1]	17	3.0-7.7	418	-	8	-

[1] Sheardown Tributary #1 was not sampled for fish moving in an upstream direction during fall 2008.

Table 4.4-10. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in tributaries of the northwest basin of Sheardown Lake, by tributary, gear type, year, and species.

Tributary	Gear Type	Year	Effort[1]	Arctic char			Ninespine stickleback		
				n	%	Mean CPUE[2]	n	%	Mean CPUE[2]
Trib 1	Electrofishing	2006	1	5	100.0	0.45	0	0.0	0.00
		2007	12	201	93.9	0.91	13	6.1	0.06
		2008	6	101	95.3	0.90	5	4.7	0.04
		Total	19	307	94.5	0.89	18	5.5	0.05
	Hoop nets	2007	24	1256	98.6	52.33	18	1.4	0.75
		2008	35	1267	95.8	23.91	56	4.2	1.05
		Total	59	2523	97.2	31.02	74	2.8	0.97
	Minnow traps	2005	3	21	100.0	-	0	0.0	-
		2006	1	2	100.0	0.01	0	0.0	0.00
		Total	4	23	100.0	-	0	0.0	-
	Total		N/A	2853	96.9	-	92	3.1	-
Trib 1b	Angling	2005	1	0	0.0	-	0	0.0	-
	Minnow traps	2005	3	11	100.0	-	0	0.0	-
	Total		N/A	11	100.0	N/A	0	0.0	N/A
Trib 12	Electrofishing	2007	6	5	100.0	0.10	0	0.0	0.00

[1] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets); hoop nets (number of days)
[2] Electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap (not calculated for 2005); hoop net CPUE = #fish/day/trap

Table 4.4-11. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in tributaries of the southeast basin of Sheardown Lake, by tributary, gear type, year, and species.

Tributary	Gear Type	Year	Effort[1]	Arctic char			Ninespine stickleback		
				n	%	Mean CPUE[2]	n	%	Mean CPUE[2]
Trib 7	Electrofishing	2008	4	73	53.7	1.08	63	46.3	0.93
Trib 9	Electrofishing	2007	3	35	100.0	0.88	0	0.0	0.00

[1] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets); hoop nets (number of days)
[2] Electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap (not calculated for 2005); hoop net CPUE = #fish/day/trap

Table 4.4-12. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in tributaries of the north basin of Mary Lake, by tributary, gear type, year, and species.

Tributary	Gear Type	Year	Effort[1]	Arctic char			Ninespine stickleback		
				n	%	Mean CPUE[2]	n	%	Mean CPUE[2]
Trib 1N	Electrofishing	2008	4	37	94.9	1.69	2	5.1	0.09
Trib 2N	Electrofishing	2008	2	0	0.0	0.00	0	0.0	0.00
Trib 3N	Electrofishing	2008	6	22	91.7	0.65	2	8.3	0.06
Trib 4N	Electrofishing	2008	2	3	75.0	0.27	1	25.0	0.09

[1] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets); hoop nets (number of days)
[2] Electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap (not calculated for 2005); hoop net CPUE = #fish/day/trap

Table 4.4-13. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in tributaries of the south basin of Mary Lake, by tributary, gear type, year, and species.

Tributary	Gear Type	Year	Effort[1]	Arctic char			Ninespine stickleback		
				n	%	Mean CPUE[2]	n	%	Mean CPUE[2]
Trib 1S	Electrofishing	2008	2	0	0.0	0.00	13	100.0	1.24
Trib 2S	Electrofishing	2008	6	11	25.6	0.15	32	74.4	0.43
Trib 3S	Electrofishing	2008	2	2	28.6	0.15	5	71.4	0.53

[1] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets); hoop nets (number of days)
[2] Electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap (not calculated for 2005); hoop net CPUE = #fish/day/trap

Table 4.4-14. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in the Mary River, by gear type, year, and species.

Gear Type	Year	Effort[1]	Arctic char			Ninespine stickleback		
			n	%	Mean CPUE[2]	n	%	Mean CPUE[2]
Angling	2005	5	13	100.0	-	0	0.0	-
Electrofishing	2006	13	70	100.0	0.44	0	0.0	0.00
	2007	16	111	100.0	0.55	0	0.0	0.00
	2008	4	79	100.0	0.51	0	0.0	0.00
	Total	33	260	100.0	0.50	0	0.0	0.00
Minnow traps	2006	3	4	66.7	< 0.00	2	33.3	< 0.00
Total		N/A	277	99.3	-	2	0.7	-

[1] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets); hoop nets (number of days)
[2] Electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap (not calculated for 2005); hoop net CPUE = #fish/day/trap

Table 4.4-15. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in the Tom River, by gear type, year, and species.

Gear Type	Year	Effort[1]	Arctic char			Ninespine stickleback		
			n	%	Mean CPUE[2]	n	%	Mean CPUE[2]
Angling	2005	2	5	100.0	-	0	0.0	-
Electrofishing	2006	2	10	100.0	0.29	0	0.0	0.00
	2007	6	15	100.0	0.38	0	0.0	0.00
	2008	2	25	100.0	1.05	0	0.0	0.00
	Total	10	50	100.0	0.40	0	0.0	0.00
Minnow traps	2006	2	0	0.0	0.00	0	0.0	0.00
Total		N/A	55	100.0	-	0	0.0	-

[1] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets); hoop nets (number of days)
[2] Electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap (not calculated for 2005); hoop net CPUE = #fish/day/trap

Table 4.4-16. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in candidate reference rivers, by gear type, year, and species.

Stream ID	Gear Type	Year	Effort[1]	Arctic char			Ninespine stickleback		
				n	%	Mean CPUE[2]	n	%	Mean CPUE[2]
Candidate Reference Stream #2	Efishing	2008	2	2	100.0	0.07	0	0.0	0.00
Candidate Reference Stream #3	Efishing	2008	2	0	100.0	0.00	0	0.0	0.00
Total			4	2	100.0	0.04	0	0.0	0.00

[1] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); minnow traps (number of sets); hoop nets (number of days)
[2] Electrofishing CPUE = #fish/minute of electrofishing; minnow trap CPUE = #fish/hour/trap (not calculated for 2005); hoop net CPUE = #fish/day/trap

Table 4.4-17. The number of fish captured and catch-per-unit-effort, by reach, during electrofishing surveys of streams in the Mine Area, 2006-2008.

Waterbody	Reach	Year	# of Surveys[1]	Fishing Effort (s)	ARCH	
					Catch	CPUE
Camp Lake Tributary #1	Reach 1	2006	2	1631	8	0.29
		2007	2	4020	196	2.93
		2008	4	1201	29	1.45
	Reach 1	**All Years**	**8**	**6852**	**233**	**2.04**
	Reach 2	2007	2	2700	135	3.00
	Reach 3	2007	2	3540	76	1.29
	Reach 4	2006	1	495	0	0.00
	All Reaches	**All Years**	**13**	**13587**	**444**	**1.96**
Camp Lake Tributary #2	Reach 1	2006	1	432	1	0.14
		2007	2	4080	222	3.26
		2008	4	1247	41	1.97
	Reach 1	**All Years**	**8**	**5759**	**264**	**2.75**
	Reach 2	2007	2	2940	187	3.82
	All Reaches	**All Years**	**10**	**8699**	**451**	**3.11**
Camp Lake Tributary #3	Reach 1	2006	1	755	11	0.87
		2008	2	2035	35	1.03
	Reach 1	**All Years**	**3**	**2790**	**46**	**0.99**
	Reach 2	2008	2	1655	36	1.31
	All Reaches	**All Years**	**5**	**4445**	**82**	**1.11**
Camp Lake Tributary #4	Reach 1	2008	2	2400	100	2.50
	Reach 1a	2008	2	1310	4	0.18
	US Pond	2006	1	728	0	0.00
		2008	2	480	0	0.00
	US Pond	**All Years**	**3**	**1208**	**0**	**0.00**
	All Reaches	**All Years**	**7**	**4918**	**104**	**1.27**
Sheardown Lake Tributary #1	Reach 1	2007	3	3930	95	1.45
		2008	3	3849	49	0.76
	Reach 1	**All Years**	**6**	**7779**	**144**	**1.11**
	Reach 2	2007	3	3120	59	1.13
		2008	3	2920	52	1.07
	Reach 2	**All Years**	**5**	**6040**	**111**	**1.10**
	Reach 3	2007	3	3120	34	0.65
	Reach 4 & 4b	2006	1	660	5	0.45
		2007	3	3030	13	0.26
	Reach 4 & 4b	**All Years**	**4**	**3690**	**18**	**0.29**
	All Reaches	**All Years**	**19**	**20629**	**307**	**0.89**
Sheardown Lake Tributary #7	Reach 1	2008	2	2005	50	1.50
	Reach 2	2008	2	2045	23	0.67
	All Reaches	**All Years**	**4**	**4050**	**73**	**1.08**

Table 4.4-17. - Continued -

Waterbody	Reach	Year	# of Surveys[1]	Fishing Effort (s)	ARCH	
					Catch	CPUE
Sheardown Lake Tributary #9	Reach 1 & 1b	2007	3	2379	35	0.88
Sheardown Lake Tributary #12	Reach 1	2007	3	1260	5	0.24
	Reach 2	2007	3	1770	0	0.00
	All Reaches	**All Years**	**6**	**3030**	**5**	**0.10**
Sheardown Lake US Pond #1	SLUSP-01	2007	1	300	0	0.00
Mary Lake-North Tributary #1	Reach 1	2008	2	440	1	0.14
	Reach 2	2008	2	870	36	2.48
	All Reaches	**All Years**	**4**	**1310**	**37**	**1.69**
Mary Lake-North Tributary #2	Reach 1	2008	2	150	0	0.00
Mary Lake-North Tributary #3	Reach 1	2008	2	560	0	0.00
	Reach 2	2008	2	755	1	0.08
	Reach 3	2008	2	720	21	1.75
	All Reaches	**All Years**	**6**	**2035**	**22**	**0.65**
Mary Lake-North Tributary #4	Reach 1	2008	2	660	3	0.27
Mary Lake-South Tributary #1	Reach 1	2008	2	630	0	0.00
Mary Lake-South Tributary #2	Reach 1	2008	3	2818	10	0.21
	Reach 2	2008	3	1694	1	0.04
	All Reaches	**All Years**	**6**	**4512**	**11**	**0.15**
Mary Lake-South Tributary #3	Reach 1	2008	2	800	2	0.15
Mary River	A0-01	2006	2	1115	22	1.18
		2007	1	1020	25	1.47
	A0-01	**All Years**	**3**	**2135**	**47**	**1.32**
	Reach 1	2007	3	1335	0	0.00
	C0-01	2006	1	1110	12	0.65
		2007	3	2880	25	0.52
	C0-01	**All Years**	**4**	**3990**	**37**	**0.56**
	C0-05	2006	1	740	2	0.16
		2007	3	3030	37	0.73
	C0-05	**All Years**	**4**	**3770**	**39**	**0.62**

Table 4.4-17. - Continued -

Waterbody	Reach	Year	# of Surveys[1]	Fishing Effort (s)	ARCH	
					Catch	CPUE
Mary River	C0-10	2006	1	370	20	3.24
		2007	3	2340	24	0.62
	C0-10	**All Years**	**4**	**2710**	**44**	**0.97**
	E0-01	2006	2	1655	12	0.44
		2008	3	8779	79	0.54
	E0-01	**All Years**	**5**	**10434**	**91**	**0.52**
	E0-01a	2006	2	1320	2	0.09
		2008	1	600	0	0.00
	E0-01a	**All Years**	**3**	**1920**	**2**	**0.06**
	G0-09	2006	4	3280	0	0.00
		2007	3	1420	0	0.00
	G0-09	**All Years**	**7**	**4700**	**0**	**0.00**
	All Reaches	**All Years**	**33**	**30994**	**260**	**0.50**
Tom River	I0-01	2007	3	2154	15	0.42
	I0-01a	2006	1	1125	10	0.53
		2008	2	1425	25	1.05
	I0-01a	**All Years**	**3**	**2550**	**35**	**0.82**
	I0-04	2006	1	935	0	0.00
		2007	3	1806	0	0.00
	I0-04	**All Years**	**4**	**2741**	**0**	**0.00**
	All Reaches	**All Years**	**10**	**7445**	**50**	**0.40**
Candidate Reference Stream #2	Reach 1	2008	2	1663	2	0.07
Candidate Reference Stream #3	Reach 1	2008	2	1680	0	0.00

[1] Includes different sites within a reach or multiple (seasonal) surveys of the same site within a reach

Table 4.4-18. Mean size and condition factor (K) of Arctic char captured during gillnetting studies in lakes in the Mine Area, 2005-2008.

Lake	Year	Sex[1]	Length				Weight				K			
			n[2]	Mean	StDev	Range	n	Mean	StDev	Range	n	Mean	StDev	Range
Camp Lake	2005	All	92	276	-	140-405	-	-	-	-	-	-	-	-
	2006	M_i	0	-	-	-	0	-	-	-	0	-	-	-
		M_{ms}	5	312	248	170-751	5	1055	2150	50-4900	5	1.03	0.10	0.88-1.16
		M_{mr}	6	353	161	195-647	6	629	879	75-2400	6	0.97	0.15	0.84-1.23
		M_T	11	335	195	170-751	11	823	1512	50-4900	11	1.00	0.13	0.84-1.23
		F_i	5	233	53	175-311	4	169	94	75-300	4	1.03	0.16	0.89-1.27
		F_{ms}	2	203	16	192-214	2	88	18	75-100	2	1.04	0.03	1.02-1.06
		F_{mr}	3	221	23	195-236	3	133	29	100-150	3	1.23	0.11	1.14-1.35
		F_T	10	224	39	175-311	9	139	69	75-300	9	1.10	0.15	0.89-1.35
		All	21	282	151	170-751	20	515	1152	50-4900	20	1.04	0.14	0.84-1.35
	2007	M_i	3	291	38	247-315	3	275	109	150-350	3	1.06	0.08	1.00-1.15
		M_{ms}	0	-	-	-	0	-	-	-	0	-	-	-
		M_{mr}	0	-	-	-	0	-	-	-	0	-	-	-
		M_T	3	291	38	247-315	3	275	109	150-350	3	1.06	0.08	1.00-1.15
		F_i	2	324	62	280-368	2	313	194	175-450	2	0.85	0.07	0.80-0.90
		F_{ms}	1	338	-	-	1	400	-	-	1	1.04	-	-
		F_{mr}	0	-	-	-	0	-	-	-	0	-	-	-
		F_T	3	329	45	280-368	3	342	147	175-450	3	1.06	0.08	1.00-1.15
		All	94	333	105	174-682	94	435	509	25-3050	94	0.96	0.19	0.47-1.43
	2008	M_i	0	-	-	-	0	-	-	-	0	-	-	-
		M_{ms}	5	498	164	350-745	5	1960	2184	400-5600	5	1.11	0.17	0.93-1.35
		M_{mr}	0	-	-	-	0	-	-	-	0	-	-	-
		M_T	9	465	137	342-745	9	1450	1705	375-5600	9	1.03	0.16	0.86-1.35
		F_i	0	-	-	-	0	-	-	-	0	-	-	-
		F_{ms}	0	-	-	-	0	-	-	-	0	-	-	-
		F_{mr}	0	-	-	-	0	-	-	-	0	-	-	-
		F_T	2	394	100	323-464	2	625	460	300-950	2	0.92	0.04	0.89-0.95
		All	22	401	117	236-745	22	876	1181	200-5600	22	1.02	0.23	0.82-1.67

Table 4.4-18. - Continued -

Lake	Year	Sex[1]	Length				Weight				K			
			n[2]	Mean	StDev	Range	n	Mean	StDev	Range	n	Mean	StDev	Range
Camp Lake	Total[3]	M_i	3	291	38	247-315	3	275	109	150-350	3	1.06	0.08	1.00-1.15
		M_{ms}	10	405	221	170-751	10	1508	2098	50-5600	10	1.07	0.14	0.88-1.35
		M_{mr}	6	353	161	195-647	6	629	879	75-2400	6	0.97	0.15	0.84-1.23
		M_T	23	380	171	170-751	23	997	1506	50-5600	23	1.02	0.14	0.84-1.35
		F_i	7	259	67	175-368	6	217	136	75-450	6	0.97	0.16	0.80-1.27
		F_{ms}	3	248	79	192-338	3	192	181	75-400	3	1.04	0.02	1.02-1.06
		F_{mr}	3	221	23	195-236	3	133	29	100-150	3	1.23	0.11	1.14-1.35
		F_T	15	267	80	175-464	14	252	234	75-950	14	1.03	0.16	0.80-1.35
		All	140	336	119	170-751	139	520	785	25-5600	139	0.99	0.19	0.47-1.67
Sheardown Lake - NW	2006	M_i	1	300	-	-	1	250	-	-	1	0.93	-	-
		M_{ms}	3	248	96	180-358	3	192	224	50-450	3	0.89	0.07	0.85-0.98
		M_{mr}	2	417	219	262-572	2	1025	1237	150-1900	2	0.92	0.13	0.83-1.02
		M_T	6	313	142	180-572	6	479	711	50-1900	6	0.91	0.08	0.83-1.02
		F_i	0	-	-	-	0	-	-	-	0	-	-	-
		F_{ms}	1	485	-	-	1	1000	-	-	1	0.88	-	-
		F_{mr}	1	284	-	-	1	200	-	-	1	0.87	-	-
		F_T	2	385	142	284-485	2	600	566	200-1000	2	0.87	0.00	0.87-0.88
		All	14	346	137	180-599	8	509	640	50-1900	8	0.90	0.07	0.83-1.02
	2007	M_i	6	351	48	278-393	6	367	145	150-525	6	0.80	0.08	0.70-0.93
		M_{ms}	1	389	-	-	1	475	-	-	1	0.81	-	-
		M_{mr}	1	507	-	-	1	1000	-	-	1	0.77	-	-
		M_T	8	375	68	278-507	8	459	253	150-1000	8	0.80	0.07	0.70-0.93
		F_i	6	345	81	240-492	6	399	284	125-950	6	0.87	0.09	0.72-0.95
		F_{ms}	2	341	18	328-354	2	325	35	300-350	2	0.82	0.04	0.79-0.85
		F_{mr}	0	-	-	-	0	-	-	-	0	-	-	-
		F_T	10	357	82	240-508	10	410	252	125-950	10	0.84	0.12	0.59-0.95
		All	92	366	97	178-587	87	509	355	50-1800	87	0.83	0.13	0.54-1.16

Table 4.4-18. - Continued -

Lake	Year	Sex[1]	Length				Weight				K			
			n[2]	Mean	StDev	Range	n	Mean	StDev	Range	n	Mean	StDev	Range
Sheardown Lake - NW	2008	M_i	0	-	-	-	0	-	-	-	0	-	-	-
		M_{ms}	0	-	-	-	0	-	-	-	0	-	-	-
		M_{mr}	0	-	-	-	0	-	-	-	0	-	-	-
		M_T	1	552	-	-	1	1750	-	-	1	1.04	-	-
		F_i	0	-	-	-	0	-	-	-	0	-	-	-
		F_{ms}	1	391	-	-	1	600	-	-	1	1.00	-	-
		F_{mr}	0	-	-	-	0	-	-	-	0	-	-	-
		F_T	1	391	-	-	1	600	-	-	1	1.00	-	-
		All	5	373	109	276-552	5	654	627	250-1750	5	1.04	0.10	0.91-1.19
	Total[4]	M_i	7	344	48	278-393	7	350	139	150-525	7	0.82	0.09	0.70-0.93
		M_{ms}	4	284	105	180-389	4	263	231	50-475	4	0.87	0.08	0.81-0.98
		M_{mr}	3	447	163	262-572	3	1017	875	150-1900	3	0.87	0.13	0.77-1.02
		M_T	15	362	115	180-572	15	553	568	50-1900	15	0.86	0.10	0.70-1.04
		F_i	6	345	81	240-492	6	399	284	125-950	6	0.87	0.09	0.72-0.95
		F_{ms}	4	390	69	328-485	4	563	320	300-1000	4	0.88	0.09	0.79-1.00
		F_{mr}	1	284	-	-	1	200	-	-	1	0.87	-	-
		F_T	13	394	83	240-508	13	454	285	125-1000	13	0.86	0.11	0.59-1.00
		All	111	364	102	178-599	100	516	394	50-1900	100	0.85	0.13	0.54-1.19
Sheardown Lake - SE	2007	M_i	4	352	35	323-401	4	388	144	300-600	4	0.86	0.06	0.80-0.93
		M_{ms}	0	-	-	-	0	-	-	-	0	-	-	-
		M_{mr}	0	-	-	-	0	-	-	-	0	-	-	-
		M_T	4	352	35	323-401	4	388	144	300-600	4	0.86	0.06	0.80-0.93
		F_i	1	335	-	-	1	350	-	-	1	0.93	-	-
		F_{ms}	3	330	35	300-368	3	333	88	250-425	3	0.92	0.07	0.85-0.98
		F_{mr}	0	-	-	-	0	-	-	-	0	-	-	-
		F_T	5	346	41	300-405	5	370	96	250-500	5	0.89	0.09	0.75-0.98
		All	36	337	68	180-415	36	395	184	50-700	36	0.94	0.16	0.60-1.62

Table 4.4-18. - Continued -

Lake	Year	Sex[1]	Length				Weight				K			
			n[2]	Mean	StDev	Range	n	Mean	StDev	Range	n	Mean	StDev	Range
Sheardown Lake - SE	2008	M_i	0	-	-	-	0	-	-	-	0	-	-	-
		M_{ms}	22	402	21	365-446	22	685	128	500-990	22	1.05	0.10	0.96-1.24
		M_{mr}	0	-	-	-	0	-	-	-	0	-	-	-
		M_T	26	396	23	360-446	26	658	135	475-990	26	1.04	0.09	0.86-1.24
		F_i	0	-	-	-	0	-	-	-	0	-	-	-
		F_{ms}	3	398	19	385-420	3	700	25	675-725	3	1.12	0.15	0.94-1.22
		F_{mr}	2	370	5	366-373	2	513	18	500-525	2	1.02	0.08	0.96-1.07
		F_T	7	382	19	364-420	7	589	109	450-725	7	1.05	0.12	0.93-1.22
		All	63	388	28	315-495	63	600	148	300-1200	63	1.02	0.13	0.49-1.51
	Total	M_i	4	352	35	323-401	4	388	144	300-600	4	0.86	0.06	0.80-0.93
		M_{ms}	22	402	21	365-446	22	685	128	500-990	22	1.05	0.10	0.96-1.24
		M_{mr}	0	-	-	-	0	-	-	-	0	-	-	-
		M_T	30	391	28	323-446	30	622	163	300-990	30	1.02	0.11	0.80-1.24
		F_i	1	335	-	-	1	350	-	-	1	0.93	-	-
		F_{ms}	6	364	45	300-420	6	517	209	250-725	6	1.02	0.15	0.85-1.22
		F_{mr}	2	370	5	366-373	2	513	18	500-525	2	1.02	0.08	0.96-1.07
		F_T	12	367	34	300-420	12	498	150	250-725	12	0.98	0.13	0.75-1.22
		All	99	370	52	180-495	99	525	189	50-1200	99	0.99	0.15	0.49-1.62
Mary Lake - South	2006	M_i	2	388	110	310-465	2	700	566	300-1100	2	1.05	0.06	1.01-1.09
		M_{ms}	10	289	113	165-403	10	338	290	25-700	10	1.02	0.29	0.56-1.47
		M_{mr}	14	455	108	350-685	14	1025	623	450-2350	14	1.02	0.29	0.73-1.93
		M_T	26	386	132	165-685	26	736	596	25-2350	26	1.03	0.27	0.56-1.93
		F_i	7	292	54	215-360	7	279	155	100-450	7	1.00	0.13	0.82-1.21
		F_{ms}	16	394	133	181-658	16	783	753	75-2450	16	0.99	0.11	0.84-1.26
		F_{mr}	10	387	102	225-490	10	663	426	125-1300	10	1.02	0.25	0.77-1.64
		F_T	33	370	116	181-658	33	639	600	75-2450	33	1.00	0.16	0.77-1.64
		All	62	384	133	165-705	62	743	709	25-3300	62	1.01	0.21	0.56-1.93

Table 4.4-18. - Continued -

Lake	Year	Sex[1]	Length				Weight				K			
			n[2]	Mean	StDev	Range	n	Mean	StDev	Range	n	Mean	StDev	Range
Mary Lake - South	2007	M_i	10	353	55	266-440	10	395	185	125-750	10	0.83	0.09	0.66-1.01
		M_{ms}	1	413	-	-	1	575	-	-	1	0.82	-	-
		M_{mr}	1	548	-	-	1	1425	-	-	1	0.87	-	-
		M_T	14	383	74	266-548	14	534	329	125-1425	14	0.85	0.08	0.66-1.01
		F_i	10	373	47	266-432	10	455	138	175-700	10	0.86	0.09	0.71-0.98
		F_{ms}	1	408	-	-	1	600	-	-	1	0.88	-	-
		F_{mr}	1	372	-	-	1	450	-	-	1	0.87	-	-
		F_T	12	375	44	266-432	12	467	132	175-700	12	0.86	0.08	0.71-0.98
		All	161	383	71	197-671	161	548	344	75-3050	161	0.88	0.11	0.60-1.41
	Total	M_i	12	359	61	266-465	12	446	267	125-1100	12	0.87	0.12	0.66-1.09
		M_{ms}	11	300	113	165-413	11	359	284	25-700	11	1.01	0.28	0.56-1.47
		M_{mr}	15	461	107	350-685	15	609	1052	450-2350	15	1.01	0.28	0.73-1.93
		M_T	40	385	114	165-685	40	665	523	25-2350	40	0.96	0.24	0.56-1.93
		F_i	17	339	63	215-432	17	382	167	100-700	17	0.92	0.13	0.71-1.21
		F_{ms}	17	395	129	181-658	17	772	730	75-2450	17	0.98	0.11	0.94-1.26
		F_{mr}	11	386	97	225-490	11	643	409	125-1300	11	1.01	0.24	0.77-1.64
		F_T	45	372	102	181-658	45	593	522	75-2450	45	0.96	0.16	0.71-1.64
		All	223	384	92	165-705	223	602	481	25-3300	223	0.92	0.16	0.56-1.93
Mary Lake - North	2007	All	98	379	41	198-458	98	493	125	75-850	98	0.90	0.13	0.60-1.20
Angajurjualuk Lake	2006	M_i	0	-	-	-	0	-	-	-	0	-	-	-
		M_{ms}	10	327	100	185-444	10	435	286	50-850	10	1.01	0.14	0.73-1.18
		M_{mr}	21	380	84	195-550	21	557	303	75-1500	21	0.93	0.10	0.66-1.10
		M_T	31	363	92	185-550	31	518	299	50-1500	31	0.95	0.12	0.66-1.18
		F_i	16	249	48	194-334	16	166	106	75-400	16	0.97	0.14	0.57-1.14
		F_{ms}	26	334	85	205-566	26	409	308	100-1650	26	0.96	0.10	0.79-1.16
		F_{mr}	10	330	52	243-415	10	395	159	150-650	10	1.04	0.07	0.91-1.12
		F_T	52	307	79	194-566	52	331	259	75-1650	52	0.98	0.11	0.57-1.16
		All	103	349	98	185-651	83	401	287	50-1650	83	0.97	0.11	0.57-1.18

Table 4.4-18. - Continued -

Lake	Year	Sex[1]	Length				Weight				K			
			n[2]	Mean	StDev	Range	n	Mean	StDev	Range	n	Mean	StDev	Range
Angajurjualuk Lake	2007	M_i	3	327	39	283-358	3	325	109	200-400	3	0.90	0.04	0.87-0.95
		M_{ms}	0	-	-	-	0	-	-	-	0	-	-	-
		M_{mr}	4	562	59	512-636	4	1713	666	1100-2450	4	0.93	0.11	0.82-1.07
		M_T	7	461	134	283-636	7	1118	881	200-2450	7	0.92	0.08	0.82-1.07
		F_i	9	349	34	272-396	9	400	98	200-550	9	0.93	0.10	0.73-1.05
		F_{ms}	0	-	-	-	0	-	-	-	0	-	-	-
		F_{mr}	1	550	-	-	1	1300	-	-	1	0.78	-	-
		F_T	10	369	71	272-550	10	490	299	200-1300	10	0.91	0.11	0.73-1.05
		All	141	404	70	200-636	141	633	573	75-4600	141	0.84	0.19	0.45-2.16
Angajurjualuk Lake	Total	M_i	3	327	39	283-358	3	325	109	200-400	3	0.90	0.04	0.87-0.95
		M_{ms}	10	327	100	185-444	10	435	286	50-850	10	1.01	0.14	0.73-1.18
		M_{mr}	25	409	105	195-636	25	742	565	75-2450	25	0.93	0.10	0.66-1.10
		M_T	38	381	106	185-636	38	628	504	50-2450	38	0.95	0.11	0.66-1.18
		F_i	25	285	65	194-396	25	250	153	75-550	25	0.95	0.13	0.57-1.14
		F_{ms}	26	334	85	205-566	26	409	308	100-1650	26	0.96	0.10	0.79-1.16
		F_{mr}	11	350	83	243-550	11	477	312	150-1300	11	1.01	0.10	0.78-1.12
		F_T	62	317	81	194-566	62	357	269	75-1650	62	0.97	0.11	0.57-1.16
		All	244	381	87	185-651	224	547	499	50-4600	224	0.89	0.17	0.45-2.16

[1] i = immature; ms = mature, current year spawners; mr = mature, resting; T = total (may include unknown maturity); All Fish includes those for which sex and maturity could not be identified
[2] May not equal total number of fish captured
[3] Does not include 2005 data because raw data were not available for combined calculations; includes 2007 winter catch
[4] Includes 2007 winter catch

Table 4.4-19. Fork length-weight relationships for Arctic char captured in experimental gillnet gangs set in lakes in the Mine Area, 2006-2008.

Waterbody	Year	n[1]	Fork Length-Weight Equation	R Square Value[2]
Camp Lake	2006	20	$Log_{10}Weight = -4.79 + 2.92 (Log10ForkLength)$	0.99
	2007	91	$Log_{10}Weight = -5.46 + 3.17 (Log10ForkLength)$	0.95
	2008	22	$Log_{10}Weight = -4.70 + 2.88 (Log10ForkLength)$	0.94
	All Years	133	$Log_{10}Weight = -5.14 + 3.05 (Log10ForkLength)$	0.96
Sheardown Lake - Northwest Basin	2006	8	$Log_{10}Weight = -5.37 + 3.13 (Log10ForkLength)$	1.00
	2007	87	$Log_{10}Weight = -4.93 + 2.94 (Log10ForkLength)$	0.96
	2008	5	$Log_{10}Weight = -4.66 + 2.87 (Log10ForkLength)$	0.99
	All Years	100	$Log_{10}Weight = -4.96 + 2.95 (Log10ForkLength)$	0.96
Sheardown Lake - Southeast Basin	2007	36	$Log_{10}Weight = -5.08 + 3.02 (Log10ForkLength)$	0.95
	2008	62	$Log_{10}Weight = -5.41 + 3.16 (Log10ForkLength)$	0.79
	All Years	98	$Log_{10}Weight = -5.40 + 3.15 (Log10ForkLength)$	0.94
Mary Lake - South Basin	2006	62	$Log_{10}Weight = -4.65 + 2.86 (Log10ForkLength)$	0.97
	2007	161	$Log_{10}Weight = -4.90 + 2.94 (Log10ForkLength)$	0.95
	All Years	223	$Log_{10}Weight = -4.76 + 2.89 (Log10ForkLength)$	0.96
Mary Lake - North Basin	2007	98	$Log_{10}Weight = -3.52 + 2.41 (Log10ForkLength)$	0.81
	All Years	98	$Log_{10}Weight = -3.52 + 2.41 (Log10ForkLength)$	0.81
Angajurjualuk Lake	2006	83	$Log_{10}Weight = -4.69 + 2.87 (Log_{10}ForkLength)$	0.98
	2007	141	$Log_{10}Weight = -5.35 + 3.10 (Log10ForkLength)$	0.90
	All Years	224	$Log_{10}Weight = -4.65 + 2.84 (Log10ForkLength)$	0.94
All Lakes Combined	All Years	876	$Log_{10}Weight = -4.80 + 2.90 (Log10ForkLength)$	0.95

[1] Number of fish measured (may not correspond to total number of fish captured)
[2] r square value indicates how well the linear model fits the data (a value closer to 1.00 indicates a better fit)

Table 4.4-20. Mean length, weight, and condition factor (K) of juvenile Arctic char captured during electrofishing surveys of lakes in the Mine Area, 2006-2008.

Waterbody	Year	Length				Weight				K			
		n[1]	Mean	StDev	Range	n	Mean	StDev	Range	n	Mean	StDev	Range
Camp Lake	2007	8	57	14	40-74	0	-	-	-	0	-	-	-
Sheardown Lake - NW	2007	220	80	29	33-180	212	7	9	1-59	212	0.99	0.24	0.44-2.04
	2008	36	87	26	44-140	35	9	6	1-28	35	1.22	0.29	0.72-2.02
	Total	256	80	29	33-180	247	8	9	1-59	247	1.02	0.26	0.44-2.04
Sheardown Lake - SE	2007	33	52	13	37-72	18	2	1	1-4	18	0.92	0.23	0.54-1.27
	2008	4	48	25	26-78	2	3	1	2-4	2	0.88	0.06	0.84-0.93
	Total	37	52	14	26-78	20	2	1	1-4	20	0.92	0.22	0.54-1.27
Mary Lake - S	2008	2	81	-	78-83	2	6	-	5-6	2	1.05	-	-
Mary Lake - N	2008	4	62	9	53-75	4	3	1	2-4	4	1.16	0.23	0.95-1.39
Angarjurjualuk Lake	2006	15	60	12	45-84	0	-	-	-	0	-	-	-

[1] May not equal total number of fish captured

Table 4.4-21. Sex and state of maturity of Arctic char captured during gillnetting surveys in lakes in the Mine Area, 2006-2008.

Waterbody	Year	Sex & Maturity[1]							
		# Mature[2]				# Immature		% Mature[3]	% Spawners[3]
		M_r	M_s	F_r	F_s	M	F		
Camp Lake	2006	6	5	3	2	0	5	76.2	33.3
	2007	0	0	0	1	3	2	16.7	16.7
	2008	0	5	0	0	0	0	100.0	100.0
	All years	6	10	3	3	3	7	68.8	40.6
Sheardown Lake - Northwest Basin	2006	2	3	1	1	1	0	87.5	50.0
	2007	1	1	0	2	6	6	25.0	18.8
	2008	0	0	0	1	0	0	100.0	100.0
	All years	3	4	1	4	7	6	48.0	32.0
Sheardown Lake - Southeast Basin	2007	0	0	0	3	4	1	37.5	37.5
	2008	0	22	2	3	0	0	100.0	92.6
	All years	0	22	2	6	4	1	85.7	80.0
Mary Lake - South Basin	2006	14	10	10	16	2	7	84.7	44.1
	2007	1	1	1	1	10	10	23.1	8.3
	All years	15	11	11	17	12	17	65.1	33.7
Angajurjualuk Lake	2006	21	10	10	26	0	16	79.5	43.4
	2007	4	0	1	0	3	9	29.4	0.0
	All years	25	10	11	26	3	25	72.0	36.0
All Lakes	2006	43	28	24	45	3	28	81.4	42.7
	2007	6	2	2	7	26	28	28.9	12.7
	2008	0	27	2	4	0	0	100.0	93.9
	All years	49	57	28	56	29	56	69.1	41.1

[1] Number of fish assessed for sex and state of maturity may not equal total number of fish captured
[2] M = male; F = female; r = resting; s = current year spawner
[3] Calculated as a percentage of fish examined for state of maturity

Table 4.4-22. The number of Chironomidae observed in stomach contents of Arctic char captured in lakes in the Mine Area, 2006.

Waterbody	# of Chironomidae				
	None	Few (<10)	Some (10-25)	Several (26-100)	Many (>100)
Camp Lake	2	2	5	4	8
Sheardown Lake - NW	1	0	0	1	6
Mary Lake - S	2	3	13	7	19
Angajurjualuk Lake	8	10	16	25	24
TOTALS	14	15	34	37	57

Table 4.4-23. Mean length, weight, and condition factor (K) of Arctic char captured during electrofishing surveys of streams in the Mine Area, 2006-2008.

Waterbody	Reach	Year	Length				Weight				K			
			n[1]	Mean	StDev	Range	n	Mean	StDev	Range	n	Mean	StDev	Range
Camp Lake Tributary #1	Reach 1	2006	8	97	48	45-158	0	-	-	-	0	-	-	-
		2007	94	104	39	41-190	51	17	14	1-68	51	0.83	0.12	0.58-1.18
		2008	27	102	24	70-140	25	11	7	4-25	25	1.07	0.26	0.79-1.75
		All Years	**129**	**103**	**37**	**41-190**	**76**	**15**	**12**	**1-68**	**76**	**0.91**	**0.21**	**0.58-1.75**
	Reach 2	2007	103	127	32	63-203	50	23	16	2-80	50	0.87	0.12	0.66-1.17
	Reach 3	2007	76	90	21	65-163	24	6	4	2-19	24	0.95	0.11	0.73-1.17
	All Reaches	**All Years**	**308**	**108**	**35**	**41-203**	**150**	**16**	**14**	**1-80**	**150**	**0.90**	**0.17**	**0.58-1.75**
Camp Lake Tributary #2	Reach 1	2006	1	52	-	-	-	-	-	-	-	-	-	-
		2007	176	71	20	39-147	102	4	3	1-15	102	0.82	0.21	0.44-1.46
		2008	22	89	26	45-145	22	8	6	1-25	22	0.99	0.19	0.67-1.32
		All Years	**199**	**73**	**22**	**39-147**	**124**	**4**	**4**	**1-25**	**124**	**0.85**	**0.21**	**0.44-1.46**
	Reach 2	2007	101	108	34	48-198	99	15	14	1-69	99	0.89	0.16	0.42-1.56
	All Reaches	**All Years**	**300**	**85**	**31**	**39-198**	**223**	**9**	**11**	**1-69**	**223**	**0.87**	**0.19**	**0.44-1.56**
Camp Lake Tributary #3	Reach 1	2006	11	51	25	35-123	-	-	-	-	-	-	-	-
		2008	35	79	27	38-156	4	9	2	5-10	4	1.11	0.16	0.97-1.34
		All Years	**46**	**72**	**29**	**39-156**	**4**	**9**	**2**	**5-10**	**4**	**1.11**	**0.16**	**0.97-1.34**
	Reach 2	2008	35	63	15	43-103	2	6	4	3-9	2	1.11	0.40	0.82-1.39
	All Reaches	**All Years**	**81**	**68**	**24**	**38-156**	**6**	**8**	**3**	**3-10**	**6**	**1.11**	**0.22**	**0.82-1.39**
Camp Lake Tributary #4	Reach 1	2008	81	74	30	34-147	66	6	6	1-24	66	0.80	0.23	0.49-1.51
	Reach 1a	2008	4	91	17	77-115	4	8	3	5-12	4	0.99	0.16	0.79-1.13
	All Reaches	**All Years**	**85**	**75**	**29**	**34-147**	**70**	**6**	**6**	**1-24**	**66**	**0.81**	**0.23**	**0.49-1.51**

Table 4.4-23. - Continued -

Waterbody	Reach	Year	Length				Weight				K			
			n[1]	Mean	StDev	Range	n	Mean	StDev	Range	n	Mean	StDev	Range
Sheardown Lake - NW Tributary #1	Reach 1	2007	95	61	11	34-107	72	2	2	1-11	72	0.78	0.21	0.42-1.27
		2008	45	66	22	40-147	28	5	5	1-23	28	1.20	0.37	0.64-2.05
		All Years	**140**	**63**	**15**	**34-147**	**100**	**3**	**3**	**1-23**	**100**	**0.90**	**0.33**	**0.42-2.05**
	Reach 2	2007	58	85	32	50-173	30	7	9	1-39	30	0.81	0.25	0.40-1.46
		2008	51	66	17	46-115	12	4	3	1-8	12	1.01	0.39	0.46-1.62
		All Years	**109**	**76**	**27**	**46-173**	**41**	**6**	**7**	**1-39**	**41**	**0.87**	**0.31**	**0.40-1.62**
	Reach 4 & 4b	2006	5	94	16	75-110	-	-	-	-	-	-	-	-
		2007	13	107	20	70-142	13	15	8	3-31	13	1.12	0.10	0.87-1.24
		All Years	**18**	**104**	**20**	**70-142**	**13**	**15**	**8**	**3-31**	**13**	**1.12**	**0.10**	**0.87-1.24**
	All Reaches	**All Years**	**301**	**72**	**23**	**34-173**	**186**	**5**	**6**	**1-39**	**186**	**0.90**	**0.30**	**0.36-2.05**
Sheardown Lake - SE Tributary #9	Reach 1	2007	35	60	19	35-111	27	3	3	1-13	27	0.88	0.32	0.42-1.66
Sheardown Lake – SE Tributary #12	Reach 1	2007	5	93	27	62-129	5	9	7	1-20	5	0.83	0.26	0.42-1.12
Mary Lake - N Tributary #1	Reach 1	2008	1	75	-	-	1	4	-	-	1	0.95	-	-
	Reach 2	2008	36	115	33	36-192	35	17	11	3-45	35	0.92	0.17	0.58-1.40
	All Reaches	**All Years**	**37**	**114**	**33**	**36-192**	**36**	**17**	**11**	**3-45**	**36**	**0.93**	**0.17**	**0.58-1.40**
Mary Lake - N Tributary #3	Reach 2	2008	1	78	-	-	1	4	-	-	1	0.84	-	-
	Reach 3	2008	21	117	28	73-166	21	21	15	6-55	21	1.21	0.31	0.81-2.10
	All Reaches	**All Years**	**22**	**115**	**28**	**73-166**	**22**	**20**	**15**	**4-55**	**22**	**1.20**	**0.32**	**0.81-2.10**
Mary Lake - N Tributary #4	Reach 1	2008	3	88	2	87-90	3	7	1	6-8	3	1.02	0.20	0.82-1.21
	All Reaches	**All Years**	**3**	**88**	**2**	**87-90**	**3**	**7**	**1**	**6-8**	**3**	**1.02**	**0.20**	**0.82-1.21**

Table 4.4-23. - Continued -

Waterbody	Reach	Year	Length				Weight				K			
			n[1]	Mean	StDev	Range	n	Mean	StDev	Range	n	Mean	StDev	Range
Mary Lake - S	Reach 1	2008	10	89	45	54-198	10	12	17	2-58	10	1.27	0.43	0.75-1.91
Tributary #2	Reach 2	2008	1	138	-	-	1	20	-	-	1	0.76	-	-
	All Reaches	**All Years**	**11**	**93**	**45**	**54-198**	**11**	**12**	**16**	**2-58**	**11**	**1.23**	**0.44**	**0.75-1.91**
Mary Lake - S	Reach 1	Summer	1	97	-	-	1	10	-	-	1	1.10	-	-
Tributary #3	**All Reaches**	**All Years**	**1**	**97**	**-**	**-**	**1**	**10**	**-**	**-**	**1**	**1.10**	**-**	**-**
Mary River	A0-01	2006	2	134	82	76-192	-	-	-	-	-	-	-	-
		2007	25	73	18	48-111	25	4	4	1-14	25	0.81	0.12	0.58-1.08
		All Years	**27**	**78**	**29**	**48-192**	**25**	**4**	**4**	**1-14**	**25**	**0.81**	**0.12**	**0.58-1.08**
	C0-01	2006	1	90	-	-	-	-	-	-	-	-	-	-
		2007	25	97	29	62-159	25	12	10	2-37	25	1.09	0.16	0.81-1.56
		All Years	**26**	**97**	**28**	**62-159**	**25**	**12**	**10**	**2-37**	**25**	**1.09**	**0.16**	**0.81-1.56**
	C0-05	2007	37	139	18	100-177	37	25	10	11-47	37	0.90	0.14	0.61-1.30
		All Years	**37**	**139**	**18**	**100-177**	**37**	**25**	**10**	**11-47**	**37**	**0.90**	**0.14**	**0.61-1.30**
	C0-10	2007	24	69	19	41-118	19	5	4	2-19	19	0.97	0.22	0.51-1.42
		All Years	**24**	**69**	**19**	**41-118**	**19**	**5**	**4**	**2-19**	**19**	**0.97**	**0.22**	**0.51-1.42**
	E0-01	2006	6	139	35	110-205	-	-	-	-	-	-	-	-
		2008	74	100	39	61-295	74	17	27	3-225	74	1.38	0.17	0.79-1.66
		All Years	**80**	**103**	**32**	**61-295**	**74**	**17**	**27**	**3-225**	**74**	**1.38**	**0.17**	**0.79-1.66**
	All Reaches	**All Years**	**194**	**101**	**35**	**41-295**	**180**	**15**	**20**	**1-225**	**180**	**1.12**	**0.28**	**0.51-1.66**
Tom River	I0-01	2007	15	78	23	43-127	13	5	4	2-15	13	0.86	0.12	0.71-1.09
		2008	25	91	18	69-151	25	9	6	3-34	25	1.03	0.21	0.71-1.61
	All Reaches	**All Years**	**40**	**86**	**21**	**43-151**	**38**	**8**	**6**	**2-34**	**38**	**0.97**	**0.20**	**0.71-1.61**

[1] May not equal total number of fish captured

Table 4.4-24. Mean length, weight, and condition factor (K) of Arctic char captured in hoop nets set in tributaries in the Mine Area, 2007-2008.

Waterbody	Year	Season	DOM[1]	Length (mm)				Weight (g)				K			
				n[2]	Mean	StDev[3]	Range	n	Mean	StDev	Range	n	Mean	StDev	Range
Camp Lake – Tributary #2	2007	Fall	DS	1699	99	40	39-370	923	14	37	1-500	923	0.83	0.14	0.35-1.54
			US	26	62	13	39-80	25	2	1	1-5	25	0.87	0.25	0.47-1.69
			Total	1725	98	39	39-370	948	14	37	1-500	948	0.83	0.14	0.35-1.69
	2008	Fall	DS	275	121	31	55-389	146	18	23	1-246	146	0.73	0.11	0.28-1.02
			US	168	120	37	43-415	104	19	61	2-620	103	0.72	0.10	0.47-0.97
			Total	443	121	33	43-415	250	18	43	1-620	249	0.73	0.10	0.28-1.02
	Years Combined			**2168**	**103**	**39**	**39-415**	**1198**	**15**	**38**	**1-620**	**1197**	**0.81**	**0.14**	**0.28-1.69**
Sheardown Lake – Tributary #1	2007	Fall	DS	664	103	34	41-335	268	15	15	1-97	268	0.90	0.11	0.60-1.39
			US	16	68	8	56-80	16	3	1	2-6	16	0.98	0.18	0.58-1.27
			Total	680	102	34	41-335	284	15	15	1-97	284	0.91	0.12	0.58-1.39
	2008	Spring	DS	408	93	30	35-242	408	9	11	1-107	405	0.84	0.29	0.28-3.29
			US	298	101	32	42-208	297	10	10	1-62	293	0.78	0.21	0.24-1.80
			Total	706	96	31	35-242	705	9	10	1-107	698	0.82	0.26	0.24-3.29
		Fall	DS	340	113	36	28-355	96	18	27	1-250	96	0.86	0.26	0.54-2.00
	Seasons Combined			1046	102	33	28-355	801	10	14	1-250	794	0.82	0.26	0.24-3.29
	Years Combined			**1726**	**102**	**34**	**28-355**	**1085**	**12**	**14**	**1-250**	**1078**	**0.84**	**0.23**	**0.24-3.29**
All Waterbodies				**3894**	**102**	**37**	**28-415**	**2283**	**13**	**29**	**1-620**	**2275**	**0.83**	**0.19**	**0.24-3.29**

[1] DOM = direction of movement
[2] Number measured may not equal total number captured
[3] StDev = standard deviation

Table 4.4-25. Summary of aquatic habitat information for lakes in the Mine Area.

Waterbody/Zone [1]	Zone Area [2]			Substrata Type									
				Cobble / Boulder		Gravel / Pebble		Sand		Fine Sand and Silt/Clay		Sand/Gravel	
	m^2	ha	% of Area	Area (m^2)	%	Area (m^2)	%	Area (m^2)	%	Area (m^2)	%	Area (m^2)	%
Camp Lake													
Zone of Potential Ice Cover (<2 m)	163,396	16.34	7.7	16,932	0.8	26,507	1.3	118,936	5.6	1,020	0.0	-	-
Preferred Spawning Depth (2 m – 10 m)	564,947	56.49	26.7	71,351	3.4	170,504	8.1	317,375	15.0	5,717	0.3	-	-
Non-Spawning Zone (>10 m)	1,384,019	138.40	65.5	19,726	0.9	398,799	18.9	853,486	40.4	112,007	5.3	-	-
Camp Lake Total	**2,112,362**	**211.24**	**100.0**	**108,009**	**5.1**	**595,810**	**28.2**	**1,289,797**	**61.1**	**118,744**	**5.6**	**0**	**0**
Sheardown Lake NW													
Zone of Potential Ice Cover (<2 m)	79,011	7.90	11.6	3,301	0.5	13,624	2.0	62,084	9.2	0	0.0	-	-
Preferred Spawning Depth (2 m – 10 m)	226,744	22.67	33.4	29,800	4.4	102,153	15.1	94,790	14.0	0	0.0	-	-
Non-Spawning Zone (>10 m)	372,596	37.26	54.9	35,735	5.3	167,982	24.8	155,241	22.9	13,638	2.0	-	-
Sheardown Lake NW Total	**678,351**	**67.84**	**100.0**	**68,836**	**10.1**	**283,759**	**41.8**	**312,115**	**46.0**	**13,638**	**2.0**	**0**	**0**
Sheardown Lake SE													
Zone of Potential Ice Cover (<2 m)	46,678	4.67	19.4	7,437	3.1	8,007	3.3	31,234	13.0	-	-	-	-
Preferred Spawning Depth (2 m – 10 m)	130,555	13.06	54.3	22,246	9.3	43,221	18.0	65,090	27.1	-	-	-	-
Non-Spawning Zone (>10 m)	63,159	6.32	26.3	12,356	5.1	36,105	15.0	14,698	6.1	-	-	-	-
Sheardown Lake SE Total	**240,392**	**24.04**	**100.0**	**42,039**	**17.5**	**87,333**	**36.3**	**111,022**	**46.2**	**0**	**0**	**0**	**0**

Table 4.4-25. - Continued -

Waterbody/Zone [1]	Zone Area [2]			Substrata Type									
				Cobble / Boulder		Gravel / Pebble		Sand		Fine Sand and Silt/Clay		Sand/Gravel	
	m^2	ha	% of Area	Area (m^2)	%	Area (m^2)	%	Area (m^2)	%	Area (m^2)	%	Area (m^2)	%
Mary Lake													
Zone of Potential Ice Cover (<2 m)	4,932,421	493.24	35.7	543,125	3.9	-	-	3,351,253	24.3	447,757	3.2	590,284	4.3
Preferred Spawning Depth (2 m - 10 m)	3,069,609	306.96	22.2	40,800	0.3	-	-	1,613,305	11.7	1,408,103	10.2	7,401	0.1
Non-Spawning Zone (>10 m)	5,797,129	579.71	42.0	1,013	0.0	-	-	607,182	4.4	5,188,935	37.6	0	0.0
Mary Lake Total	**13,799,159**	**1,379.92**	**100.0**	**584,938**	**4.2**	**0**	**0**	**5,571,740**	**40.4**	**7,044,795**	**51.1**	**597,685**	**4.3**
Candidate Reference Lake													
Zone of Potential Ice Cover (<2 m)	245,330	24.53	21.1	23,281	2.0	-	-	27,782	2.4	194,267	16.7	-	-
Preferred Spawning Depth (2 m - 10 m)	918,672	91.87	78.9	0	0.0	-	-	117	0.0	918,555	78.9	-	-
Non-Spawning Zone (>10 m)	25	0.00	0.0	0	0.0	-	-	0	0.0	25	0.0	-	-
Candidate Reference Lake Total	**1,164,027**	**116.40**	**100.0**	**23,281**	**2.0**	**0**	**0**	**27,899**	**2.4**	**1,112,847**	**95.6**	**0**	**0**

[1] Zone area and substrate areas may not add up due to rounding
[2] Zone boundaries adjusted for water level variation at time of bathymetric survey to sill elevation: Camp Lake +0.43 m; Sheardown NW +0.35 m; Sheardown SE +0.40 m; Mary Lake S +0.82 m; and Mary Lake N +0.93
No corrections were available for the Candidate Reference Lake

Table 4.4-26. Summary of Arctic char marked with Floy® tags and recaptured in the Mine Area, 2006-2008.

Waterbody	Year	No. Fish Tagged	No. Fish Recaptured	Recapture Comments
Angajurjualuk Lake	2007	117	0	
Camp Lake	2006	3	0	
	2007	64	1	Recaptured in hoop net set in CLT2 during fall 2007
	2008	16	0	
Mary Lake - North Basin	2007	77	0	
Mary Lake - South Basin	2007	119	0	
Sheardown Lake[1]	2007	79	1	Recaptured in the same location during fall 2008
	2008	57	0	

[1] One of the fish tagged in the Sheardown Lake watershed in 2008 was captured in a hoop net set at the confluence with Sheardown Lake Tributary 1; all others were captured in gill nets set in the lake

Table 4.5-1. Number of Arctic char tissue samples analysed for metals in the Mine Area.

Waterbody	2006		2007		2008	
	Muscle	Liver	Muscle	Liver	Muscle	Liver
Camp Lake	10	10	-	-	-	-
Sheardown Lake NW	8	8	20	20	-	-
Mary Lake	14	14	22	22	-	-
Angajurjualuk Lake	10	10	18	18	-	-
Mary River	-	-	-	-	30	30

Table 4.5-2. Fork length, weight, age, and condition factor of Arctic char sampled for analysis of metals in the Mine Area: 2006-2008.

Waterbody	Year	Sample Size	Fork Length (mm)			Weight (g)			Condition Factor			Age (years)		
			Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Camp Lake	2006	10	351	197	170-751	895	1573	50-4900	0.97	0.12	0.84-1.16	12	4	6-19
Sheardown Lake NW	2006	8	331	136	180-572	509	640	50-1900	0.90	0.07	0.83-1.02	12	5	6-19
	2007	20	366	71	240-508	418	229	125-1000	0.84	0.08	0.70-0.95	14	5	5-22
	2006-2007	28	356	93	180-572	445	385	50-1900	0.86	0.08	0.70-1.02	14	5	5-22
Mary Lake	2006	14	444	163	165-685	1192	837	100-2450	1.02	0.29	0.73-1.93	14	5	9-24
	2007	22	387	60	266-548	545	255	125-1425	0.85	0.07	0.71-1.01	14	3	8-23
	2006-2007	36	409	113	165-685	793	629	100-2450	0.92	0.20	0.71-1.93	14	4	8-24
Angajurjualuk Lake	2006	10	446	82	323-566	825	449	300-1650	0.86	0.09	0.66-0.98	18	5	11-25
	2007	18	396	114	228-636	708	666	100-2450	0.91	0.09	0.73-1.07	15	5	8-24
	2006-2007	28	414	105	228-636	750	591	100-2450	0.89	0.09	0.66-1.07	16	5	8-25
All Lakes	2006	42	401	156	165-751	897	972	50-4900	0.95	0.19	0.66-1.93	14	5	6-25
	2007	60	383	82	228-636	554	430	100-2450	0.86	0.09	0.70-1.07	14	4	5-24
	2006-2007	102	390	118	165-751	696	722	50-4900	0.90	0.14	0.66-1.93	14	5	5-25
Mary River	2008	30	99	21	63-150	15.74	10.83	4.11-49.42	1.42	0.11	1.07-1.64	3	1	2-5

Table 4.5-3. Summary statistics for metals (µg/g w.w.) in in liver of Arctic char captured in Camp Lake: 2006.

		2006 Statistics[2]					
Parameter	Analytical DL [1]	Mean	Min	Max	SD	N	%detection
Aluminum	2	11.3	2	28.9	8.0	10	100
Antimony	0.010 - 0.040	-	<0.010	<0.040	-	0	0
Arsenic	0.01	0.07	0.02	0.20	0.06	10	100
Barium	0.01	0.434	0.028	1.800	0.630	10	100
Beryllium	0.10 - 0.40	-	<0.10	<0.40	-	0	0
Bismuth	0.10 - 0.40	-	<0.10	<0.40	-	0	0
Cadmium	0.005	0.202	0.031	0.482	0.142	10	100
Calcium	2	163	43	497	166	10	100
Chromium	0.10 - 0.40	-	<0.10	0.21	-	3	30
Cobalt	0.02	0.170	0.102	0.265	0.052	10	100
Copper	0.01	45.7	5.18	130	42.4	10	100
Iron	0.2	994	456	2120	508	10	100
Lead	0.020 - 0.080	-	<0.020	0.035	-	1	10
Lithium	0.10 - 0.40	-	<0.10	<0.40	-	0	0
Magnesium	1	242	152	388	65.6	10	100
Manganese	0.01	3.92	1.22	18.70	5.23	10	100
Molybdenum	0.01	0.297	0.209	0.428	0.071	10	100
Nickel	0.10 - 0.40	-	<0.10	0.13	-	3	30
Potassium	20	3180	2730	3640	337	10	100
Selenium	0.2	2.76	1.31	4.46	1.12	10	100
Sodium	20	1012	620	1260	204	10	100
Strontium	0.01 - 0.02	0.083	<0.020	0.361	0.118	9	90
Thallium	0.01	0.152	0.046	0.482	0.138	10	100
Tin	0.50 - 0.20	-	<0.050	<0.20	-	0	0
Titanium	0.10 - 2.0	-	<0.10	1.37	-	2	20
Uranium	0.002	0.020	<0.0020	0.0812	0.027	9	90
Vanadium	0.10 - 0.40	-	<0.10	<0.40	-	2	20
Zinc	0.1	40.5	26	56.4	10.5	10	100

[1]Analytical detection limits (DL) varied for some parameters.
[2] Summary statistics derived for parameters with > 75% detection frequency.

Table 4.5-4. Summary statistics for mercury (µg/g w.w.) in Arctic char muscle tissue: 2006-2008.

Parameter	Year	Analytical DL	Mean	Minimum	Maximum	SD	n	% Detection	% samples Hg > 0.5 µg/g	% samples Hg > 0..2 µg/g	Mean Length-Standardized (400 mm) Conccentration
Camp Lake	2006	0.005	0.159	0.059	0.449	0.131	10	100	0	20	0.162
Sheardown Lake NW	2006	0.005	0.224	0.035	0.769	0.272	8	100	25	25	0.218
	2007	0.01	0.136	0.030	0.728	0.182	20	100	5	15	0.129
	2006-2007	0.005/0.01	0.161	0.030	0.769	0.210	28	100	11	18	0.137
Mary Lake	2006	0.005	0.518	0.113	2.13	0.602	14	100	29	43	0.290
	2007	0.01	0.134	0.056	0.434	0.111	22	100	0	14	0.124
	2006-2007	0.005/0.01	0.284	0.056	2.13	0.422	36	100	11	25	0.166
Angajurjualuk Lake	2006	0.005	0.526	0.090	1.46	0.473	10	100	40	80	0.225
	2007	0.01	0.265	0.067	0.990	0.312	18	100	17	33	0.181
	2006-2007	0.005/0.01	0.358	0.067	1.46	0.390	28	100	25	50	0.211
All Lakes	2006	0.005	0.379	0.03	2.13	0.46	42	100	24	43	0.250
	2007	0.01	0.174	0.030	0.990	0.216	60	100	7	20	0.137
	2006-2007	0.005/0.01	0.258	0.030	2.13	0.350	102	100	14	29	0.171
Mary River	2008	0.0010	0.032	0.016	0.054	0.009	30	100	0	0	NA

Table 4.5-5. Summary statistics for metals (µg/g w.w.) in Arctic char liver tissue captured in Sheardown Lake: 2006-2007.

		2006/2007 Statistics[2]					
Parameter	Analytical DL [1]	Mean	Min	Max	SD	N	%detection
Aluminum [3]	2	6.1	1.0	13.7	3.4	27	89
Antimony	0.010 - 0.030	-	<0.010	<0.040	-	28	0
Arsenic	0.01	-	<0.010	0.034	-	28	61
Barium	0.01-0.06	-	<0.010	16.0	-	28	64
Beryllium	0.10 - 0.30	-	<0.10	<0.30	-	28	0
Bismuth	0.03 - 0.30	-	<0.03	<0.30	-	28	0
Cadmium	0.005	0.177	0.061	0.343	0.064	28	100
Calcium	2	104	35.3	429	94.0	28	100
Chromium	0.10 - 0.30	-	<0.10	<0.30	-	28	0
Cobalt	0.02	0.097	0.027	0.232	0.051	28	100
Copper	0.01	15.4	2.1	41.8	8.7	28	100
Iron	0.20 - 1.00	835	220	1620	391	28	100
Lead	0.020 - 0.060	-	<0.020	<0.060	-	28	4
Lithium	0.10 - 0.30	-	<0.10	<0.30	-	28	0
Magnesium	1	225	140	345	51.8	28	100
Manganese	0.01	1.51	0.88	2.64	0.44	28	100
Molybdenum	0.01	0.205	0.104	0.316	0.046	28	100
Nickel	0.10 - 0.40	-	<0.10	<0.40	-	28	4
Potassium	20 - 100	2680	1780	3160	321	28	100
Selenium	0.2	1.82	0.72	3.33	0.69	28	100
Sodium	20 - 100	1167	740	1700	218	28	100
Strontium	0.010	0.039	<0.010	0.499	0.098	28	79
Thallium	0.010	0.079	0.018	0.236	0.055	28	100
Tin	0.050 - 0.15	-	<0.050	<0.15	-	28	0
Titanium	0.10 - 1.4	-	<0.20	0.17 [4]	-	28	7
Uranium	0.002	0.0070	<0.0020	0.0390	0.0076	28	86
Vanadium	0.10 - 0.30	-	<0.10	<0.30	-	28	11
Zinc	0.1	31.9	22.3	40.1	5.3	28	100

[1]Analytical detection limits (DL) varied for some parameters.
[2] Summary statistics derived for parameters with > 75% detection frequency.
[3] Excluding value of <6 µg/g.
[4] Excluding value of < 1.4 ug/g.

Table 4.5-6. Summary statistics for metals (µg/g w.w.) in Arctic char muscle tissue captured in Sheardown Lake: 2007.

		2007 Statistics[2]					
Parameter	Analytical DL [1]	Mean	Min	Max	SD	N	%detection
Moisture	0.1	78.2	73.1	83.9	2.2	20	100
Aluminum	2	3.3	1.0	5.4	1.4	20	80
Antimony	0.01	-	<0.010	<0.010	-	20	0
Arsenic	0.01	-	<0.010	<0.010	-	20	0
Barium	0.01-0.09	-	<0.010	<0090	-	20	20
Beryllium	0.1	-	<0.10	<0.10	-	20	0
Bismuth	0.03	-	<0.030	<0.030	-	20	0
Cadmium	0.005	-	<0.0050	<0.0050	-	20	0
Calcium	2	164	45.7	476	101	20	100
Chromium	0.1	-	<0.10	0.11	-	20	15
Cobalt	0.02	-	<0.020	0.022	-	20	5
Copper	0.01	0.430	0.291	0.547	0.073	20	100
Iron	0.20 - 0.60	7.07	4.56	12.50	2.11	20	100
Lead	0.02	-	<0.020	<0.020	-	20	0
Lithium	0.1	-	<0.10	<0.10	-	20	0
Magnesium	1	282	194	340	35.6	20	100
Manganese	0.01	0.108	0.065	0.187	0.036	20	100
Molybdenum	0.01	-	<0.010	<0.010	-	20	0
Nickel	0.1	-	<0.10	0.13	-	20	5
Potassium	20-60	3930	3150	4840	400	20	100
Selenium	0.2	0.41	0.29	0.48	0.05	20	100
Sodium	100	344	238	524	83	20	100
Strontium	0.01	0.025	<0.010	0.060	0.016	20	85
Thallium	0.01	-	<0.010	0.042	-	20	50
Tin	0.05	-	<0.050	<0.050	-	20	0
Titanium	0.1 - 0.3	-	<0.10	<0.30	-	20	5
Uranium	0.002	-	<0.0020	<0.0020	-	20	0
Vanadium	0.1	-	<0.10	<0.10	-	20	0
Zinc	0.1	6.9	4.0	10.6	2.3	20	100

[1]Analytical detection limits (DL) varied for some parameters.

[2] Summary statistics derived for parameters with > 75% detection frequency.

Table 4.5-7. Summary statistics for mercury (µg/g w.w.) in Arctic char liver tissue: 2007-2008.

Parameter	Year	Analytical DL	Mean	Minimum	Maximum	SD	n	% Detection
Sheardown Lake NW	2007	0.01	0.378	0.082	1.500	0.437	20	100
Mary Lake	2007	0.010	0.385	0.142	1.470	0.320	22	100
Angajurjualuk Lake	2007	0.01	0.670	0.122	1.92	0.623	18	100
Mary River	2008	0.001-0.043	0.092	0.0437	0.183	0.0308	30	100
All data	2007-2008	0.01-0.043	0.343	0.044	1.92	0.428	90	100

Table 4.5-8. Summary statistics for metals (µg/g w.w.) in Arctic char liver tissue captured in Mary Lake: 2006-2007.

		2006/2007 Statistics[2]					
Parameter	Analytical DL [1]	Mean	Min	Max	SD	N	%detection
Aluminum	2	15.6	2.1	78.8	14.9	36	100
Antimony	0.010-0.050	-	<0.010	<0.050	-	36	0
Arsenic	0.010	0.029	<0.010	0.072	0.018	36	92
Barium	0.010-0.040	0.060	<0.010	0.240	0.047	36	86
Beryllium	0.10-0.50	-	<0.10	<0.50	-	36	0
Bismuth	0.03-0.40	-	<0.030	<0.40	-	36	0
Cadmium	0.0050	0.1779	0.0437	0.7100	0.1264	36	100
Calcium	2.0	150	35.2	455	101	36	100
Chromium	0.10-0.50	-	<0.10	0.6	-	36	22
Cobalt	0.02	0.154	0.042	0.730	0.135	36	100
Copper	0.01	18.0	3.57	88.9	15.5	36	100
Iron	0.20-1.00	1010	218	3190	627	36	100
Lead	0.020-0.10	-	<0.020	0.629	-	36	19
Lithium	0.10-0.50	-	<0.10	0.32	-	36	28
Magnesium	1	231	128	342	46	36	100
Manganese	0.01	1.67	0.74	2.91	0.53	36	100
Molybdenum	0.01	0.254	0.139	0.413	0.063	36	100
Nickel	0.10 - 0.50	-	<0.10	0.250	-	36	3
Potassium	20 - 100	2901	2130	5000	586	36	100
Selenium	0.20	2.16	0.82	7.19	1.21	36	100
Sodium	20-100	1229	780	1800	240	36	100
Strontium	0.010	0.069	0.015	0.330	0.062	36	100
Thallium	0.010	0.104	0.019	0.428	0.099	36	100
Tin	0.050-0.25	-	<0.050	<0.25	-	36	6
Titanium	0.10-2.4	-	<0.10	<2.4	-	36	11
Uranium	0.002	0.0226	<0.002	0.1580	0.0315	36	97
Vanadium	0.10-0.50	-	<0.10	1.03	-	36	56
Zinc	0.1	36.0	23.9	57.9	7.0	36	100

[1]Analytical detection limits (DL) varied for some parameters.

[2] Summary statistics derived for parameters with > 75% detection frequency.

Table 4.5-9. Summary statistics for metals (µg/g w.w.) in Arctic char muscle tissue captured in Mary Lake: 2007.

		2007 Statistics[2]					
Parameter	Analytical DL [1]	Mean	Min	Max	SD	N	%detection
Moisture	0.1	78.2	73.0	82.8	2.7	22	100
Aluminum	2	-	<2.0	4.0	-	22	41
Antimony	0.01	-	<0.010	<0.010	-	22	0
Arsenic	0.01	-	<0.010	<0.010	-	22	0
Barium	0.01-0.09	-	<0.01	0.52	-	22	64
Beryllium	0.1	-	<0.10	<0.10	-	22	0
Bismuth	0.03	-	<0.030	<0.030	-	22	0
Cadmium	0.005	-	<0.0050	<0.0050	-	22	0
Calcium	2	115.1	48.3	255.0	64.1	22	100
Chromium	0.1	-	<0.10	0.10	-	22	5
Cobalt	0.02	-	<0.020	<0.020	-	22	0
Copper	0.01	0.408	0.264	0.651	0.106	22	100
Iron	0.20 - 1.00	5.50	3.68	9.98	1.46	22	100
Lead	0.02	-	<0.020	<0.020	-	22	0
Lithium	0.1	-	<0.10	0.10	-	22	5
Magnesium	1	257.1	181.0	344.0	41.7	22	100
Manganese	0.01	0.108	0.055	0.303	0.053	22	100
Molybdenum	0.01	-	<0.010	<0.010	-	22	0
Nickel	0.1	-	<0.10	<0.10	-	22	0
Potassium	20 - 100	3796	2930	5570	679	22	100
Selenium	0.2	0.35	0.24	0.60	0.09	22	100
Sodium	100	277	203	367	41	22	100
Strontium	0.01	0.043	0.010	0.073	0.018	22	100
Thallium	0.01	-	<0.010	0.06	-	22	50
Tin	0.05	-	<0.050	<0.050	-	22	0
Titanium	0.1 - 0.5	-	<0.10	<0.10	-	22	0
Uranium	0.002	-	<0.0020	<0.0020	-	22	0
Vanadium	0.1	-	<0.10	<0.10	-	22	0
Zinc	0.1	4.80	2.88	14.40	2.26	22	100

[1]Analytical detection limits (DL) varied for some parameters.
[2] Summary statistics derived for parameters with > 75% detection frequency.

Table 4.5-10. Summary statistics for metals (µg/g w.w.) in Arctic char liver tissue captured in Angajurjualuk Lake: 2006-2007.

		2006/2007 Statistics[2]					
Parameter	Analytical DL [1]	Mean	Min	Max	SD	N	%detection
Aluminum	2	8.6	<2	39.6	7.6	28	93
Antimony	0.01	-	<0.010	<0.010	-	28	0
Arsenic	0.01	-	<0.010	0.048	-	28	50
Barium	0.01-0.05	0.072	<0.02	0.715	0.131	28	86
Beryllium	0.1	-	<0.10	<0.10	-	28	0
Bismuth	0.03-0.10	-	<0.03	<0.10	-	28	0
Cadmium	0.005	0.133	0.023	0.283	0.060	28	100
Calcium	2	71.4	28.4	407.0	71.0	28	100
Chromium	0.1	-	<0.10	0.13	-	28	18
Cobalt	0.02	0.109	0.040	0.302	0.069	28	100
Copper	0.01	11.4	2.78	25.1	5.92	28	100
Iron	0.20 - 1.00	803	265	2000	399	28	100
Lead	0.02	-	<0.020	0.046	-	28	14
Lithium	0.1	-	<0.10	<0.10	-	28	0
Magnesium	1	202	89.7	307	45.4	28	100
Manganese	0.01	1.35	0.556	2.29	0.400	28	100
Molybdenum	0.01	0.220	0.123	0.298	0.047	28	100
Nickel	0.1	-	<0.10	0.11	-	28	4
Potassium	20 - 100	2795	1550	3540	439	28	100
Selenium	0.2	2.53	1.47	3.66	0.60	28	100
Sodium	20-100	1203	650	1700	227	28	100
Strontium	0.01	0.055	0.018	0.154	0.036	28	100
Thallium	0.01	0.086	0.023	0.203	0.051	28	100
Tin	0.05	-	<0.050	<0.050	-	28	0
Titanium	0.1 - 0.5	-	<0.20	<0.50	-	28	0
Uranium	0.002	0.0153	<0.0020	0.1600	0.0302	28	75
Vanadium	0.1	-	<0.10	1.14	-	28	25
Zinc	0.1	34.0	15.9	50.2	9.3	28	100

[1]Analytical detection limits (DL) varied for some parameters.
[2] Summary statistics derived for parameters with > 75% detection frequency.

Table 4.5-11. Summary statistics for metals (µg/g w.w.) in Arctic char muscle tissue captured in Angajurjualuk Lake: 2007.

		2007 Statistics[2]					
Parameter	Analytical DL [1]	Mean	Min	Max	SD	N	%detection
Moisture	0.1	77.7	73.9	83.7	3.3	18	100
Aluminum	2	-	<2.0	4.7	-	18	44
Antimony	0.01	-	<0.010	<0.010	-	18	0
Arsenic	0.01	-	<0.010	0.012	-	18	5
Barium	0.01-0.06	0.045	<0.01	0.153	0.036	18	83
Beryllium	0.1	-	<0.10	<0.10	-	18	0
Bismuth	0.03	-	<0.030	<0.030	-	18	0
Cadmium	0.005	-	<0.0050	<0.0050	-	18	0
Calcium	2	119.9	18.0	336.0	100.2	18	100
Chromium	0.1	-	<0.10	0.15	-	18	6
Cobalt	0.02	-	<0.020	<0.020	-	18	0
Copper	0.01	0.464	0.277	0.720	0.144	18	100
Iron	0.20 - 1.00	6.20	2.63	10.40	1.75	18	100
Lead	0.02	-	<0.020	<0.020	-	18	0
Lithium	0.1	-	<0.10	<0.10	-	18	0
Magnesium	1	259	144	390	62	18	100
Manganese	0.01	0.090	0.023	0.190	0.051	18	100
Molybdenum	0.010	-	<0.010	<0.010	-	18	0
Nickel	0.10	-	<0.10	<0.10	-	18	0
Potassium	20 - 100	3552	2020	4720	691	18	100
Selenium	0.2	0.50	0.29	0.73	0.13	18	100
Sodium	100	283	172	422	62	18	100
Strontium	0.01	0.075	0.014	0.200	0.063	18	100
Thallium	0.01	-	<0.010	0.051	-	18	72
Tin	0.05	-	<0.050	<0.050	-	18	0
Titanium	0.1 - 0.5	-	<0.10	<0.50	-	18	0
Uranium	0.002	-	<0.0020	<0.0020	-	18	0
Vanadium	0.1	-	<0.10	<0.10	-	18	0
Zinc	0.1	5.8	2.0	9.2	2.1	18	100

[1]Analytical detection limits (DL) varied for some parameters.
[2] Summary statistics derived for parameters with > 75% detection frequency.

Table 4.5-12. Summary statistics for metals (µg/g w.w.) in Arctic char liver tissue captured in the Mary River: 2008.

		2008 Statistics[2]					
Parameter	Analytical DL [1]	Mean	Min	Max	SD	N	%detection
Aluminum	2-86	-	<2.0	<86	-	30	0
Antimony	0.01-0.43	-	<0.010	<0.43	-	30	0
Arsenic	0.01-0.43	-	<0.010	<0.43	-	30	7
Barium	0.01-0.43	-	<0.010	0.7490	-	30	30
Beryllium	0.1-4.3	-	<0.10	<4.3	-	30	0
Bismuth	0.03-1.29	-	<0.030	<1.3	-	30	0
Cadmium	0.005-0.215	-	<0.005	<0.215	-	30	47
Calcium	2-86	289	90.2	733	135	30	100
Chromium	0.1-4.3	-	<0.10	11.5	-	30	13
Cobalt	0.02-0.86	-	<0.02	<0.86	-	30	10
Copper	0.01-0.43	4.58	2.06	10.8	1.99	30	100
Iron	0.6-26	117	48	175	34	30	100
Lead	0.02-0.86	-	<0.020	<0.86	-	30	0
Lithium	0.1-4.3	-	<0.10	<4.3	-	30	0
Magnesium	1-43	301	208	432	44	30	100
Manganese	0.01-0.43	1.63	0.901	3.26	0.61	30	100
Molybdenum	0.01-0.43	0.229	<0.43	1.63	0.296	30	80
Nickel	0.1-4.3	-	<0.10	9.5	-	30	17
Potassium	60-2600	3059	2400	3680	265.6	30	100
Selenium	0.2-8.6	-	<0.2	<8.6	-	30	27
Sodium	60-2600	-	<700	<2600	-	30	67
Strontium	0.01-0.43	-	0.028	<0.43	-	30	60
Thallium	0.01-0.43	-	<0.020	<0.43	-	30	7
Tin	0.05-2.15	-	<0.050	<2.2	-	30	0
Titanium	0.3-13	-	<0.30	<13	-	30	0
Uranium	0.002-0.086	-	<0.002	<0.086	-	30	10
Vanadium	0.1-4.3	-	<0.10	<4.3	-	30	0
Zinc	0.1-4.3	46.2	26.9	69.0	8.8	30	100

[1]Analytical detection limits (DL) varied for some parameters.
[2] Summary statistics derived for parameters with > 75% detection frequency.

Table 4.5-13. Summary statistics for metals (µg/g w.w.) in Arctic char muscle tissue captured in the Mary River: 2008.

		2008 Statistics[1]					
Parameter	Analytical DL	Mean	Min	Max	SD	N	%detection
Moisture	0.1	77.0	75.1	78.8	1.4	8	100
Aluminum	2.0	3.3	<2.0	16.0	2.7	30	77
Antimony	0.010	-	<0.010	<0.010	-	30	0
Arsenic	0.010	-	<0.010	0.011	-	30	7
Barium	0.010	0.033	0.011	0.068	0.014	30	100
Beryllium	0.10	-	<0.10	<0.10	-	30	0
Bismuth	0.030	-	<0.030	<0.030	-	30	0
Cadmium	0.005	-	<0.005	<0.005	-	30	0
Calcium	2	364	209	697	124	30	100
Chromium	0.10	-	<0.10	0.46	-	30	27
Cobalt	0.020	-	<0.020	<0.020	-	30	0
Copper	0.010	0.435	0.346	0.588	0.057	30	100
Iron	0.60	4.73	2.82	14.6	2.06	30	100
Lead	0.020	-	<0.020	<0.020	-	30	0
Lithium	0.10	-	<0.10	<0.10	-	30	0
Magnesium	1	280	236	337	27	30	100
Manganese	0.010	0.174	0.091	0.386	0.065	30	100
Molybdenum	0.010	-	<0.010	0.011	-	30	3
Nickel	0.10	-	<0.10	0.17	-	30	3
Potassium	60	3598	3000	4190	303	30	100
Selenium	0.20	0.44	0.32	0.55	0.05	30	100
Sodium	60	790	604	911	74	30	100
Strontium	0.010	0.092	0.054	0.176	0.031	30	100
Thallium	0.010	-	<0.010	0.011	-	30	7
Tin	0.050	-	<0.050	<0.050	-	30	0
Titanium	0.30	-	<0.30	<0.30	-	30	0
Uranium	0.0020	-	<0.002	<0.002	-	30	0
Vanadium	0.10	-	<0.10	<0.10	-	30	0
Zinc	0.10	9.44	7.32	15.1	1.52	30	100

[1]Analytical detection limits (DL) varied for some parameters.
[2] Summary statistics derived for parameters with > 75% detection

Table 5-1. Summary of stream crossing, lake encroachment and potential quarry site assessments, 2007-2010.

Study Area	Aquatic Program Component	No. Completed in		
		2007	2008	2010
Railway	Stream Crossing Assessments	228	108	2
	Encroachment Assessments	20	46	2
	Quarry Assessments	4	8	2
Construction Access Road	Stream Crossing Assessments	31	90	63

Table 5.1-1. Summary of fish presence/absence information for railway stream crossings, 2007-2010.

Watershed	No. of Streams Surveyed	Presence Confirmed or Suspected						No Fish Habitat	
		Arctic Char		Ninespine Stickleback		Both Species			
		n	%	n	%	n	%	n	%
Ravn River	122	46	38%	42	34%	39	32%	72	59%
Cockburn River	90	16	18%	14	16%	9	10%	69	77%
Ikpikitturjuaq River	18	6	33%	7	39%	6	33%	11	61%
Combined	**230**	**68**	**30%**	**63**	**27%**	**54**	**23%**	**152**	**66%**

Table 5.1-2. Summary of Arctic char habitat information for railway stream crossings, 2007-2010.

Watershed	No. of Streams Surveyed	Sites with Arctic Char Habitat	Habitat Quality Rating					
			Important		Marginal		Combined	
			n	%	n	%	n	%
Ravn River	122	46	32	26%	14	11%	46	38%
Cockburn River	90	16	12	14%	4	5%	16	18%
Ikpikitturjuaq River	18	6	4	22%	2	11%	6	33%
Combined	**230**	**68**	**48**	**21%**	**20**	**9%**	**68**	**30%**

Table 5.1-3. Summary of fish presence/absence information for access road stream crossings, 2007-2010 (includes only sites where the access road will deviate from the railway alignment).

Watershed	No. of Streams Surveyed	Presence Confirmed or Suspected						No Fish Habitat	
		Arctic Char		Ninespine Stickleback		Both Species			
		n	%	n	%	n	%	n	%
Ravn River	42	13	31%	15	36%	13	31%	27	65%
Cockburn River	44	5	11%	6	14%	5	11%	38	86%
Ikpikitturjuaq River	7	1	14%	2	29%	1	14%	5	71%
Combined	**93**	**19**	**20%**	**23**	**25%**	**19**	**20%**	**70**	**75%**

Table 5.1-4. Summary of Arctic char habitat information for access road stream crossings, 2007-2010 (includes only sites where the access road will deviate from the railway alignment).

Watershed	No. of Streams Surveyed	Sites with Arctic Char Habitat	Habitat Quality Rating					
			Important		Marginal		Combined	
			n	%	n	%	n	%
Ravn River	42	13	8	19%	5	12%	13	30%
Cockburn River	44	5	3	7%	2	5%	5	11%
Ikpikitturjuaq River	7	1	1	14%	0	0%	1	14%
Combined	**93**	**19**	**12**	**13%**	**7**	**8%**	**19**	**20%**

Table 5.1-5. Catch-per-unit-effort (CPUE) and size of Arctic char captured in experimental gill net gangs set in Cockburn Lake during fall, 2008.

Site	n[1]	CPUE[2]	Fork Length (mm)				Weight (g)			
			n	Mean	StDev[3]	Range	n	Mean	StDev	Range
CBL-08-01	7	86.3	7	469	56	384-543	7	1121	479	450-1900
CBL-08-02	2	13.0	2	342	12	333-350	1	350	-	-
CBL-08-03	1	4.5	1	442	-	-	1	800	-	-
CBL-08-04	1	8.7	1	332	-	-	1	300	-	-
CBL-08-05	5	85.8	5	473	183	230-731	5	1510	1300	150-3300
Total Catch	16	96.2	16	444	114	230-731	15	1123	856	150-3300

[1] Total number of fish captured (may not correspond to total number of fish measured or weighed)
[2] #fish/100 m/24h
[3] StDev = standard deviation

Table 5.2-1. Summary of fish presence/absence information for railway/access road lake encroachment sites, 2007-2010.

Watershed	No. of Lakes/Ponds Surveyed	Presence Confirmed or Suspected						No Fish Habitat	
		Arctic Char		Ninespine Stickleback		Both Species			
		n	%	n	%	n	%	n	%
Ravn River	21	6	29%	7	33%	4	19%	12	57%
Cockburn River	8	4	50%	4	50%	4	50%	4	50%
Ikpikitturjuaq River	17	9	53%	14	82%	9	53%	3	18%
Combined	**46**	**19**	**41%**	**25**	**54%**	**17**	**37%**	**18**	**39%**

Table 5.2-2. Summary of Arctic char habitat information for railway/access road lake encroachment sites, 2007-2010.

Watershed	No. of Lakes/Ponds Surveyed	Sites with Arctic Char Habitat	Habitat Quality Rating					
			Important		Marginal		Combined	
			n	%	n	%	n	%
Ravn River	21	6	2	10%	4	19%	6	29%
Cockburn River	8	4	4	50%	0	0%	4	50%
Ikpikitturjuaq River	17	9	5	29%	4	24%	9	53%
Combined	**46**	**19**	**11**	**24%**	**8**	**17%**	**19**	**41%**

Table 5.3-1. Summary of fish presence/absence information for potential quarry sites, 2007-2010.

Watershed	No. of Sites Surveyed	Presence Confirmed or Suspected						No Fish Habitat	
		Arctic Char		Ninespine Stickleback		Both Species			
		n	%	n	%	n	%	n	%
Ravn River	3	1	33%	1	33%	1	33%	2	67%
Cockburn River	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ikpikitturjuaq River	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Combined	**3**	**1**	**33%**	**1**	**33%**	**1**	**33%**	**2**	**67%**

Table 5.3-2. Summary of Arctic char habitat information for potential quarry sites, 2007-2010.

Watershed	No. of Sites Surveyed	Sites with Arctic Char Habitat	Habitat Quality Rating					
			Important		Marginal		Combined	
			n	%	n	%	n	%
Ravn River	3	1	1	33%	0	0%	1	33%
Cockburn River	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ikpikitturjuaq River	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Combined	**3**	**1**	**1**	**33%**	**0**	**0%**	**1**	**33%**

Table 6-1. Summary characteristics of available fish habitat measured for selected waterbodies in the Steensby Port Area, 2007-2010.

Watershed Name	Waterbody Name	Season/Year(s) Assessed[1]	Habitat			
			Dominant Substrate(s)	Dominant Channel Morphology	Barrier Type	Barrier Location[2]
ST-01	ST-029	Su/08; Su/10	Cobble	N/A	None	N/A
	ST-030	Su/10	Sand	N/A	None	N/A
	ST-032	Su/08; Su/10	Sand	N/A	None	N/A
	SPS-001a	Su/10	Fines/Cobble/Boulder	Pool	None	N/A
	SPS-018	Su/08	Cobble/Fines	Pool/Riffle	Steep Gradient	100 m US from ST-029
	SPS-019	Fa/07; Su/08; Su/10	Cobble/Gravel/Boulder	Pool/Cascade	No connection	100 m US from Steensby
ST-02	ST-022	Su/10	Cobble	N/A	None	N/A
	ST-023	Su/08	Cobble/Boulder	N/A	None	N/A
	ST-024	Su/08	Fines/Cobble	N/A	None	N/A
	ST-026	Su/10	Fines	N/A	None	N/A
	ST-027	Su/08	Boulder/Cobble	N/A	None	N/A
	ST-028	Su/08	Cobble	N/A	None	N/A
	ST-037	Su/10	Fines	N/A	No connection	~250 m US in SPS-002c
	ST-038	Su/10	Fines	N/A	None	N/A
	ST-039	Su/10	Cobble	N/A	None	N/A
	ST-040	Su/10	Cobble	N/A	None	N/A
	SPS-002b	Su/10	Fines/Cobble	Riffle/Pool	None	N/A
	SPS-002e	Su/10	Cobble	Pool	Steep Gradient	~ 250 m US from ST-038
	SPS-002h	Su/10	Fines	Pool	Steep Gradient	17 W 593576 7802852
	SPS-002i	Su/08	Cobble/Boulder	Riffle	None	N/A
	SPS-017	Su/08; Su/10	Cobble/Fines	Pool/Riffle	None	N/A
	SPS-022	Su/08	Boulder/Cobble	Riffle/Pool	None	N/A
ST-03	ST-085	Su/10	Cobble/Fines	N/A	None	N/A
	ST-086	Su/10	Fines/Boulder	N/A	None	N/A
	SPS-003b	Su/10	Fines	Pool	None	N/A

Table 6-1. - Continued -

Watershed Name	Waterbody Name	Season/Year(s) Assessed[1]	Habitat			
			Dominant Substrate(s)	Dominant Channel Morphology	Barrier Type	Barrier Location[2]
ST-04	ST-090	Su/10	Fines/Boulder/Cobble	N/A	None	N/A
	ST-092	Su/08; Su/10	Fines/Boulder/Cobble	N/A	None	N/A
	ST-093	Su/10	Fines	N/A	None	N/A
	SPS-004a	Su/10	Cobble/Gravel	Riffle/Pool	Subterranean Flow	17 W 596789 7804142
	SPS-004c	Su/10	Cobble/Fines	Pool	None	N/A
ST-05	ST-051	Su/10	Fines	N/A	None	N/A
	ST-052	Su/10	Fines	N/A	None	N/A
	ST-053	Su/10	Fines	N/A	None	N/A
	ST-055	Su/10	Fines	N/A	None	N/A
	ST-061-062	Su/10	Fines	N/A	None	N/A
	ST-063	Su/08; Su/10	Fines	N/A	None	N/A
	ST-064	Su/10	Cobble	N/A	None	N/A
	ST-072	Su/08; Su/10	Cobble/Boulder	N/A	None	N/A
	ST-353	Su/08	Cobble/Boulder	N/A	None	N/A
	SPS-005b	Su/10	Cobble	Pool/Cascade/Riffle	None	N/A
	SPS-005c	Fa/07	Fines	Pool	No connection	DS
	SPS-005e	Fa/07	Flooded Terrestrial	Pool	None	N/A
	SPS-005f	Su/10	Fines	Pool	None	N/A
	SPS-005j	Su/10	Cobble	Pool	None	N/A
	SPS-005k	Su/10	Fines	Pool	None	N/A
	SPS-005q	Fa/07; Su/10	Cobble/Fines	Pool	None	N/A
	SPS-005v	Fa/07	No water	N/A	None	N/A
ST-06	ST-176	Su/08	Fines	N/A	None	N/A
	ST-195	Su/08	Cobble	N/A	None	N/A
ST-08	ST-352	Su/08	Cobble	N/A	None	N/A

Table 6-1. - Continued -

Watershed Name	Waterbody Name	Season/Year(s) Assessed[1]	Habitat			
			Dominant Substrate(s)	Dominant Channel Morphology	Barrier Type	Barrier Location[2]
ST-11	ST-077	Su/10	Fines/Cobble	N/A	Steep Gradient	between ST-077 & 078
	ST-081	Su/08	Bedrock/Cobble	N/A	None	N/A
	ST-083	Su/08; Su/10	Fines/Boulder/Cobble	N/A	None	N/A
	SPS-011a	Su/10	Cobble/Fines	Pool	No connection	50 m US from Steensby
	SPS-011k	Fa/07	Cobble/Fines	Pool/Riffle	None	N/A
	SPS-025	Su/08	Flooded Terrestrial/Sand	Pool	None	N/A
ST-14	SPS-024	Su/08	Gravel/Sand	Riffle/Pool	None	N/A
ST-17	ST-007	Su/10	Cobble/Fines	N/A	None	N/A
ST-18	ST-005	Su/10	Fines/Cobble	N/A	None	N/A
	ST-006	Su/08; Su/10	Fines/Cobble	N/A	None	N/A
ST-19	ST-003	Su/08; Su/10	Fines/Cobble/Boulder	N/A	None	N/A
	ST-004	Su/10	Fines	N/A	None	N/A
	SPS-021	Su/08	Flooded Terrestrial	Riffle	Yes	100 m US
ST-20	SPS-020	Su/08	Fines/Flooded Terrestrial	Pool	None	N/A
ST-22	ST-087	Su/10	Fines/Cobble	N/A	None	N/A
ST-23	ST-018	Fa/07	Fines	N/A	None	N/A
	ST-019	Fa/07	Fines	N/A	None	N/A
ST-24	ST-009	Fa/07	Fines	N/A	None	N/A
	ST-010	Fa/07	Cobble	N/A	None	N/A
	ST-010a	Fa/07	Fines	N/A	None	N/A
	ST-012	Fa/07	Fines	N/A	None	N/A
ST-26	ST-016	Fa/07	Gravel	N/A	None	N/A
	ST-017	Fa/07	Fines	N/A	None	N/A
ST-27	ST-013	Fa/07	Fines	N/A	None	N/A
	ST-014	Fa/07	Fines	N/A	None	N/A
	ST-015	Fa/07	Fines	N/A	None	N/A

Table 6-1. - Continued -

Watershed Name	Waterbody Name	Season/Year(s) Assessed[1]	Habitat			
			Dominant Substrate(s)	Dominant Channel Morphology	Barrier Type	Barrier Location[2]
ST-28	ST-015b	Fa/07	Fines	N/A	None	N/A
ST-29	ST-036	Su/10	Cobble	N/A	No connection	~ halfway between ST-036 & 3km Lake
	SPS-029	Fa/07; Su/10	Fines/Gravel	Pool	None	N/A

[1] Sp = spring, Su = summer, Fa = fall
[2] Includes confirmed and suspected barriers to fish movements

Table 6-2. Summary hydrology for available fish habitat measured in selected waterbodies in the Steensby Port Area, 2007-2010.

Watershed Name	Waterbody Name	Season/Year(s) Assessed[1]	Hydrology			
			Wetted Width (m)	Approximate Average Depth (m)	Maximum Depth (m)	Water Velocity (m/s)
ST-01	ST-029	Su/08; Su/10	-	-	8.2	-
	ST-030	Su/10	-	-	-	-
	ST-032	Su/08; Su/10	-	-	10.0	-
	SPS-001a	Su/10	-	-	0.08	-
	SPS-018	Su/08	2.46	-	-	-
	SPS-019	Fa/07; Su/08; Su/10	2.0-20.1	0.05	0.40	0.28
ST-02	ST-022	Su/10	-	-	-	-
	ST-023	Su/08	-	-	5.8	-
	ST-024	Su/08	-	-	4.4	-
	ST-026	Su/10	-	-	-	-
	ST-027	Su/08	-	-	23.0	-
	ST-028	Su/08	-	-	-	-
	ST-037	Su/10	-	-	-	-
	ST-038	Su/10	-	-	-	-
	ST-039	Su/10	-	-	-	-
	ST-040	Su/10	-	-	-	-
	SPS-002b	Su/10	-	0.06	0.10	0.31
	SPS-002e	Su/10	0.2-0.5	0.17	0.30	0.05
	SPS-002h	Su/10	0.80	-	-	-
	SPS-002i	Su/08	3.9	-	-	-
	SPS-017	Su/08; Su/10	1.7-4.1	0.11	-	0.10
	SPS-022	Su/08	12.2	-	-	-
ST-03	ST-085	Su/10	-	-	-	-
	ST-086	Su/10	-	-	-	-
	SPS-003b	Su/10	-	-	0.25	-
ST-04	ST-090	Su/10	-	-	-	-
	ST-092	Su/08; Su/10	-	-	-	-
	ST-093	Su/10	-	-	-	-
	SPS-004a	Su/10	50.6	0.10	-	0.11
	SPS-004c	Su/10	18.7	0.11	-	0.05
ST-05	ST-051	Su/10	-	-	-	-
	ST-052	Su/10	-	-	-	-
	ST-053	Su/10	-	-	-	-
	ST-055	Su/10	-	-	-	-
	ST-061-062	Su/10	-	-	0.2	-
	ST-063	Su/08; Su/10	-	-	-	-
	ST-064	Su/10	-	-	-	-
	ST-072	Su/08; Su/10	-	-	-	-
	ST-353	Su/08	-	-	> 5	-
	SPS-005b	Su/10	1.5	0.08	-	0.30
	SPS-005c	Fa/07	-	-	< 0.10	-
	SPS-005e	Fa/07	-	-	-	-

Table 6-2. - Continued -

Watershed Name	Waterbody Name	Season/Year(s) Assessed[1]	Hydrology			
			Wetted Width (m)	Approximate Average Depth (m)	Maximum Depth (m)	Water Velocity (m/s)
ST-05	SPS-005f	Su/10	-	-	-	-
	SPS-005j	Su/10	2.0	0.11	-	0.01
	SPS-005k	Su/10	6.5	-	-	-
	SPS-005q	Fa/07; Su/10	>20	0.18	0.3	0.04
	SPS-005v	Fa/07	-	-	-	-
ST-06	ST-176	Su/08	-	-	-	-
	ST-195	Su/08	-	-	-	-
ST-08	ST-352	Su/08	-	-	> 5	-
ST-11	ST-077	Su/10	-	-	-	-
	ST-081	Su/08	-	-	-	-
	ST-083	Su/08; Su/10	-	-	21.0	-
	SPS-011a	Su/10	0.10-1.50	-	-	-
	SPS-011k	Fa/07	-	-	-	-
	SPS-025	Su/08	2.3	-	-	-
ST-14	SPS-024	Su/08	0.58	-	-	-
ST-17	ST-007	Su/10	-	-	-	-
ST-18	ST-005	Su/10	-	-	-	-
	ST-006	Su/08; Su/10	-	-	4.0	-
ST-19	ST-003	Su/08; Su/10	-	-	6.6	-
	ST-004	Su/10	-	-	-	-
	SPS-021	Su/08	1.3	-	-	-
ST-20	SPS-020	Su/08	-	-	-	-
ST-22	ST-087	Su/10	-	-	-	-
ST-23	ST-018	Fa/07	-	-	0.25	-
	ST-019	Fa/07	-	-	0.4	-
ST-24	ST-009	Fa/07	-	-	0.9	-
	ST-010	Fa/07	-	-	1.0	-
	ST-010a	Fa/07	-	-	0.4	-
	ST-012	Fa/07	-	-	0.5	-
ST-26	ST-016	Fa/07	-	-	0.8	-
	ST-017	Fa/07	-	-	1.0	-
ST-27	ST-013	Fa/07	-	-	0.2	-
	ST-014	Fa/07	-	-	0.4	-
	ST-015	Fa/07	-	-	0.2	-
ST-28	ST-015b	Fa/07	-	-	0.4	-
ST-29	ST-036	Su/10	-	-	> 3	-
	SPS-029	Fa/07; Su/10	21.6	0.15	0.20-0.30	0.0

[1] Sp = spring, Su = summer, Fa = fall

Table 6-3. Summary statistics for chlorophyll a concentrations (µg/L) in water samples collected from lakes in the Steensby Port Area, 2008. Values in blue italics are considered outliers.

Site	Sampling	Surface					Bottom				
ID	Date	Mean	Min	Max	SE	n	Mean	Min	Max	SE	n
ST24	2008	0.2	<0.2	0.3	0.1	2	0.9	0.4	1.4	0.5	2
ST28	2008	2.6	1.1	4.1	1.5	2	1.8	<0.2	3.5	1.7	2
ST29	2008	1.4	0.2	2.5	1.2	2	1.8	0.7	2.9	1.1	2
ST3	2008	1.5	<0.2	2.9	1.4	2	0.2	<0.2	0.3	0.1	2
ST32	2008	0.7	0.5	1.0	0.3	2	0.3	<0.2	0.5	0.2	2
ST6	2008	2.8	<0.2	5.5	2.7	2	2.3	0.4	4.2	1.9	2
ST81	2008	<0.2	<0.2	<0.2	0.0	2	n/s	n/s	n/s	n/s	0
ST88	2008	<0.2	-	-	-	1	n/s	n/s	n/s	n/s	0
ST195	2008	<0.2	-	-	-	1	n/s	n/s	n/s	n/s	0
ST92	2008	19.7	<0.2	*39.2*	19.6	2	n/s	n/s	n/s	n/s	0
ST-352	2008	1.4	<0.2	2.7	1.3	2	<0.2	-	-	-	1
ST-353	2008	0.8	<0.2	1.5	0.7	2	<0.2	-	-	-	1
All Sites	Summer 2008	0.2	<0.2	1.1	0.1	12	0.3	<0.2	0.7	0.1	8
All Sites	Fall 2008	5.4	<0.2	*39.2*	3.4	11	2.0	<0.2	4.2	0.7	6
All Sites	2008	2.8	<0.2	*39.2*	1.8	22	1.1	<0.2	4.2	0.4	14
All Sites - outlier removed	Fall 2008	1.9	<0.2	5.5	0.5	11	2.0	<0.2	4.2	0.7	6
All Sites - outlier removed	2008	1.1	<0.2	5.5	0.3	21	1.1	<0.2	4.2	0.4	14

Table 6-4. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in Steensby Port Area waterbodies, by gear type, year, and species.

Watershed	Site ID	Gear Type	Year	Effort[1]	Arctic char				Ninespine stickleback			
					n	%	Mean CPUE[2]	Size Range (mm)	n	%	Mean CPUE[3]	Size Range (mm)
ST-01	ST-029	OB/EF	2010	1	14	93.3	1.6	-	1	6.7	0.1	YOY
	ST-029	GN	2008	1	0	-	-	-	0	-	-	-
	ST-030	OB/EF	2010	1	1	-	0.1	120	Many	-	-	YOY
	ST-032	EF	2010	1	1	100.0	0.2	80	0	0.0	0.0	-
	ST-032	GN	2008	1	0	-	-	-	0	-	-	-
	ST-032	AN	2008	1	0	-	-	-	0	-	-	-
	SPS-001a	OB	2010	1	0	0.0	-	-	Many	100.0	-	-
	SPS-018	OB/EF	2008	1	11	91.7	1.1	62-103	1	8.3	0.1	48
	SPS-018	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-019	EF/OB	2008	2	18	94.7	0.9	58-155	1	0.1	0.05	49
	SPS-019	EF/OB	2010	1	2	100.0	0.7	-	0	0.0	0.0	-
	Total	-	-	12	47	-	-	58-155	Many	-	-	YOY-49
ST-02	ST-022	EF	2010	1	0	-	-	-	0	-	-	-
	ST-023	GN	2008	1	1	100.0	24.3	-	0	0.0	-	-
	ST-024	GN	2008	1	0	-	-	-	0	-	-	-
	ST-024	OB	2008	1	0	0.0	-	-	Many	100.0	-	-
	ST-025	OB	2010	1	0	-	-	-	0		-	-
	ST-026	EF/OB	2010	1	0	0.0	-	-	15	100.0	2.7	45-65
	ST-027	GN	2008	1	3	100.0	72.9	100-658	0	0.0	-	-
	ST-027	OB	2008	1	Many	100.0	-	-	0	0.0	-	-
	ST-027	ANG	2008	1	0	-	-	-	0	-	-	-
	ST-028	OB	2008	1	0	0.0	-	-	1	100.0	-	-
	ST-028	GN	2008	1	0	-	-	-	0	-	-	-
	ST-037	OB/EF	2010	1	0	0.0	-	-	Many	100.0	-	YOY
	ST-038	OB/EF	2010	1	3	42.9	0.6	30-40	4	57.1	0.8	30-65
	ST-039	OB/EF	2010	1	3	33.3	0.6	110-150	6	66.7	1.1	40-60
	ST-040	OB/EF	2010	1	0	0.0	-	-	61	100.0	10.2	-
	ST-041	OB	2010	1	0	-	-	-	0	-	-	-

Table 6-4. - Continued -

Watershed	Site ID	Gear Type	Year	Effort[1]	Arctic char				Ninespine stickleback			
					n	%	Mean CPUE[2]	Size Range (mm)	n	%	Mean CPUE[3]	Size Range (mm)
ST-02	SPS-002b	EF	2010	1	3	6.0	0.5	120-205	47	94.0	7.8	50-70
	SPS-002c	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-002d	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-002e	EF/OB	2010	1	23	95.8	3.8	32-120	1	4.2	0.2	-
	SPS-002f	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-002g	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-002h	EF/OB	2010	1	15	88.2	6.0	-	2	11.8	0.8	45-55
	SPS-002i	EF/OB	2008	1	15	45.5	0.08	65-123	18	54.5	0.9	36-61
	SPS-017	EF/OB	2010	1	0	0.0	-	-	38	100.0	6.3	-
	SPS-017	EF/OB	2008	1	0	0.0	-	-	8	100.0	0.8	33-36
	SPS-022	EF/OB	2008	1	2	4.4	0.1	59-75	43	95.6	2.2	34-74
	SPS-022	OB	2010	1	0	-	-	-	0	-	-	-
	Total	-	-	28	> 68	~ 22	-	30-658	> 244	~ 78	-	YOY-74
ST-03	ST-085	OB/EF	2010	1	0	-	-	-	0	-	-	-
	ST-086	OB/EF	2010	1	0	0.0	-	-	17	100.0	2.6	-
	SPS-003a	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-003b	OB/EF	2010	1	0	0.0	-	-	50	100.0	14.3	YOY-60
	Total	-	-	4	0	0.0	-	-	67	100.0	-	YOY-60
ST-04	ST-090	OB/EF	2010	1	7	53.8	1.3	60-120	6	46.2	1.1	40-65
	ST-092	OB	2008	1	Many	100.0	-	268-300	0	0.0	-	-
	ST-092	AN/OB	2008	1	1	100.0	0.0	-	0	0.0	-	-
	ST-092	GN	2008	1	1	100.0	16.7	-	0	0.0	-	-
	ST-092	OB/EF	2010	1	12	75.0	2.2	30-45	4	25.0	0.7	30-40
	ST-093	OB/EF	2010	1	5	83.3	0.7	-	1	16.7	0.1	-
	ST-094	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-004a	OB/EF	2010	3	112	99.1	12.0	60-250	1	0.9	0.1	-
	SPS-004c	OB/EF	2010	1	18	85.7	3.0	63-106	3	14.3	0.5	52-79
	Total	-	-	11	> 156	~ 92	-	30-300	15	~ 8	-	30-79

Table 6-4. - Continued -

Watershed	Site ID	Gear Type	Year	Effort[1]	Arctic char				Ninespine stickleback			
					n	%	Mean CPUE[2]	Size Range (mm)	n	%	Mean CPUE[3]	Size Range (mm)
ST-05	ST-048	OB	2010	1	0	-	-	-	0	-	-	-
	ST-051	OB	2010	1	0	-	-	-	20	100.0	-	-
	ST-052	OB	2010	1	70	70.0	-	-	30	30.0	-	-
	ST-053	OB	2010	1	2	2.8	-	65-90	70	97.2	-	YOY-50
	ST-055	OB	2010	1	3	25.0	-	70-95	9	75.0	-	YOY-60
	ST-061/62	OB	2010	1	Several	-	-	-	Several	-	-	YOY-60
	ST-061/62	EF	2010	1	0	-	-	-	0	-	-	-
	ST-063	OB	2008	1	Several	-	-	60-402	0	-	-	-
	ST-063	AN/OB	2008	1	0	-	-	-	0	-	-	-
	ST-063	GN	2008	1	1	-	-	-	0	-	-	-
	ST-063	OB	2010	1	Many	-	-	-	Many	-	-	-
	ST-064	OB/EF	2010	1	22	84.6	3.7	-	4	15.4	0.7	60-70
	ST-072	OB	2008	2	Several	-	-	125	Several	-	-	-
	ST-072	OB/EF	2010	1	43	43.0	12.3	80-170	57	57.0	16.3	-
	ST-353	GN	2008	1	1	100.0	14.0	623	0	0.0	-	-
	SPS-005a	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-005b	OB/EF	2010	1	27	79.4	6.8	55-180	7	20.5	1.8	58-70
	SPS-005c	OB/EF	2007	1	0	-	-	-	0	-	-	-
	SPS-005c	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-005d	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-005e	OB	2007	1	0	-	-	-	0	-	-	-
	SPS-005e	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-005f	OB/EF	2010	1	0	-	-	-	>100	100.0	>33.3	-
	SPS-005g	OB	2007	1	0	-	-	-	0	-	-	-
	SPS-005g	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-005h	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-005i	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-005j	OB	2010	1	0	0.0	-	-	>100	100.0	-	YOY-50
	SPS-005k	OB	2010	1	0	-	-	-	Several	-	-	YOY

Table 6-4. - Continued -

Watershed	Site ID	Gear Type	Year	Effort[1]	Arctic char				Ninespine stickleback			
					n	%	Mean CPUE[2]	Size Range (mm)	n	%	Mean CPUE[3]	Size Range (mm)
ST-05	SPS-005q	OB/EF	2007	1	0	-	-	-	0	-	-	-
	SPS-005q	OB/EF	2010	1	23	67.6	5.8	80-170	11	32.4	2.8	50-80
	SPS-005v	OB	2007	1	0	-	-	-	0	-	-	-
	SPS-005v	OB	2010	1	0	-	-	-	0	-	-	-
	Total	-	-	34	> 192	~ 32	-	55-623	> 408	~ 68	-	YOY-80
ST-06	ST- 176	OB	2008	1	6	5.7	-	-	>100	94.3	-	-
	ST- 176	OB/AN	2008	1	1	100.0	0.06	411	0	0.0	-	-
	ST-195	GN	2008	1	0	-	-	-	0	-	-	-
	ST-195	AN	2008	1	0	-	-	-	0	-	-	-
	ST-195	OB	2008	1	Several	100.0	-	>100	0	0.0	-	-
	Total	-	-	5	>7	~ 10	-	100-411	>100	~ 90	-	-
ST-08	ST-352	OB	2008	1	0	-	-	-	0	-	-	-
	Total	-	-	1	0	-	-	-	0	-	-	-
ST-11	ST-077	OB/EF	2010	1	0	0.0	-	-	>100	100.0	-	-
	ST-078	OB	2010	1	0	-	-	-	0	-	-	-
	ST-079	OB	2010	1	0	-	-	-	0	-	-	-
	ST-081	OB	2008	1	0	-	-	-	0	-	-	-
	ST-083	OB	2008	1	1	100.0	-	-	0	0.0	-	-
	ST-083	AN	2008	1	0	-	-	-	0	-	-	-
	ST-083	GN	2008	1	1	100.0	22.2	458	0	0.0	-	-
	ST-083	OB/EF	2010	1	3	100.0	0.6	79-91	0	0.0	-	-
	SPS-011a	OB/EF	2010	1	0	0.0	-	-	12	100.0	0.6	YOY
	SPS-011b	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-011c	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-011d	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-011e	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-011f	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-011k	OB/EF	2007	1	Several	100.0	-	-	0	0.0	-	-

Table 6-4. - Continued -

Watershed	Site ID	Gear Type	Year	Effort[1]	Arctic char				Ninespine stickleback			
					n	%	Mean CPUE[2]	Size Range (mm)	n	%	Mean CPUE[3]	Size Range (mm)
ST-11	SPS-025	OB/EF	2008	2	0	-	-	-	0	-	-	-
	SPS-025	OB	2010	1	0	-	-	-	0	-	-	-
	Total	-	-	18	>5	~ 5	-	79-458	>112	~ 95	-	YOY
ST-14	SPS-024	OB/EF	2008	1	0	-	-	-	0	-	-	-
	SPS-024	OB	2010	1	0	-	-	-	0	-	-	-
	Total	-	-	2	0	-	-	-	0	-	-	-
ST-17	ST-007	OB/EF	2010	1	0	-	-	-	0	-	-	-
	Total	-	-	1	0	-	-	-	0	-	-	-
ST-18	ST-005	OB	2010	1	0	0.0	-	-	14	100.0	-	40-65
	ST-006	GN	2008	1	0	-	-	-	0	-	-	-
	ST-006	OB/EF	2010	1	0	0.0	-	-	54	100.0	10.8	YOY-55
	SPS-018a	OB	2010	1	0	-	-	-	0	-	-	-
	Total	-	-	4	0	0.0	-	-	68	100.0	-	YOY-65
ST-19	ST-003	GN	2008	1	0	-	-	-	0	-	-	-
	ST-003	OB/EF	2010	1	0	-	-	-	6	-	1.5	60-70
	ST-004	OB/EF	2010	1	0	0.0	-	-	>20	100.0	>10	-
	SPS-019a	OB	2010	1	0	-	-	-	0	-	-	-
	SPS-021	OB/EF	2008	1	0	-	-	-	0	-	-	-
	SPS-021	OB	2010	1	0	-	-	-	0	-	-	-
	Total	-	-	5	0	0.0	-	-	>26	100.0	-	60-70
ST-20	SPS-020	OB	2008	1	0	-	-	-	0	-	-	-
	SPS-020	OB	2010	1	0	-	-	-	0	-	-	-
	Total	-	-	2	0	-	-	-	-	-	-	-
ST-22	ST-087	OB/EF	2010	1	0	-	-	-	0	-	-	-
	SPS-022a	OB	2010	1	0	-	-	-	0	-	-	-
	Total	-	-	2	0	-	-	-	0	-	-	-
ST-23	ST-018	OB/EF	2007	1	0	-	-	-	0	-	-	-
	ST-019	OB/EF	2007	1	0	-	-	-	0	-	-	-
	Total	-	-	2	0	-	-	-	0	-	-	-

Table 6-4 - Continued -

Watershed	Site ID	Gear Type	Year	Effort[1]	Arctic char				Ninespine stickleback			
					n	%	Mean CPUE[2]	Size Range (mm)	n	%	Mean CPUE[3]	Size Range (mm)
ST-24	ST-009	OB/EF	2007	1	0	-	-	-	0	-	-	-
	ST-010	OB/EF	2007	1	0	-	-	-	0	-	-	-
	ST-010a	OB/EF	2007	1	0	-	-	-	0	-	-	-
	ST-012	OB/EF	2007	1	0	-	-	-	0	-	-	-
	Total	-	-	4	0	-	-	-	0	-	-	-
ST-26	ST-016	OB/EF	2007	1	0	-	-	-	0	-	-	-
	ST-017	OB/EF	2007	1	0	-	-	-	0	-	-	-
	Total	-	-	2	0	-	-	-	0	-	-	-
ST-27	ST-013	OB/EF	2007	1	0	-	-	-	0	-	-	-
	ST-014	OB/EF	2007	1	0	-	-	-	0	-	-	-
	ST-015	OB/EF	2007	1	0	-	-	-	0	-	-	-
	Total	-	-	5	0	-	-	-	0	-	-	-
ST-28	ST-015b	OB	2007	1	0	-	-	-	0	-	-	-
	Total	-	-	1	0	-	-	-	0	-	-	-
ST-29	ST-036	OB/EF	2010	1	7	63.6	1.4	90-200	4	36.4	0.8	40-60
	SPS-029	OB/EF	2007	1	1	9.1	0.2	-	10	90.9	2.0	YOY
	SPS-029	OB/EF	2010	1	4	80.0	2.0	100	1	20.0	0.5	49
	SPS-029a	OB	2010	1	0	-	-	-	0	-	-	-
	Total	-	-	4	12	44.4	-	90-200	15	55.6	-	YOY-60

[1] Angling (number of sites); electrofishing (number of runs); gill nets (number of sets); observation (number of visits)
[2] Gill net CPUE = #fish/100m of net/24 hrs; electrofishing CPUE = #fish/minute of electrofishing

Table 6-5. Summary of potential Arctic char and ninespine stickleback habitat use in waterbodies in the Steensby Port Area, 2007-2010.

Watershed Name	Waterbody Name	Year(s) Surveyed	Arctic char[1]				Ninespine stickleback				Fish Habitat Quality Rating[2] ARCH/NNST
			Sp	Re	Wi	Mi	Sp	Re	Wi	Mi	
ST-01	ST-029	2008 & 2010	H	H	H	N	H	H	H	N	IMP/IMP
	ST-030	2010	N	H	N	N	H	H	H	N	IMP/IMP
	ST-032	2008 & 2010	M	H	H	N	L	L	L	N	IMP/MAR
	SPS-001a	2010	N	N	N	N	H	H	N	M	NFB/IMP
	SPS-018	2008 & 2010	N	M	N	N	L	M	N	N	MAR/MAR
	SPS-019	2008 & 2010	N	M	N	L	N	L	N	L	MAR/MAR
ST-02	ST-022	2010	N	N	N	N	N	N	N	N	NFB/NFB
	ST-023	2008	M	H	H	L	L	H	H	N	IMP/IMP
	ST-024	2008	L	M	L	N	M	H	M	N	MAR/IMP
	ST-025	2010	N	N	N	N	N	N	N	N	NFB/NFB
	ST-026	2010	N	L	N	N	H	H	L	M	MAR/IMP
	ST-027	2008	H	H	H	L	L	M	M	N	IMP/IMP
	ST-028	2008	L	M	L	N	M	M	L	N	MAR/MAR
	ST-037	2010	N	L	N	N	H	H	L	N	MAR/IMP
	ST-038	2010	H	H	H	N	H	H	H	N	IMP/IMP
	ST-039	2010	M	H	H	N	H	H	H	N	IMP/IMP
	ST-040	2010	N	L	L	N	H	H	H	N	MAR/IMP
	ST-041	2010	N	N	N	N	N	N	N	N	NFB/NFB
	SPS-002b	2010	N	H	N	L	M	H	N	H	IMP/IMP
	SPS-002c	2010	N	N	N	N	N	L	N	N	NFB/MAR
	SPS-002d	2010	N	N	N	N	N	L	N	N	NFB/MAR
	SPS-002e	2010	N	H	N	M	M	H	N	M	IMP/IMP
	SPS-002f	2010	N	N	N	N	N	L	N	N	NFB/MAR
	SPS-002g	2010	N	N	N	N	N	L	N	N	NFB/MAR
	SPS-002h	2010	N	L	N	L	H	H	N	H	MAR/IMP
	SPS-002i	2008	N	H	N	M	H	H	N	M	IMP/IMP
	SPS-017	2008 & 2010	N	L	N	L	H	H	N	H	MAR/IMP
	SPS-022	2008 & 2010	N	L	N	L	M	M	N	M	MAR/MAR

Table 6-5. - Continued -

Watershed Name	Waterbody Name	Year(s) Surveyed	Arctic char[1]				Ninespine stickleback				Fish Habitat Quality Rating[2] ARCH/NNST
			Sp	Re	Wi	Mi	Sp	Re	Wi	Mi	
ST-03	ST-085	2010	N	N	N	N	N	N	N	N	NFB/NFB
	ST-086	2010	N	N	N	N	H	H	L	N	NFB/IMP
	SPS-003a	2010	N	N	N	N	N	N	N	N	NFB/NFB
	SPS-003b	2010	N	N	N	N	H	H	N	N	NFB/IMP
ST-04	ST-090	2010	H	H	H	N	H	H	H	N	IMP/IMP
	ST-092	2008 & 2010	H	H	H	L	H	H	H	L	IMP/IMP
	ST-093	2010	M	H	M	L	H	H	M	L	IMP/IMP
	ST-094	2010	N	N	N	N	N	N	N	N	NFB/NFB
	SPS-004a	2010	N	H	N	L	L	L	N	L	IMP/MAR
	SPS-004c	2010	N	H	N	H	M	H	N	H	IMP/IMP
ST-05	ST-048	2010	M	M	M	N	M	M	M	L	IMP/IMP
	ST-051	2010	N	L	L	L	H	H	L	M	MAR/IMP
	ST-052	2010	M	H	L	M	H	H	L	M	IMP/IMP
	ST-053	2010	M	H	L	M	H	H	L	M	IMP/IMP
	ST-055	2010	M	H	N	H	H	H	L	H	IMP/IMP
	ST-061	2010	N	H	N	M	H	H	N	H	IMP/IMP
	ST-062	2010	N	H	N	M	H	H	N	H	IMP/IMP
	ST-063	2008 & 2010	H	H	H	N	H	H	H	N	IMP/IMP
	ST-064	2010	M	H	N	M	M	H	N	M	IMP/IMP
	ST-072	2008 & 2010	H	H	H	N	M	H	M	N	IMP/IMP
	ST-353	2008	H	H	H	L	M	H	H	L	IMP/IMP
	SPS-005a	2010	N	N	N	N	N	N	N	N	NFB/NFB
	SPS-005b	2010	N	H	N	H	M	H	N	H	IMP/IMP
	SPS-005c	2007 & 2010	N	N	N	N	N	N	N	N	NFB/NFB
	SPS-005d	2010	N	N	N	N	N	L	N	N	NFB/MAR
	SPS-005e	2010	N	N	N	N	N	N	N	N	NFB/NFB
	SPS-005f	2010	N	N	N	N	H	H	N	H	NFB/IMP
	SPS-005g	2007 & 2010	N	N	N	N	N	N	N	N	NFB/NFB

Table 6-5. - Continued -

Watershed Name	Waterbody Name	Year(s) Surveyed	Arctic char[1]				Ninespine stickleback				Fish Habitat Quality Rating[2] ARCH/NNST
			Sp	Re	Wi	Mi	Sp	Re	Wi	Mi	
ST-05	SPS-005h	2010	N	L	N	N	N	L	N	N	MAR/MAR
	SPS-005i	2010	N	N	N	N	L	L	N	N	NFB/MAR
	SPS-005j	2010	N	N	N	N	H	H	N	H	NFB/IMP
	SPS-005k	2010	N	N	N	N	H	H	N	M	NFB/IMP
	SPS-005q	2007 & 2010	N	H	N	H	M	H	N	H	IMP/IMP
	SPS-005v	2007	N	N	N	N	N	N	N	N	NFB/NFB
ST-06	ST-176	2008	M	H	H	N	L	H	H	N	IMP/IMP
	ST-195	2008	M	H	H	N	L	M	M	N	IMP/IMP
ST-08	ST-352	2008	H	H	H	N	L	M	M	N	IMP/IMP
ST-11	ST-077	2010	N	N	N	N	H	H	H	N	NFB/IMP
	ST-078	2010	N	N	N	N	N	N	N	N	NFB/NFB
	ST-079	2010	N	N	N	N	N	N	N	N	NFB/NFB
	ST-081	2008	N	N	N	N	L	L	L	N	NFB/MAR
	ST-083	2008 & 2010	M	H	H	L	L	L	L	L	IMP/MAR
	SPS-011a	2010	N	N	N	N	M	H	N	H	NFB/IMP
	SPS-011b	2010	N	N	N	N	N	L	N	N	NFB/MAR
	SPS-011c	2010	N	N	N	N	N	L	N	N	NFB/MAR
	SPS-011d	2010	N	N	N	N	N	L	N	N	NFB/MAR
	SPS-011e	2010	N	L	N	N	N	L	N	N	MAR/MAR
	SPS-011f	2010	N	L	N	N	N	L	N	N	MAR/MAR
	SPS-011k	2007	N	M	N	M	L	L	N	L	MAR/MAR
	SPS-025	2008	N	N	N	N	N	L	N	N	NFB/MAR
ST-14	SPS-024	2008 & 2010	N	N	N	N	N	N	N	N	NFB/NFB
ST-17	ST-007	2010	N	N	N	N	N	N	N	N	NFB/NFB
ST-18	ST-005	2010	N	N	N	N	H	H	H	N	NFB/IMP
	ST-006	2008 & 2010	N	N	N	N	H	H	H	N	NFB/IMP
	SPS-018a	2010	N	N	N	N	L	L	N	N	NFB/MAR

Table 6-5. - Continued -

Watershed Name	Waterbody Name	Year(s) Surveyed	Arctic char[1]				Ninespine stickleback				Fish Habitat Quality Rating[2] ARCH/NNST
			Sp	Re	Wi	Mi	Sp	Re	Wi	Mi	
ST-19	ST-003	2008 & 2010	N	N	N	N	H	H	H	N	NFB/IMP
	ST-004	2010	N	N	N	N	H	H	H	N	NFB/IMP
	SPS-019a	2010	N	N	N	N	M	M	N	M	NFB/IMP
	SPS-021	2008 & 2010	N	N	N	N	N	L	N	N	NFB/MAR
ST-20	SPS-020	2008	N	L	N	N	M	M	N	N	MAR/MAR
ST-22	ST-087	2010	N	N	N	N	N	N	N	N	NFB/NFB
	SPS-022a	2010	N	N	N	N	N	L	N	N	NFB/MAR
ST-23	ST-018	2007	N	N	N	N	N	N	N	N	NFB/NFB
	ST-019	2007	N	N	N	N	N	N	N	N	NFB/NFB
ST-24	ST-009	2007	N	N	N	N	N	N	N	N	NFB/NFB
	ST-010	2007	N	N	N	N	N	N	N	N	NFB/NFB
	ST-010a	2007	N	N	N	N	N	N	N	N	NFB/NFB
	ST-012	2007	N	N	N	N	N	N	N	N	NFB/NFB
ST-26	ST-016	2007	N	N	N	N	N	N	N	N	NFB/NFB
	ST-017	2007	N	N	N	N	N	N	N	N	NFB/NFB
ST-27	ST-013	2007	N	N	N	N	N	N	N	N	NFB/NFB
	ST-014	2007	N	N	N	N	N	N	N	N	NFB/NFB
	ST-015	2007	N	N	N	N	N	N	N	N	NFB/NFB
ST-28	ST-015b	2007	N	N	N	N	N	N	N	N	NFB/NFB
ST-29	ST-036	2010	M	H	H	N	H	H	H	N	IMP/IMP
	SPS-029	2007 & 2010	N	H	N	N	H	H	N	L	IMP/IMP
	SPS-029a	2010	N	N	N	N	N	L	N	N	NFB/MAR

[1] Sp = spawning; Re = rearing; Wi = wintering; Mi = migration; N - no use; L - low potential use; M - moderate potential use; H - high potential use
[2] NFB = not fish bearing, MAR = marginal, IMP = important

Table 7-1. Summary of potential Arctic char and ninespine stickleback habitat use in waterbodies in the vicinity of Milne Inlet, 2007-2010.

Site	Year(s) Surveyed	UTM Coordinates			Arctic char[1]				Ninespine stickleback				Fish Habitat Quality Rating[2] ARCH/NNST
		Zone	Easting	Northing	Sp	Re	Wi	Mi	Sp	Re	Wi	Mi	
Lakes													
ML-01	2010	17V	503037	7975570	N	N	N	N	N	N	N	N	NFB/NFB
ML-02	2010	17V	503066	7975380	N	N	N	N	N	N	N	N	NFB/NFB
ML-03	2010	17V	503095	7975200	N	N	N	N	N	N	N	N	NFB/NFB
ML-04	2010	17V	503214	7975245	N	N	N	N	N	N	N	N	NFB/NFB
ML-05	2010	17V	503093	7975007	N	N	N	N	N	N	N	N	NFB/NFB
ML-06	2010	17V	503116	7974917	N	N	N	N	N	N	N	N	NFB/NFB
ML-07	2010	17V	503193	7974824	N	N	N	N	N	N	N	N	NFB/NFB
ML-08	2010	17V	503235	7974655	N	N	N	N	N	N	N	N	NFB/NFB
ML-09	2010	17V	503828	7974713	N	N	N	N	N	N	N	N	NFB/NFB
ML-10	2010	17V	503587	7975779	N	N	N	N	N	N	N	N	NFB/NFB
ML-11	2010	17V	503648	7975800	N	N	N	N	N	N	N	N	NFB/NFB
ML-12	2010	17V	503645	7975853	N	N	N	N	N	N	N	N	NFB/NFB
ML-13	2010	17V	503839	7976033	N	N	N	N	N	N	N	N	NFB/NFB
ML-15	2010	17V	505683	7974095	N	N	N	N	N	N	N	N	NFB/NFB
ML-16	2010	17V	506108	7974790	N	N	N	N	N	N	N	N	NFB/NFB
ML-18	2010	17V	507401	7972979	N	N	N	N	N	N	N	N	NFB/NFB
ML-19	2010	17V	507620	7972835	N	N	N	N	N	N	N	N	NFB/NFB
ML-20	2010	17V	508433	7973033	H	H	H	N	L	L	L	N	IMP/MAR
Streams													
M01-1	2010	17V	501250	7975810	N	N	N	N	N	N	N	N	NFB/NFB
M02-1	2010	17V	501250	7975810	N	M	N	N	N	N	N	N	MAR/NFB
M03-1	2010	17V	502646	7975190	L	M	L	M	N	N	N	N	IMP/NFB
M03-2	2010	17V	502814	7975070	N	L	N	N	N	N	N	N	MAR/NFB
M03-3	2010	17V	502666	7974750	N	L	N	N	N	N	N	N	MAR/NFB
M05-1	2010	17V	502659	7975880	N	N	N	N	N	N	N	N	NFB/NFB
M05-2	2010	17V	503144	7975550	N	N	N	N	N	N	N	N	NFB/NFB
M05-3	2010	17V	503074	7975470	N	N	N	N	N	N	N	N	NFB/NFB

Table 7-1. - Continued -

Site	Year(s) Surveyed	UTM Coordinates			Arctic char[1]				Ninespine stickleback				Fish Habitat Quality Rating[2] ARCH/NNST
		Zone	Easting	Northing	Sp	Re	Wi	Mi	Sp	Re	Wi	Mi	
M05-4	2010	17V	503117	7975330	N	N	N	N	N	N	N	N	NFB/NFB
M05-5	2010	17V	503275	7975190	N	N	N	N	N	N	N	N	NFB/NFB
M05-6	2010	17V	503201	7975110	N	N	N	N	N	N	N	N	NFB/NFB
M06-1	2010	17V	503233	7976420	N	N	N	N	N	N	N	N	NFB/NFB
M07-1	2010	17V	503650	7976360	N	N	N	N	N	N	N	N	NFB/NFB
M08-1	2010	17V	503722	7976340	N	N	N	N	N	N	N	N	NFB/NFB
M09-1	2010	17V	503811	7976300	N	N	N	N	N	N	N	N	NFB/NFB
M10-1	2010	17V	503920	7976240	N	N	N	N	N	N	N	N	NFB/NFB
M11-1	2008-2010	17V	504062	7976440	N	L	N	N	N	N	N	N	MAR/NFB
M11-2	2010	17V	504189	7976280	N	N	N	N	N	N	N	N	NFB/NFB
M11-3	2010	17V	504142	7976140	N	N	N	N	N	N	N	N	NFB/NFB
M11-4	2010	17V	504080	7975800	N	N	N	N	N	N	N	N	NFB/NFB
M11-5	2010	17V	504304	7975870	N	N	N	N	N	N	N	N	NFB/NFB
M12-1	2010	17V	504375	7976410	N	N	N	N	N	N	N	N	NFB/NFB
M13-1	2008-2010	17V	504686	7976410	N	H	N	N	N	N	N	N	MAR/NFB
M13-2	2010	17V	505150	7975970	N	N	N	N	N	N	N	N	NFB/NFB
M13-2c	2010	17V	505696	7975080	N	N	N	N	N	N	N	N	NFB/NFB
M13-3	2010	17V	505405	7976010	N	N	N	N	N	N	N	N	NFB/NFB
M13-9	2010	17V	506917	7975140	N	N	N	N	N	N	N	N	NFB/NFB
M13-10	2010	17V	507738	7975030	N	N	N	N	N	N	N	N	NFB/NFB
M14-1	2010	17V	505061	7976480	N	N	N	N	N	N	N	N	NFB/NFB
M15-1	2010	17V	505190	7976540	N	N	N	N	N	N	N	N	NFB/NFB
M16-1	2010	17V	505235	7976580	N	N	N	N	N	N	N	N	NFB/NFB
M17-1	2010	17V	505300	7976610	N	N	N	N	N	N	N	N	NFB/NFB
M18-1	2010	17V	505500	7976640	N	M	N	N	N	N	N	N	MAR/NFB

[1] Sp = spawning; Re = rearing; Wi = wintering; Mi = migration; N - no use; L - low potential use; M - moderate potential use; H - high potential use
[2] NFB = Not Fish bearing, MAR = Marginal, IMP = Important

Table 7-2. Number, percent composition, and catch-per-unit-effort (CPUE) for fish species captured in Milne Port Site waterbodies during 2010, by gear type and species.

Site ID	Gear Type[1]	Effort[2]	Arctic char				Ninespine stickleback			
			n	%	Mean CPUE[3]	Size Range (mm)	n	%	Mean CPUE[3]	Size Range (mm)
ML-01	OB	1	0	0.0	-	-	0	0.0	-	-
ML-02	OB	1	0	0.0	-	-	0	0.0	-	-
ML-03	OB/EF	1	0	0.0	0.0	-	0	0.0	0.0	-
ML-04	OB	1	0	0.0	-	-	0	0.0	-	-
ML-05	OB	1	0	0.0	-	-	0	0.0	-	-
ML-06	OB	1	0	0.0	-	-	0	0.0	-	-
ML-07	OB	1	0	0.0	-	-	0	0.0	-	-
ML-08	OB	1	0	0.0	-	-	0	0.0	-	-
ML-09	OB	1	0	0.0	-	-	0	0.0	-	-
ML-10	OB	1	0	0.0	-	-	0	0.0	-	-
ML-11	OB	1	0	0.0	-	-	0	0.0	-	-
ML-12	OB	1	0	0.0	-	-	0	0.0	-	-
ML-13	OB	1	0	0.0	-	-	0	0.0	-	-
ML-15	OB/EF	1	0	0.0	0.0	-	0	0.0	0.0	-
ML-16	OB/EF	1	0	0.0	0.0	-	0	0.0	0.0	-
ML-18	OB/EF	1	0	0.0	0.0	-	0	0.0	0.0	-
ML-19	OB/EF	1	0	0.0	0.0	-	0	0.0	0.0	-
ML-20	OB/EF	1	43	100.0	8.6	50-90	0	0.0	0.0	-
M01-1	OB	1	0	0.0	-	-	0	0.0	-	-
M02-1	OB/EF	1	0	0.0	0.0	-	0	0.0	0.0	-
M03-1	OB/EF	1	0	0.0	0.0	-	0	0.0	0.0	-
	HN	6	0	0.0	0.0	-	0	0.0	0.0	-
M03-2	OB	1	0	0.0	-	-	0	0.0	-	-
M03-3	OB/EF	1	0	0.0	0.0	-	0	0.0	0.0	-
M05-1	OB	1	0	0.0	-	-	0	0.0	-	-
M05-2	OB	1	0	0.0	-	-	0	0.0	-	-
M05-3	OB	1	0	0.0	-	-	0	0.0	-	-

Table 7-2. - Continued -

Site ID	Gear Type[1]	Effort[2]	Arctic char				Ninespine stickleback			
			n	%	Mean CPUE[3]	Size Range (mm)	n	%	Mean CPUE[3]	Size Range (mm)
M05-4	OB	1	0	0.0	-	-	0	0.0	-	-
M05-5	OB	1	0	0.0	-	-	0	0.0	-	-
M05-6	OB	1	0	0.0	-	-	0	0.0	-	-
M06-1	OB	1	0	0.0	-	-	0	0.0	-	-
M07-1	OB	1	0	0.0	-	-	0	0.0	-	-
M08-1	OB	1	0	0.0	-	-	0	0.0	-	-
M09-1	OB	1	0	0.0	-	-	0	0.0	-	-
M10-1	OB	1	0	0.0	-	-	0	0.0	-	-
M11-1	OB/EF	1	0	0.0	0.0	-	0	0.0	0.0	-
M11-2	OB	1	0	0.0	-	-	0	0.0	-	-
M11-3	OB	1	0	0.0	-	-	0	0.0	-	-
M11-4	OB	1	0	0.0	-	-	0	0.0	-	-
M11-5	OB	1	0	0.0	-	-	0	0.0	-	-
M12-1	OB	1	0	0.0	-	-	0	0.0	-	-
M13-1	OB/EF	1	4	100.0	0.5	140-170	0	0.0	0.0	-
M13-2	OB	1	0	0.0	-	-	0	0.0	-	-
M13-2c	OB	1	0	0.0	-	-	0	0.0	-	-
M13-3	OB	1	0	0.0	-	-	0	0.0	-	-
M13-9	OB	1	0	0.0	-	-	0	0.0	-	-
M13-10	OB	1	0	0.0	-	-	0	0.0	-	-
M14-1	OB	1	0	0.0	-	-	0	0.0	-	-
M15-1	OB	1	0	0.0	-	-	0	0.0	-	-
M16-1	OB	1	0	0.0	-	-	0	0.0	-	-
M17-1	OB	1	0	0.0	-	-	0	0.0	-	-
M18-1	OB/EF	1	1	100.0	0.2	100	0	0.0	0.0	-

[1] EF = electrofishing; HN = hoop nets; OB = observation
[2] Electrofishing (number of runs); observation (number of visits); hoop nets (number of days)
[3] Electrofishing CPUE = #fish/minute of electrofishing; hoop net CPUE = #fish/day/net

Table 8-1. Location and general characteristics of watercourse crossings along the Milne Inlet Tote Road.

Crossing ID	Crossing Designation[1]	Stream Size Category[2]	Road Chainage (km)	UTM Coordinates			Detailed Site Survey[3]
				Zone	Easting	Northing	
CV-183	HC	XL	0.145	17W	504696	7976417	Y
CV-182	-	XS	0.480	17W	504231	7976244	N
CV-181	HC	M	0.583	17W	504133	7976216	Y
CV-180	-	XS	0.796	17W	503925	7976249	N
CV-179	-	XS	1.507	17W	503390	7976035	N
CV-178	-	XS	1.776	17W	503492	7975787	N
CV-177	-	XS	2.427	17W	503818	7975265	N
CV-176	HC	S	2.638	17W	503834	7975057	Y
CV-175	-	XS	2.867	17W	503799	7974831	N
CV-174	-	XS	3.734	17W	504169	7974099	N
CV-173	LOA	XS	4.430	17W	504465	7973535	Y
CV-172	-	XS	4.722	17W	504663	7973321	N
CV-171	-	XS	4.867	17W	504750	7973210	N
CV-170	HC	S	5.267	17W	505015	7972923	Y
CV-169	-	XS	5.427	17W	505134	7972813	N
CV-168	-	XS	5.882	17W	505485	7972534	N
CV-167	LOA	XS	5.960	17W	505519	7972462	Y
CV-166	HC	S	6.056	17W	505538	7972370	Y
CV-165	-	S	7.038	17W	506128	7971635	N
CV-164	-	XS	7.299	17W	506376	7971647	N
CV-163	-	XS	7.832	17W	506616	7971287	N
CV-162	-	XS	7.922	17W	506670	7971224	N
CV-161	-	XS	8.230	17W	506802	7970956	N
CV-159	HC	XS	8.407	17W	506909	7970830	Y
CV-158	-	XS	8.648	17W	507091	7970680	N
CV-157	HC	S	8.960	17W	507374	7970538	Y
CV-156	HC	XS	9.223	17W	507580	7970389	Y
CV-155	-	XS	9.328	17W	507575	7970284	N
CV-154	HC	S	9.570	17W	507620	7970076	Y
CV-153	LOA	S	10.218	17W	508152	7969718	Y
CV-152	HC	S	10.280	17W	508201	7969684	Y
CV-151	LOA	S	10.460	17W	508341	7969584	Y
CV-150	-	XS	10.507	17W	508343	7969540	N
CV-149	-	XS	10.954	17W	508517	7969146	N
CV-148	-	XS	11.180	17W	508683	7968996	N
CV-147	-	XS	N/A	17W	508704	7968978	N
CV-146	-	S	11.348	17W	508786	7968870	Y
CV-145	-	XS	11.208	17W	509070	7968520	N
CV-144	-	XS	12.205	17W	509408	7968377	N
CV-143	-	XS	12.236	17W	509429	7968362	N
CV-142	-	XS	12.266	17W	509466	7968351	N
CV-141	-	XS	12.453	17W	509625	7968255	N
CV-140	-	XS	12.501	17W	509663	7968226	N
CV-139	-	XS	12.679	17W	509811	7968128	N

Table 8-1. - Continued -

Crossing ID	Crossing Designation[1]	Stream Size Category[2]	Road Chainage (km)	UTM Coordinates			Detailed Site Survey[3]
				Zone	Easting	Northing	
CV-138	-	XS	12.784	17W	509911	7968083	N
CV-137	-	XS	13.042	17W	510127	7967945	N
CV-136	-	XS	13.425	17W	510396	7967677	N
CV-135	-	XS	13.675	17W	510585	7967522	N
CV-134	-	XS	14.014	17W	510885	7967357	N
CV-133	-	XS	14.201	17W	511045	7967273	N
CV-132	-	XS	14.625	17W	511449	7967157	N
CV-131	-	XS	14.709	17W	511529	7967128	N
CV-195	-	XS	15.008	17W	511818	7967067	N
CV-130	-	XS	15.202	17W	512008	7967027	N
CV-129	HADD	L	15.650	17W	512381	7966783	Y
CV-196	-	XS	15.839	17W	512531	7966682	N
CV-128	HADD	XL	17.486	17W	513545	7965895	Y
CV-127	-	XS	18.279	17W	513911	7965372	N
CV-126	-	XS	19.243	17W	514689	7964867	N
CV-125	LOA	S	20.447	17W	515296	7963841	Y
CV-124	-	XS	20.626	17W	515390	7963690	N
CV-123	-	XS	21.399	17W	515918	7963156	N
CV-122	-	XS	21.949	17W	516315	7962859	N
CV-121	-	XS	23.199	17W	517208	7962003	N
CV-120	LOA	S	23.515	17W	517294	7961707	Y
CV-119	LOA	S	24.264	17W	517762	7961153	Y
CV-197	-	XS	25.633	17W	518425	7959973	N
CV-118	-	XS	25.878	17W	518495	7959742	N
CV-198	-	XS	26.444	17W	518764	7959244	N
CV-199	-	XS	26.658	17W	518863	7959068	N
CV-117	-	S	27.073	17W	519010	7958681	N
CV-116	-	XS	27.388	17W	519057	7958370	N
CV-115	LOA	S	27.686	17W	519222	7958135	Y
CV-200	-	XS	28.938	17W	519722	7957107	N
CV-114	HADD	M	29.647	17W	520278	7956528	Y
CV-201	-	XS	30.483	17W	520676	7955818	N
CV-113	HC	S	30.655	17W	520747	7955659	Y
CV-112	LOA	S	31.450	17W	521033	7954935	Y
CV-111	HADD	M	31.990	17W	521355	7954524	Y
CV-110	-	XS	32.220	17W	521449	7954310	N
CV-109	-	XS	32.441	17W	521521	7954105	N
CV-108	-	XS	32.513	17W	521547	7954037	N
CV-202	LOA	S	32.825	17W	521603	7953731	Y
CV-107	-	XS	33.091	17W	521657	7953471	N
CV-106	LOA	S	33.170	17W	521663	7953392	Y
CV-105	-	XS	33.307	17W	521660	7953255	N
CV-104	-	M	33.794	17W	521732	7952788	Y
CV-203	LOA	S	34.153	17W	521782	7952435	Y
CV-204	-	XS	35.154	17W	521938	7951458	N

Table 8-1. - Continued -

Crossing ID	Crossing Designation[1]	Stream Size Category[2]	Road Chainage (km)	UTM Coordinates			Detailed Site Survey[3]
				Zone	Easting	Northing	
CV-103	-	XS	35.885	17W	521958	7950732	N
CV-102	LOA	S	36.028	17W	521934	7950591	Y
CV-101	-	XS	36.954	17W	521779	7949680	N
CV-100	-	XS	37.052	17W	521755	7949585	N
CV-099	HADD	L	37.840	17W	521811	7948820	Y
CV-098	-	M	38.525	17W	522197	7948306	N
CV-097	-	XS	39.028	17W	522383	7947852	N
CV-096	-	XS	40.967	17W	522548	7945982	N
CV-095	-	XS	41.100	17W	522618	7945799	Y
CV-094	HADD	L	41.613	17W	522805	7945397	Y
CV-093	-	S	42.216	17W	523116	7944890	Y
CV-092	-	M	42.949	17W	523107	7944187	Y
CV-091	-	M	42.949	17W	523111	7944176	N
CV-205	-	XS	43.871	17W	523226	7943292	N
CV-090	-	S	44.832	17W	523389	7942336	N
CV-089	-	XS	45.016	17W	523413	7942158	N
CV-088	-	XS	45.991	17W	523619	7941258	N
CV-087	-	M	46.223	17W	523704	7941040	Y
CV-086	LOA	S	46.300	17W	523746	7940983	Y
CV-085	-	S	46.422	17W	523827	7940898	N
CV-084	-	XS	47.045	17W	524108	7940357	N
CV-083	-	S	47.643	17W	524454	7939876	N
CV-206	-	XS	49.031	17W	525055	7938639	N
CV-082	LOA	S	49.655	17W	525254	7938131	Y
CV-081	-	XS	49.792	17W	525273	7938001	N
CV-080	-	XS	49.929	17W	525249	7937866	N
CV-079	HADD	L	50.600	17W	525562	7937276	Y
CV-207	-	XS	50.762	17W	525652	7937138	Y
CV-078	HADD	L	51.171	17W	525852	7936787	Y
CV-077	-	XS	52.091	17W	525986	7935924	N
CV-076	LOA	S	53.028	17W	526617	7935335	Y
CV-075	-	S	53.337	17W	526767	7935078	N
CV-074	-	XS	53.764	17W	526850	7934679	N
CV-073	-	XS	53.842	17W	526885	7934609	N
CV-072	HADD	L	53.878	17W	526897	7934576	Y
CV-071	-	XS	54.144	17W	526987	7934327	N
CV-070	-	XS	54.173	17W	526994	7934299	N
CV-069	-	XS	54.669	17W	527017	7933814	N
CV-068	-	XS	54.861	17W	527045	7933624	N
CV-067	-	XS	55.197	17W	526984	7933301	N
CV-066	-	XS	55.383	17W	527023	7933125	N
CV-065	-	XS	55.401	17W	527027	7933108	N
CV-064	-	XS	55.469	17W	527050	7933045	N
CV-063	-	XS	55.524	17W	527057	7932993	N
CV-062	-	XS	55.692	17W	527107	7932830	N

Table 8-1. - Continued -

Crossing ID	Crossing Designation[1]	Stream Size Category[2]	Road Chainage (km)	UTM Coordinates			Detailed Site Survey[3]
				Zone	Easting	Northing	
CV-061	-	XS	57.761	17W	527283	7931336	N
CV-060	HADD	M	58.856	17W	527622	7930342	Y
CV-059	LOA	S	59.960	17W	528102	7929356	Y
CV-058	LOA	S	60.523	17W	528322	7928839	Y
CV-057	LOA	S	60.712	17W	528379	7928657	Y
CV-056	-	XS	61.810	17W	528789	7927662	N
CV-055	-	XS	61.904	17W	528842	7927584	Y
CV-054	-	XS	62.018	17W	528899	7927487	N
CV-053	-	XS	62.117	17W	528956	7927408	N
CV-052	-	XS	62.332	17W	529054	7927220	N
CV-051	-	XS	62.390	17W	529088	7927173	N
CV-050	-	XS	62.495	17W	529159	7927096	N
BG-50	HADD	XL	62.804	17W	529334	7926846	Y
CV-049	HADD	L	63.302	17W	529677	7926542	Y
CV-048	HADD/PHC	L	64.312	17W	530415	7925875	Y
CV-208	-	XS	64.672	17W	530647	7925619	N
CV-209	-	XS	64.847	17W	530750	7925520	N
CV-047	-	XS	66.426	17W	531650	7924311	N
CV-046	LOA	S	66.490	17W	531686	7924265	Y
CV-045	-	XS	66.873	17W	531782	7923900	N
CV-044	-	XS	67.036	17W	531790	7923744	N
CV-043	-	S	67.469	17W	532044	7923419	N
CV-042	-	XS	69.294	17W	533481	7922557	N
CV-041	-	XS	69.369	17W	533556	7922563	N
CV-210	-	XS	71.871	17W	534811	7920421	N
CV-040	HADD/PHC	L	72.263	17W	535175	7920305	Y
CV-039	-	XS	72.845	17W	535736	7920177	N
CV-038	-	XS	72.943	17W	535828	7920145	N
CV-037	-	XS	73.105	17W	535987	7920171	N
CV-036	-	XS	73.351	17W	536218	7920087	N
CV-211	-	XS	73.779	17W	536642	7920141	N
CV-212	-	XS	74.410	17W	537265	7920232	N
CV-033	-	XS	75.783	17W	538548	7920713	N
BG-33	-	XS	77.025	17W	539715	7921098	N
CV-031	-	XS	77.219	17W	539978	7921243	N
CV-032	-	XS	77.343	17W	539888	7921171	N
CV-030	LOA	S	77.506	17W	540123	7921310	Y
BG-32	HADD	L	78.161	17W	540706	7921622	Y
CV-213	-	XS	78.401	17W	540938	7921776	N
CV-214	-	XS	78.877	17W	541272	7921955	N
CV-215	-	S	79.572	17W	541930	7922217	N
CV-217	HADD	XL	79.915	17W	542219	7922158	Y
CV-216	HADD	L	80.646	17W	542774	7921700	Y
BG-31	PHC	XS	82.076	17W	543924	7920872	Y
CV-023	-	S	83.147	17W	544739	7920201	N

Table 8-1. - Continued -

Crossing ID	Crossing Designation[1]	Stream Size Category[2]	Road Chainage (km)	UTM Coordinates			Detailed Site Survey[3]
				Zone	Easting	Northing	
BG-30	PHC	S	84.636	17W	546070	7919858	Y
BG-29	LOA	S	84.805	17W	546229	7919877	Y
CV-022	-	XS	85.062	17W	546467	7919877	N
CV-021	-	XS	85.079	17W	546481	7919869	N
CV-020	-	XS	85.614	17W	546970	7919663	N
CV-019	-	XS	85.763	17W	547095	7919588	N
CV-018	-	XS	85.813	17W	547145	7919587	N
CV-017	-	XS	85.891	17W	547220	7919573	N
BG-28	-	XS	86.263	17W	547567	7919479	Y
CV-016	-	XS	86.434	17W	547719	7919401	N
BG-27	LOA	S	86.609	17W	547876	7919342	Y
CV-015	-	XS	86.765	17W	548006	7919255	N
CV-014	-	XS	86.834	17W	548064	7919217	N
CV-013	-	XS	86.934	17W	548167	7919229	N
BG-26	-	XS	86.978	17W	548211	7919237	N
BG-25	-	XS	87.054	17W	548284	7919255	N
CV-218	-	XS	87.617	17W	548674	7918883	N
BG-24	HADD	M	87.710	17W	548766	7918878	Y
BG-23	-	XS	87.784	17W	548837	7918862	N
CV-012	-	XS	88.171	17W	549211	7918781	N
CV-011	-	XS	88.232	17W	549271	7918770	N
CV-010	-	XS	88.316	17W	549355	7918763	N
CV-009	-	XS	88.896	17W	549846	7918511	N
BG-22	-	XS	89.275	17W	550104	7918239	N
BG-21	-	XS	89.415	17W	550224	7918170	N
BG-20	-	XS	89.512	17W	550313	7918143	N
CV-008	-	XS	89.696	17W	550414	7917992	N
BG-19	-	XS	89.815	17W	550489	7917912	N
BG-18	-	XS	90.092	17W	550646	7917688	N
BG-17	HADD	L	90.167	17W	550703	7917643	Y
BG-16	HC	XS	90.218	17W	550742	7917611	Y
BG-15	-	XS	90.331	17W	550812	7917523	N
BG-14	-	XS	90.389	17W	550839	7917471	N
CV-007	-	XS	90.670	17W	550967	7917223	N
BG-13	-	XS	90.995	17W	551137	7916952	N
CV-006	-	XS	91.092	17W	551178	7916866	N
BG-12	-	XS	91.394	17W	551431	7916709	N
CV-005	-	XS	91.513	17W	551502	7916615	N
BG-11	-	XS	91.601	17W	551527	7916532	N
BG-10	-	XS	91.705	17W	551604	7916467	N
BG-09	-	XS	91.890	17W	551715	7916334	N
CV-219	-	XS	92.093	17W	551810	7916153	N
CV-220	-	XS	92.207	17W	551867	7916055	N
CV-221	-	XS	92.288	17W	551909	7915986	N
BG-08	-	XS	92.514	17W	552021	7915791	N

Table 8-1. - Continued -

Crossing ID	Crossing Designation[1]	Stream Size Category[2]	Road Chainage (km)	UTM Coordinates			Detailed Site Survey[3]
				Zone	Easting	Northing	
CV-004	-	XS	92.660	17W	552074	7915655	N
CV-003	-	XS	92.908	17W	552228	7915463	N
BG-07	-	XS	93.123	17W	552369	7915301	N
CV-002	-	XS	93.199	17W	552423	7915249	N
BG-04	HADD	M	94.148	17W	553250	7915113	Y
CV-001	HC	S	94.728	17W	553782	7914922	Y
CV-222	-	XS	95.216	17W	554254	7914968	N
BG-03	-	XS	95.735	17W	554763	7915031	N
BG-02	-	XS	96.041	17W	554921	7914771	N
CV-223	HADD	XL	97.155	17W	555818	7914691	Y
CV-224	HADD	M	97.758	17W	556238	7915044	Y
CV-225	HADD	L	98.989	17W	557407	7915138	Y
BG-01	HADD	M	99.672	17W	557991	7914919	Y
CV-184	-	XS	101.557	17W	559536	7913935	N
CV-185	-	XS	101.764	17W	559740	7913898	N
CV-186	LOA	S	102.812	17W	560705	7913498	Y
CV-187	HC	S	103.078	17W	560957	7913414	Y
CV-188	-	XS	104.701	17W	562393	7912843	N
CV-189	-	XS	105.342	17W	562973	7912668	N
CV-190	-	XS	105.454	17W	563023	7912739	N
CV-191	-	XS	106.047	17W	563305	7912982	N
CV-192	-	XS	106.189	17W	563355	7913105	N
CV-193	-	XS	106.216	17W	563378	7913119	N
CV-194	-	XS	106.430	17W	563577	7913172	N

[1] HADD = harmful alteration, disruption, or destruction sites; HC = habitat compensation sites; PHC = potential habitat compensation sites; LOA = letter of advice sites

[2] XS = extra small (< 0.5 km^2), S = small (0.5-2.5 km^2); M = medium (2.5-7.5 km^2); L = large (7.5-30.0 km^2); XL = extra large (> 30.0 km^2)

[3] Crossings that were initially identified as being non fish-bearing (dry creek beds, spring runoff from mountains, no connections to overwintering habitat) were not further assessed for detailed habitat characteristics or fisheries information; detailed surveys revealed additional sites as non fish-bearing

Table 8-2. Summary characteristics of available aquatic habitat measured at selected watercourse crossings along the Milne Inlet Tote Road, 2006-2010.

Crossing ID	Road Chainage (km)	Season/Year(s) Assessed[1]	Downstream of Crossing				
			Habitat				
			Dominant Substrate(s)	Dominant Channel Morphology	Dominant Cover	Barrier Location[2]	Barrier Type
CV-183	0.145	Sp/09; Su/06; Fa/09	Cobble	Riffle	Lg. Cobble	None	-
CV-181	0.583	Sp/09; Fa/09	Gravel/Sand	Riffle/Pool	Deep Pool	None	-
CV-176	2.638	Sp/09; Fa/09	Gravel/Sand	Riffle	None	100 m DS	Steep gradient
CV-173	4.430	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing				
CV-170	5.267	Sp/09; Fa/09	Cobble	Riffle	Lg. Cobble	250 m DS	No channel
CV-167	5.960	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing				
CV-166	6.056	Sp/09; Fa/09	Cobble/Gravel	Pool/Riffle	Deep Pool	500 m DS	Steep gradient
CV-159	8.407	Sp/09; Fa/09	Cobble/Gravel	Riffle	Lg. Cobble	500 m DS	Steep gradient
CV-157	8.960	Sp/09; Fa/09	Cobble/Gravel	Riffle	Lg. Cobble	100 m DS	Steep gradient
CV-156	9.223	Sp/09; Su/06	Crossing Avoided by Road			N/A	-
CV-154	9.570	Sp/09; Fa/09	Cobble/Gravel	Riffle	Lg. Cobble	100 m DS	Insufficient flow
CV-153	10.218	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing				
CV-152	10.280	Sp/09; Fa/09	NM - No Fish Habitat			50 m DS	No surface water
CV-151	10.460	Sp/09; Fa/09	Cobble	Cascade/Riffle	Lg. Cobble	100 m DS	Steep gradient
CV-146	11.348	Su/06	Cobble	Riffle/Pool	Lg. Cobble	50 m DS	Falls
CV-129	15.650	Sp/08,09; Su/08; Fa/09	Cobble/Gravel	Riffle/Pool	Lg. Cobble	None	-
CV-128	17.486	Sp/09; Su/06; Fa/09	Cobble	Run/Riffle	Lg. Cobble	None	-
CV-125	20.447	Sp/09; Fa/09	Gravel/Cobble	Riffle/Pool	None	None	-
CV-120	23.515	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing				
CV-119	24.264	Sp/09; Fa/09	Sand/Silt	Pool	Deep Pool	100 m DS	Steep gradient
CV-115	27.686	Sp/09; Fa/09	Cobble/Gravel	Riffle	None	None	-
CV-114	29.647	Sp/09; Su/06; Fa/09	Cobble/Gravel	Riffle/Cascade	Lg. Cobble	None	-
CV-113	30.655	Fa/09	Gravel/Cobble	Riffle	Lg. Cobble	150 m DS	Not Connected
CV-112	31.450	Sp/09; Fa/09	Cobble	Riffle/Pool	Lg. Cobble	None	-

Table 8-2. - Continued -

Downstream of Crossing							
Crossing ID	Road Chainage (km)	Season/Year(s) Assessed[1]	Habitat				
			Dominant Substrate(s)	Dominant Channel Morphology	Dominant Cover	Barrier Location[2]	Barrier Type
CV-111	31.990	Fa/09	Cobble	Riffle	Lg. Cobble	None	-
CV-202	32.825	Sp/09; Fa/09	NM - No Fish Habitat			10 m DS	Not Connected
CV-106	33.170	Sp/09; Fa/09	Sand/Gravel	Riffle/Cascade	Lg. Cobble	Crossing area	Dry during fall
CV-104	33.794	Sp/09; Su/06; Fa/09	Cobble/Gravel	Riffle/Pool	Lg. Cobble	None	-
CV-203	34.153	Sp/09	N/M - There is no fish habitat at this crossing				
CV-102	36.028	Sp/09; Fa/09	Gravel/Cobble	Riffle	Lg. Cobble	None	-
CV-099	37.840	Sp/08,09; Su/06,08; Fa/09	Cobble	Riffle/Pool	Lg. Cobble	None	-
CV-095	41.100	Su/06	N/M - There is no fish habitat at this crossing				
CV-094	41.613	Sp/08,09; Su/08; Fa/09	Cobble/Gravel	Cascade/Pool	Lg. Cobble	30 m DS	Falls
CV-093	42.216	Su/06	N/M - There is no fish habitat at this crossing				
CV-092	42.949	Su/06	N/M - There is no fish habitat at this crossing				
CV-087	46.223	Su/06	Cobble	Cascade	Boulders	100 m DS	Steep gradient
CV-086	46.300	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing			DS	Steep gradient & Dry
CV-082	49.655	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing			DS	Steep gradient & Dry
CV-079	50.600	Sp/09; Su/08; Fa/09	Cobble/Sand	Riffle/Pool	Lg. Cobble	None	-
CV-207	50.762	Fa/08	Cobble	Riffle/Pool	Lg. Cobble/Deep Pool	None	-
CV-078	51.171	Sp/09; Su/06,08; Fa/09	Cobble	Riffle/Pool	Lg. Cobble	None	-
CV-076	53.028	Sp/09; Fa/09	Sand/Gravel	Pool/Riffle	Deep Pool	None	-
CV-072	53.878	Sp/09; Fa/09	Cobble	Riffle	Lg. Cobble	None	-
CV-060	58.856	Sp/09; Su/06; Fa/09	Sand/Gravel	Pool	Deep Pool	None	-
CV-059	59.960	Sp/09; Fa/09	Cobble/Sand	Riffle/Pool	Deep Pool	None	-
CV-058	60.523	Sp/09; Fa/09	Sand	Riffle/Pool	Deep Pool	None	-
CV-057	60.712	Su/06	Sand	Pool	Vegetation	None	-
CV-055	61.904	Su/06	Sand	Riffle/Cascade	Vegetation	50m DS	Steep gradient
BG-50	62.804	Sp/08,09; Su/06,08; Fa/09	Cobble	Riffle	Lg. Cobble	None	-
CV-049	63.302	Sp/09; Su/06; Fa/09	Cobble	Riffle	Lg. Cobble	None	-
CV-048	64.312	Sp/09; Fa/09	Cobble	Riffle/Pool	Lg. Cobble	From 50 m to 200 m DS of UTM 529952 7926524	Subsurface Flow
CV-046	66.490	Sp/09; Fa/09	Cobble	Riffle	Lg. Cobble	None	-

Table 8-2. - Continued -

Crossing ID	Road Chainage (km)	Season/Year(s) Assessed[1]	Downstream of Crossing				
			Habitat				
			Dominant Substrate(s)	Dominant Channel Morphology	Dominant Cover	Barrier Location[2]	Barrier Type
CV-040	72.263	Sp/08,09; Su/06,08; Fa/09	Cobble/Gravel	Riffle/Pool	Lg. Cobble	UTM 535208 7918632 to 535245 7918872	Subsurface Flow
CV-030	77.506	Sp/09; Fa/09	Sand/Silt	Pool	Deep Pool	DS	Becomes disconnected at low water
BG-32	78.161	Sp/09; Fa/09	Sand	Pool	Deep Pool	None	-
CV-217	79.915	Sp/09; Su/06; Fa/08,09	Gravel/Sand	Run/Pool	Deep Pool/Run	None	-
CV-216	80.646	Sp/09; Su/06; Fa/09	Sand	Flat	None	None	-
BG-31	82.076	Su/10	Sand	Flat	None	At the crossing	Steep gradient
BG-30	84.636	Su/10	Cobble	Riffle/Pool	Lg. Cobble	25m DS	Boulder piles
BG-29	84.805	Sp/09; Fa/09	Sand/Gravel	Pool/Riffle	Deep Pool	None	-
BG-28	86.263	Su/06	N/M - There is no fish habitat at this crossing				
BG-27	86.609	Su/06	Cobble	Cascade	Boulders	None	-
BG-24	87.710	Sp/08,09; Su/06,08; Fa/09	Cobble/Gravel	Riffle/Pool	Undercut Banks	None	-
BG-17	90.167	Sp/09; Su/06; Fa/09	Cobble/Gravel	Run/Riffle/Pool	Deep Pool/Run	None	-
BG-16	90.218	Sp/09; Su/06; Fa/09	N/M - There is no crossing of this stream				
BG-04	94.148	Sp/09; Fa/09	Sand/Gravel	Pool/Flat	Deep Pool	None	-
CV-001	94.728	Fa/09	Sand/Gravel	Riffle/Pool	Undercut Banks	None	-
CV-223	97.155	Sp/09; Su/06; Fa/09	Cobble	Rapid/Riffle/Pool	Lg. Cobble/Deep Pool	None	-
CV-224	97.758	Sp/09; Su/06; Fa/09	Cobble/Gravel	Riffle/Pool	Lg. Cobble	None	-
CV-225	98.989	Sp/08,09; Su/06,08; Fa/09	Cobble/Sand	Riffle/Pool	Lg. Cobble	None	-
BG-01	99.672	Sp/08,09; Su/06,08; Fa/09	Cobble	Riffle/Pool	Lg. Cobble	None	-
CV-186	102.812	Sp/09; Fa/09	Cobble	Riffle	Lg. Cobble	None	-
CV-187	103.078	Sp/09; Su/06; Fa/09	Sand	Pool	Deep Pool	None	-
CV-183	0.145	Sp/09; Su/06; Fa/09	Cobble	Riffle	Lg. Cobble	UTM 507554 7974733	Falls
CV-181	0.583	Sp/09; Fa/09	Cobble	Riffle/Pool	Deep Pool/Lg. Cobble	400 m US	Falls
CV-176	2.638	Sp/09; Fa/09	Gravel	Riffle	Lg. Cobble	N/M	-
CV-173	4.430	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing				
CV-170	5.267	Sp/09; Fa/09	Cobble	Pool/Cascade	Deep Pool	25 m US	Steep gradient
CV-167	5.960	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing				

Table 8-2. - Continued -

Crossing ID	Road Chainage (km)	Season/Year(s) Assessed[1]	Upstream of Crossing				
			Habitat				
			Dominant Substrate(s)	Dominant Channel Morphology	Dominant Cover	Barrier Location[2]	Barrier Type
CV-166	6.056	Sp/09; Fa/09	Cobble/Sand	Pool	Deep Pool	N/M	-
CV-159	8.407	Sp/09; Fa/09	Cobble/Gravel	Riffle	Lg. Cobble	N/M	-
CV-157	8.960	Sp/09; Fa/09	Gravel/Cobble	Riffle	Lg. Cobble	25 m US	Steep gradient
CV-156	9.223	Sp/09; Su/06	Crossing Avoided by Road			N/A	-
CV-154	9.570	Sp/09; Fa/09	Cobble/Gravel	Cascade/Pool	Deep Pool/Lg Cobble	25 m US	Steep gradient
CV-153	10.218	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing				
CV-152	10.280	Sp/09; Fa/09	NM - No Fish Habitat			10 m US	Steep gradient
CV-151	10.460	Sp/09; Fa/09	Cobble	Cascade/Riffle	Lg. Cobble	None	-
CV-146	11.348	Su/06	Cobble	Riffle/Pool	Lg. Cobble	None	-
CV-129	15.650	Sp/08,09; Su/08; Fa/09	Cobble	Pool/Riffle	Deep Pool	None	-
CV-128	17.486	Sp/09; Su/06; Fa/09	Cobble	Run/Riffle	Lg. Cobble	None	-
CV-125	20.447	Sp/09; Fa/09	Sand	Pool	Deep Pool	Crossing	Disconnected at low water
CV-120	23.515	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing				
CV-119	24.264	Sp/09; Fa/09	N/M - There is no fish habitat upstream of this crossing				
CV-115	27.686	Sp/09; Fa/09	Cobble/Gravel	Riffle	None	None	-
CV-114	29.647	Sp/09; Su/06; Fa/09	Cobble	Cascade/Riffle/Pool	Lg. Cobble	150 m US	Steep gradient
CV-113	30.655	Fa/09	Cobble/Gravel	Riffle/Cascade/Pool	None	25 m US	Steep gradient
CV-112	31.450	Sp/09; Fa/09	Cobble/Gravel	Riffle/Cascade/Pool	Lg. Cobble	None	-
CV-111	31.990	Fa/09	Cobble	Cascade/Riffle	Lg. Cobble	100 m US	Steep gradient
CV-202	32.825	Sp/09; Fa/09	NM - No Fish Habitat			US	No surface flow
CV-106	33.170	Sp/09; Fa/09	Sand	Riffle/Pool	None	None	-
CV-104	33.794	Sp/09; Su/06; Fa/09	Cobble	Riffle/Pool	Lg. Cobble	None	-
CV-203	34.153	Sp/09	N/M - There is no fish habitat at this crossing				
CV-102	36.028	Sp/09; Fa/09	Sand/Cobble	Pool	Lg. Cobble	None	-
CV-099	37.840	Sp/08,09; Su/06,08; Fa/09	Cobble	Riffle/Pool	Lg. Cobble	None	-
CV-095	41.100	Su/06	N/M - There is no fish habitat at this crossing				
CV-094	41.613	Sp/08,09; Su/08; Fa/09	Cobble	Cascade/Pool	Lg. Cobble	N/M	-

Table 8-2. - Continued -

Crossing ID	Road Chainage (km)	Season/Year(s) Assessed[1]	Upstream of Crossing				
			Habitat				
			Dominant Substrate(s)	Dominant Channel Morphology	Dominant Cover	Barrier Location[2]	Barrier Type
CV-093	42.216	Su/06	N/M - There is no fish habitat at this crossing				
CV-092	42.949	Su/06	N/M - There is no fish habitat at this crossing				
CV-087	46.223	Su/06	Cobble	Cascade	Boulders	None	-
CV-086	46.300	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing				
CV-082	49.655	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing				
CV-079	50.600	Sp/09; Su/08; Fa/09	Cobble/Sand	Run/Riffle/Cascade	Lg. Cobble	None	-
CV-207	50.762	Fa/08	Cobble/Gravel	Pool/Riffle	UC Banks	None	-
CV-078	51.171	Sp/09; Su/06,08; Fa/09	Cobble	Riffle	Lg. Cobble	None	-
CV-076	53.028	Sp/09; Fa/09	Gravel/Cobble	Pool/Riffle	Deep Pool	None	-
CV-072	53.878	Sp/09; Fa/09	Cobble	Riffle	Lg. Cobble	None	-
CV-060	58.856	Sp/09; Su/06; Fa/09	Cobble	Pool	Deep Pool	None	-
CV-059	59.960	Sp/09; Fa/09	Sand/Silt	Pool	Deep Pool	None	-
CV-058	60.523	Sp/09; Fa/09	Sand	Pool	Deep Pool	None	-
CV-057	60.712	Su/06	Sand	Pool	Vegetation	None	-
CV-055	61.904	Su/06	Sand	Riffle/Cascade	Vegetation	None	-
BG-50	62.804	Sp/08,09; Su/06,08; Fa/09	Cobble	Riffle	Lg. Cobble	None	-
CV-049	63.302	Sp/09; Su/06; Fa/09	Cobble	Riffle/Pool	Lg. Cobble	See DS barrier for CV-048	Subsurface Flow
CV-048	64.312	Sp/09; Fa/09	Cobble	Riffle/Pool	Lg. Cobble	None	-
CV-046	66.490	Sp/09; Fa/09	Cobble/Boulder	Riffle/Pool	Lg. Cobble/Boulder	100m US	Steep gradient
CV-040	72.263	Sp/08,09; Su/06,08; Fa/09	Cobble	Riffle/Pool	Lg. Cobble	None	-
CV-030	77.506	Sp/09; Fa/09	Sand/Silt	Pool	Deep Pool	None	-
BG-32	78.161	Sp/09; Fa/09	Sand	Pool	Deep Pool	None	-
CV-217	79.915	Sp/09; Su/06; Fa/08,09	N/A - immediately US is a large lake that is known to be important habitat for both species				
CV-216	80.646	Sp/09; Su/06; Fa/09	Sand	Flat	None	None	-
BG-31	82.076	Su/10	Sand	Flat	None	At the crossing	Steep gradient
BG-30	84.636	Su/10	Cobble	Riffle/Pool	Lg. Cobble	17 W 545542 7919749	Steep gradient
BG-29	84.805	Sp/09; Fa/09	Sand/Silt	Pool	Deep Pool	None	-
BG-28	86.263	Su/06	N/M - There is no fish habitat at this crossing				
BG-27	86.609	Su/06	Cobble	Cascade	Boulders	100m US	Steep gradient
BG-24	87.710	Sp/08,09; Su/06,08; Fa/09	Cobble/Gravel	Pool/Cascade/Riffle	Lg. Cobble/Deep Pool	None	-

Table 8-2. - Continued -

Upstream of Crossing							
Crossing ID	Road Chainage (km)	Season/Year(s) Assessed[1]	Habitat				
			Dominant Substrate(s)	Dominant Channel Morphology	Dominant Cover	Barrier Location[2]	Barrier Type
BG-17	90.167	Sp/09; Su/06; Fa/09	Sand/Silt	Run/Pool	Deep Pool	None	-
BG-16	90.218	Sp/09; Su/06; Fa/09	N/M - There is no crossing of this stream				
BG-04	94.148	Sp/09; Fa/09	Sand/Gravel	Pool	Deep Pool	None	-
CV-001	94.728	Fa/09	Sand/Silt	Pool	Deep Pool	None	-
CV-223	97.155	Sp/09; Su/06; Fa/09	Cobble	Run/Rapid/Riffle	Lg. Cobble/Deep Pool	3.5km US	Falls
CV-224	97.758	Sp/09; Su/06; Fa/09	Cobble/Gravel	Riffle/Pool	Lg. Cobble	Probable US	-
CV-225	98.989	Sp/08,09; Su/06,08; Fa/09	Sand/Cobble	Run/Riffle	Lg. Cobble	500m US	Falls
BG-01	99.672	Sp/08,09; Su/06,08; Fa/09	Cobble	Riffle/Run	Lg. & Sm. Cobble	600m US	Falls
CV-186	102.812	Sp/09; Fa/09	Cobble	Riffle	Lg. Cobble	None	-
CV-187	103.078	Sp/09; Su/06; Fa/09	Cobble	Pool	Lg. Cobble	561023 7913219	Steep, no water

[1] Sp = spring, Su = summer, Fa = fall
[2] Natural DS barriers surveyed between crossing and nearest potential DS overwintering site; US barriers only surveyed within 500 m of crossing unless otherwise indicated

Table 8-3. Hydrological summary for selected watercourse crossings along the Milne Inlet Tote Road, 2006-2010.

Crossing ID	Road Chainage (km)	Season/Year(s) Assessed[1]	Downstream of Crossing					
			Hydrology[2]					
			Wetted Width[3] (m)	Approximate Average Depth (m)	Maximum Depth (m)	Water Velocity (natural) (m/s)	Water Velocity (culvert) (m/s)	Water Velocity (sea can) (m/s)
CV-183	0.145	Sp/09; Su/06; Fa/09	12.0-17.4	0.20-0.30	0.55-0.65	0.00-1.43	No culvert	-
CV-181	0.583	Sp/09; Fa/09	8.1	0.20	0.48	0.00-0.27	No culvert	-
CV-176	2.638	Sp/09; Fa/09	1.2-1.9	0.03-0.05	0.06-0.10	0.00-0.33	0.17-0.61	-
CV-173	4.430	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-170	5.267	Sp/09; Fa/09	1.1	0.04	0.10-0.11	0.00-0.85	0.60-1.09	-
CV-167	5.960	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-166	6.056	Sp/09; Fa/09	1.3-1.4	0.10	0.38-0.40	0.00-0.89	0.00-0.11	-
CV-159	8.407	Sp/09; Fa/09	1.2	0.03	0.07-0.08	0.00-0.65	0.40-0.56	-
CV-157	8.960	Sp/09; Fa/09	1.2-1.5	0.03-0.05	0.05-0.08	0.00-1.18	0.30-0.40	-
CV-156	9.223	Sp/09; Su/06	N/M - Crossing avoided by road					
CV-154	9.570	Sp/09; Fa/09	2.6-3.0	0.04	0.10-0.14	0.00-0.67	0.09-0.26	-
CV-153	10.218	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-152	10.280	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-151	10.460	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-146	11.348	Su/06	2.4	0.10	0.30	NM	-	-
CV-129	15.650	Sp/08,09; Su/08; Fa/08,09	22.6-25.6	0.05-0.40	0.40-1.00	0.06-0.94	1.41-2.51	-
CV-128	17.486	Sp/09; Su/06; Fa/08,09	41.1-45.7	0.50-1.00	>1.00	0.11-0.53	-	0.21-1.50
CV-125	20.447	Sp/09; Fa/09	1.5-2.0	0.02-0.10	0.30-0.31	0.00-0.17	0.00-0.01	-
CV-120	23.515	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-119	24.264	Sp/09; Fa/09	1.2-27.0	0.50-1.00	1.00	0.00	0.40	-
CV-115	27.686	Sp/09; Fa/09	1.6	0.05	0.07	0.18-0.36	0.28-0.39	-
CV-114	29.647	Sp/09; Su/06; Fa/08,09	6.0-8.0	0.05-0.07	0.10-0.12	0.01-0.81	0.74-1.36	-
CV-113	30.655	Fa/09	3.5	0.04	0.06	0.37	0.24	-
CV-112	31.450	Sp/09; Fa/09	1.9-2.1	0.08-0.10	0.35-0.36	0.01-0.92	0.44-1.26	-
CV-111	31.990	Fa/08,09	5.5-6.4	0.05-0.07	0.10-0.24	0.43-0.89	0.37-1.34	-
CV-202	32.825	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-106	33.170	Sp/09; Fa/09	1.0	<0.05	0.05	0.41	0.43	-
CV-104	33.794	Sp/09; Su/06; Fa/08,09	3.0-6.0	0.05-0.08	0.16-0.24	0.01-0.60	0.10-0.22	-

Table 8-3. - Continued -

Crossing ID	Road Chainage (km)	Season/Year(s) Assessed[1]	Downstream of Crossing					
			Hydrology[2]					
			Wetted Width[3] (m)	Approximate Average Depth (m)	Maximum Depth (m)	Water Velocity (natural) (m/s)	Water Velocity (culvert) (m/s)	Water Velocity (sea can) (m/s)
CV-203	34.153	Sp/09	N/M - There is no fish habitat at this crossing					
CV-102	36.028	Sp/09; Fa/09	12.8	0.03	0.05-0.10	0.00-0.35	0.35-0.52	-
CV-099	37.840	Sp/08,09; Su/06,08; Fa/08,09	7.3-9.1	0.15-0.40	0.54-1.30	0.00-1.84	0.38-2.02	-
CV-095	41.100	Su/06	N/M - There is no fish habitat at this crossing					
CV-094	41.613	Sp/08,09; Su/08; Fa/08,09	6.8-8.2	0.15-0.25	0.16-0.35	0.00-1.86	0.20-2.48	-
CV-093	42.216	Su/06	N/M - There is no fish habitat at this crossing					
CV-092	42.949	Su/06	N/M - There is no fish habitat at this crossing					
CV-087	46.223	Su/06	10.0	0.10	0.20	NM	-	-
CV-086	46.300	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-082	49.655	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-079	50.600	Sp/09; Su/08; Fa/08,09	13.7-19.6	0.08-0.15	0.40-0.50	0.00-0.62	0.33-1.88	-
CV-207	50.762	Fa/08	4.1	0.15	0.32	0.00-0.12	0.20	-
CV-078	51.171	Sp/09; Su/06,08; Fa/08,09	17.4-25.8	0.06-0.30	0.47-2.00	0.01-1.19	0.76-1.19	-
CV-076	53.028	Sp/09; Fa/09	6.2-6.4	0.10	0.31	0.00-0.56	0.07-0.09	-
CV-072	53.878	Sp/09; Fa/08,09	2.8-15.5	0.14-0.30	0.35-0.80	0.01-0.63	0.03-0.79	-
CV-060	58.856	Sp/09; Su/06; Fa/08,09	3.6-8.5	0.15-0.30	0.25-0.75	0.00-0.66	0.03-0.54	-
CV-059	59.960	Sp/09; Fa/09	4.1	0.10	0.22-0.25	0.00-0.94	0.38-0.60	-
CV-058	60.523	Sp/09; Fa/09	1.8-2.0	0.15-0.20	0.31-0.46	0.04-0.59	0.10-0.19	-
CV-057	60.712	Su/06	1.0	0.30	0.60	NM	-	-
CV-055	61.904	Su/06	1.1	0.02	0.03	NM	-	-
BG-50	62.804	Sp/08,09; Su/06,08; Fa/08,09	44.8-61.0	0.10-0.20	> 1.00	0.00-1.42	1.82-2.79	0.01-1.01
CV-049	63.302	Sp/09; Su/06; Fa/08,09	12.0-12.8	0.10-0.20	0.45-0.70	0.03-0.86	0.27-0.60	-
CV-048	64.312	Sp/09; Fa/08,09	8.8-10.1	0.05-0.15	0.28-0.34	0.02-0.70	0.16-0.88	-
CV-046	66.490	Sp/09; Fa/09	2.2	0.08	0.13	0.00-0.35	0.82	-
CV-040	72.263	Sp/08,09; Su/06,08; Fa/08,09	6.8-27.4	0.10-0.25	0.50-0.65	0.00-0.94	0.07-1.45	-
CV-030	77.506	Sp/09; Fa/09	-	-	-	-	-	-

Table 8-3. - Continued -

Downstream of Crossing								
Crossing ID	Road Chainage (km)	Season/Year(s) Assessed[1]	Hydrology[2]					
			Wetted Width[3] (m)	Approximate Average Depth (m)	Maximum Depth (m)	Water Velocity (natural) (m/s)	Water Velocity (culvert) (m/s)	Water Velocity (sea can) (m/s)
BG-32	78.161	Sp/09; Fa/08,09	3.8	>1.00	>2.00	0.00-0.17	0.02-0.25	-
CV-217	79.915	Sp/09; Su/06; Fa/08,09	71.3-137.1	0.35-0.50	1.00-2.00	0.00-0.76	0.96-1.27	0.00-0.25
CV-216	80.646	Sp/09; Su/06; Fa/08,09	6.4-28.0	0.03	0.07-0.15	0.00-0.27	0.33-1.06	-
BG-31	82.076	Su/10	~ 0.5-3.0	0.05	~0.10	N/M	N/M	-
BG-30	84.636	Su/10	~ 2.0-3.0	0.10	0.15	N/M	N/M	-
BG-29	84.805	Sp/09; Fa/09	2.3	0.30	0.52-0.68	0.00-0.26	0.62-0.68	-
BG-28	86.263	Su/06	N/M - There is no fish habitat at this crossing					
BG-27	86.609	Sp/09; Su/06; Fa/09	5.0	0.05	0.10	-	0.83-1.04	-
BG-24	87.710	Sp/08,09; Su/06,08; Fa/08,09	1.8-5.5	0.15-0.40	0.20-0.65	0.00-1.41	0.49-2.20	-
BG-17	90.167	Sp/09; Su/06; Fa/08,09	3.3-8.0	0.25	0.36-0.98	0.00-0.67	0.39-1.59	-
BG-16	90.218	Sp/09; Su/06; Fa/09	N/M - There is no crossing of this stream					
BG-04	94.148	Sp/09; Fa/08,09	9.1-12.8	0.15-0.20	0.25-0.40	0.00-0.44	0.33-1.27	-
CV-001	94.728	Fa/09	1.4	0.08	0.26	0.02-0.63	0.36	-
CV-223	97.155	Sp/09; Su/06; Fa/08,09	39.1-117.0	0.20-0.30	0.50-1.00	0.01-1.26	0.57	0.05-1.35
CV-224	97.758	Sp/09; Su/06; Fa/08,09	3.6-9.5	0.08-0.10	0.22-0.25	0.00-0.35	0.31-0.89	-
CV-225	98.989	Sp/08,09; Su/06,08; Fa/08,09	7.0-19.20	0.12-0.20	0.40-1.20	0.00-1.03	1.61-2.85	-
BG-01	99.672	Sp/08,09; Su/06,08; Fa/08,09	5.0-23.77	0.10-0.20	0.50-1.00	0.00-1.34	2.08-3.14	-
CV-186	102.812	Sp/09; Fa/09	4.6-4.7	0.05-0.10	0.25	0.00-0.73	0.13-0.55	-
CV-187	103.078	Sp/09; Su/06; Fa/09	11.0	0.18-0.25	0.30-0.40	0.00	0.01-0.03	-
CV-183	0.145	Sp/09; Su/06; Fa/09	12.0-17.4	0.20-0.30	0.55-0.65	0.00-1.43	No culvert	-
CV-181	0.583	Sp/09; Fa/09	7.7-10.2	0.12-0.15	0.34-0.40	0.00-0.60	No culvert	-
CV-176	2.638	Sp/09; Fa/09	0.8-2.0	0.05-0.07	0.13-0.15	0.00-0.32	0.20-0.31	-
CV-173	4.430	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-170	5.267	Sp/09; Fa/09	2.7	0.10	0.24-0.25	0.00-0.01	0.25-0.69	-
CV-167	5.960	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-166	6.056	Sp/09; Fa/09	3.1	0.08	0.20	0.00-0.30	0.08-0.22	-
CV-159	8.407	Sp/09; Fa/09	3.9	0.15-0.20	0.41-0.50	0.00-0.01	0.11-0.49	-

Table 8-3. - Continued -

Upstream of Crossing								
Crossing ID	Road Chainage (km)	Season/Year(s) Assessed[1]	Hydrology[2]					
			Wetted Width[3] (m)	Approximate Average Depth (m)	Maximum Depth (m)	Water Velocity (natural) (m/s)	Water Velocity (culvert) (m/s)	Water Velocity (sea can) (m/s)
CV-157	8.960	Sp/09; Fa/09	5.0-5.2	0.08	0.30-0.31	0.01-0.32	0.16-0.38	-
CV-156	9.223	Sp/09; Su/06	N/M - Crossing avoided by road					
CV-154	9.570	Sp/09; Fa/09	4.5	0.15	0.50-0.55	0.00-0.01	0.30-0.57	-
CV-153	10.218	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-152	10.280	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-151	10.460	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-146	11.348	Su/06	2.4	0.10	0.30	NM	-	-
CV-129	15.650	Sp/08,09; Su/08; Fa/08,09	9.8-12.8	0.10-0.15	0.30-0.50	0.00-0.81	0.45-0.75	-
CV-128	17.486	Sp/09; Su/06; Fa/08,09	44.0-64.0	0.50-1.00	>1.00	0.01-1.11	-	0.29-0.61
CV-125	20.447	Sp/09; Fa/09	200.0	1.00	2.00	0.00	0.00	-
CV-120	23.515	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-119	24.264	Sp/09; Fa/09	N/M - There is no fish habitat upstream of the crossing					
CV-115	27.686	Sp/09; Fa/09	2.7	0.03	0.10-0.14	0.24-0.90	0.01-0.20	-
CV-114	29.647	Sp/09; Su/06; Fa/08,09	8.0-12.2	0.05-0.08	0.12-0.28	0.00-0.51	0.54-1.07	-
CV-113	30.655	Fa/09	1.0	0.08	0.15	0.02-0.38	0.49	-
CV-112	31.450	Sp/09; Fa/09	3.1-3.5	0.07	0.13	0.03-0.68	0.54-0.62	
CV-111	31.990	Fa/08,09	6.2-7.0	0.05-0.08	0.15	0.07-1.17	0.16-0.62	-
CV-202	32.825	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-106	33.170	Sp/09; Fa/09	1.4	<0.05	0.05	0.20	0.38	-
CV-104	33.794	Sp/09; Su/06; Fa/08,09	5.7-6.0	0.10	0.10-0.15	0.00-0.60	0.31-0.80	-
CV-203	34.153	Sp/09	N/M - There is no fish habitat at this crossing					
CV-102	36.028	Sp/09; Fa/09	11.9	0.05	0.12-0.16	0.00	0.33-0.57	
CV-099	37.840	Sp/08,09; Su/06,08; Fa/08,09	8.0-36.6	0.12-0.25	0.38-0.50	0.00-1.43	0.45-1.23	-
CV-095	41.100	Su/06	N/M - There is no fish habitat at this crossing					
CV-094	41.613	Sp/08,09; Su/08; Fa/08,09	2.0-10.4	0.10-0.20	0.14-0.35	0.00-1.04	0.89-1.43	-
CV-093	42.216	Su/06	N/M - There is no fish habitat at this crossing					
CV-092	42.949	Su/06	N/M - There is no fish habitat at this crossing					
CV-087	46.223	Su/06	10.0	0.10	0.20	NM	-	-

Table 8-3. - Continued -

Upstream of Crossing

Crossing ID	Road Chainage (km)	Season/Year(s) Assessed[1]	Hydrology[2]					
			Wetted Width[3] (m)	Approximate Average Depth (m)	Maximum Depth (m)	Water Velocity (natural) (m/s)	Water Velocity (culvert) (m/s)	Water Velocity (sea can) (m/s)
CV-086	46.300	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-082	49.655	Sp/09; Fa/09	N/M - There is no fish habitat at this crossing					
CV-079	50.600	Sp/09; Su/08; Fa/08,09	3.9-8.7	0.20-0.25	0.30-0.41	0.10-1.16	0.14-0.96	-
CV-207	50.762	Fa/08	3.9	0.15	0.20	0.12-0.45	0.55	-
CV-078	51.171	Sp/09; Su/06,08; Fa/08,09	9.1-21.0	0.15-0.20	0.45-0.75	0.41-1.38	0.50-0.91	-
CV-076	53.028	Sp/09; Fa/09	1.9	0.10	0.15-0.16	0.00-0.56	0.13-0.16	-
CV-072	53.878	Sp/09; Fa/08,09	4.1-12.8	0.10	0.17-0.31	0.01-1.50	0.30-0.70	-
CV-060	58.856	Sp/09; Su/06; Fa/08,09	3.6-6.0	0.20-0.30	0.56-0.70	0.00-0.19	0.09-0.56	-
CV-059	59.960	Sp/09; Fa/09	5.5	0.25	0.35-0.49	0.00	0.02-0.04	-
CV-058	60.523	Sp/09; Fa/09	3.1-6.5	0.50	0.81	0.00-1.18	0.33-0.40	-
CV-057	60.712	Su/06	1.0	0.30	0.60	NM	-	-
CV-055	61.904	Su/06	1.1	0.02	0.03	NM	-	-
BG-50	62.804	Sp/08,09; Su/06,08; Fa/08,09	45.7-61.0	0.15-0.25	0.47-0.54	0.00-1.31	0.62-1.16	0.02-1.38
CV-049	63.302	Sp/09; Su/06; Fa/08,09	12.0-27.4	0.07-0.15	0.30-0.40	0.00-0.89	0.31-1.04	-
CV-048	64.312	Sp/09; Fa/08,09	3.3-6.4	0.08-0.20	0.30-0.33	0.01-0.60	0.34-0.72	-
CV-046	66.490	Sp/09; Fa/09	1.7	0.10	0.23	0.00-0.31	0.36	-
CV-040	72.263	Sp/08,09; Su/06,08; Fa/08,09	8.7-22.9	0.05-0.25	0.20-0.37	0.00-0.47	0.26-0.92	-
CV-030	77.506	Sp/09; Fa/09	-	-	-	-	-	-
BG-32	78.161	Sp/09; Fa/08,09	4.0	1.00	1.50	0.05-0.27	0.05-0.15	-
CV-217	79.915	Sp/09; Su/06; Fa/08,09	N/A - immediately US is a large lake that is known to be important habitat for both species					
CV-216	80.646	Sp/09; Su/06; Fa/08,09	22.9-29.3	0.03	0.10-0.16	0.00-0.18	0.59-0.78	-
BG-31	82.076	Su/10	N/M	N/M	N/M	N/M	N/M	-
BG-30	84.636	Su/10	~ 1.0-2.0	0.15-0.20	0.30-0.50	N/M	N/M	-
BG-29	84.805	Sp/09; Fa/09	5.1-5.6	0.20-0.25	0.290.35	0.00-0.17	0.71-0.78	-
BG-28	86.263	Su/06	N/M - There is no fish habitat at this crossing					
BG-27	86.609	Sp/09; Su/06; Fa/09	5.0	0.05	0.10	-	0.72-0.75	-
BG-24	87.710	Sp/08,09; Su/06,08; Fa/08,09	2.30-6.50	0.09-0.30	0.20-0.60	0.00-1.40	0.54-1.09	-

Table 8-3. - Continued -

Upstream of Crossing								
Crossing ID	Road Chainage (km)	Season/Year(s) Assessed[1]	Hydrology[2]					
			Wetted Width[3] (m)	Approximate Average Depth (m)	Maximum Depth (m)	Water Velocity (natural) (m/s)	Water Velocity (culvert) (m/s)	Water Velocity (sea can) (m/s)
BG-17	90.167	Sp/09; Su/06; Fa/08,09	8.0-11.9	0.25	0.30-0.40	0.13-0.17	0.43-1.41	-
BG-16	90.218	Sp/09; Su/06; Fa/09	N/M - There is no crossing of this stream					
BG-04	94.148	Sp/09; Fa/08,09	20.1	0.50	> 1.00	0.00	0.24-1.09	-
CV-001	94.728	Fa/09	22.9	0.50	0.75	0.00	0.00	-
CV-223	97.155	Sp/09; Su/06; Fa/08,09	54.8-117.0	0.25-0.30	0.75-1.50	0.48	-	0.10-1.36
CV-224	97.758	Sp/09; Su/06; Fa/08,09	6.7-10.8	0.07	0.10-0.20	0.00-0.38	0.42-1.07	-
CV-225	98.989	Sp/08,09; Su/06,08; Fa/08,09	3.8-27.43	0.10-0.50	0.50-1.00	0.00-1.35	1.27-1.82	-
BG-01	99.672	Sp/08,09; Su/06,08; Fa/08,09	4.0-25.60	0.30-0.40	0.55-1.05	0.02-0.90	0.74-1.40	-
CV-186	102.812	Sp/09; Fa/09	3.2-3.8	0.10-0.15	0.15-0.17	0.01-0.62	0.25-1.03	-
CV-187	103.078	Sp/09; Su/06; Fa/09	4.0-9.1	0.08	0.25	0.00-0.01	0.25-0.82	-

[1] Sp = spring, Su = summer, Fa = fall; fall 2008 data only include water velocities and not complete habitat assessments
[2] For sites surveyed more than once or parameters measured multiple times per site, values are presented as a range of recorded data; detailed site assessments are provided in Appendix 8-1.
[3] May include multiple channels for braided streams

Table 8-4. Summary statistics relating to fish surveys conducted during surveys of Tote Road watercourse crossings, 2006-2010.

Site ID	Season/Year(s) Surveyed[1]	Gear Types Used	Arctic char				Ninespine stickleback			
			Observed/ Captured	CPUE		Fork Length Range (mm)	Observed/ Captured	CPUE		Fork Length Range (mm)
				Electrofishing (#fish/min)	Minnow Traps (#fish/hour)			Electrofishing (#fish/min)	Minnow Traps (#fish/hour)	
CV-183	Sp/09; Su/06; Fa/09	EF, OB, MT	Y	0.00-0.12	0.00	> 100	N	0.00	0.00	-
CV-181	Sp/09; Fa/09	EF, OB	N	0.00	-	-	N	0.00	-	-
CV-176	Sp/08,09; Fa/09	EF, OB	N	0.00	-	-	N	0.00	-	-
CV-173	Sp/08,09	OB	N	-	-	-	N	-	-	-
CV-170	Sp/08,09; Fa/09	EF, OB	N	0.00	-	-	N	0.00	-	-
CV-167	Sp/08,09	OB	N	-	-	-	N	-	-	-
CV-166	Sp/08,09; Fa/09	EF, OB	N	0.00	-	-	N	0.00	-	-
CV-159	Sp/08,09; Fa/09	EF, OB	N	0.00	-	-	N	0.00	-	-
CV-157	Sp/08,09; Fa/09	EF, OB	N	0.00	-	-	N	0.00	-	-
CV-154	Sp/08,09; Fa/09	EF, OB	N	0.00	-	-	N	0.00	-	-
CV-153	Sp/08,09	OB	N	-	-	-	N	-	-	-
CV-152	Sp/08,09	OB	N	-	-	-	N	-	-	-
CV-151	Sp/08,09	OB	N	-	-	-	N	-	-	-
CV-146	Su/06	OB	N	-	-	-	N	-	-	-
CV-129	Sp/08,09; Su/08,10; Fa/09	EF, OB	Y	0.11-1.29	-	60-203	Y	0.14	-	42
CV-128	Sp/08,09; Su/06; Fa/09	EF, OB, MT	Y	0.00	0.01	84-300	N	0.00	0.00	-
CV-125	Sp/08,09	OB	N	-	-	-	N	-	-	-
CV-120	Sp/08,09	OB	N	-	-	-	N	-	-	-
CV-119	Sp/08,09	OB	N	-	-	-	N	-	-	-
CV-115	Sp/08,09; Fa/09	EF, OB	N	0.00	-	-	N	0.00	-	-
CV-114	Sp/08,09; Su/06,10; Fa/09	EF, OB	Y	0.35-1.00	-	55-108	N	0.00	-	-
CV-113	Sp/08,09	OB	N	-	-	-	N	-	-	-
CV-112	Sp/08,09,10; Su/10; Fa/09	EF, OB	Y	0.86-2.46	-	40-150	N	0.00	-	-
CV-111	Sp/08,09; Fa/09	OB	Y	0.80-1.51	-	53-114	N	-	-	-
CV-202	Sp/08,09; Fa/09	OB	N	-	-	-	N	-	-	-
CV-106	Sp/08,09; Fa/09	OB	Y	-	-	75-100	N	-	-	-
CV-104	Sp/08,09; Su/06; Fa/09	EF, OB	Y	0.52	-	< 75	N	0.00	-	-
CV-203	Sp/08,09	OB	N	-	-	-	N	-	-	-

Table 8-4. - Continued -

Site ID	Season/Year(s) Surveyed[1]	Gear Types Used	Arctic char				Ninespine stickleback			
			Observed/ Captured	CPUE		Fork Length Range (mm)	Observed/ Captured	CPUE		Fork Length Range (mm)
				Electrofishing (#fish/min)	Minnow Traps (#fish/hour)			Electrofishing (#fish/min)	Minnow Traps (#fish/hour)	
CV-102	Sp/08,09; Fa/09	EF, OB	Y	0.70-0.74	-	45-48	N	0.00	-	-
CV-099	Sp/08,09; Su/06,08,10; Fa/09	EF, OB, MT	Y	0.97-2.07	0.08	64-148	N	0.00	0.00	-
CV-095	Su/06	OB	N	-	-	-	N	-	-	-
CV-094	Sp/08,09; Su/08; Fa/09	EF, OB	Y[1]	0.20-0.25	-	119-151	N	-	-	-
CV-093	Su/06	OB	N	-	-	-	N	-	-	-
CV-092	Su/06	OB	N	-	-	-	N	-	-	-
CV-087	Su/06	OB	N	-	-	-	N	-	-	-
CV-086	Sp/08,09	OB	N	-	-	-	N	-	-	-
CV-082	Sp/08,09	OB	N	-	-	-	N	-	-	-
CV-079	Sp/08,09; Su/08; Fa/09	EF, OB	Y	2.09	-	38-158	N	-	-	-
CV-207	Fa/08	EF, OB	Y	0.16	-	131-133	N	-	-	-
CV-078	Sp/08,09; Su/06,10; Fa/09	EF, OB, MT	Y	2.70	0.18	63-150	N	-	0.00	-
CV-076	Sp/08,09; Fa/09	OB	Y	-	-	50-100	N	-	-	-
CV-072	Sp/08,09; Fa/09	EF, OB	Y	0.00-2.10	-	63-105	N	0.00	-	-
CV-060	Sp/08,09; Su/06; Fa/09	OB, MT	Y	-	0.22	60-120	N	-	0.00	-
CV-059	Sp/08,09; Fa/09	EF, OB	Y	0.38-0.80	-	80-87	N	0.00	-	-
CV-058	Sp/08,09; Fa/09	EF, OB	Y	0.39-0.70	-	85-100	N	0.00	-	-
CV-057	Sp/08,09; Su/06; Fa/09	EF, OB, MT	Y	0.00-1.05	0.09	70-135	N	0.00	0.00	-
CV-055	Su/06	OB	N	-	-	-	N	-	-	-
BG-50	Sp/08,09; Su/06,08,10; Fa/09	EF, OB, MT	Y	0.44-2.42	0.01	71-280	Y	0.33	0.00	51-53
CV-049	Sp/08,09; Su/06; Fa/09	OB, MT	Y	-	0.00	100-150	N	-	0.00	-
CV-048	Sp/08,09; Fa/09	EF, OB	N	0.00	-	-	N	0.00	-	-
CV-046	Sp/08,09; Fa/09	EF, OB	N	0.00	-	-	N	0.00	-	-
CV-040	Sp/08,09; Su/06,08,10; Fa/09	EF, OB, MT	Y[2]	0.00	0.00	-	N	-	0.00	-
CV-030	Sp/08,09; Fa/09	OB	Y	-	-	50-60	Y	-	-	-
BG-32	Sp/08,09; Su/10; Fa/09	OB	Y	-	-	50-200	Y	-	-	50-60
CV-217	Sp/08,09; Su/06,10; Fa/09	EF, OB, MT	Y	3.43	-	YOY-300	Y	1.00	-	38-60
CV-216	Sp/08,09; Su/06; Fa/09	OB	Y	-	-	50-70	N	-	-	-

Table 8-4. - Continued -

Site ID	Season/Year(s) Surveyed[1]	Gear Types Used	Arctic char				Ninespine stickleback			
			Observed/ Captured	CPUE		Fork Length Range (mm)	Observed/ Captured	CPUE		Fork Length Range (mm)
				Electrofishing (#fish/min)	Minnow Traps (#fish/hour)			Electrofishing (#fish/min)	Minnow Traps (#fish/hour)	
BG-31	Su/10	OB	Y	-	-	-	N	-	-	-
BG-30	Su/10	OB	N	-	-	-	N	-	-	-
BG-29	Sp/08,09; Fa/09	OB	Y	-	-	50-100	Y	-	-	-
BG-28	Su/06	OB	N	-	-	-	N	-	-	-
BG-27	Sp/08,09,10; Su/06,10; Fa/09	EF, OB	Y	0.00-2.00	-	49-150	N	0.00	-	-
BG-24	Sp/08,09; Su/06,08; Fa/09	EF, OB, MT	Y	0.99-4.04	0.17	50-378	N	0.00	0.00	-
BG-17	Sp/08,09; Su/06; Fa/09	EF, OB, MT	Y	1.20-2.61	0.07	46-179	Y	0.31	0.00	61-72
BG-16	Sp/09; Su/06; Fa/09	OB	N	-	-	-	N	-	-	-
BG-04	Sp/08,09; Fa/09	OB	Y	-	-	-	N	-	-	-
CV-001	Su/10; Fa/09	OB	Y	-	-	50-150	Y	-	-	YOY
CV-223	Sp/08,09; Su/06; Fa/09	EF, OB, MT	Y	3.47	0.00	95-232	N	0.00	0.00	-
CV-224	Sp/08,09; Su/06; Fa/09	OB	Y	-	-	<60	N	-	-	-
CV-225	Sp/08,09,10; Su/06,08,10; Fa/09	EF, OB	Y	0.87-14.48	-	36-181	Y	0.11	-	-
BG-01	Sp/08,09,10; Su/06,08,10; Fa/09	EF, OB, MT	Y	0.48-39.63	0.02	50-227	Y	0.13-0.45	0.00	45-61
CV-186	Sp/08,09; Fa/09	OB	Y	-	-	-	Y	-	-	-
CV-187	Sp/08,09; Su/06,10; Fa/09	EF, OB, MT	Y	0.45	0.01	75-150	Y	0.00	0.00	< 70

[1] Fish were only captured downstream of the falls barrier (at 30 m DS of the crossing); no fish were captured at the crossing or further upstream
[2] Fish were captured downstream of the reach of subterranean flow approximately 1.5-2.0 km downstream of the crossing

Table 8-5. Potential fish use of habitat in assessed watercourse crossings along the Milne Inlet Tote Road, 2006-2010.

Crossing ID	Road Chainage (km)	Arctic char				Ninespine stickleback				Fish Habitat Quality Rating[2]
		Spawning[1]	Rearing	Overwintering	Migration	Spawning	Rearing	Overwintering	Migration	
CV-183	0.145	N	M	N	N	N	N	N	N	MAR
CV-181	0.583	N	L	N	N	N	N	N	N	MAR
CV-176	2.638	N	N	N	N	N	N	N	N	NFB
CV-173	4.430	N	N	N	N	N	N	N	N	NFB
CV-170	5.267	N	N	N	N	N	N	N	N	NFB
CV-167	5.960	N	N	N	N	N	N	N	N	NFB
CV-166	6.056	N	N	N	N	N	N	N	N	NFB
CV-159	8.407	N	N	N	N	N	N	N	N	NFB
CV-157	8.960	N	N	N	N	N	N	N	N	NFB
CV-156	9.223	N	N	N	N	N	N	N	N	NFB
CV-154	9.570	N	N	N	N	N	N	N	N	NFB
CV-153	10.218	N	N	N	N	N	N	N	N	NFB
CV-152	10.280	N	N	N	N	N	N	N	N	NFB
CV-151	10.460	N	N	N	N	N	N	N	N	NFB
CV-146	11.348	N	N	N	N	N	N	N	N	NFB
CV-129	15.650	N	H	N	H	N	L	N	L	IMP
CV-128	17.486	N	H	N	H	L	M	N	M	IMP
CV-125	20.447	N	N	N	N	N	N	N	N	NFB
CV-120	23.515	N	N	N	N	N	N	N	N	NFB
CV-119	24.264	N	N	N	N	N	N	N	N	NFB
CV-115	27.686	N	L	N	N	N	N	N	N	MAR
CV-114	29.647	N	M	N	M	N	L	N	L	MAR
CV-113	30.655	N	N	N	N	N	N	N	N	NFB
CV-112	31.450	N	H	N	L	N	N	N	N	IMP
CV-111	31.990	N	H	N	H	N	L	N	L	IMP
CV-202	32.825	N	N	N	N	N	N	N	N	NFB
CV-106	33.170	N	H	N	L	N	L	N	L	MAR
CV-104	33.794	N	H	N	L	N	L	N	L	MAR
CV-203	34.153	N	N	N	N	N	N	N	N	NFB

Table 8-5. - Continued -

Crossing ID	Road Chainage (km)	Arctic char				Ninespine stickleback				Fish Habitat Quality Rating[2]
		Spawning[1]	Rearing	Overwintering	Migration	Spawning	Rearing	Overwintering	Migration	
CV-102	36.028	N	H	N	M	N	N	N	N	IMP
CV-099	37.840	N	H	N	H	N	N	N	N	IMP
CV-095	41.100	N	N	N	N	N	N	N	N	NFB
CV-094	41.613	N	H[3]	N	N	N	N	N	N	NFB
CV-093	42.216	N	N	N	N	N	N	N	N	NFB
CV-092	42.949	N	N	N	N	N	N	N	N	NFB
CV-087	46.223	N	L	N	N	N	N	N	N	MAR
CV-086	46.300	N	N	N	N	N	N	N	N	NFB
CV-082	49.655	N	N	N	N	N	N	N	N	NFB
CV-079	50.600	N	H	N	H	N	L	N	L	IMP
CV-207	50.762	N	M	N	L	N	N	N	N	IMP
CV-078	51.171	N	H	N	H	N	L	N	N	IMP
CV-076	53.028	N	M	N	L	N	N	N	N	MAR
CV-072	53.878	N	M	N	M	L	L	N	L	IMP
CV-060	58.856	N	H	N	H	N	L	N	N	IMP
CV-059	59.960	N	H	N	L	N	N	N	N	MAR
CV-058	60.523	N	H	N	L	N	N	N	N	MAR
CV-057	60.712	N	M	N	N	N	N	N	N	MAR
CV-055	61.904	N	N	N	N	N	N	N	N	NFB
BG-50	62.804	N	H	N	H	M	M	N	L	IMP
CV-049	63.302	N	H	N	H	L	L	N	L	IMP
CV-048	64.312	N	N	N	N	N	N	N	N	NFB
CV-046	66.490	N	N	N	N	N	N	N	N	NFB
CV-040	72.263	N	L	N	N	N	N	N	N	MAR
CV-030	77.506	N	M	N	L	N	L	N	L	MAR
BG-32	78.161	N	H	N	H	M	H	N	H	IMP
CV-217	79.915	N	L	N	H	L	L	N	H	IMP

Table 8-5. - Continued -

Crossing ID	Road Chainage (km)	Arctic char				Ninespine stickleback				Fish Habitat Quality Rating[2]
		Spawning[1]	Rearing	Overwintering	Migration	Spawning	Rearing	Overwintering	Migration	
CV-216	80.646	N	M	N	M	N	N	N	N	MAR
BG-31	82.076	N	L	N	N	N	N	N	N	MAR
BG-30	84.636	N	N	N	N	N	N	N	N	NFB
BG-29	84.805	N	M	N	L	L	L	N	L	MAR
BG-28	86.263	N	N	N	N	N	N	N	N	NFB
BG-27	86.609	N	M	N	N	N	N	N	N	MAR
BG-24	87.710	N	H	N	M	L	L	N	L	IMP
BG-17	90.167	N	H	N	H	M	M	N	M	IMP
BG-16	90.218	N	N	N	N	N	N	N	N	NFB
BG-04	94.148	N	H	N	L	N	L	N	N	IMP
CV-001	94.728	N	M	N	M	M	H	N	H	IMP
CV-223	97.155	N	H	N	H	N	N	N	N	IMP
CV-224	97.758	N	H	N	H	N	N	N	N	IMP
CV-225	98.989	N	H	N	H	L	M	N	L	IMP
BG-01	99.672	N	H	N	L	N	M	N	L	IMP
CV-186	102.812	N	H	N	H	N	L	N	L	IMP
CV-187	103.078	N	H	N	L	L	L	N	L	MAR

[1] N = no use, L = low potential use, M = moderate potential use, H = high potential use
[2] NFB = not fish bearing, MAR = marginal, IMP = important
[3] Fish use of habitat in CV-094 only occurs downstream of the falls barrier at 30 m DS from the crossing
Migration use can include migration to spawning habitat, migration from overwintering to feeding areas or migrations between feeding areas

Table 8-6. Existing and potential habitat compensation sites along the Milne Inlet Tote Road.

Crossing ID	Type[1]	Area Compensated (m^2)	Compensation Description	Status	Results
CV-183	RH	900	Remove old culverts	Completed	Sea run char occasionally captured in this stream
CV-181	RH	300	Remove old culvert	Completed	Sea run char potential use of this stream
CV-176	HE	500	Erosion control - reduce DS sediment load	Completed	Habitat not fish bearing
CV-170	RA	13374	Perched culvert, restore fish passage	Culvert perched again - reinstall; Natural barrier discovered ~200 m DS - remove, if possible	Habitat at crossing currently not fish bearing due to natural barrier; removal of barrier and perched culvert could successfully restore access
CV-166	RA	9236	Perched culvert, restore fish passage, stabilize	Completed	Habitat not fish bearing
CV-159	RH	20	Fix culvert crossing	Completed	Habitat not fish bearing
CV-157	RA	18256	Perched culvert, restore fish passage	Culvert still perched, but stream not fish-bearing anyway	Habitat not fish bearing
CV-154	RH	100	Remove culvert remnants - clean up	Completed	Habitat not fish bearing
CV-152	RA	17721	Restore stream channel, redirect water to channel, eliminate barrier to fish passage	Completed	Habitat not fish bearing
CV-113	RA	3798	Remove gravel - install culvert for fish passage	Completed	Habitat not fish bearing
CV-094	RA	-	Good quality habitat but natural falls barrier ~50 m DS prevents access to the crossing area - removal of the falls (could be very difficult) may allow fish access to abundant US habitat	Planning stages only	N/A
CV-048	RA	-	Subterranean flow for ~ 100m between CV-049 (known to be fish bearing) and CV-048 following spring freshet - if this reach could be watered, access to abundant, high quality US habitat would be created	Planning stages only	N/A
CV-046	RA	-	Same stream system as CV-048	Planning stages only	N/A

Table 8-6. - Continued -

Crossing ID	Type[1]	Area Compensated (m^2)	Compensation Description	Status	Results
CV-040	RA	-	Flow becomes subterranean (>250m reach) ~1.5-2.0 km DS of the crossing following spring freshet, below which fish have been captured - if this reach could be watered, easier and persistent access to abundant, high quality US habitat would be created	Planning stages only	N/A
BG-31	HE	-	Existing habitat between the crossing and Muriel Lake DS is poor (mainly sandy flats) and in >1km of river only 3 fish observed - improve habitat quality by adding larger substrates and channelizing flows	Planning stages only	N/A
BG-30	RA	-	Natural boulder barriers within 50m DS of the crossing prevent access from fish in stream BG-29 from accessing abundant habitat (~1km) US of the crossing - removal of natural barriers and perched culvert will restore access	Planning stages only	N/A
BG-16	HE	500	Remove barrels leaching into BG-17, which is important fish habitat	Completed	Habitat not fish bearing
CV-001	RH	100	Remove debris	Completed	Both char and stickleback abundant in the vicinity of the crossing
CV-187	RH	114	Replace fuel drum culvert	Completed	Char use of habitat in the vicinity of the crossing has been confirmed

[1] HE = habitat enhancement, RA = restore access, RH = restore habitat

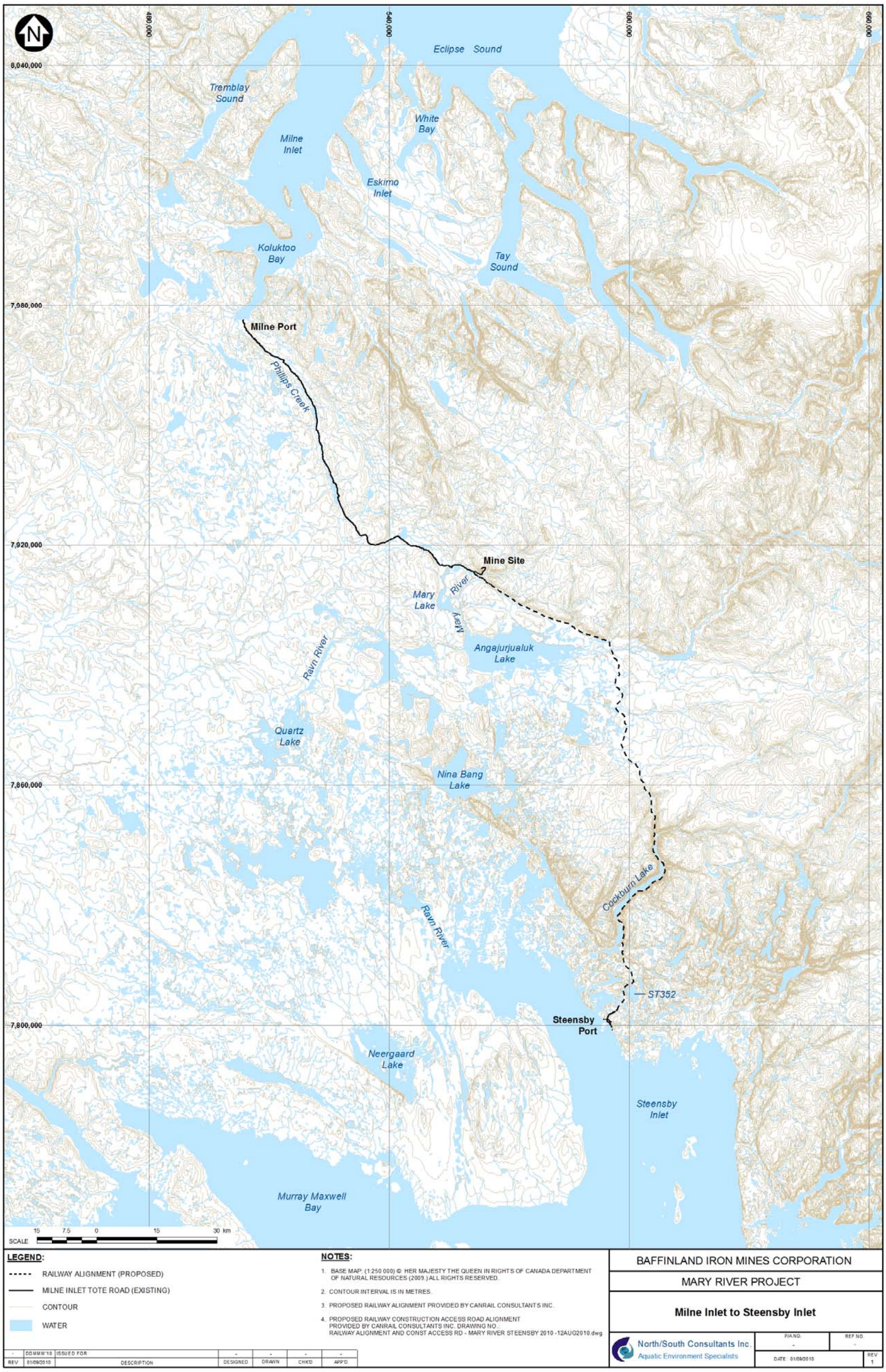

Figure 1-1. Location of the Mary River Project.

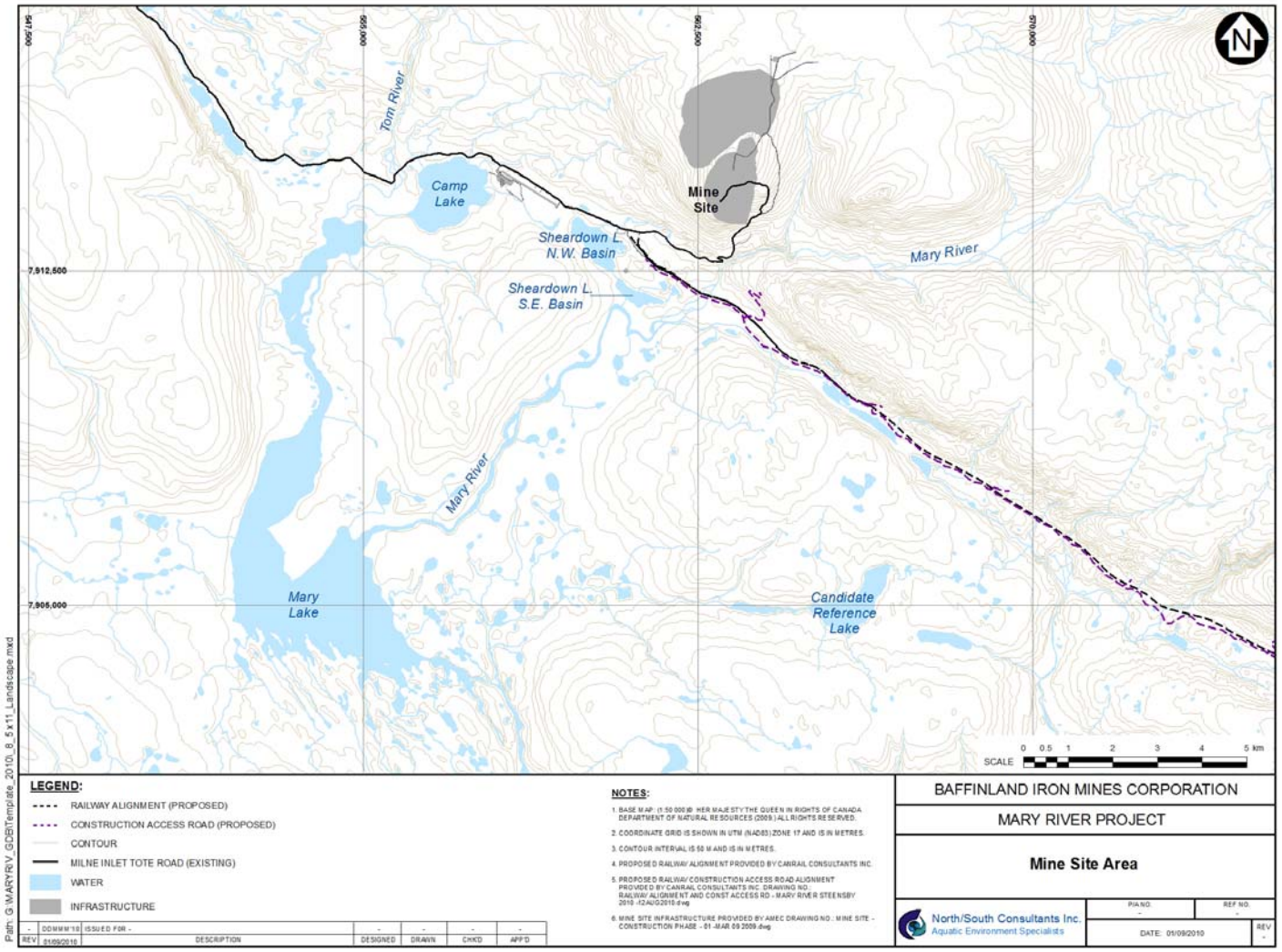

Figure 1.1-1. Mine Area.

Figure 1.1-2. Railway/Access Road Area.

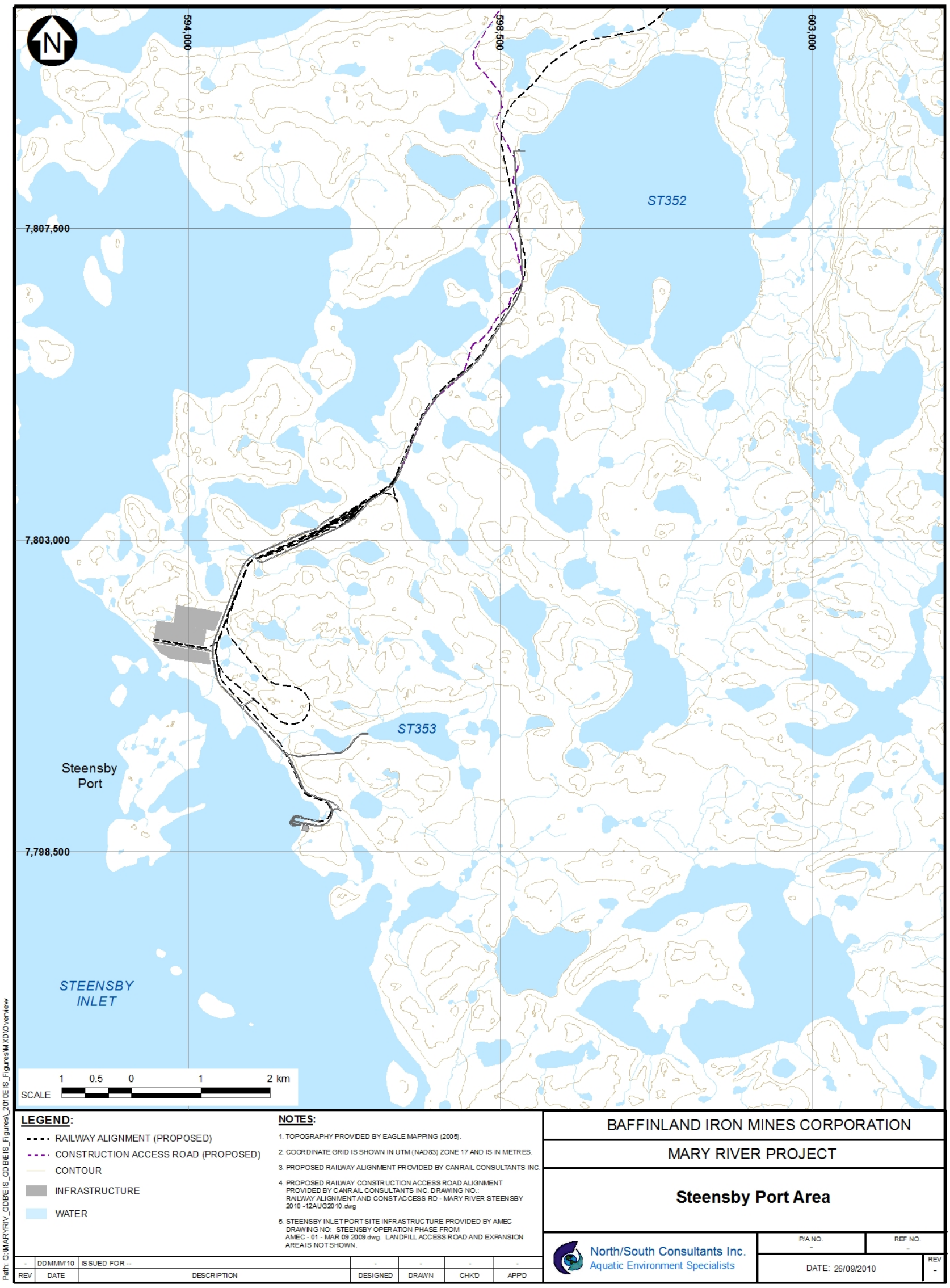

Figure 1.1-3. Steensby Port Area.

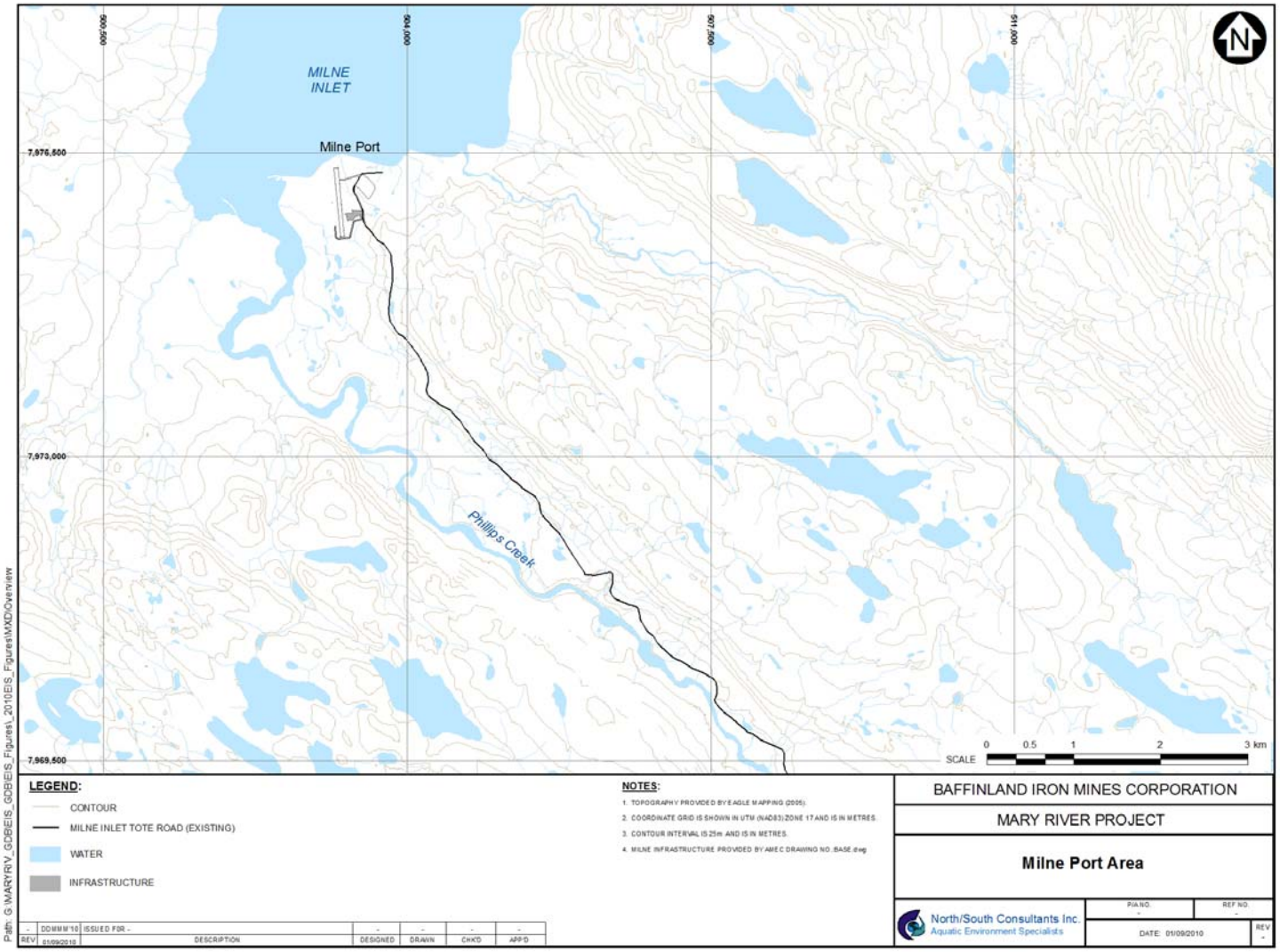

Figure 1.1-4. Milne Port Area.

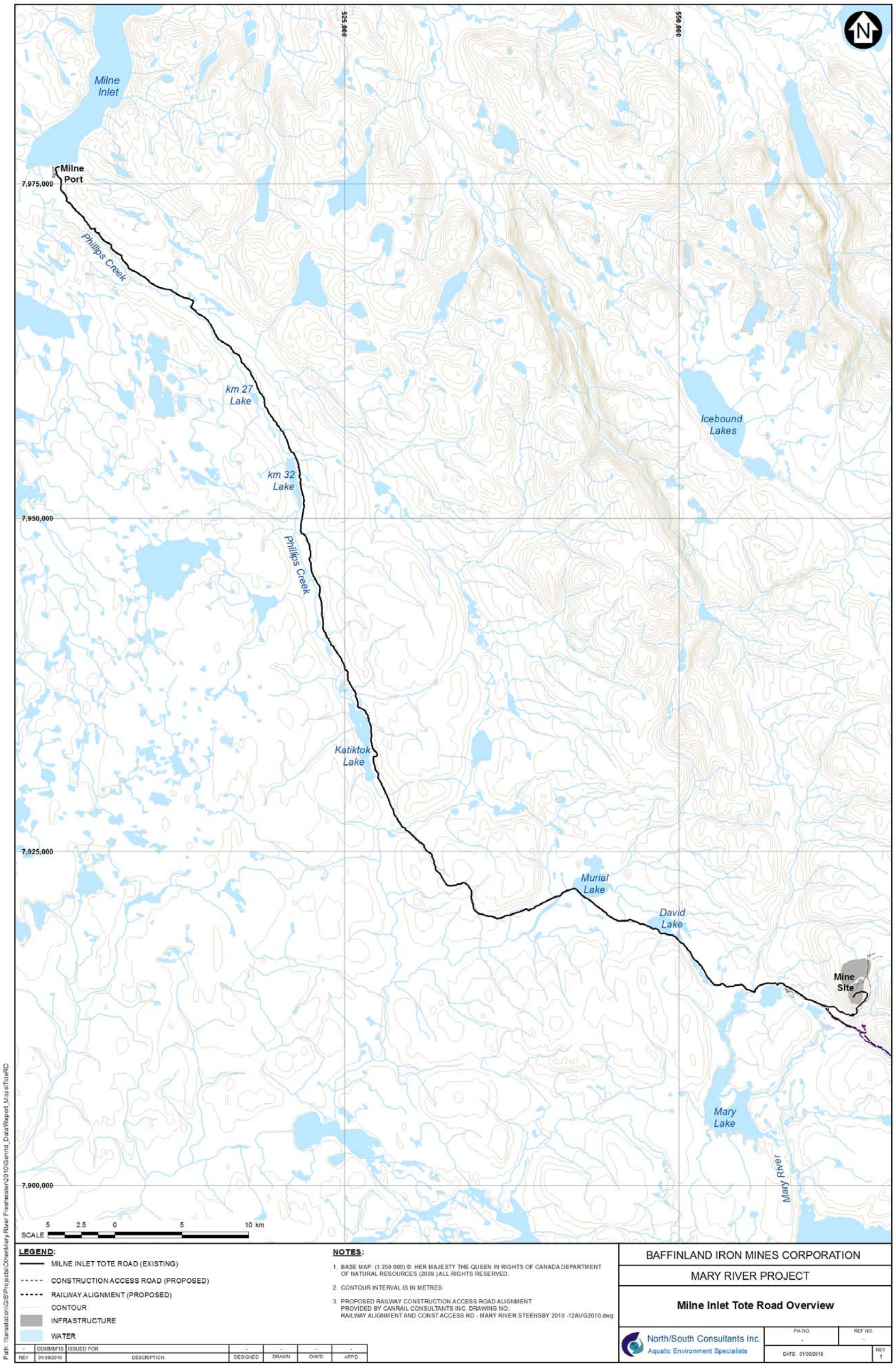

Figure 1.1-5. Milne Inlet Tote Road Area.

Figure 2.2-1. IQ study results for presence of Arctic char and waterbodies of importance.

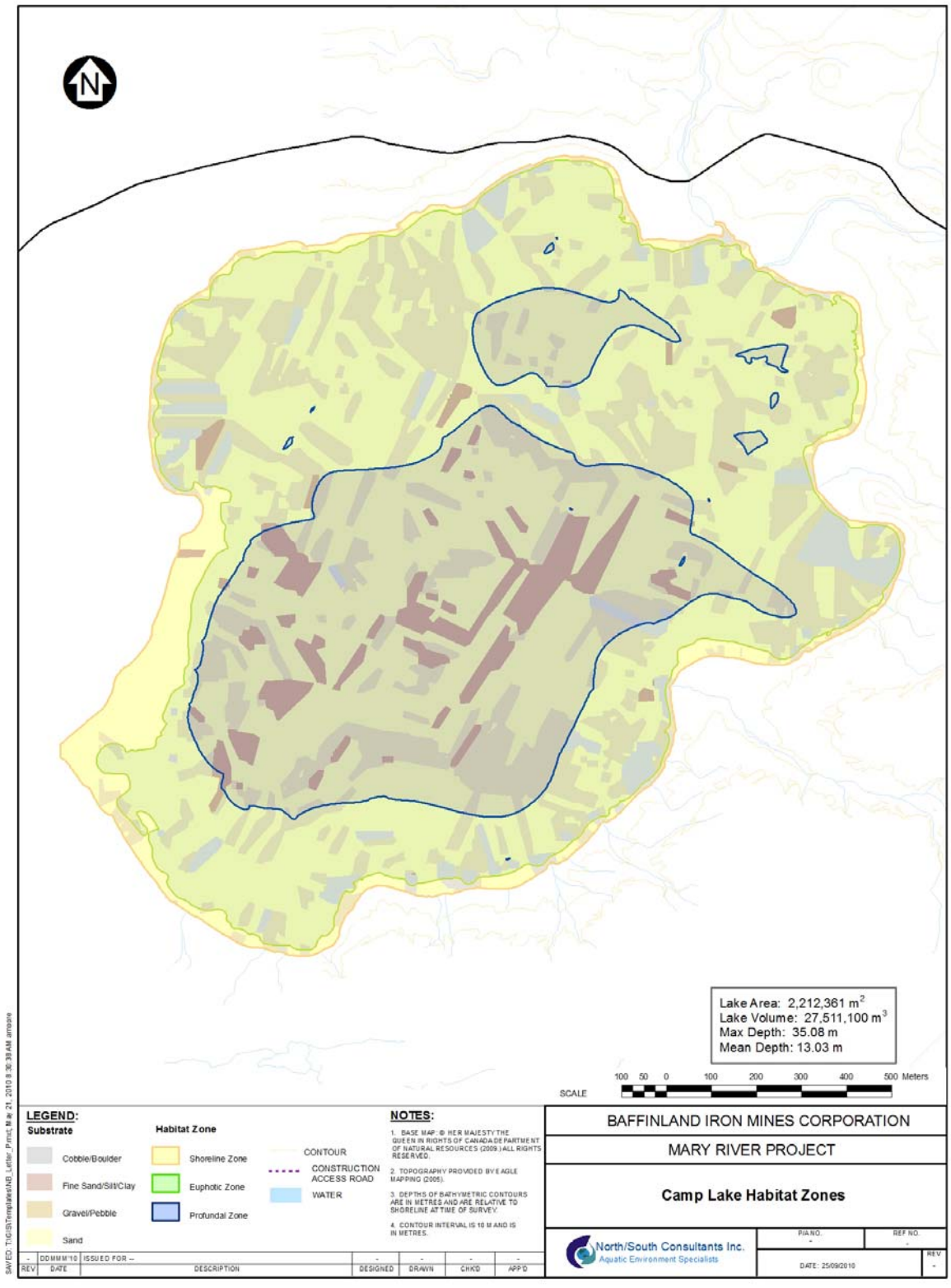

Figure 4.1-1. Camp Lake aquatic habitat zones.

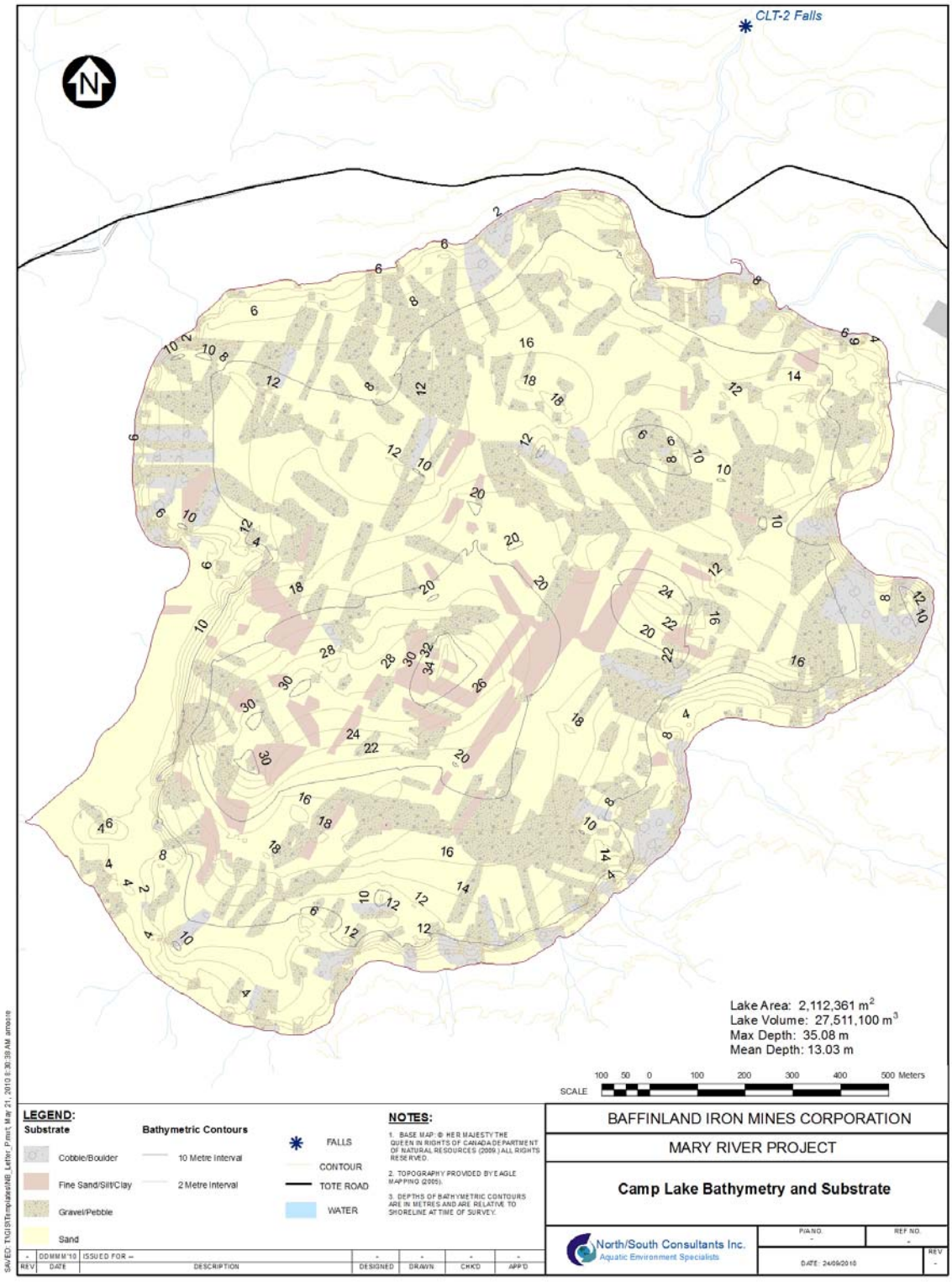

Figure 4.1-2. Camp Lake bathymetry and substrate.

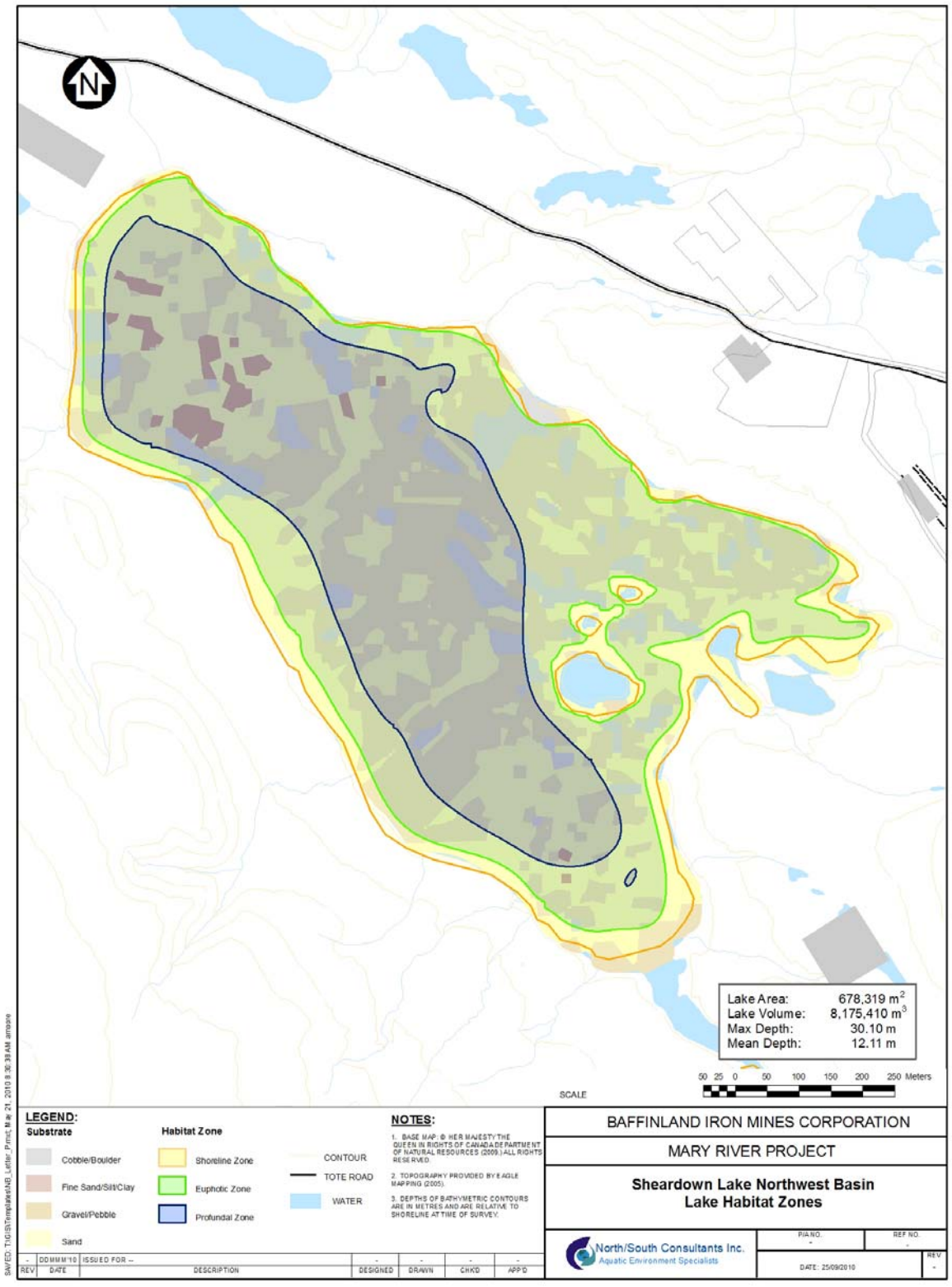

Figure 4.1-3. Sheardown Lake NW aquatic habitat zones.

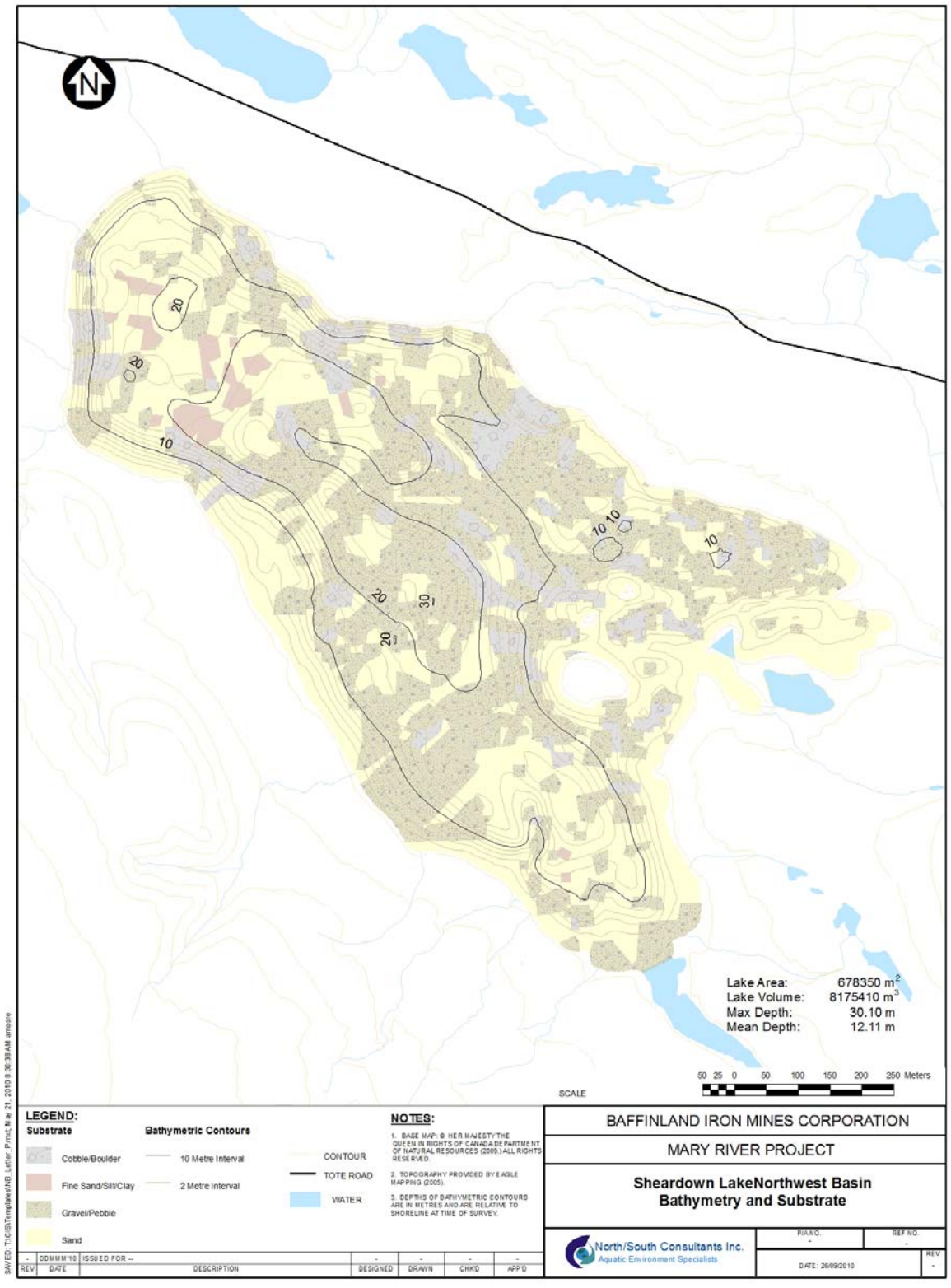

Figure 4.1-4. Sheardown Lake NW bathymetry and substrate.

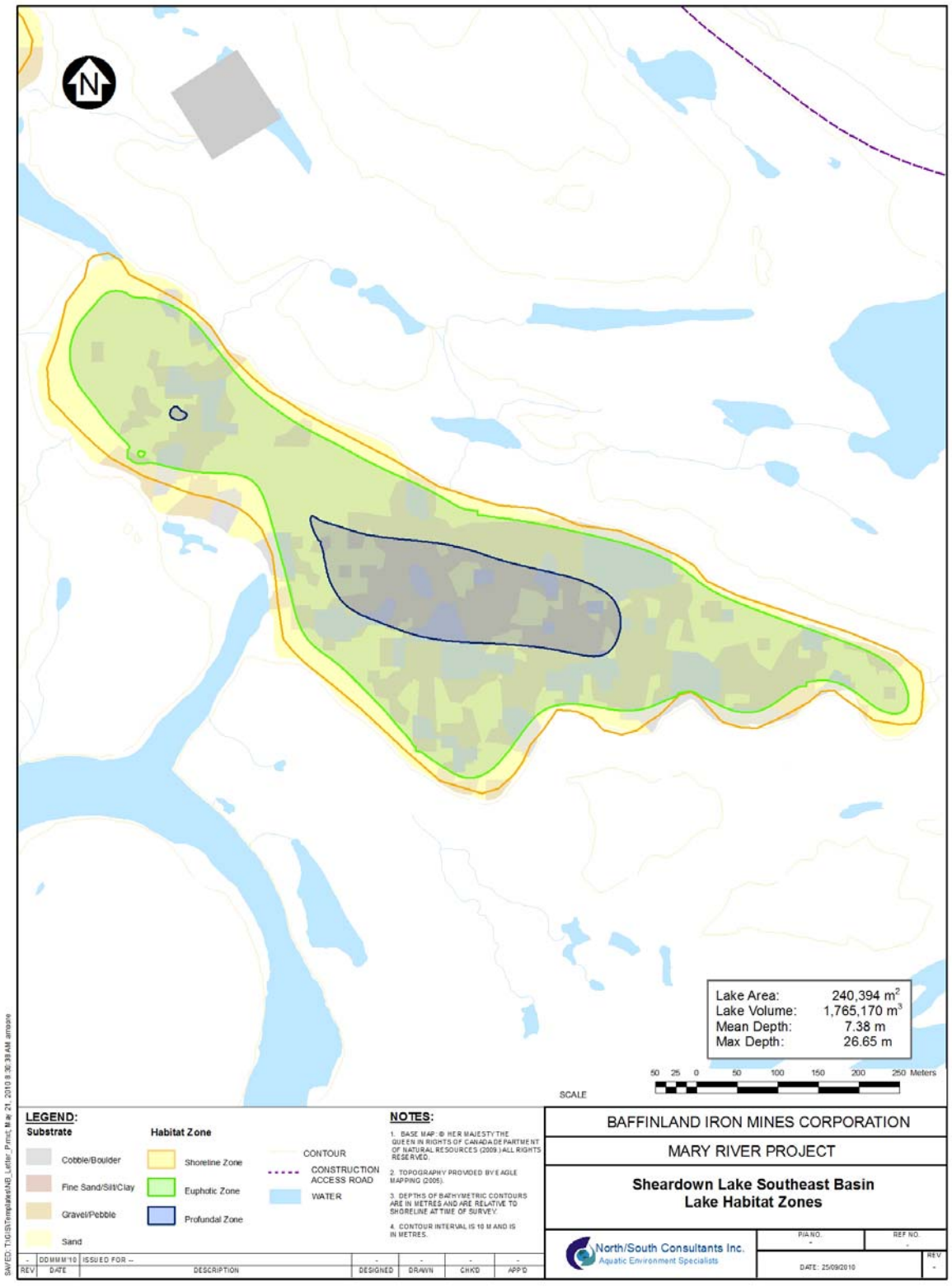

Figure 4.1-5. Sheardown Lake SE aquatic habitat zones.

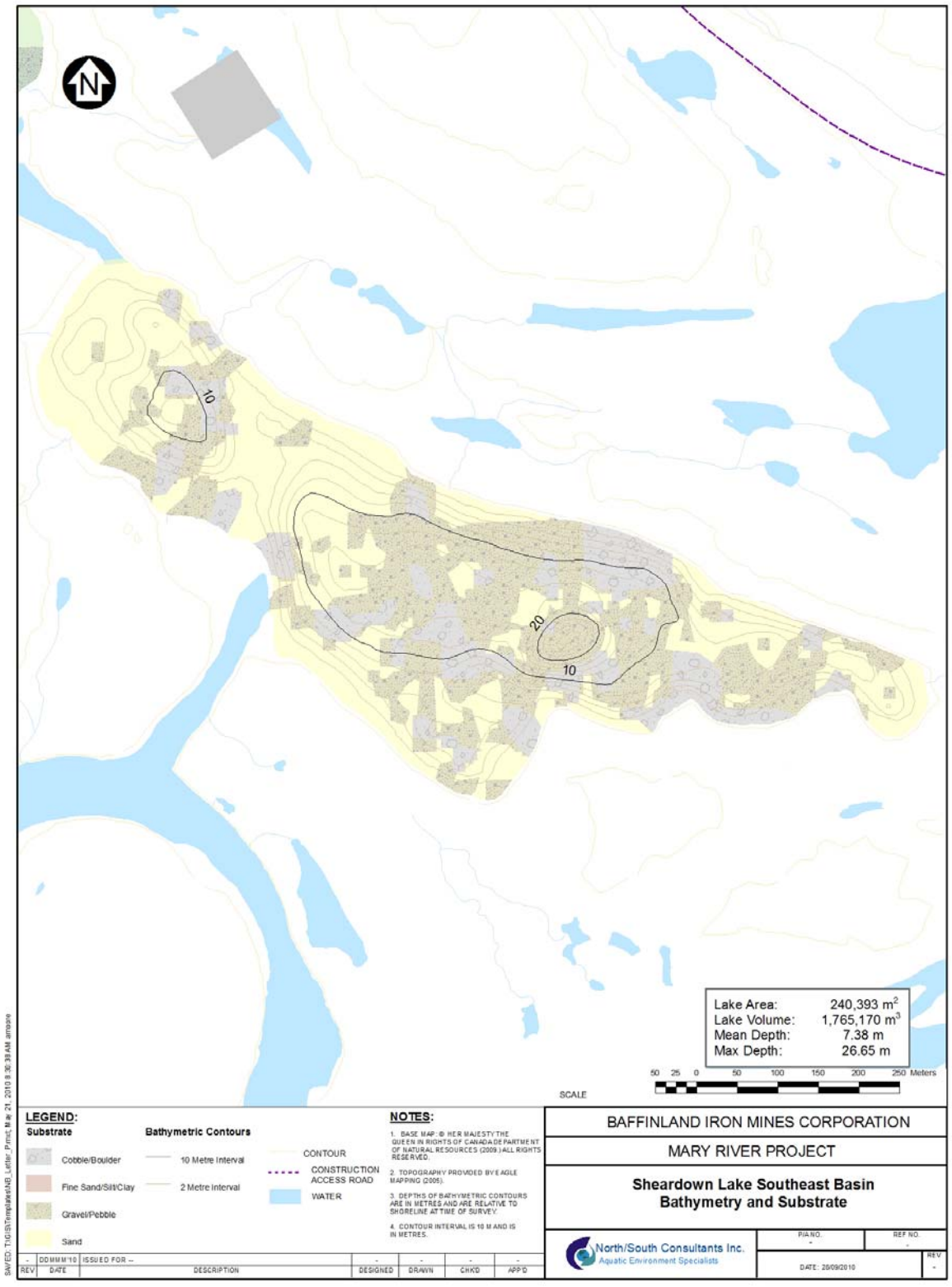

Figure 4.1-6. Sheardown Lake SE bathymetry and substrate.

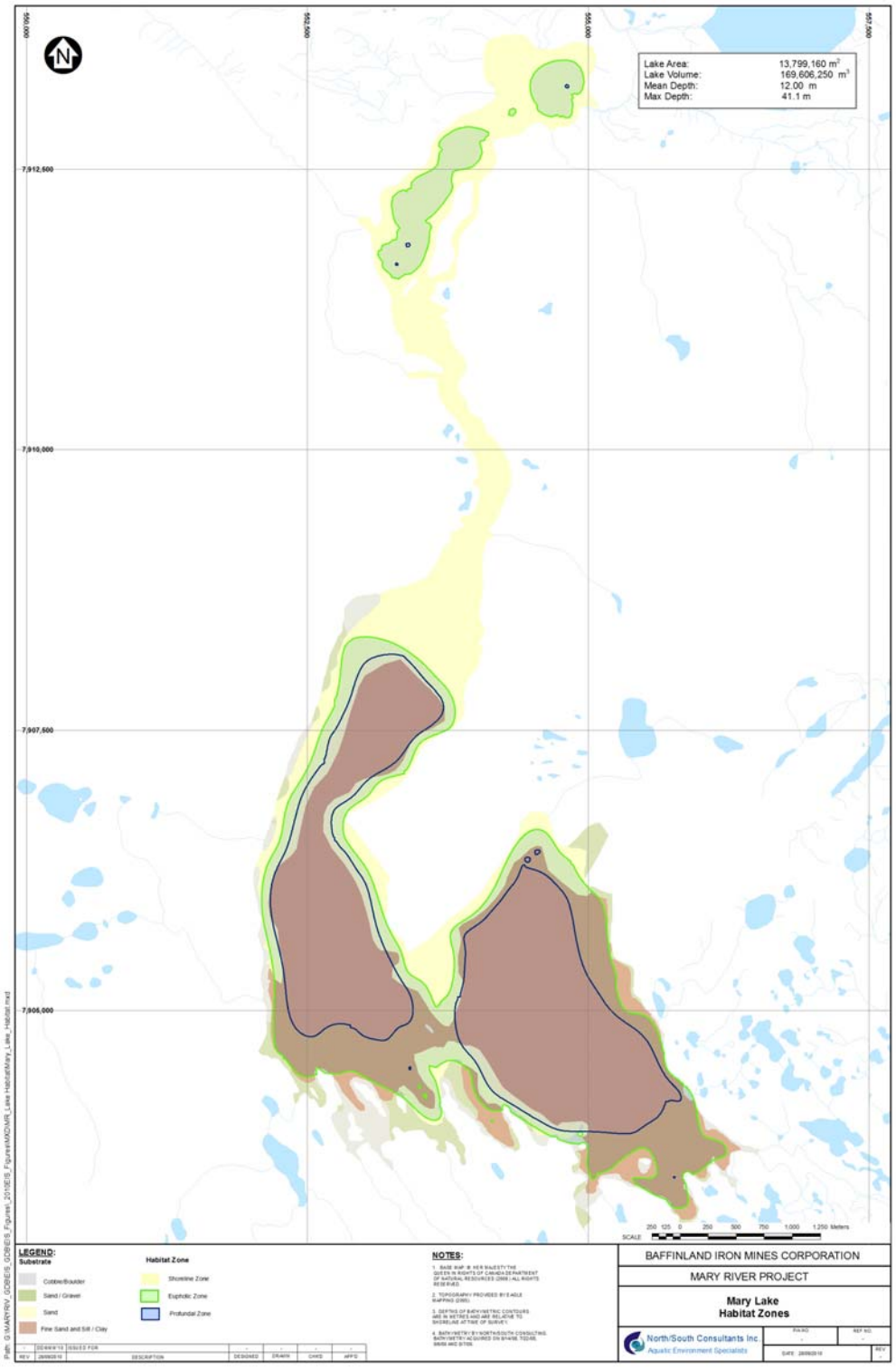

Figure 4.1-7. Mary Lake aquatic habitat zones.

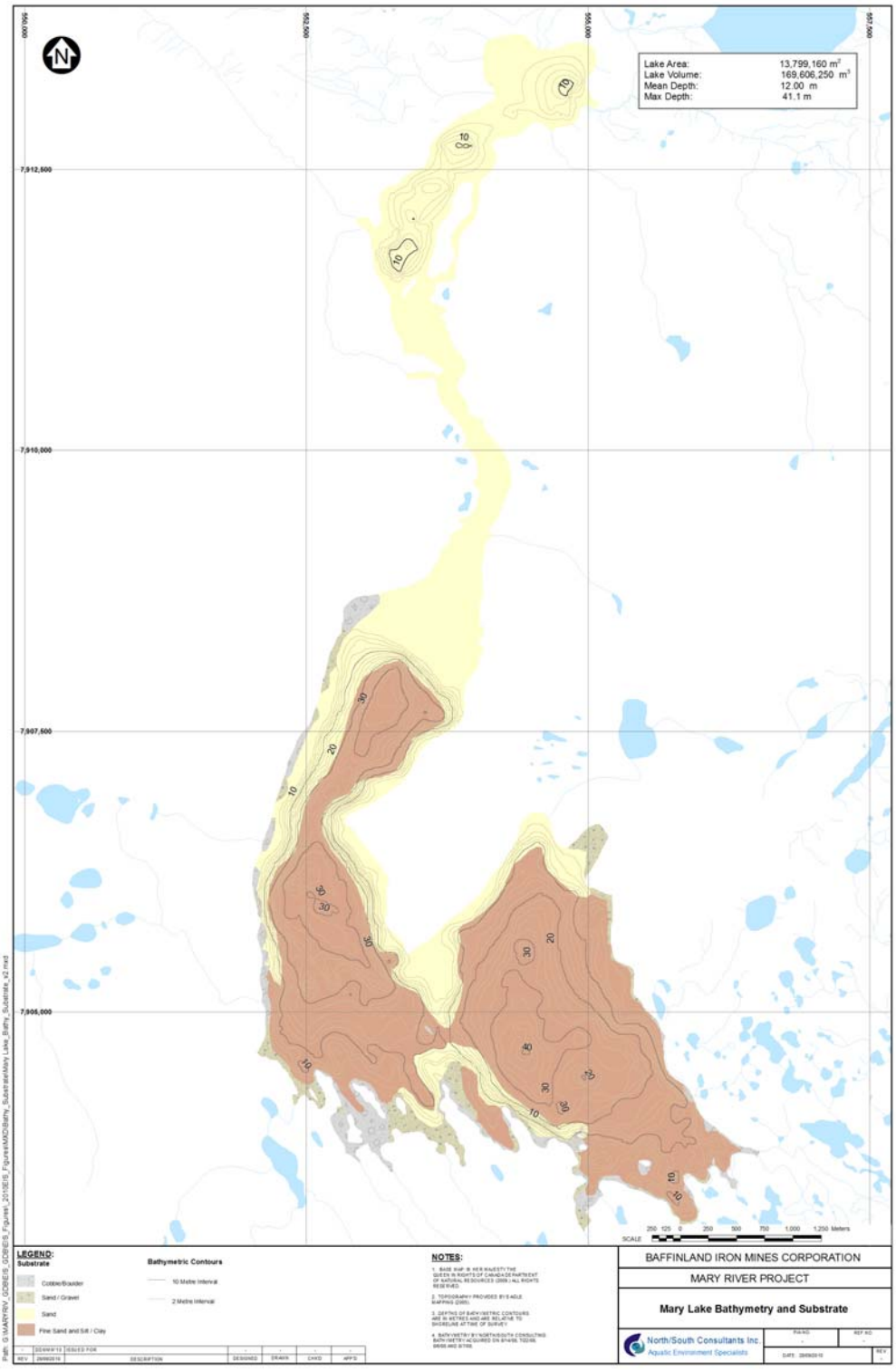

Figure 4.1-8. Mary Lake bathymetry and substrate.

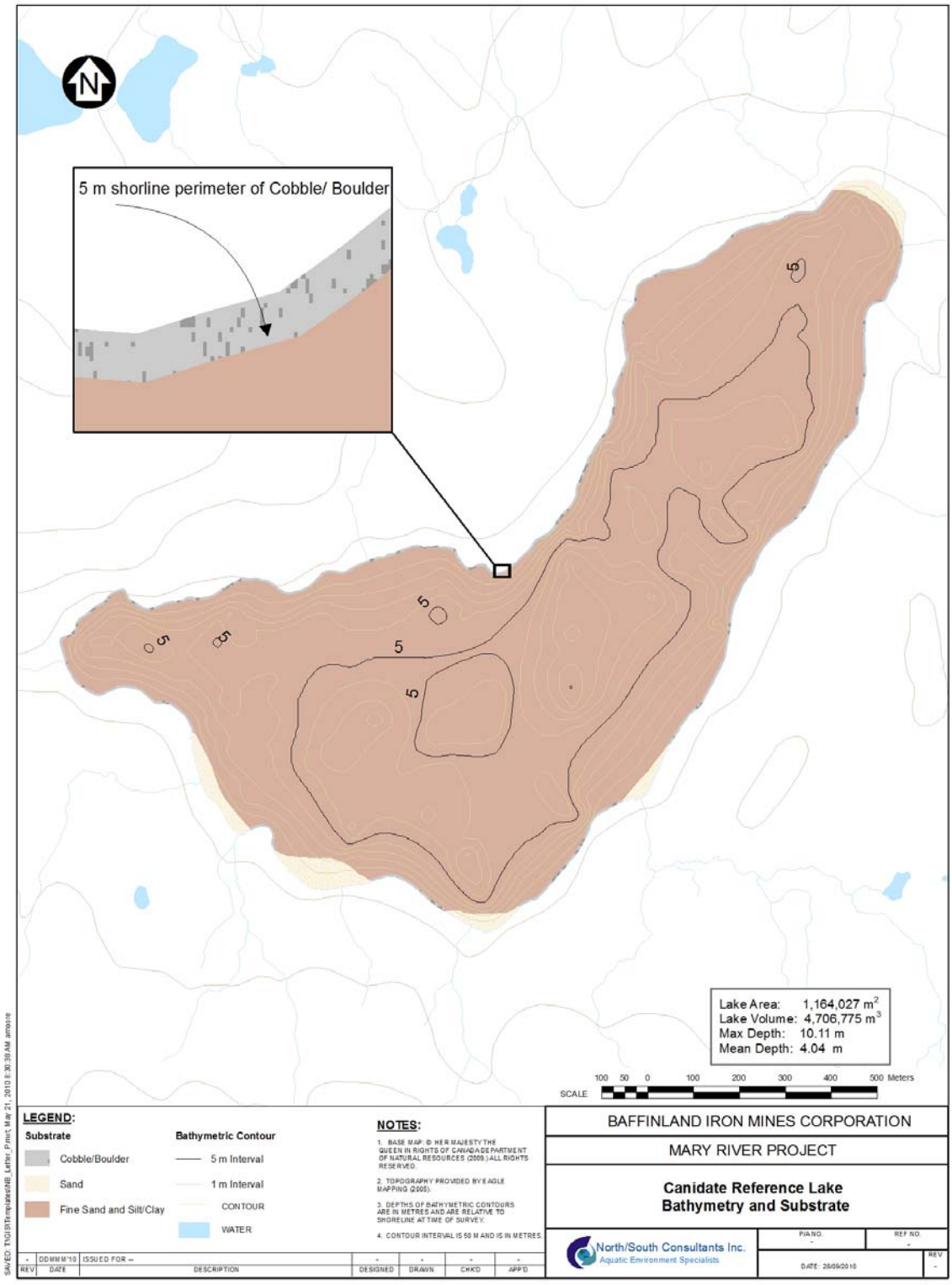

Figure 4.1-9. Candidate Reference Lake bathymetry and substrate.

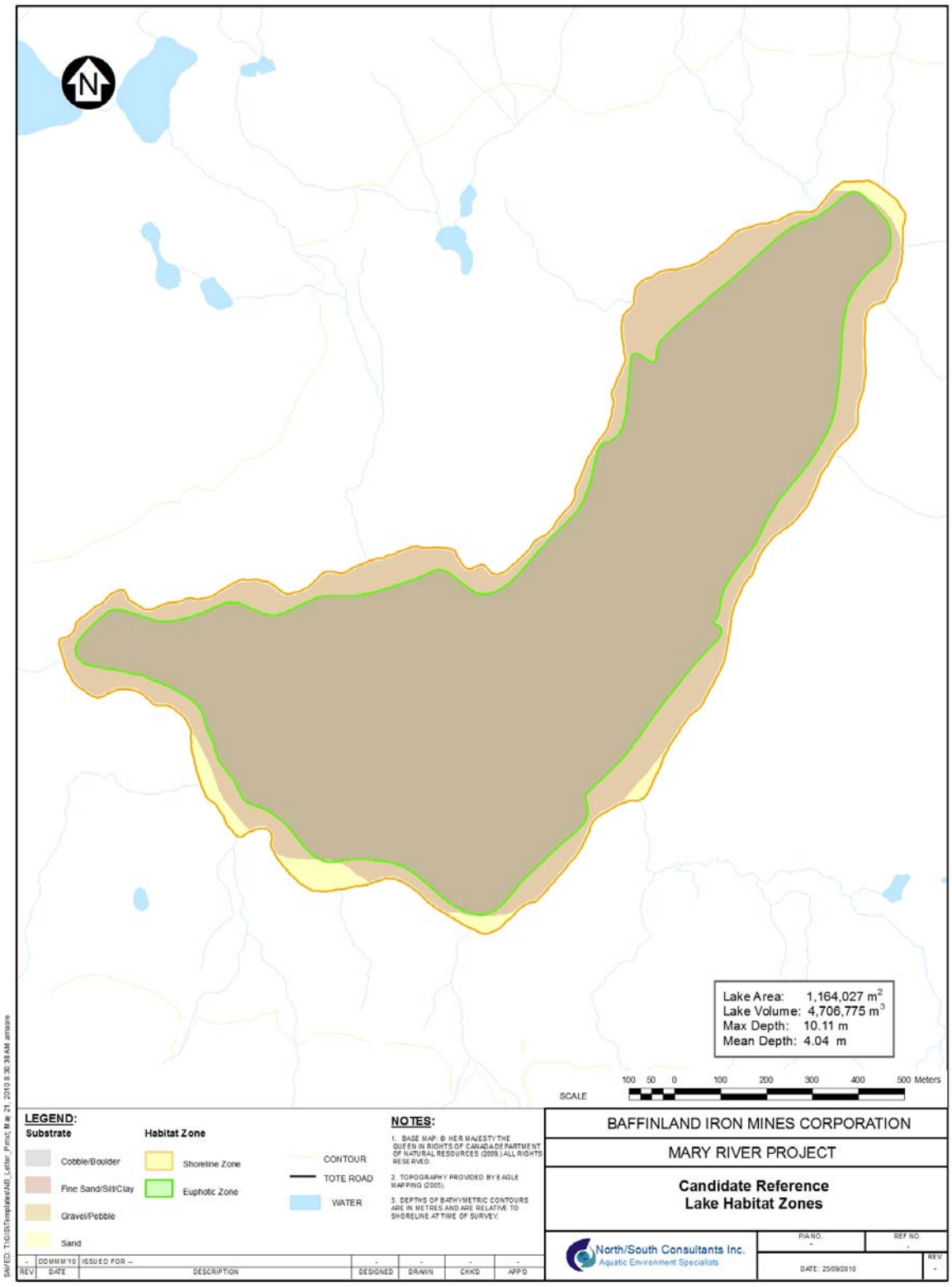

Figure 4.1-10. Candidate Reference Lake aquatic habitat zones.

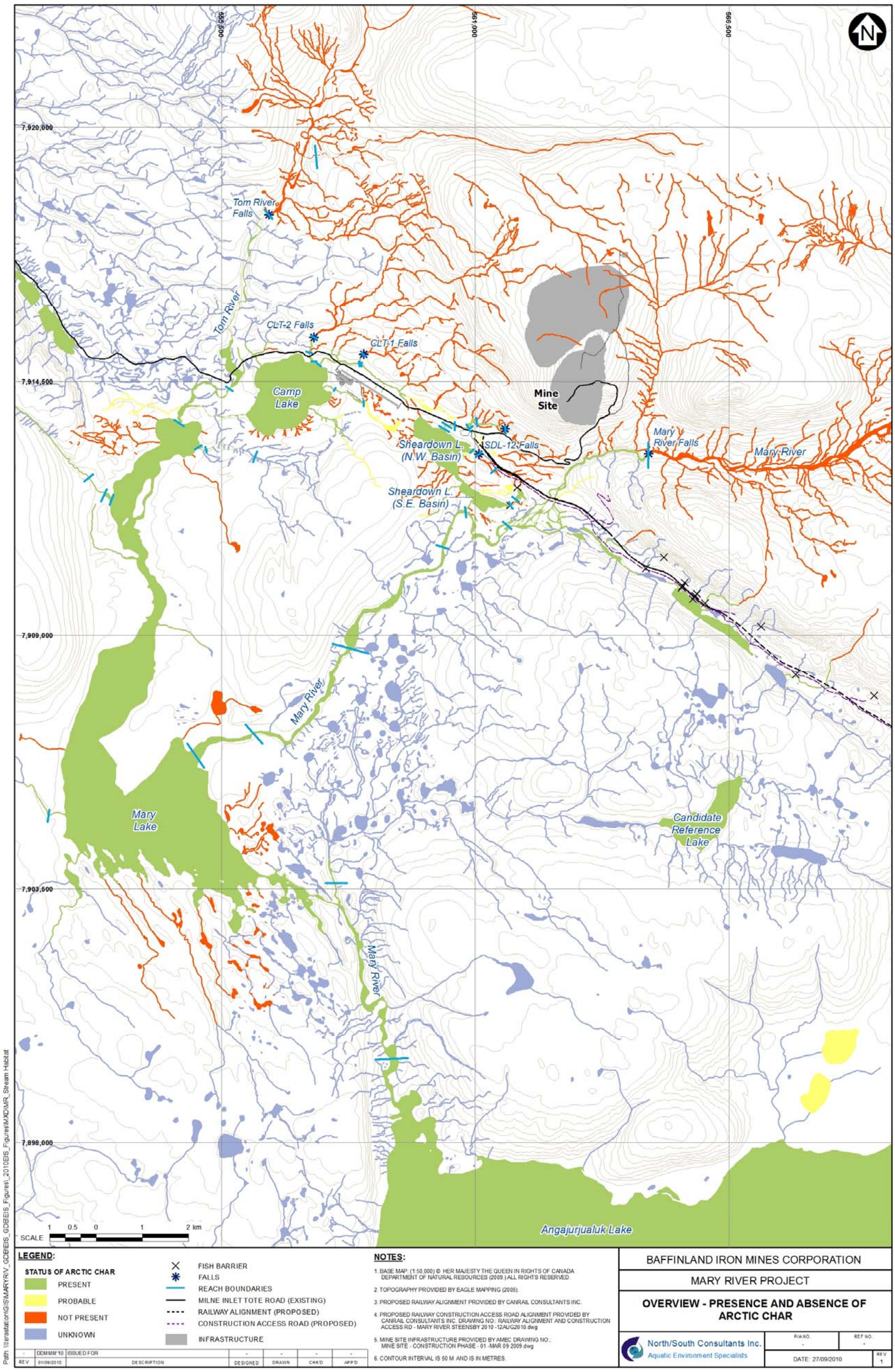

Figure 4.1-11. Location of aquatic stream habitat surveyed in the Mine Area, 2006-2010.

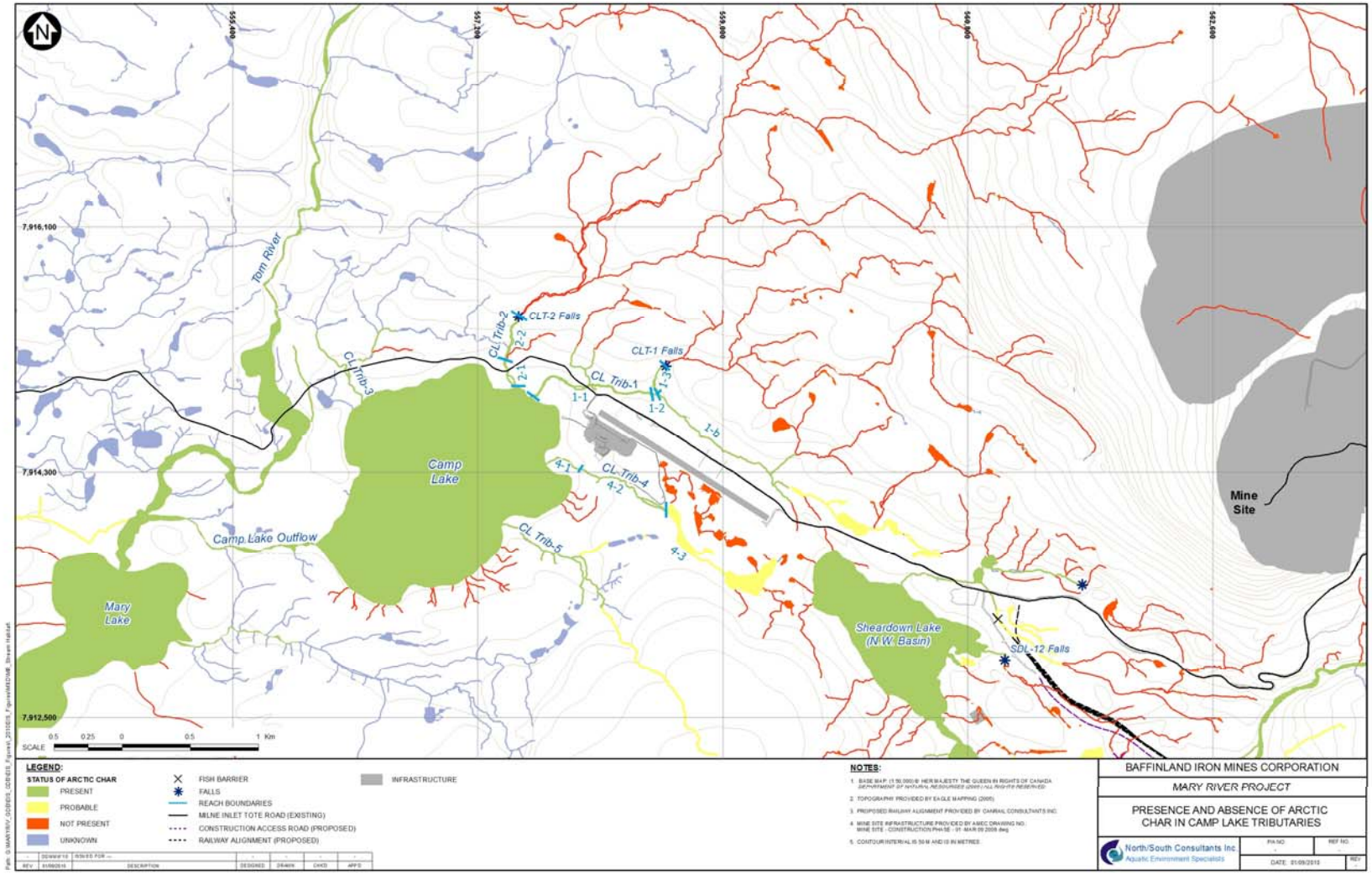

Figure 4.1-12. Map of aquatic habitat surveyed in Camp Lake inflows.

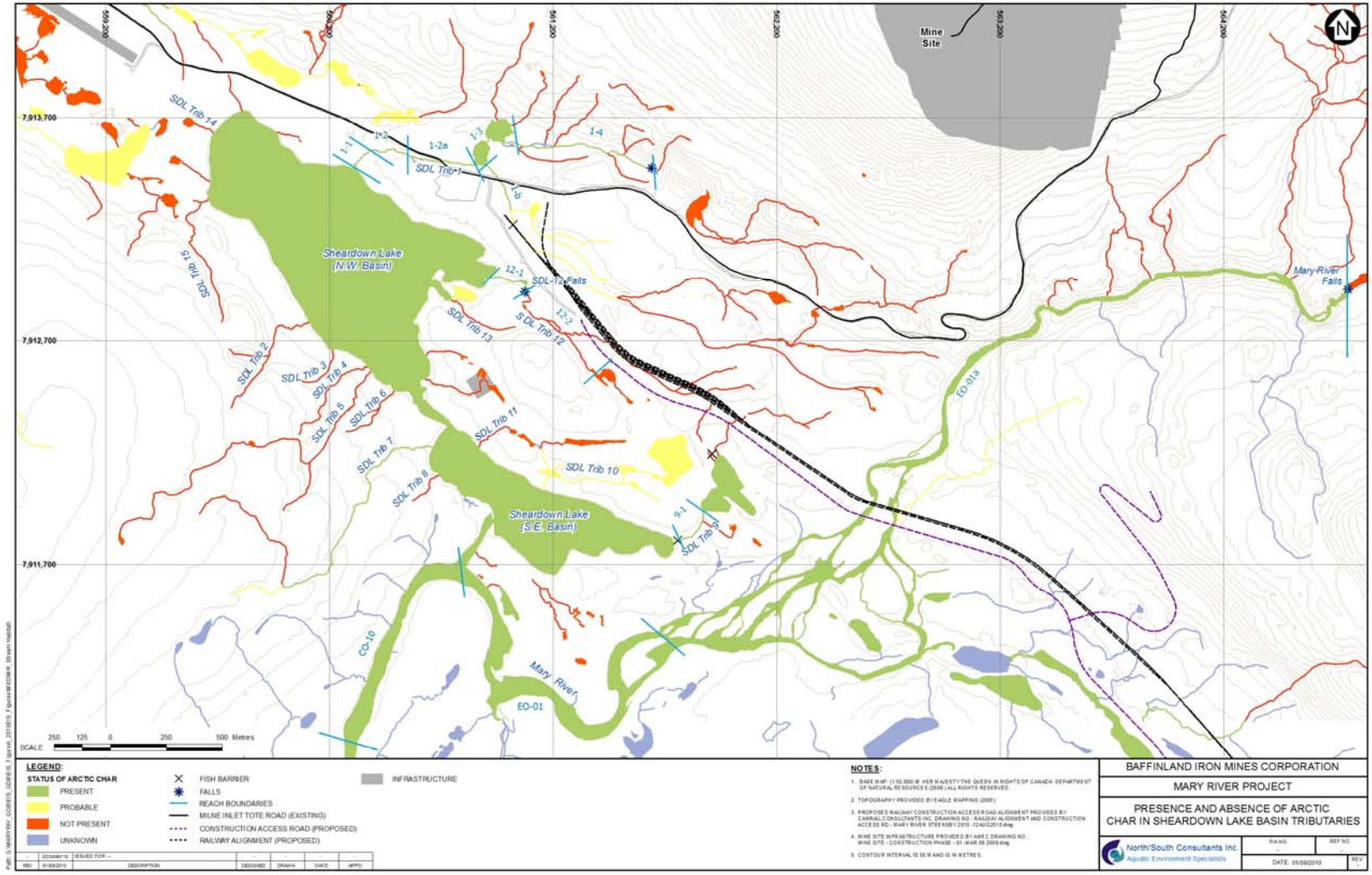

Figure 4.1-13. Map of aquatic habitat surveyed in inflows to the northeast and southwest basins of Sheardown Lake.

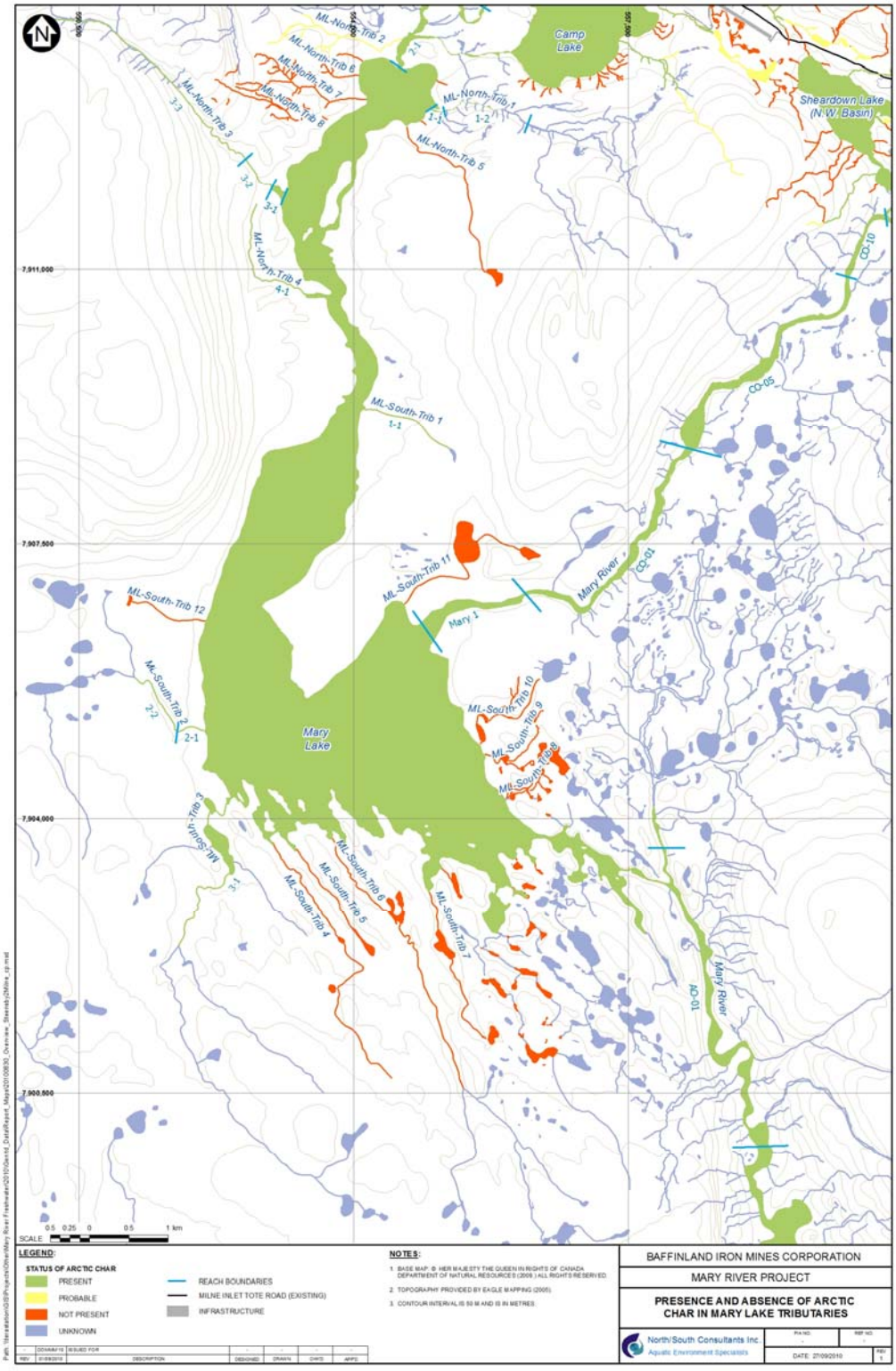

Figure 4.1-14. Map of aquatic habitat surveyed in Mary Lake inflows.

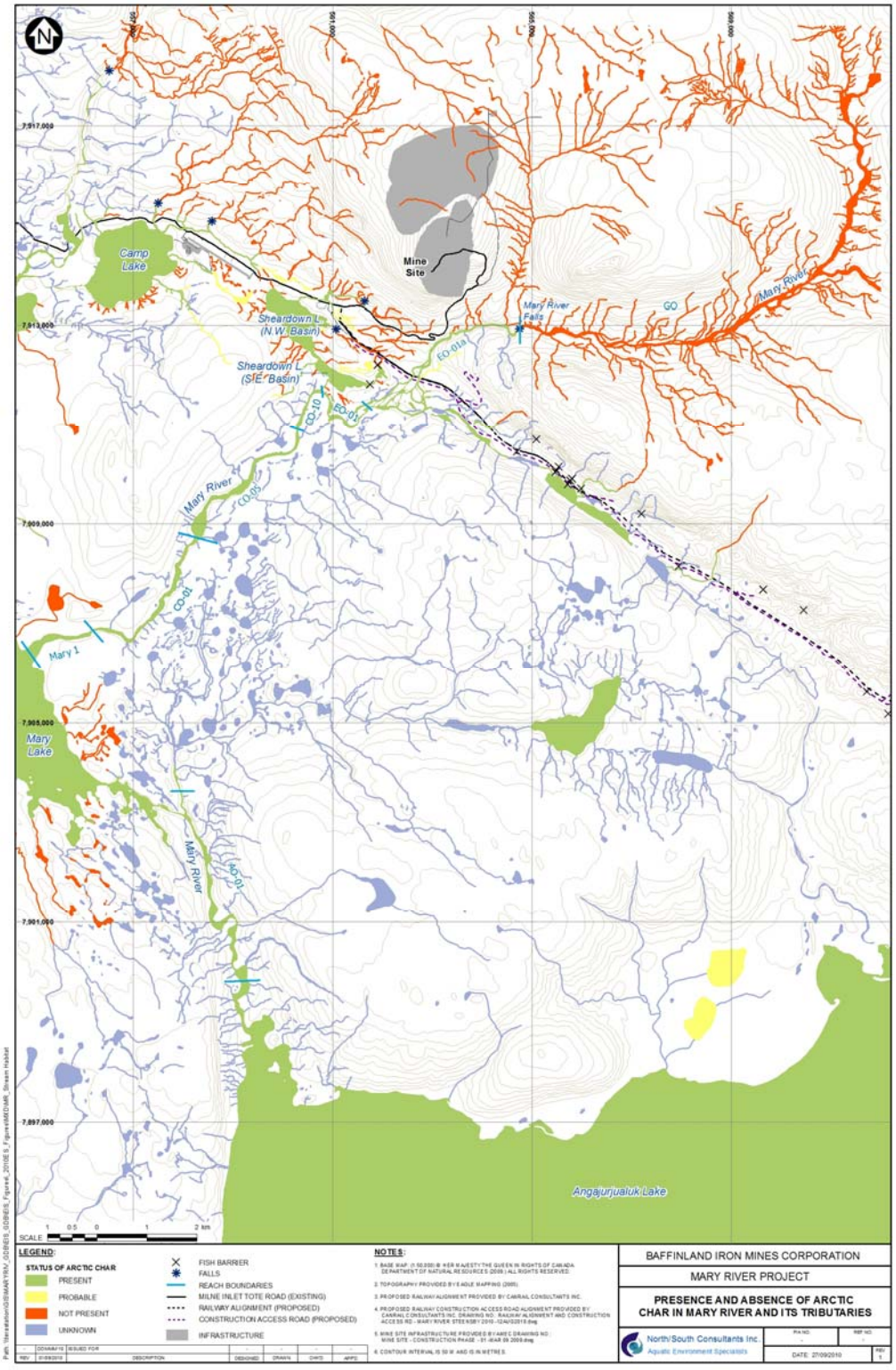

Figure 4.1-15. Map of aquatic habitat surveyed in the Mary River and its tributaries.

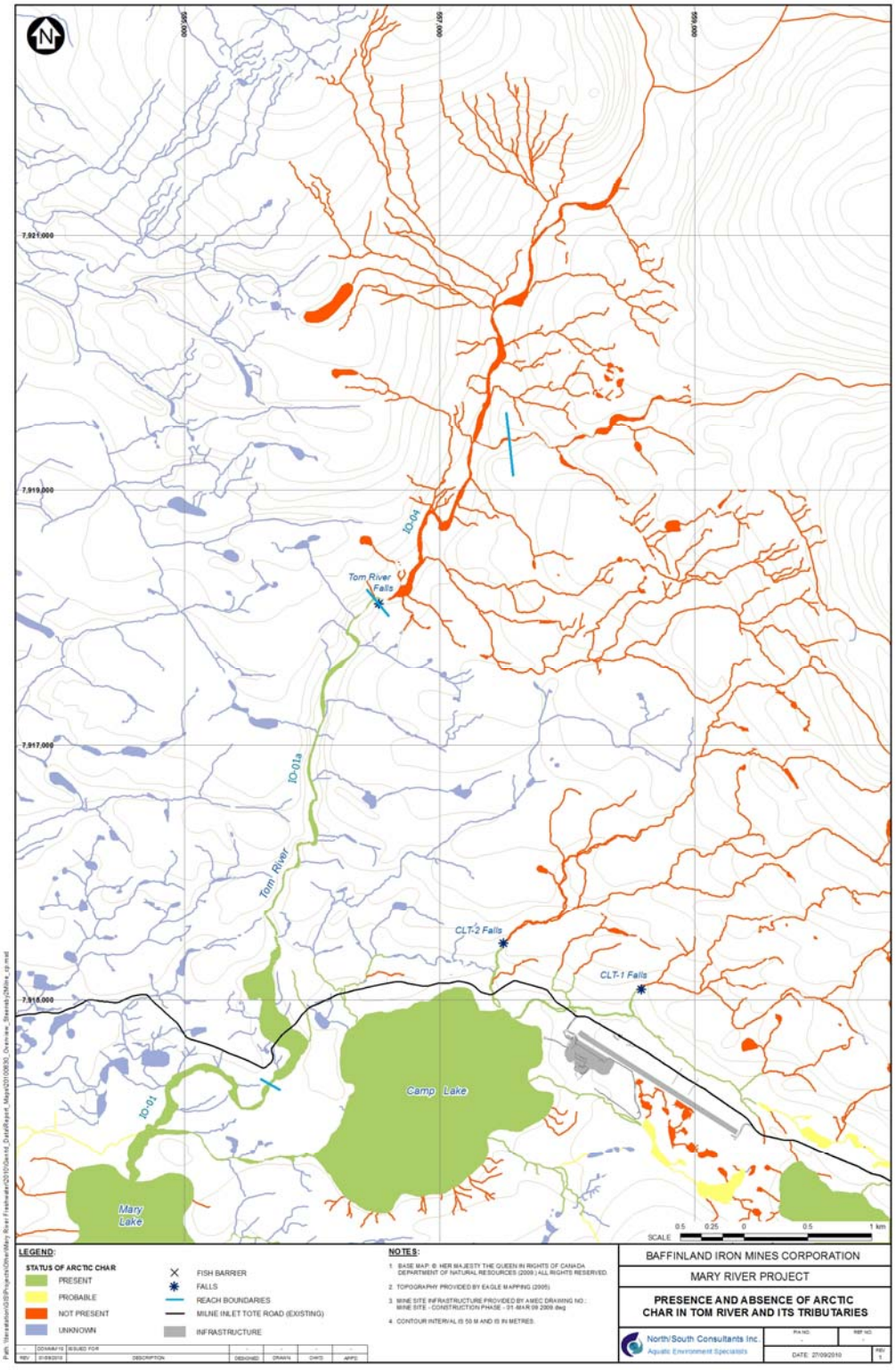

Figure 4.1-16. Map of aquatic habitat surveyed in the Tom River and its tributaries.

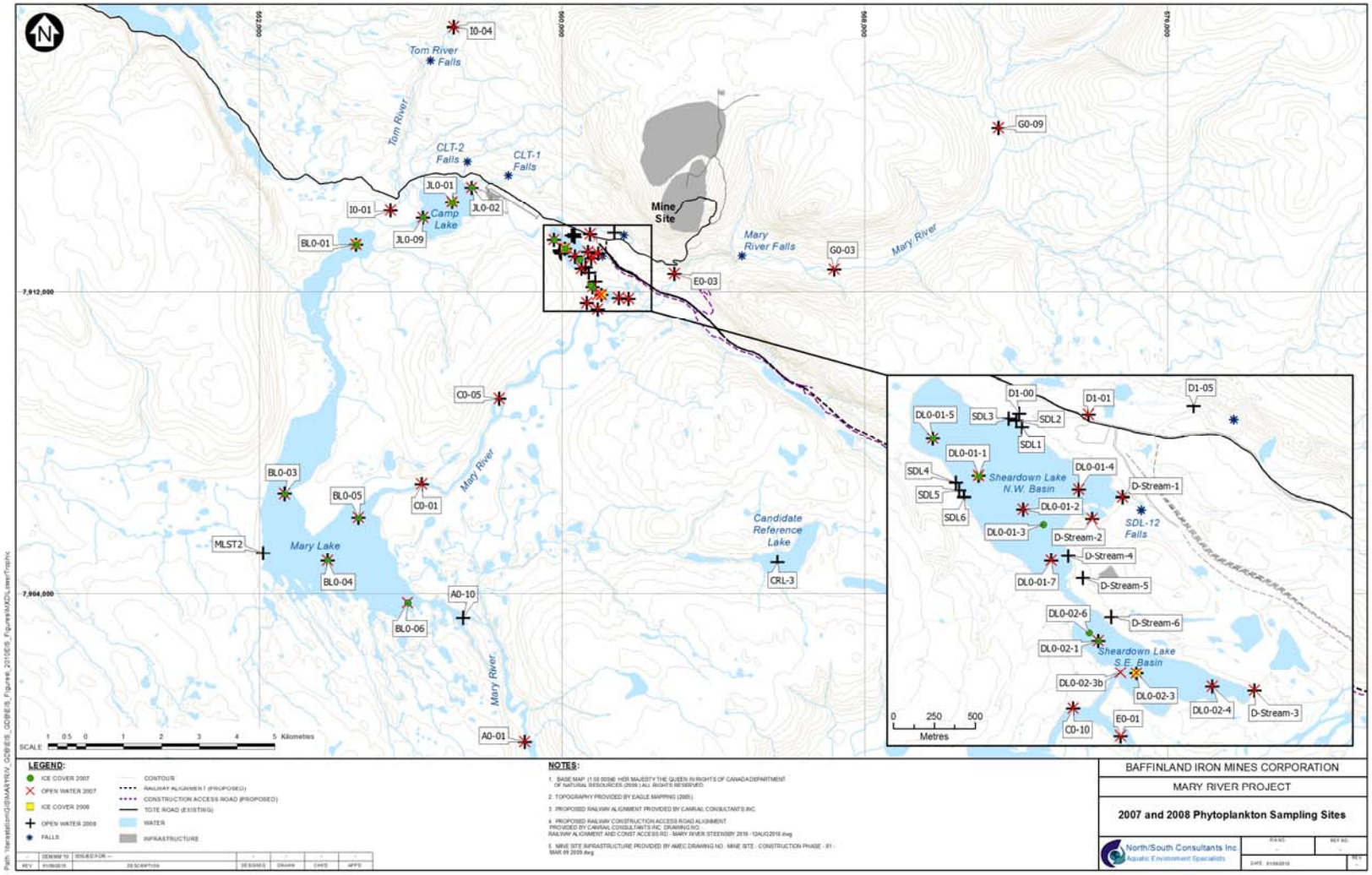

Figure 4.2-1. Water quality sampling locations in the Mine Area where phytoplankton and/or chlorophyll *a* samples were collected: 2007-2008.

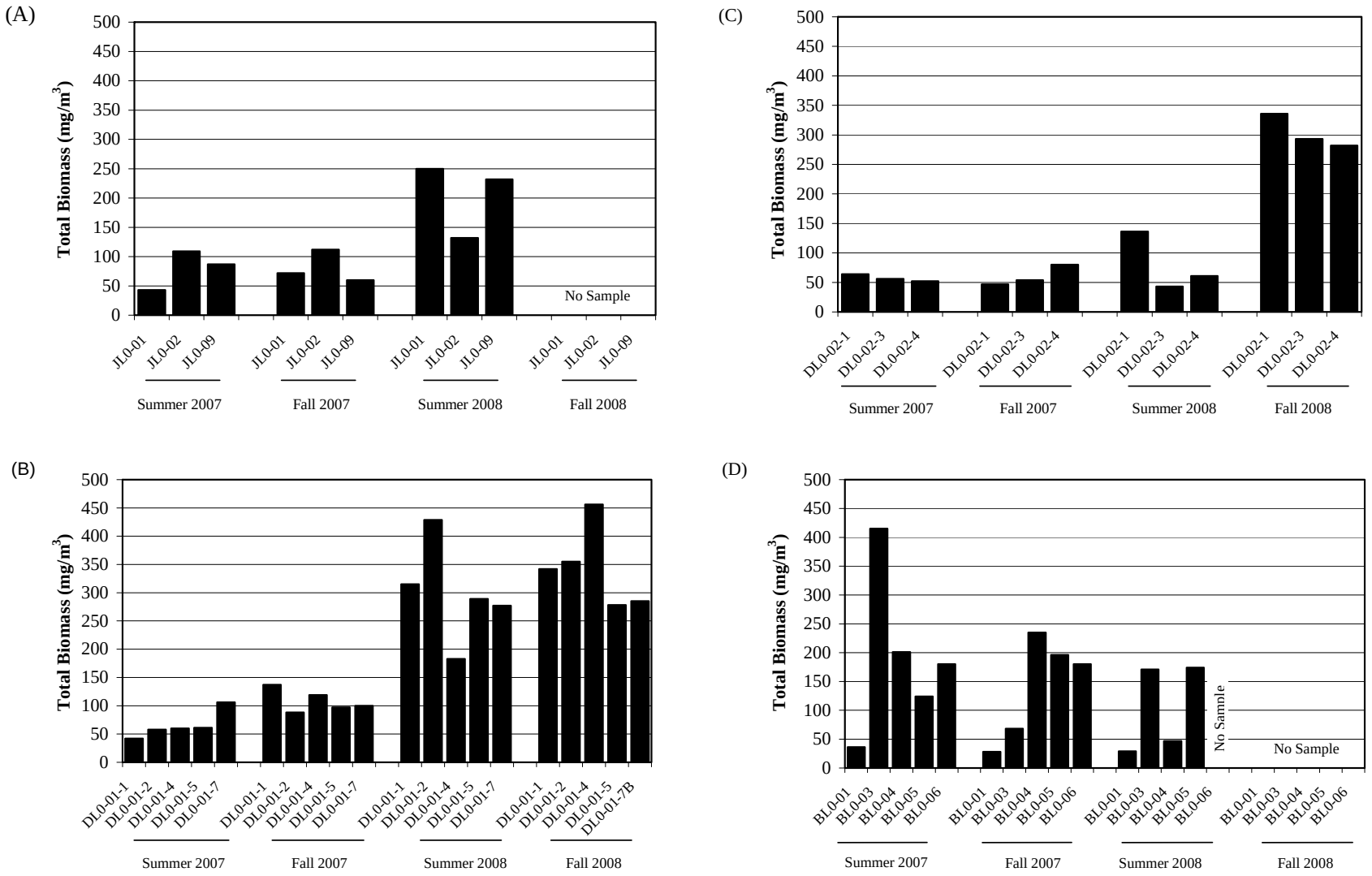

Figure 4.2-2. Phytoplankton biomass in: (A) Camp Lake; (B) Sheardown Lake NW; (C) Sheardown Lake SE; and (D) Mary Lake.

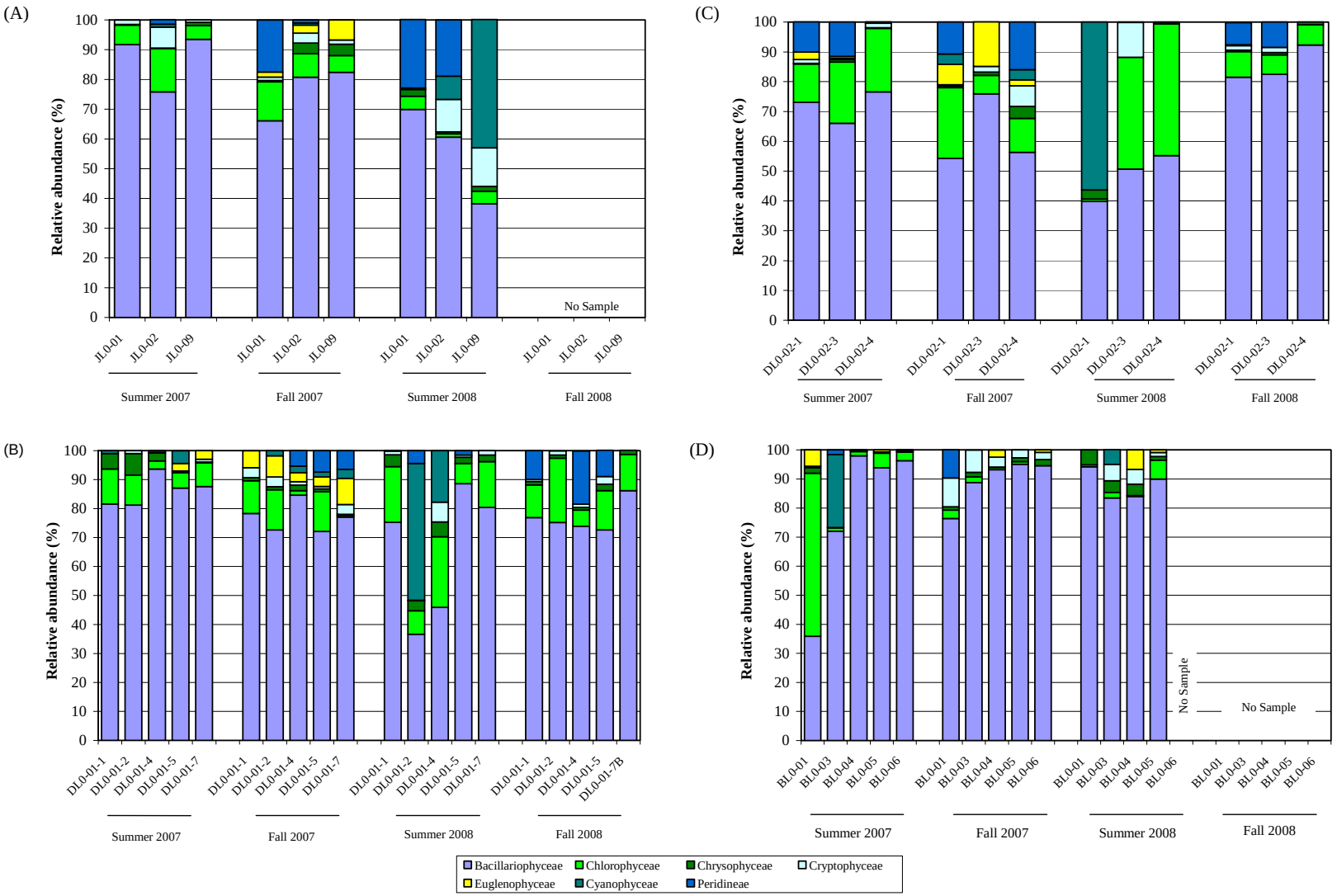

Figure 4.2-3. Phytoplankton relative abundance in: (A) Camp Lake; (B) Sheardown Lake NW; (C) Sheardown Lake SE; and (D) Mary Lake.

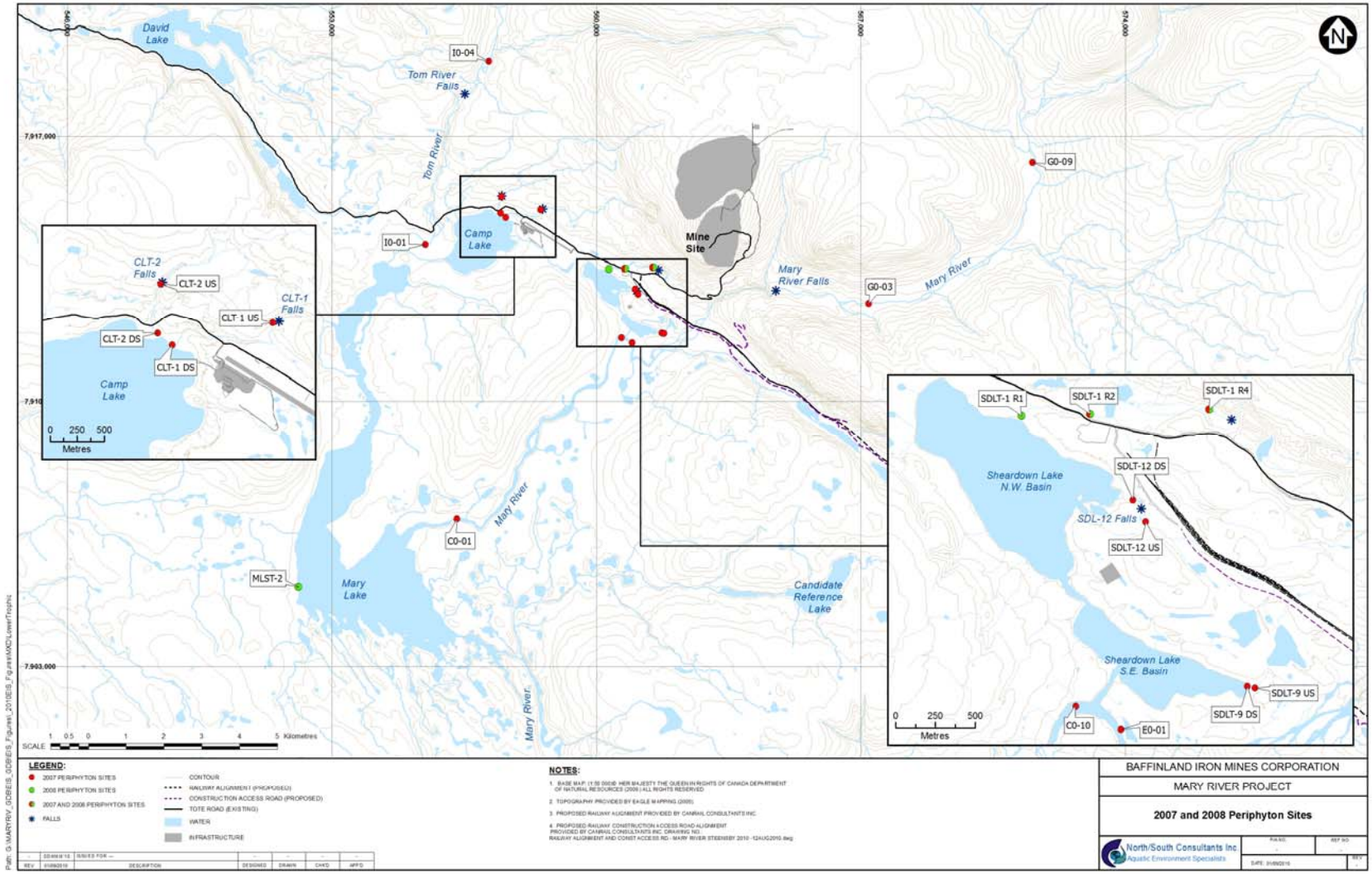

Figure 4.2-4. Periphyton sampling locations: open-water seasons 2007-2008.

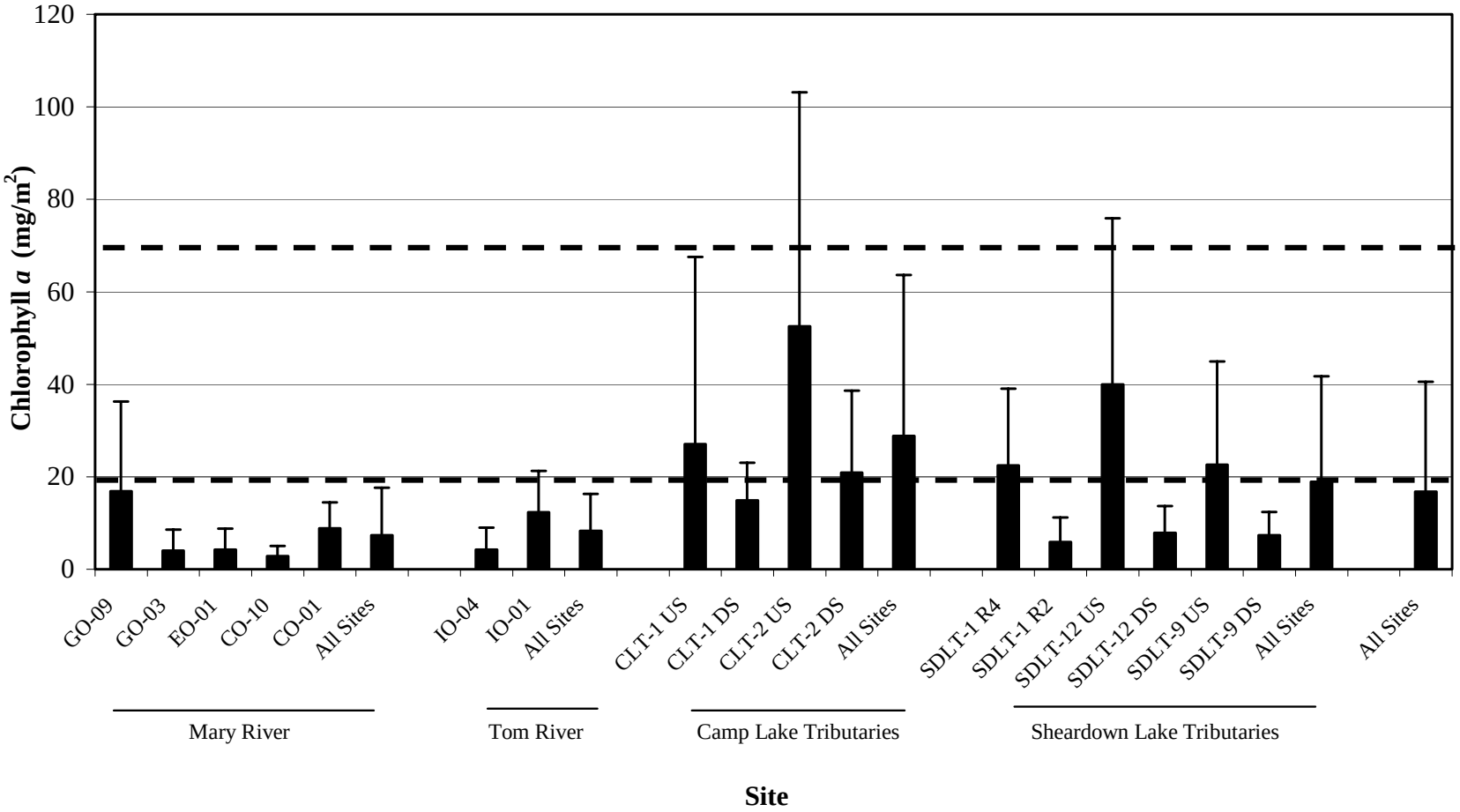

Figure 4.2-5. Means and standard deviations of periphyton chlorophyll *a* measured in Mine Area streams: open-water season 2007. Dashed lines represent trophic state transitions (oligotrophic-mesotrophic-eutrophic) proposed by Dodds et al. (1998).

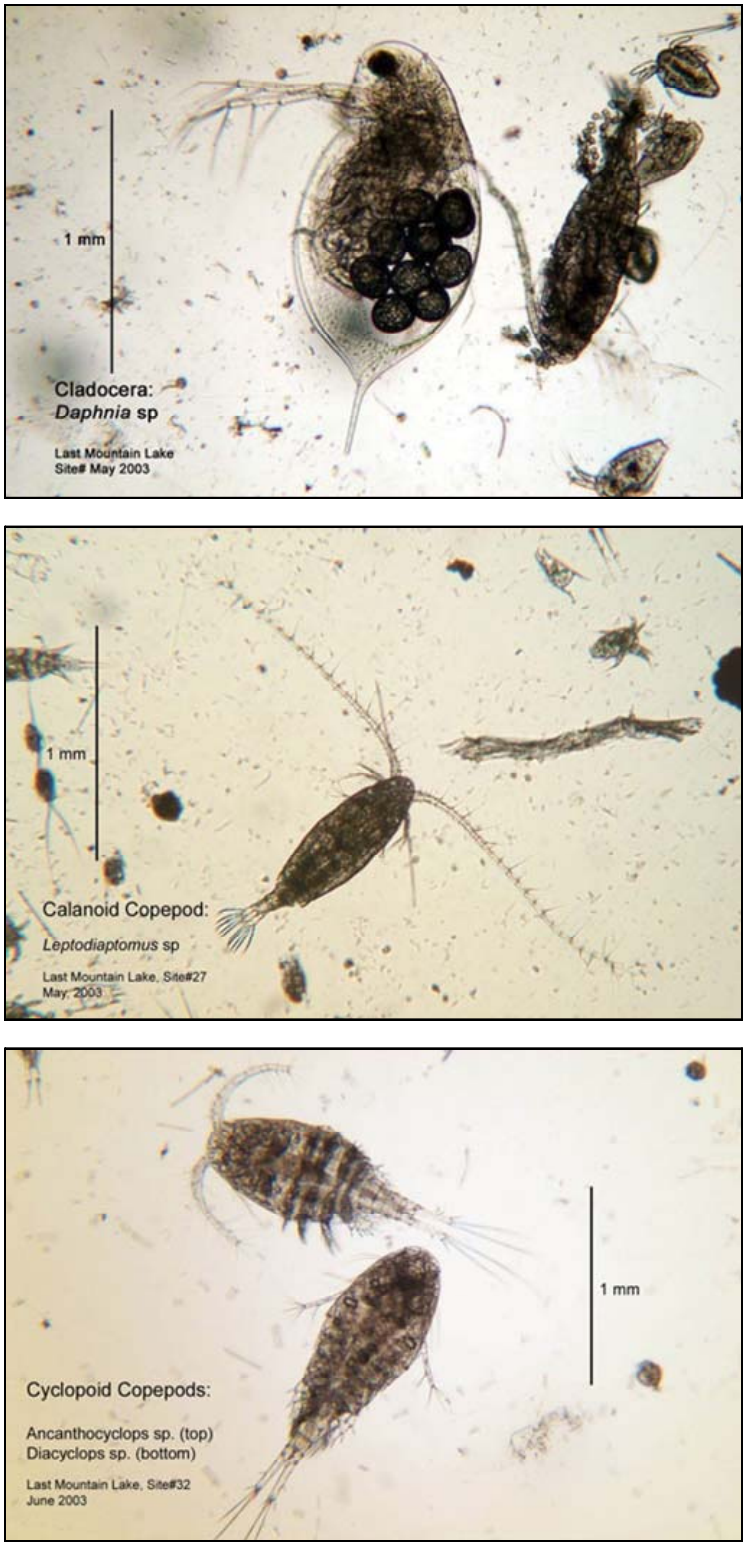

Figure 4.3-1. Representative cladoceran (top panel) and calanoid (middle panel) and cyclopoid (bottom panel) copepods (photo source: Saskatchewan Environment [K. Scott]).

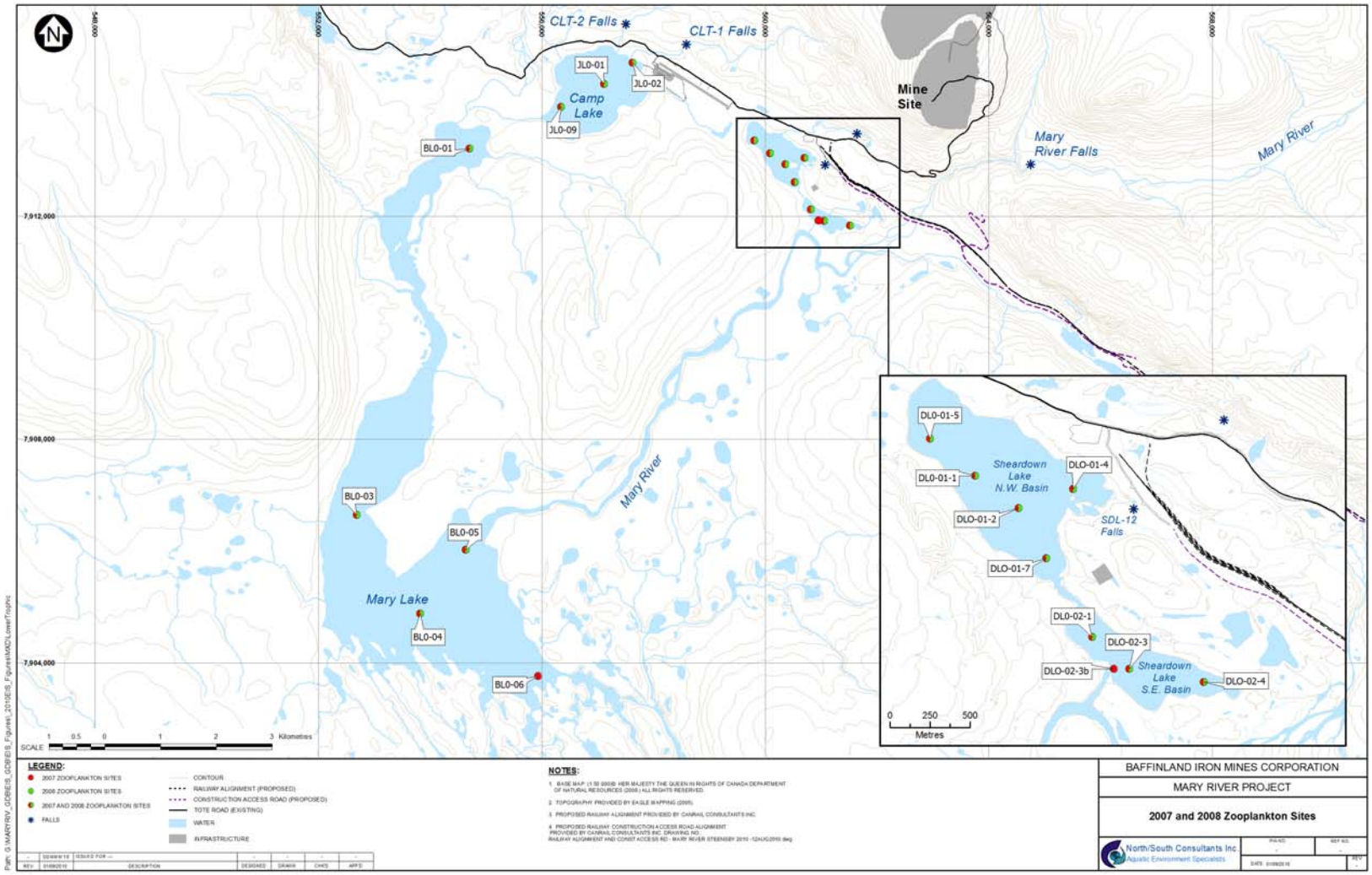

Figure 4.3-2. Locations of zooplankton sampling sites in Mine Area lakes: 2007-2008.

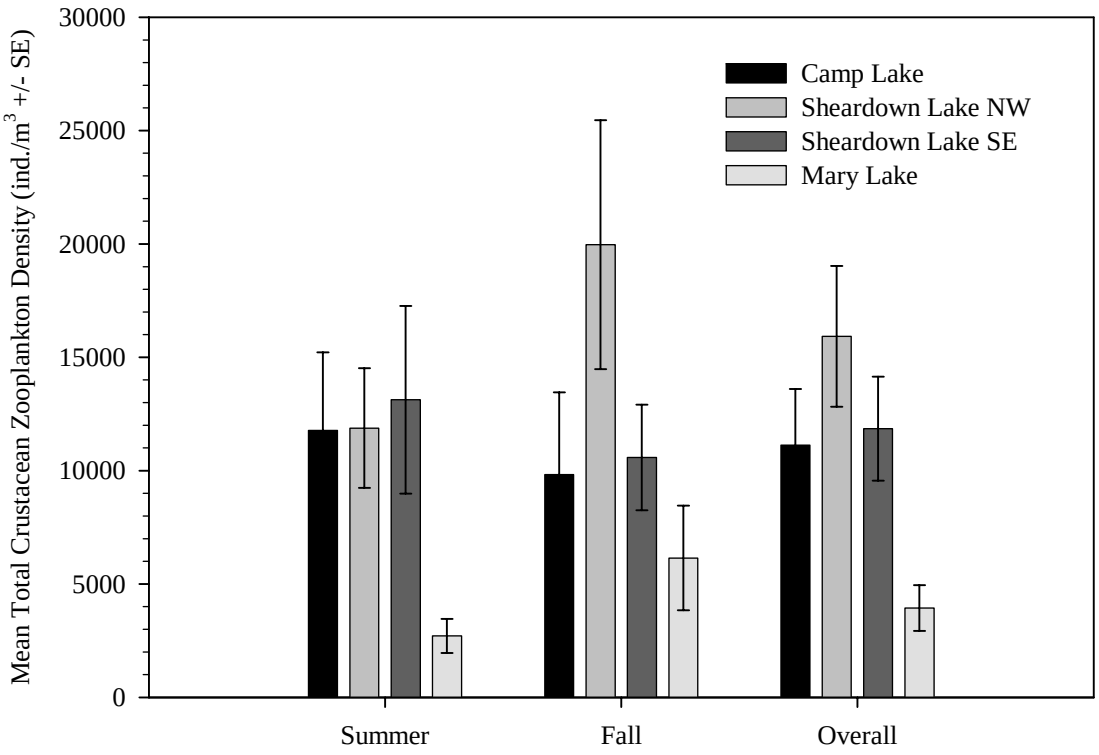

Figure 4.3-3. Mean seasonal densities of crustacean zooplankton in Mine Area Lakes: 2007-2008.

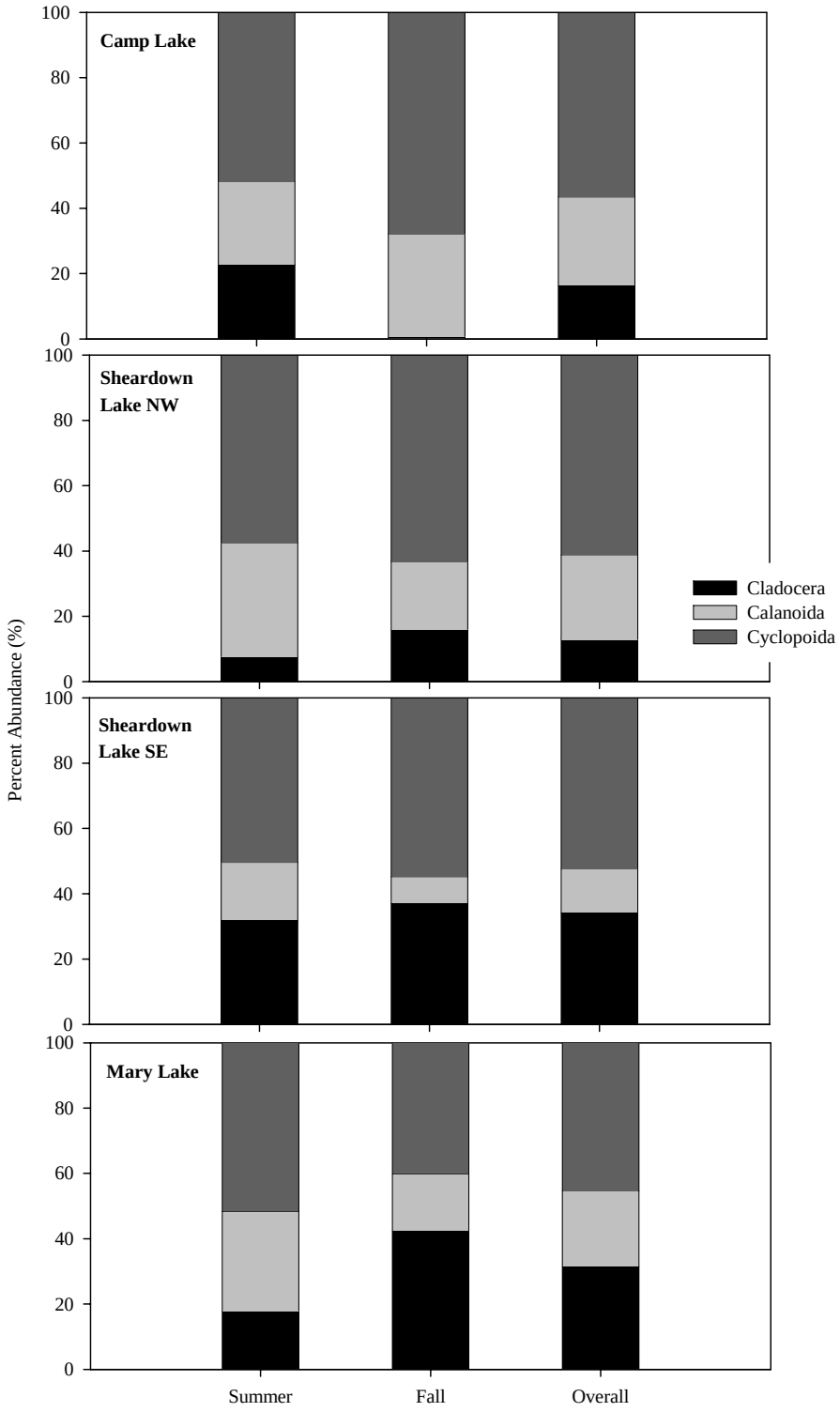

Figure 4.3-4. Seasonal relative abundance of crustacean zooplankton in Mine Area lakes: 2007-2008.

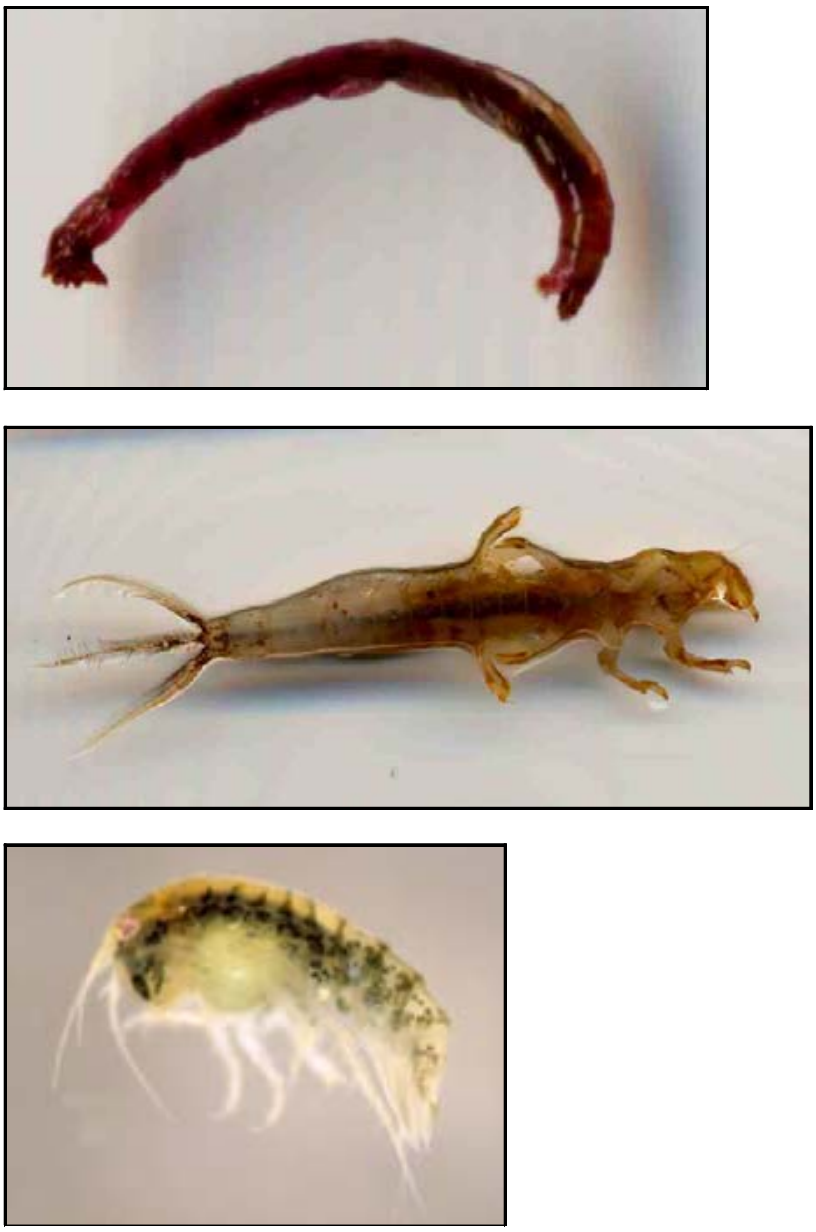

Figure 4.3-5. Representatives of macroinvertebrate groups: chironomid larva (top panel); ephemeropteran larva (middle panel); and amphipod (bottom panel) (photo source: North/South Consultants Inc.).

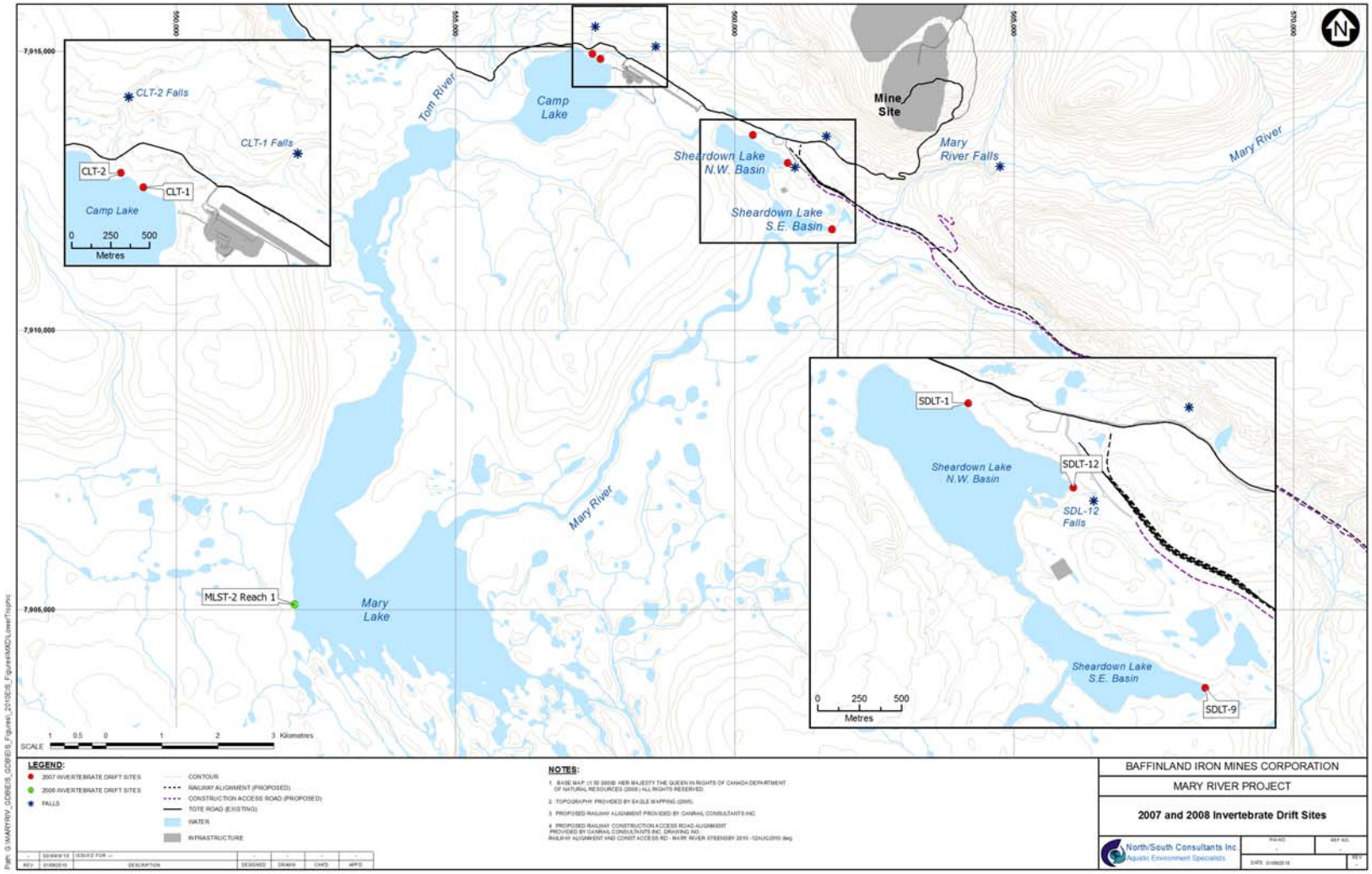

Figure 4.3-6. Locations of invertebrate drift sampling sites in Mine Area streams: 2007-2008.

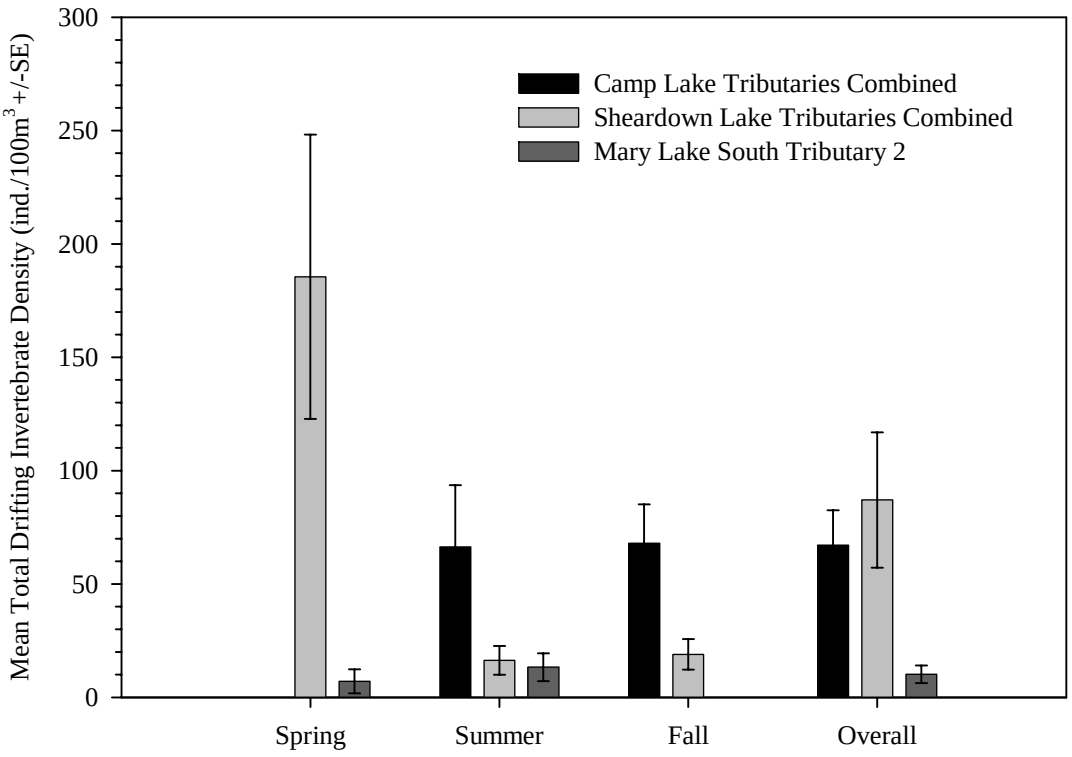

Figure 4.3-7. Seasonal mean drifting invertebrate densities for Mine Area streams: 2007-2008.

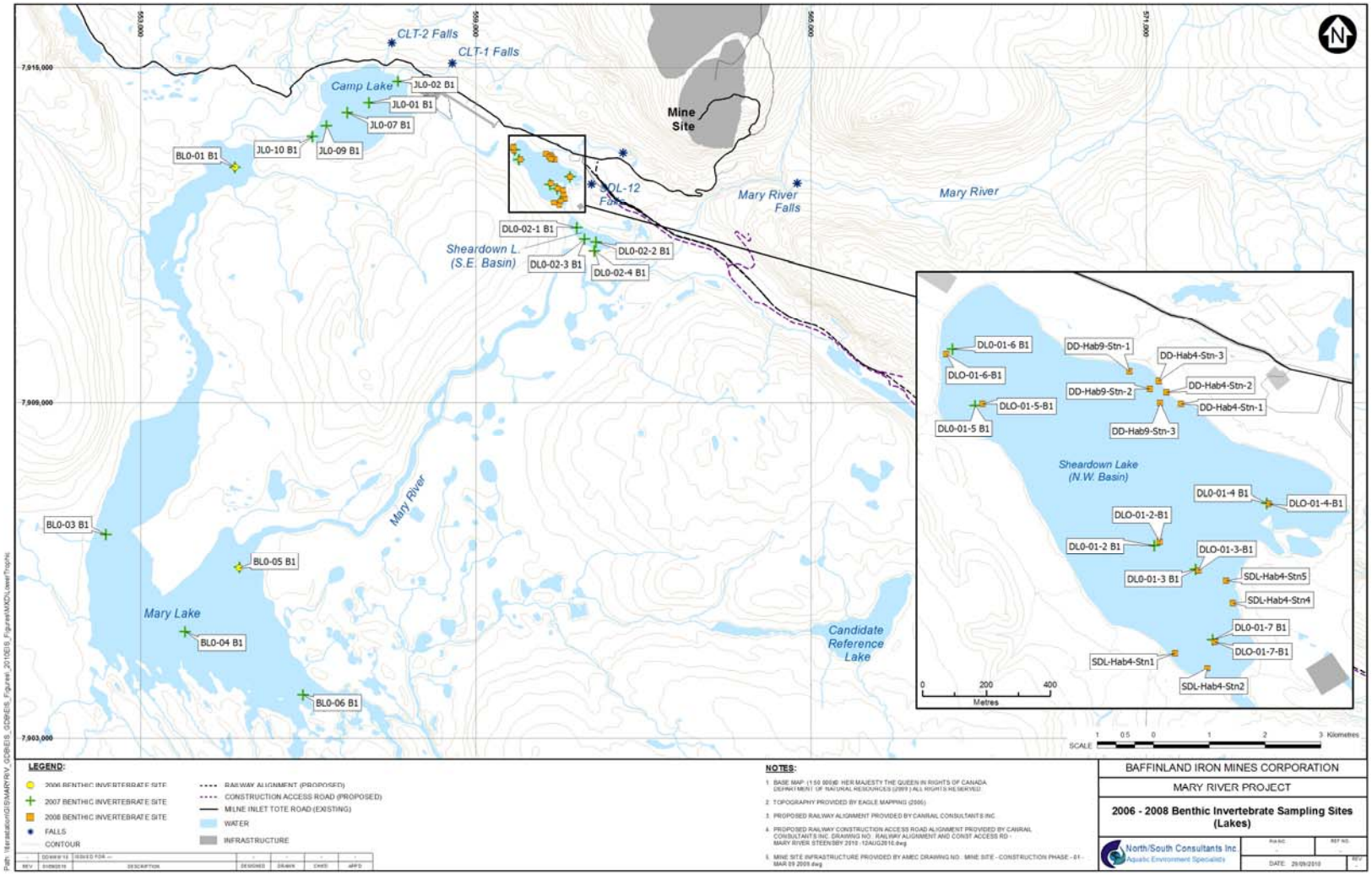

Figure 4.3-8. Benthic macroinvertebrate sampling sites in Mine Area lakes: 2006-2008.

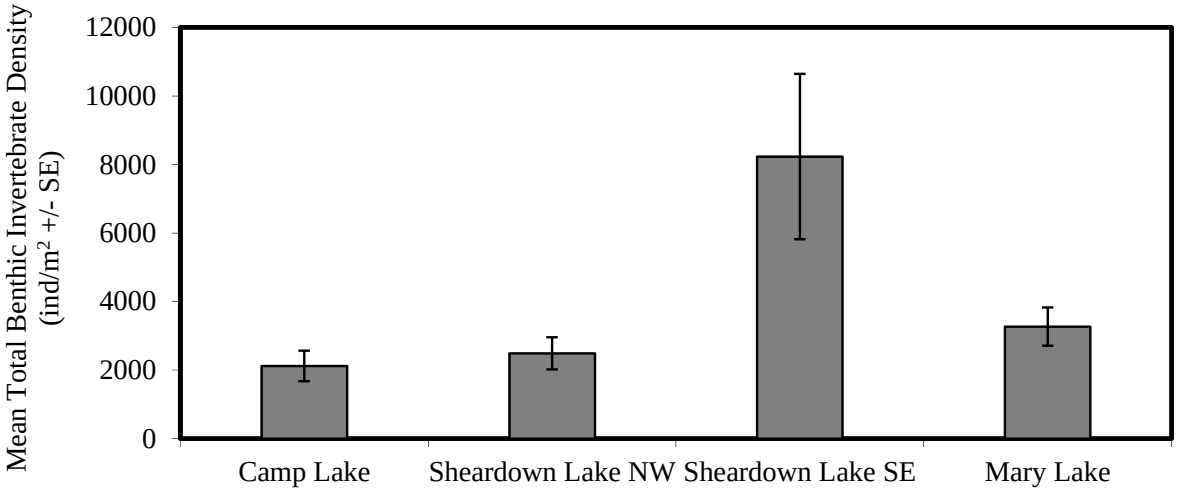

Figure 4.3-9. Overall mean total benthic invertebrate density (individuals/m^2 ± SE) collected at lake sites in the Mine Area: 2006-2008.

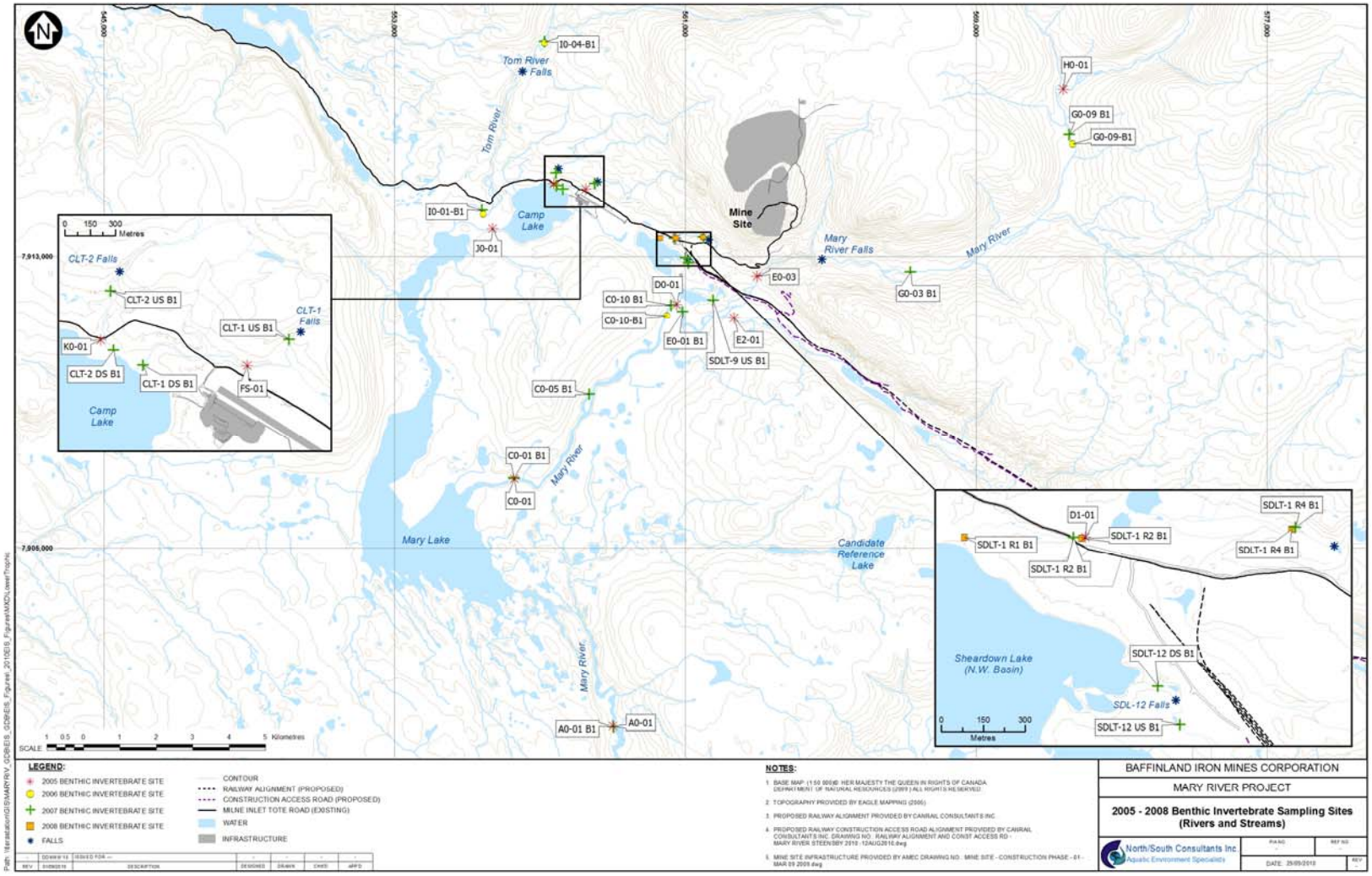

Figure 4.3-10. Benthic macroinvertebrate sampling sites in Mine Area streams: 2005-2008.

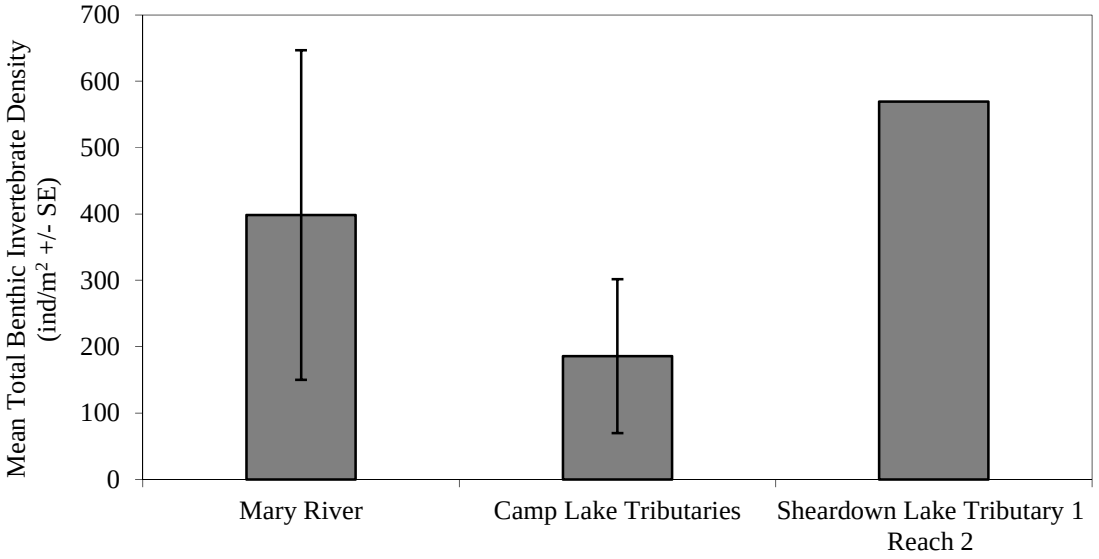

Figure 4.3-11. Overall mean total benthic invertebrate density (individuals/m^2 ± SE) collected in Mine Area streams: 2005.

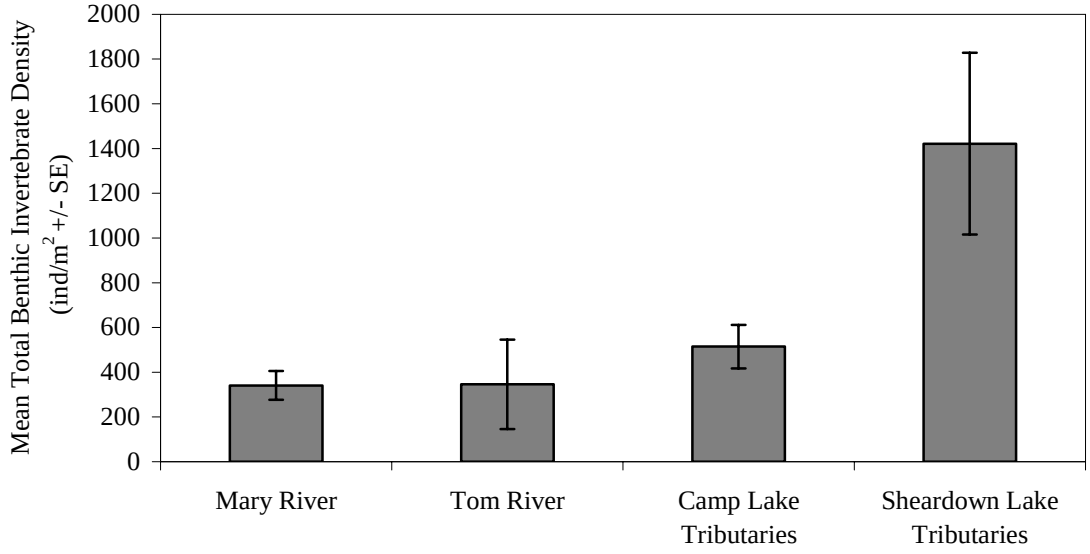

Figure 4.3-12. Overall mean total benthic invertebrate density (individuals/m^2 ± SE) collected in Mine area streams: 2006-2008.

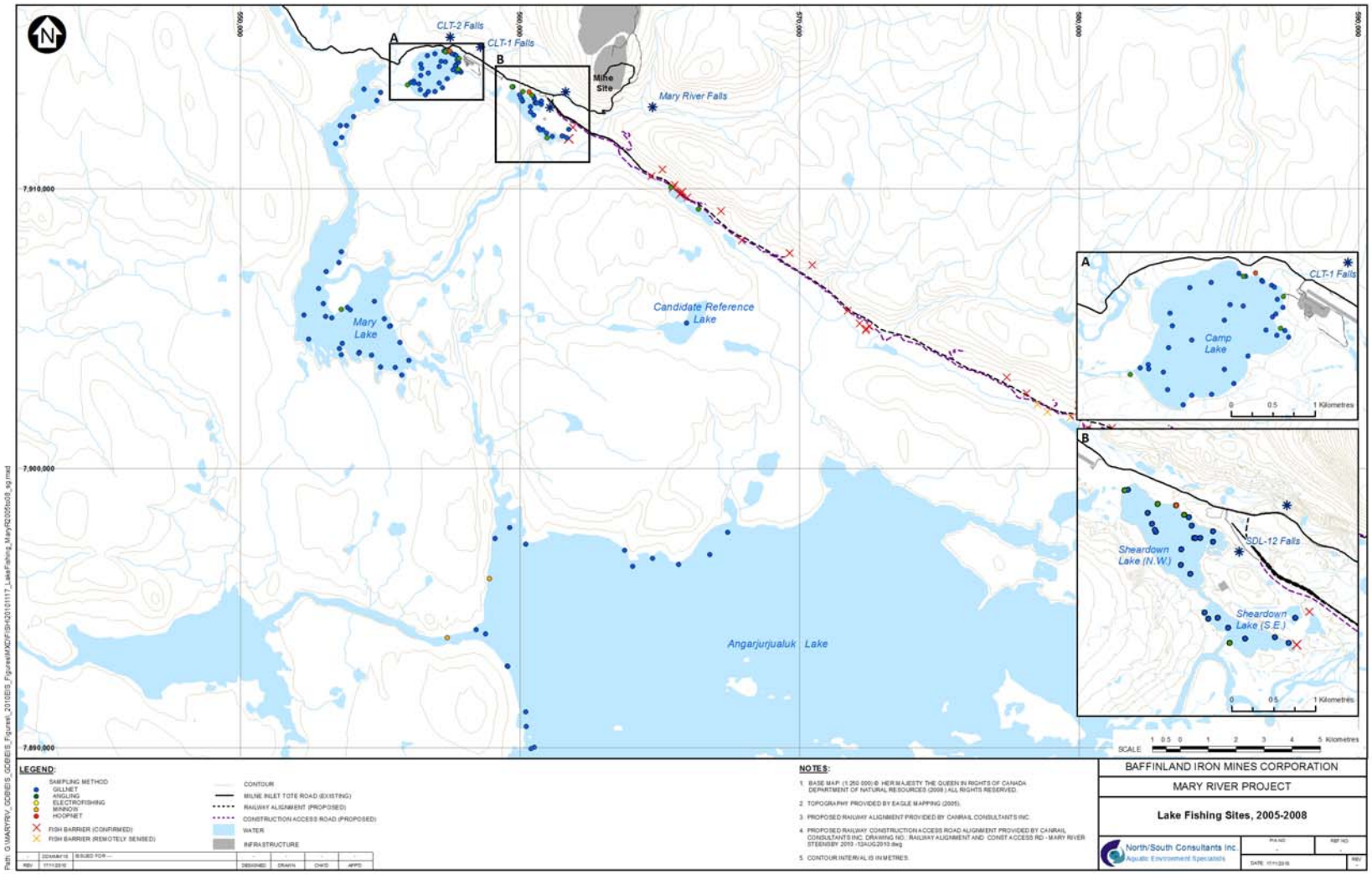

Figure 4.4-1. Map showing fish sampling sites in Mine Area lakes, 2005-2010.

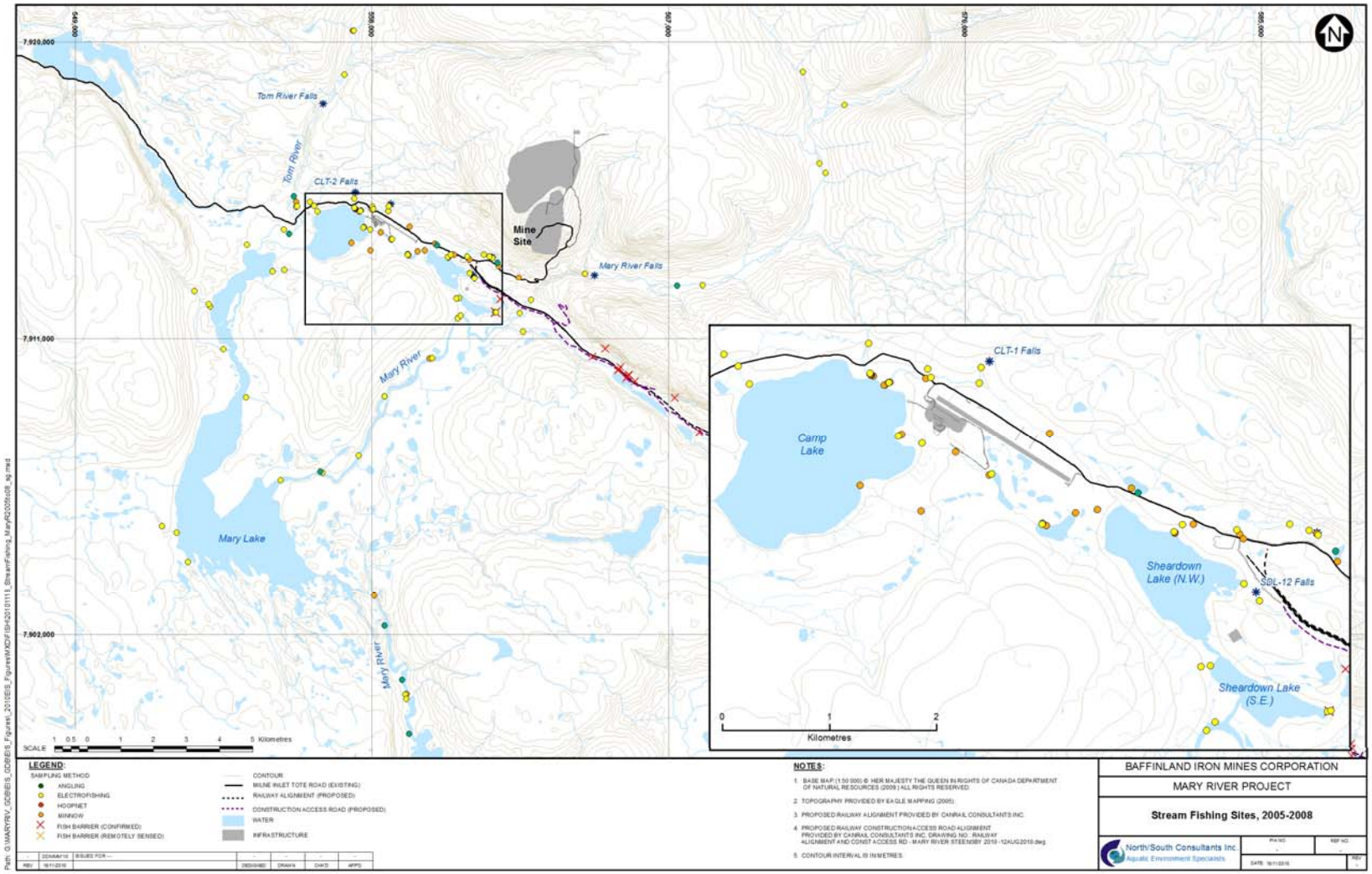

Figure 4.4-2. Map showing fish sampling sites in Mine Area streams, 2005-2010.

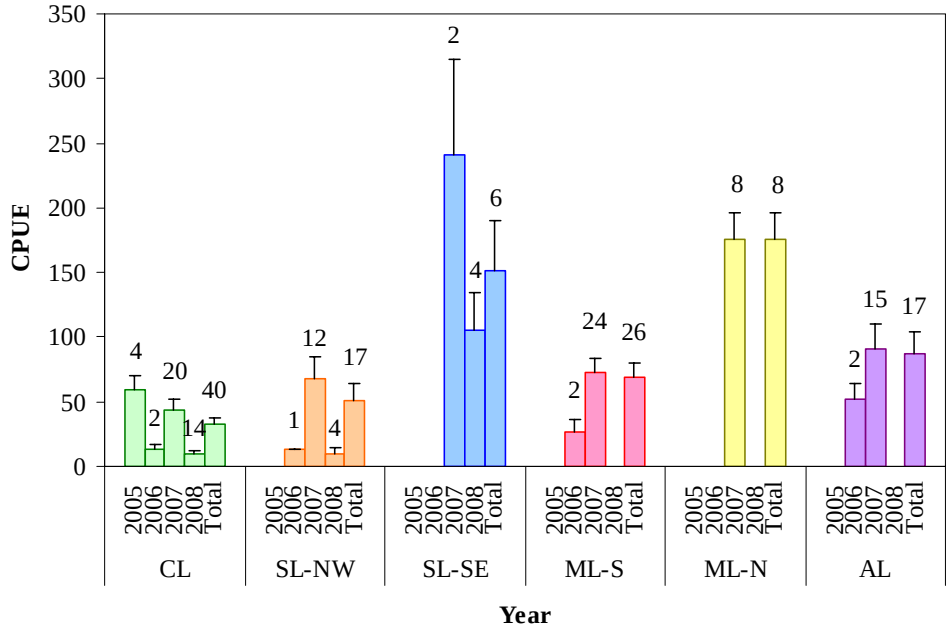

Figure 4.4-3. Mean catch-per-unit-effort (CPUE: # fish/ 100 m/ 24 hrs) for Arctic char captured in gill nets set in lakes in the Mine Area from 2005-2008. Numbers above the error bars indicate the number of gillnet sets each year.

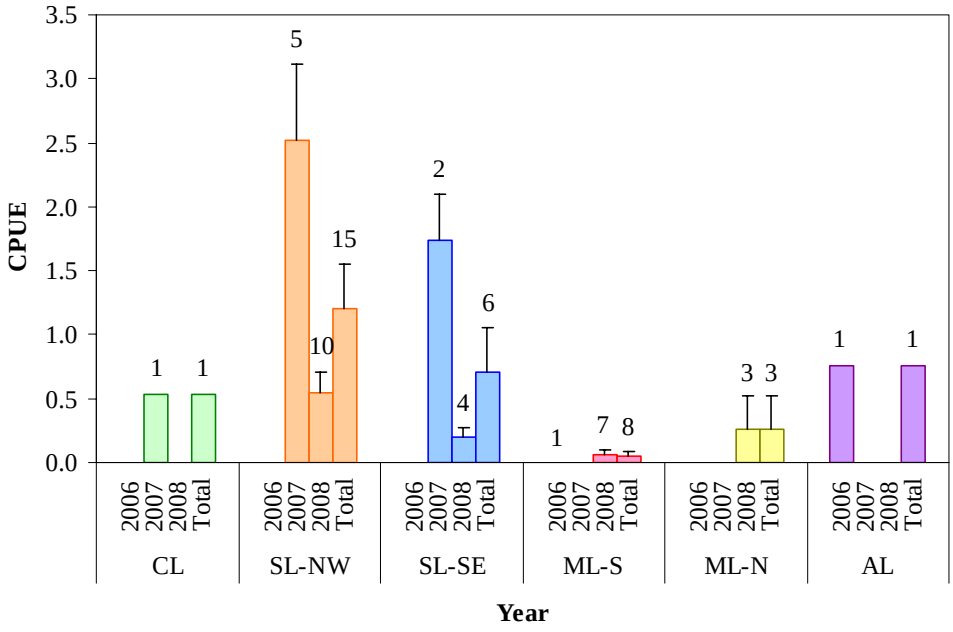

Figure 4.4-4. Mean catch-per-unit-effort (CPUE; # fish/ 100 m/ 24 hrs) for Arctic char captured during electrofishing surveys in lakes in the Mine Area from 2005-2008. Numbers above the error bars indicate the number of electrofishing sites each year.

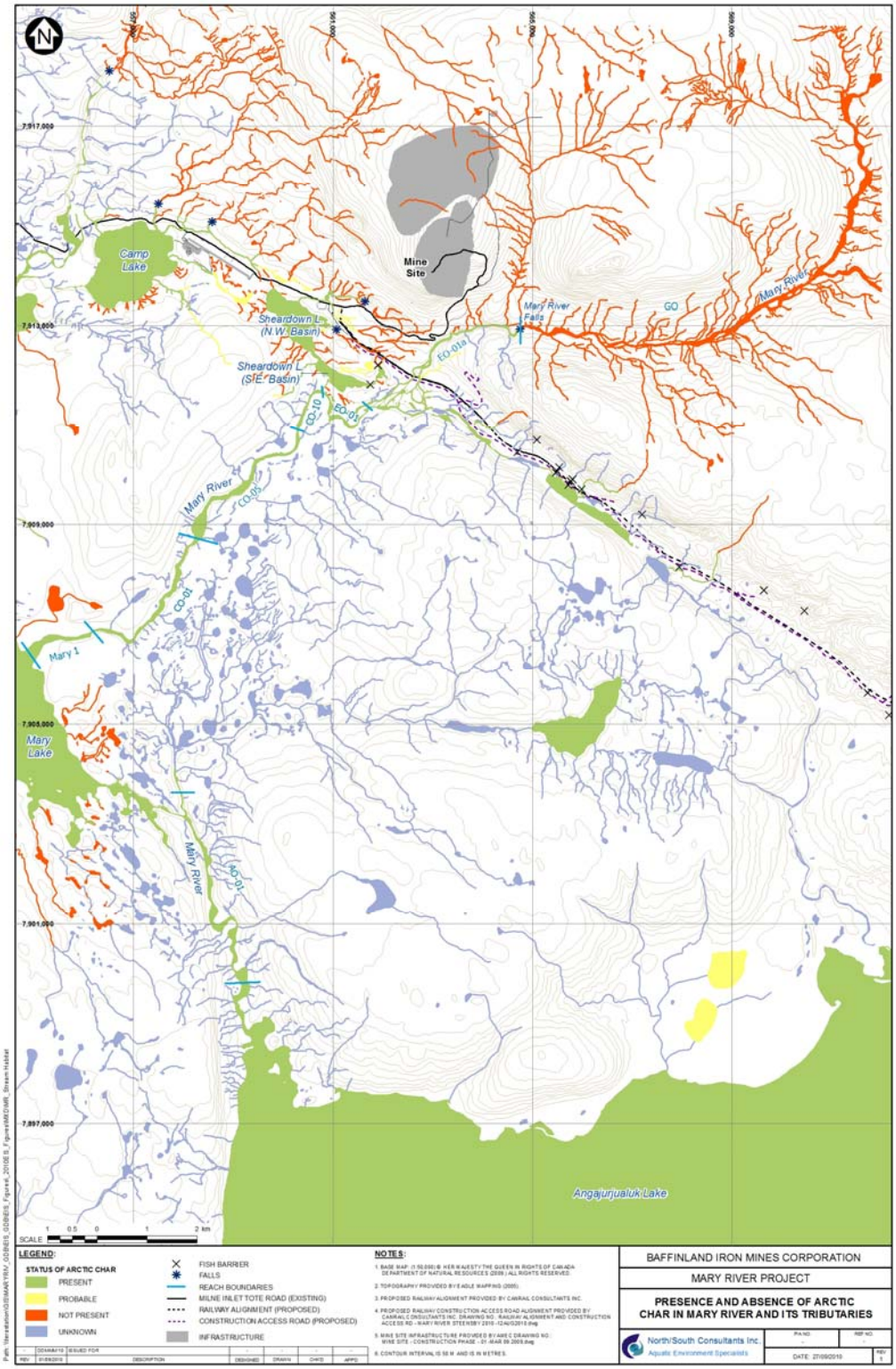

Figure 4.4-5. Map of the Mary River showing fish use of the different habitat reaches.

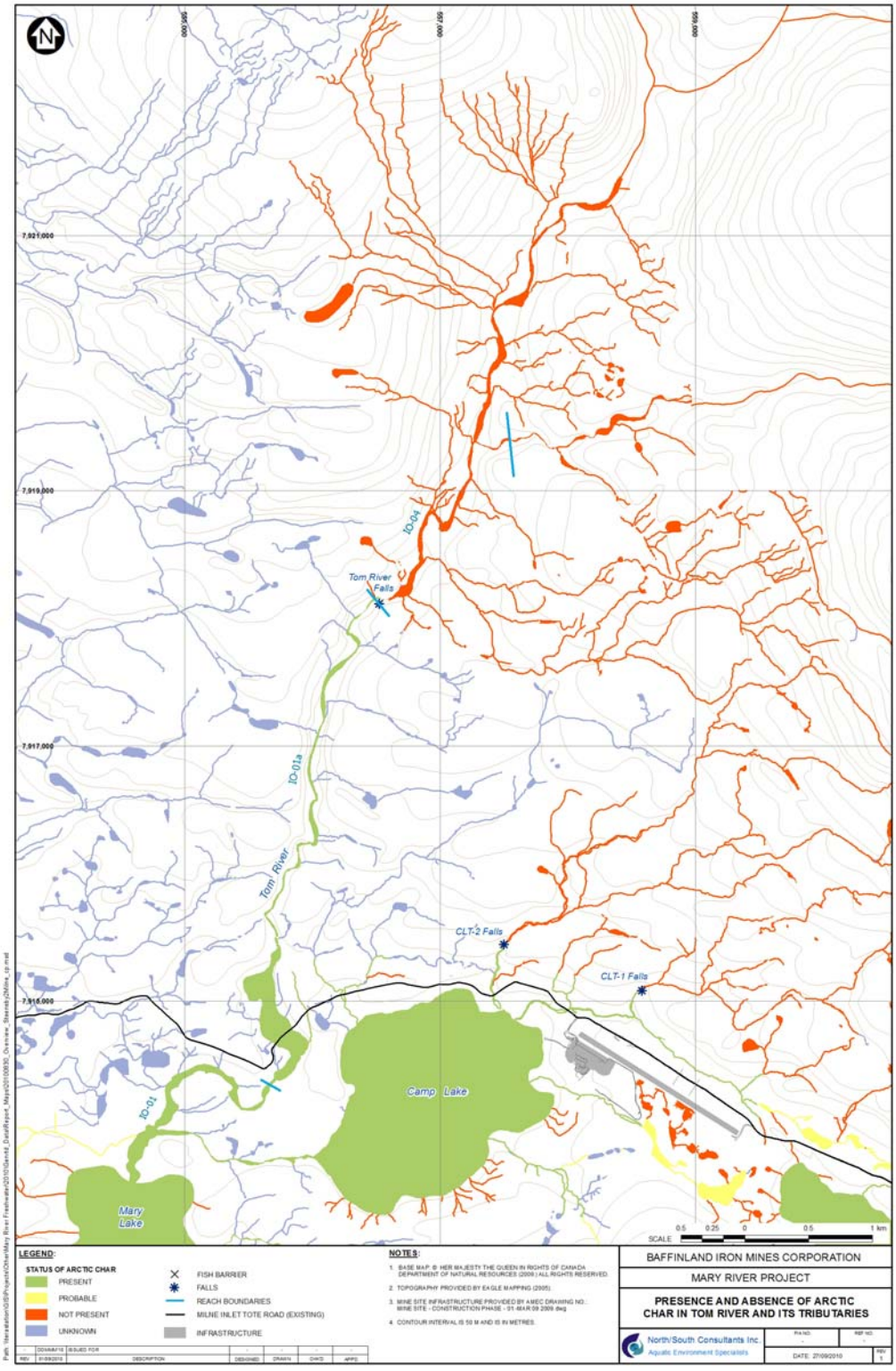

Figure 4.4-6. Map of the Tom River showing fish use of the different habitat reaches.

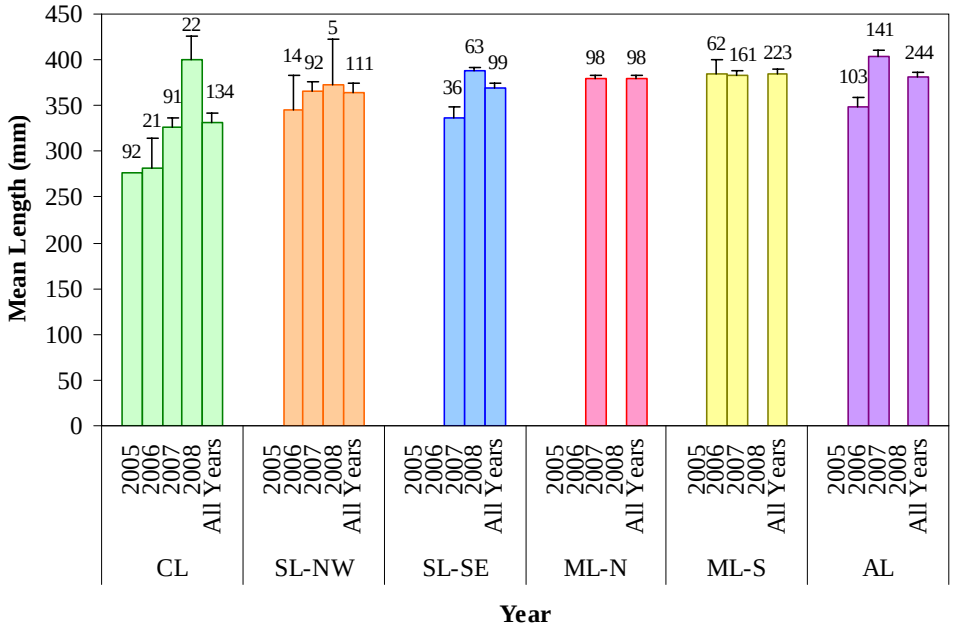

Figure 4.4-7. Mean fork length of Arctic char captured in gill nets set in lakes in the Mine Area from 2005-2008. Numbers above the error bars indicate the number of fish measured each year.

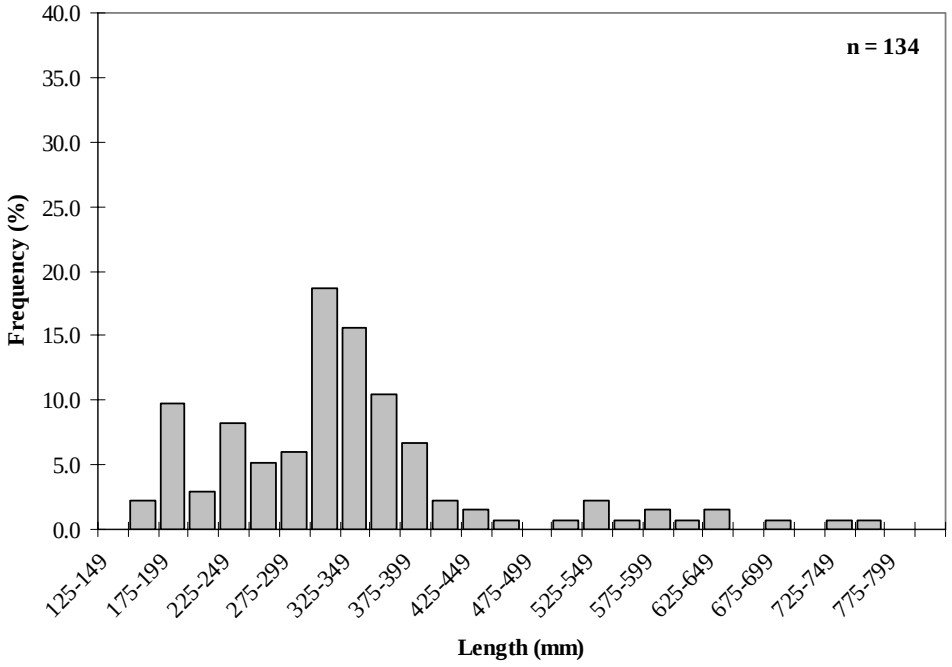

Figure 4.4-8. Length-frequency distributions for Arctic char captured in experimental gillnet gangs set in Camp Lake from 2006-2008.

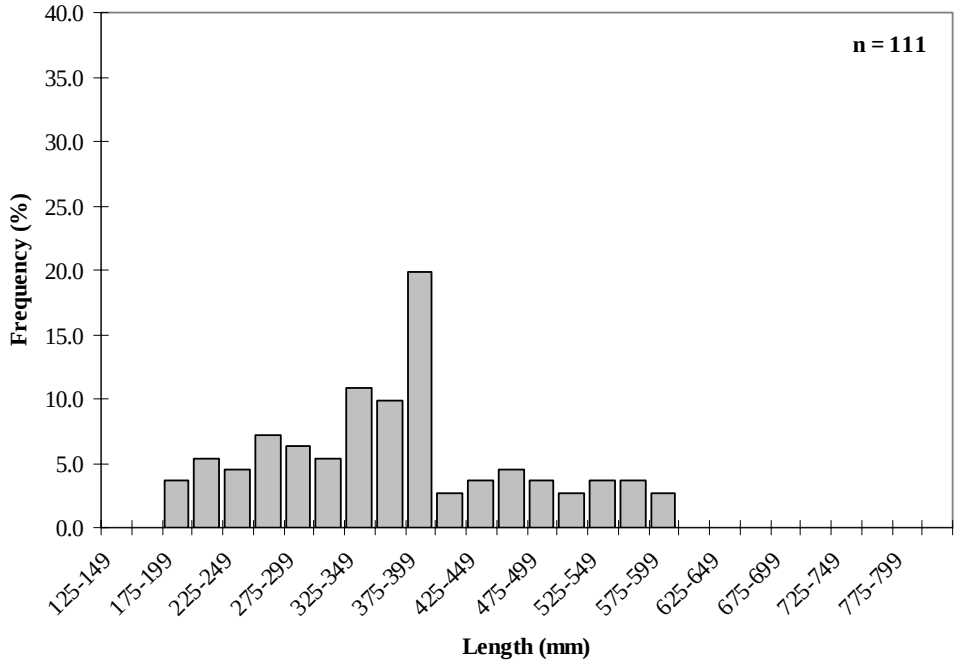

Figure 4.4-9. Length-frequency distributions for Arctic char captured in experimental gillnet gangs set in the northwest basin of Sheardown Lake from 2006-2008.

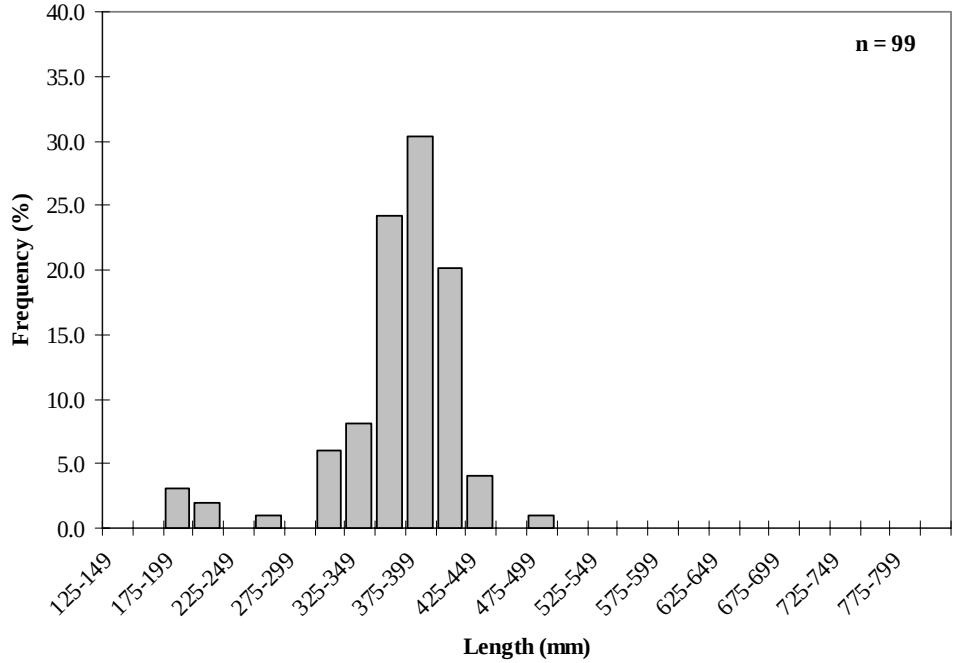

Figure 4.4-10. Length-frequency distributions for Arctic char captured in experimental gillnet gangs set in the southeast basin of Sheardown Lake from 2006-2008.

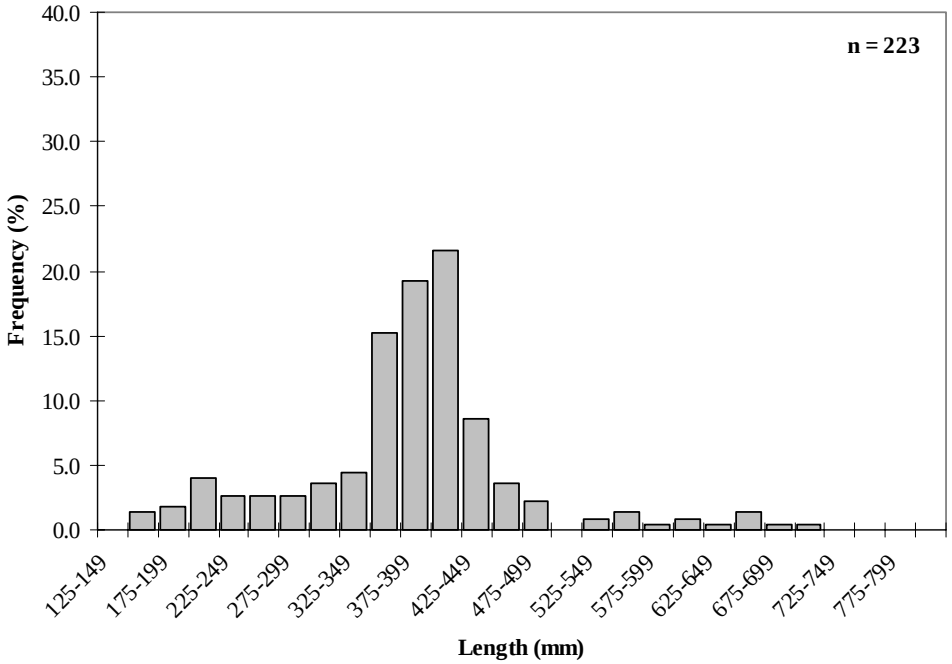

Figure 4.4-11. Length-frequency distributions for Arctic char captured in experimental gillnet gangs set in the south basin of Mary Lake from 2006-2007.

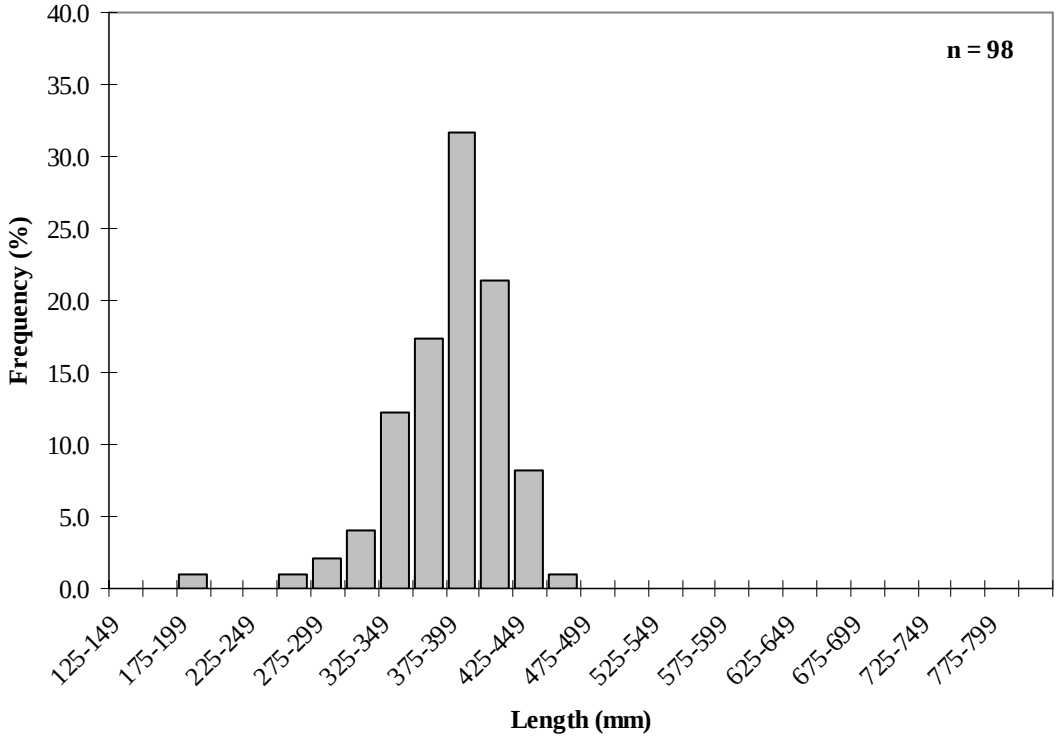

Figure 4.4-12. Length-frequency distributions for Arctic char captured in experimental gillnet gangs set in the north basin of Mary Lake during-2007.

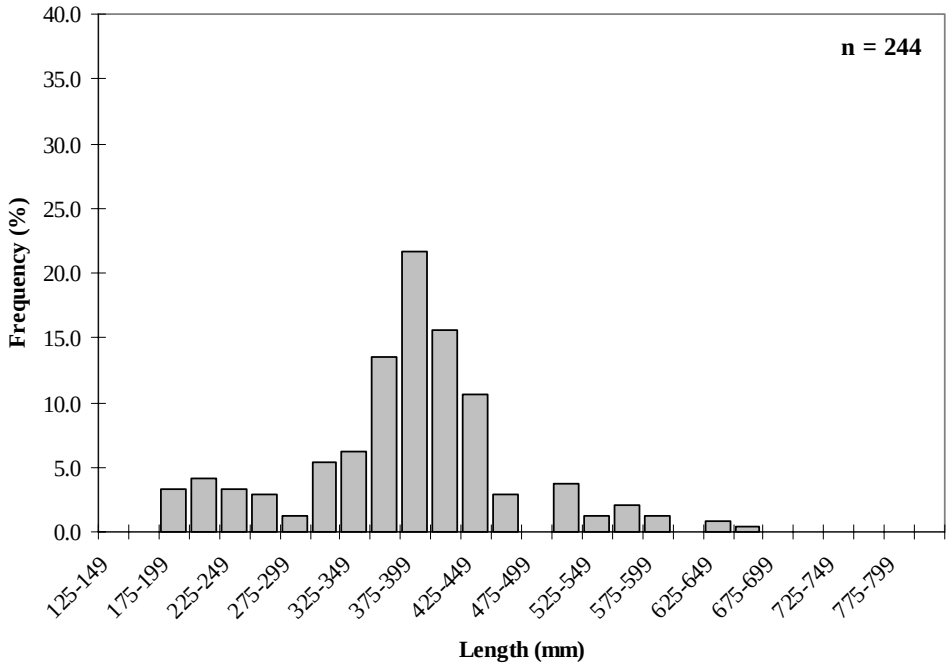

Figure 4.4-13. Length-frequency distributions for Arctic char captured in experimental gillnet gangs set in Angajurjualuk Lake from 2006-2007.

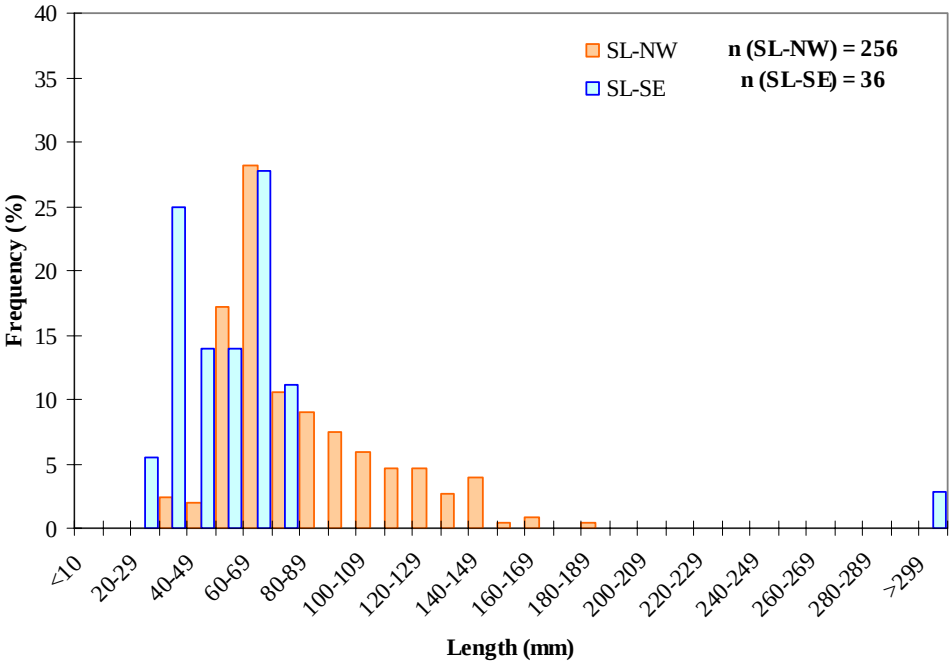

Figure 4.4-14. Length-frequency distributions for Arctic char captured during electrofishing studies in Sheardown Lake, 2007-2008.

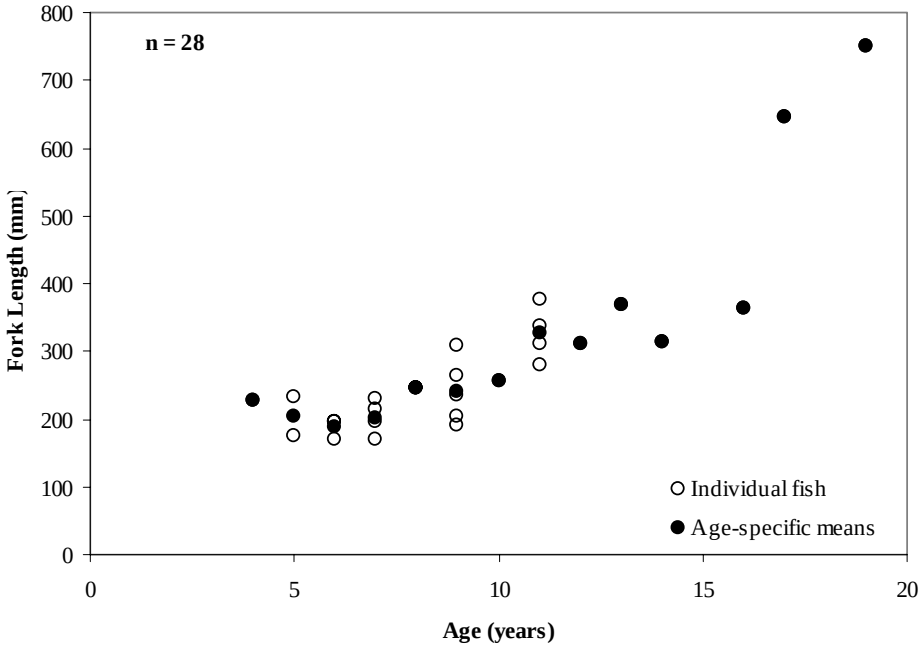

Figure 4.4-15. Age-length relationship for Arctic char captured in experimental gillnet gangs set in Camp Lake from 2006-2007.

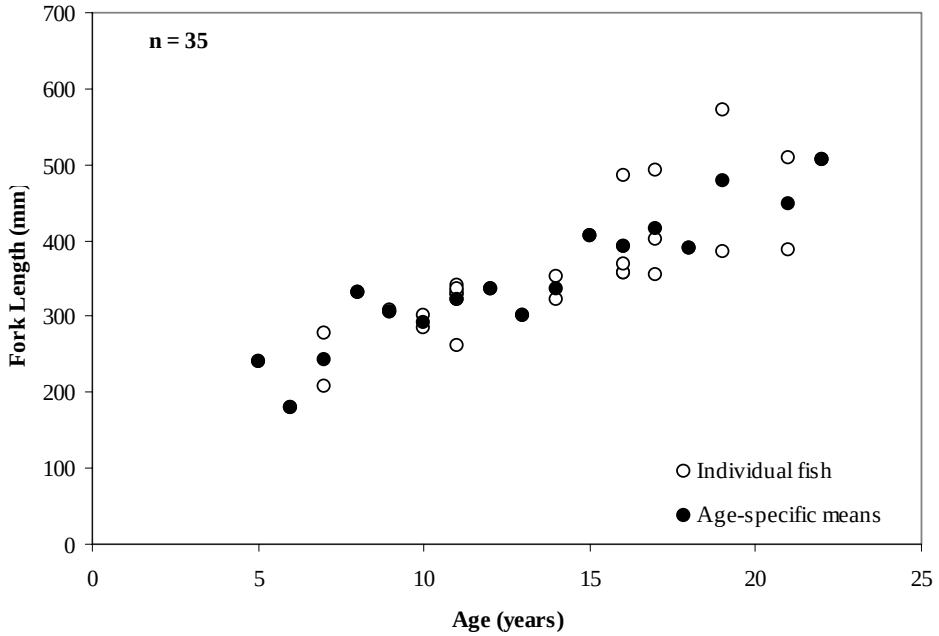

Figure 4.4-16. Age-length relationship for Arctic char captured in experimental gillnet gangs set in both basins of Sheardown Lake from 2006-2007.

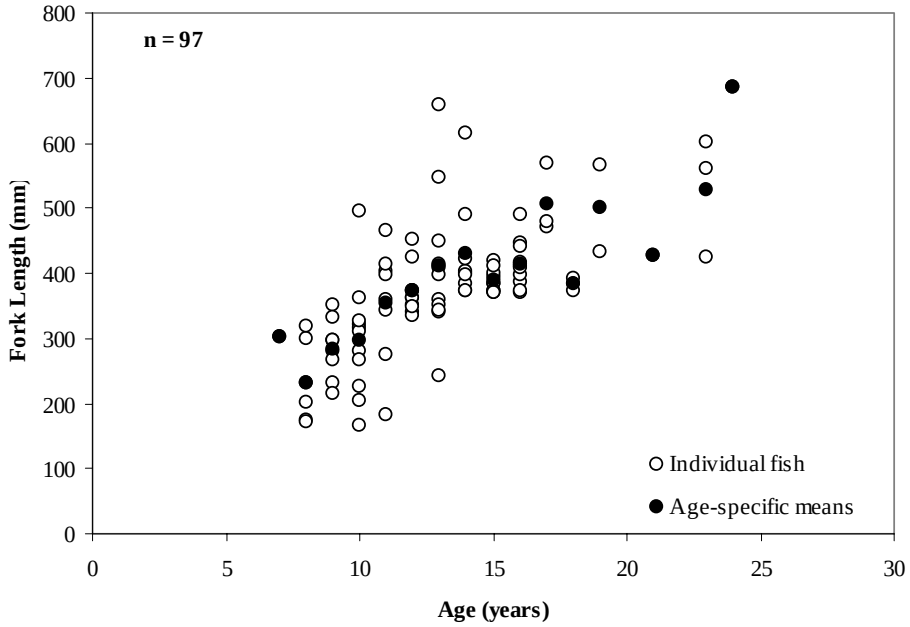

Figure 4.4-17. Age-length relationship for Arctic char captured in experimental gillnet gangs set in both basins of Mary Lake from 2006-2007.

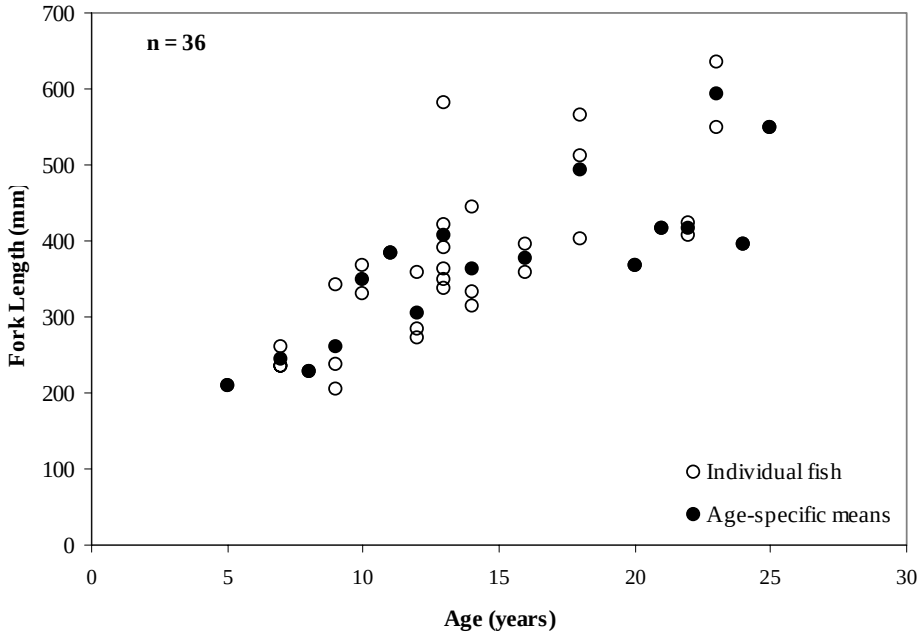

Figure 4.4-18. Age-length relationship for Arctic char captured in experimental gillnet gangs set in Angajurjualuk Lake from 2006-2007.

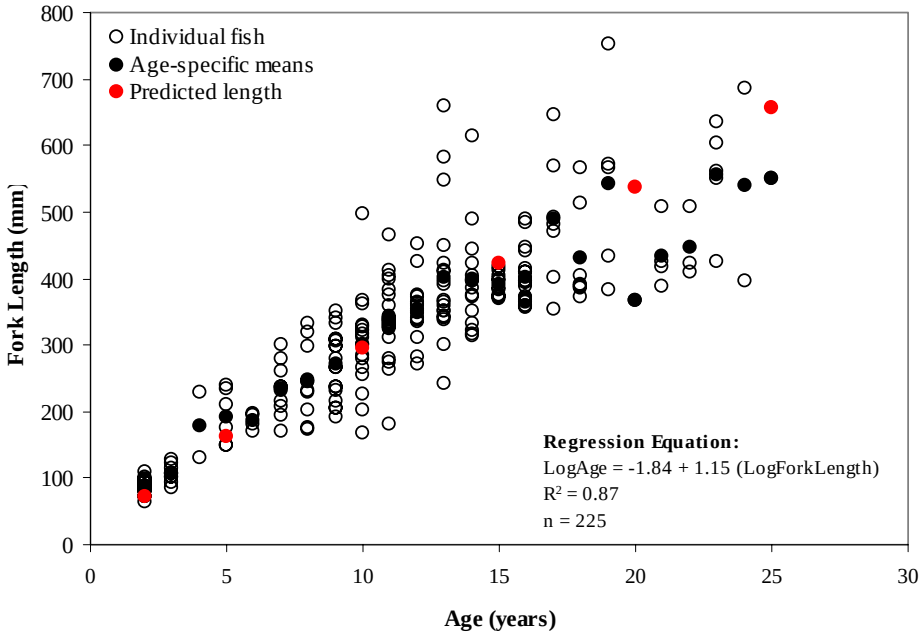

Figure 4.4-19. Age-length relationship for Arctic char captured during fish population investigations in the Mine Area, 2006-2008. Red dots represent the fork lengths predicted from the age-length regression equation.

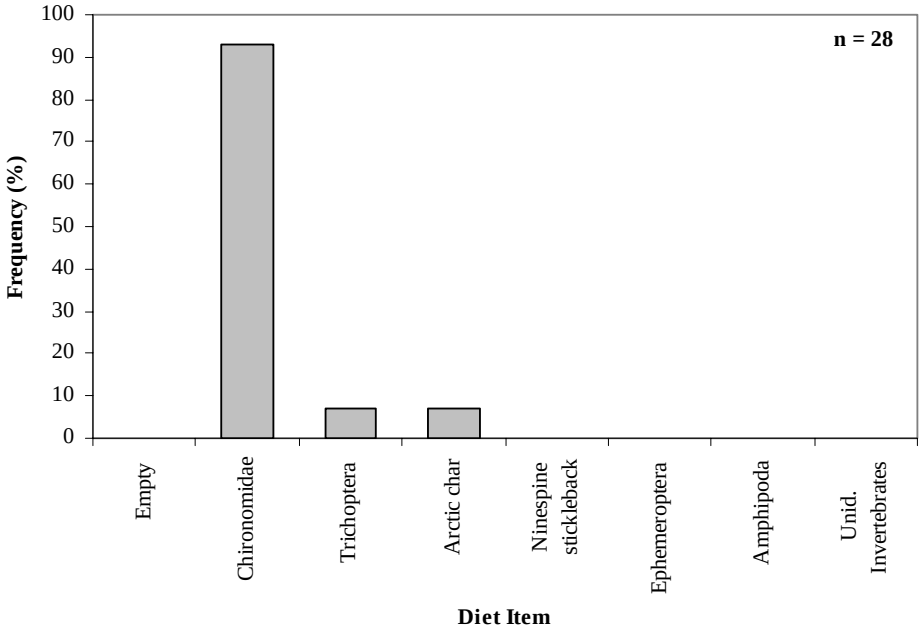

Figure 4.4-20. Frequency (proportion of stomachs examined with each prey type) of dietary items found in char captured in experimental gillnet gangs set in Camp Lake in 2006 and 2007.

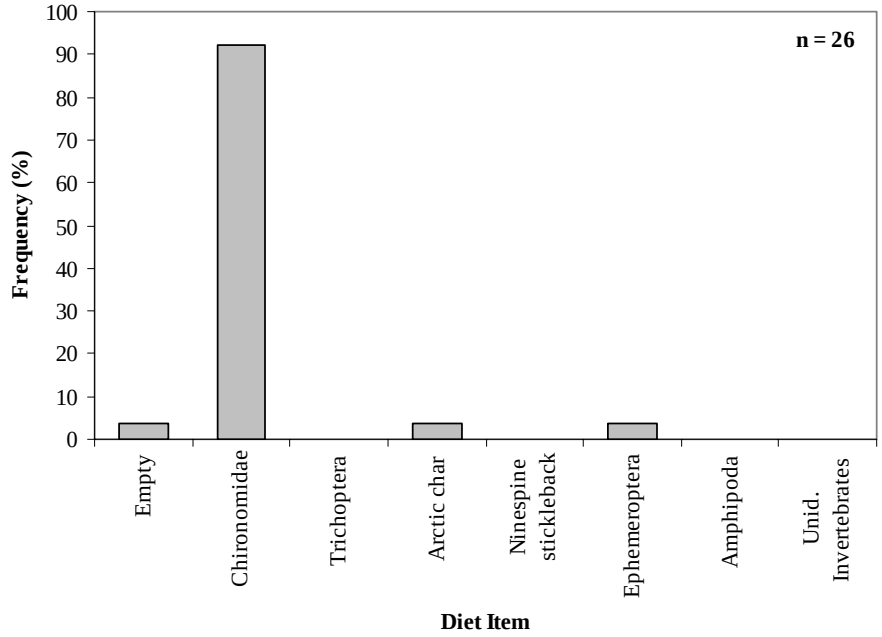

Figure 4.4-21. Frequency of dietary items found in char stomachs from gillnetting catches in the northwest basin of Sheardown Lake in 2006 and 2007. Note: Total frequency may add up to more than 100% due to stomachs containing multiple prey types.

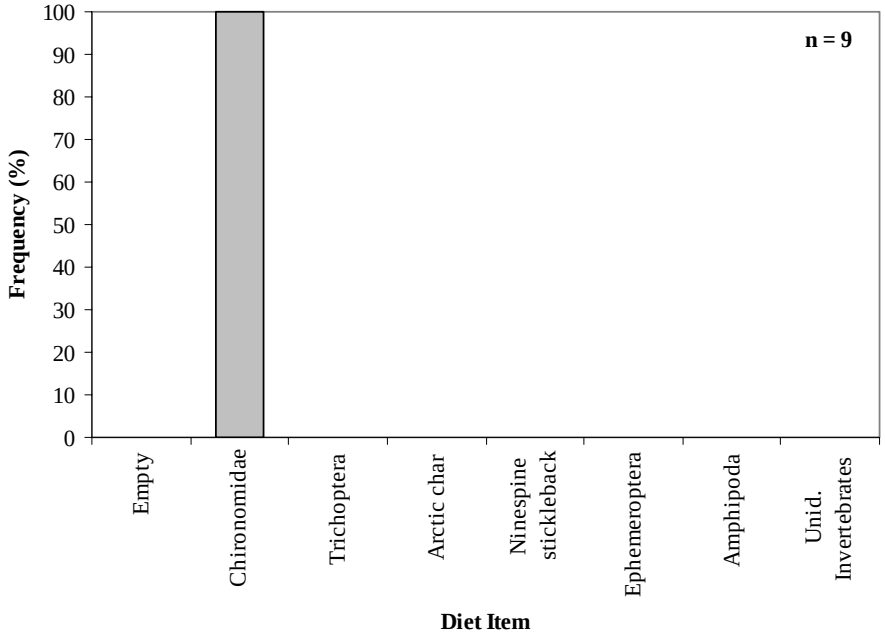

Figure 4.4-22. Frequency of dietary items found in char stomachs from gillnetting catches in the southeast basin of Sheardown Lake in 2007.

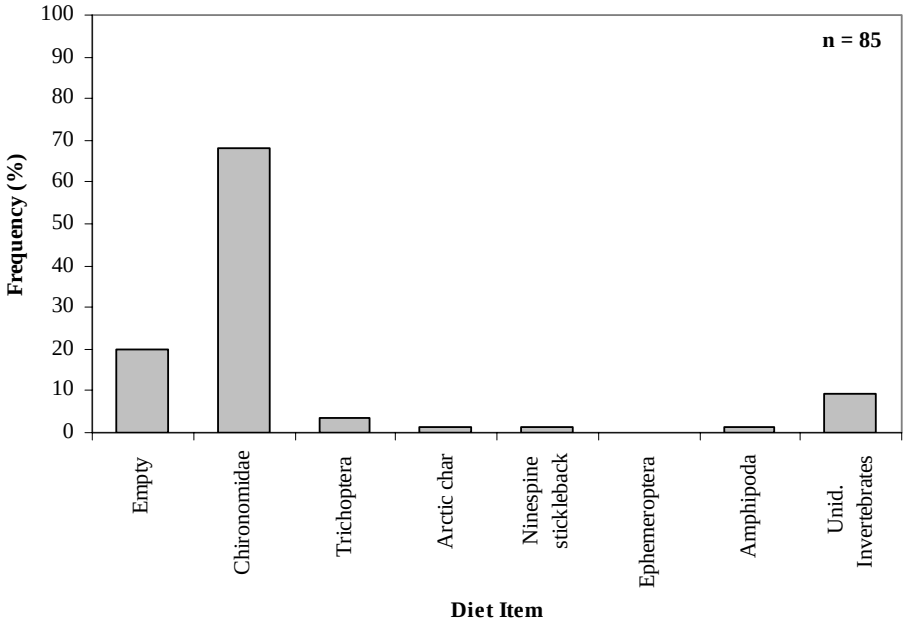

Figure 4.4-23. Frequency of dietary items found in char stomachs from gillnetting catches in the south basin of Mary Lake in 2006 and 2007.

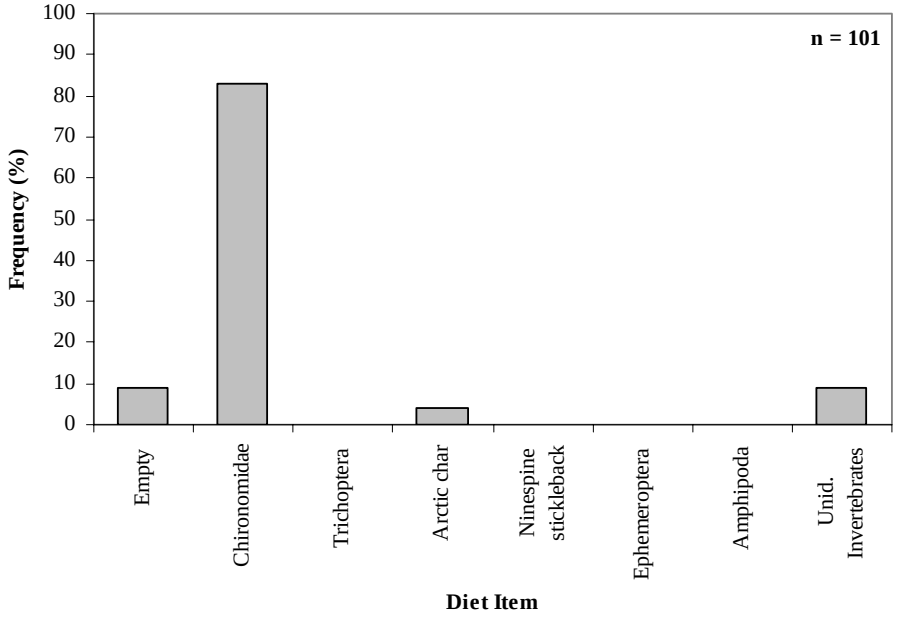

Figure 4.4-24. Frequency of dietary items found in char stomachs from gillnetting catches in Angajurjualuk Lake in 2006 and 2007.

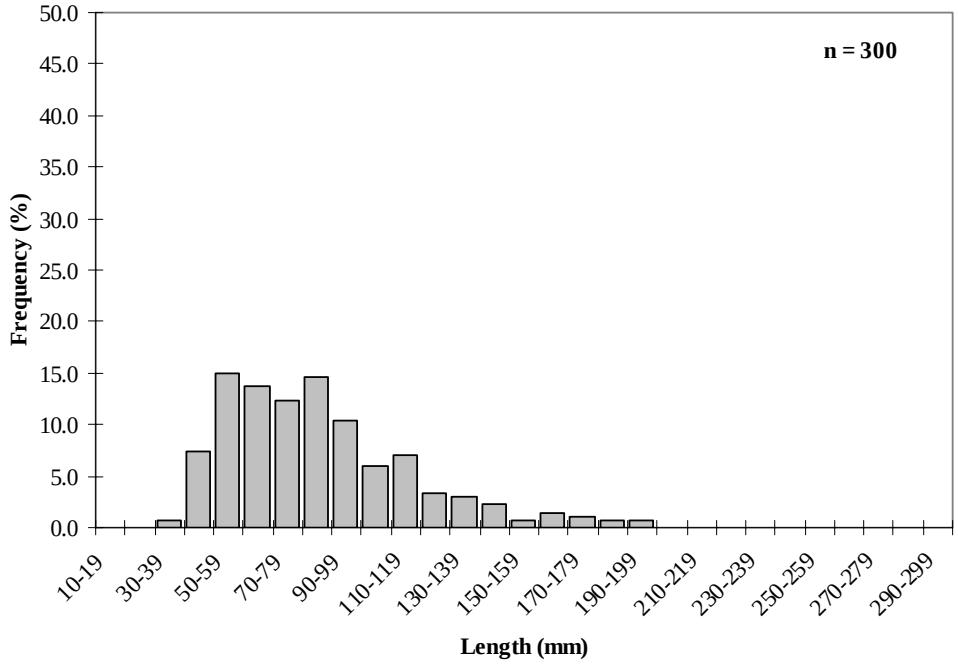

Figure 4.4-25. Length-frequency distributions for Arctic char captured during electrofishing studies in Camp Lake Tributary 2, 2006-2008.

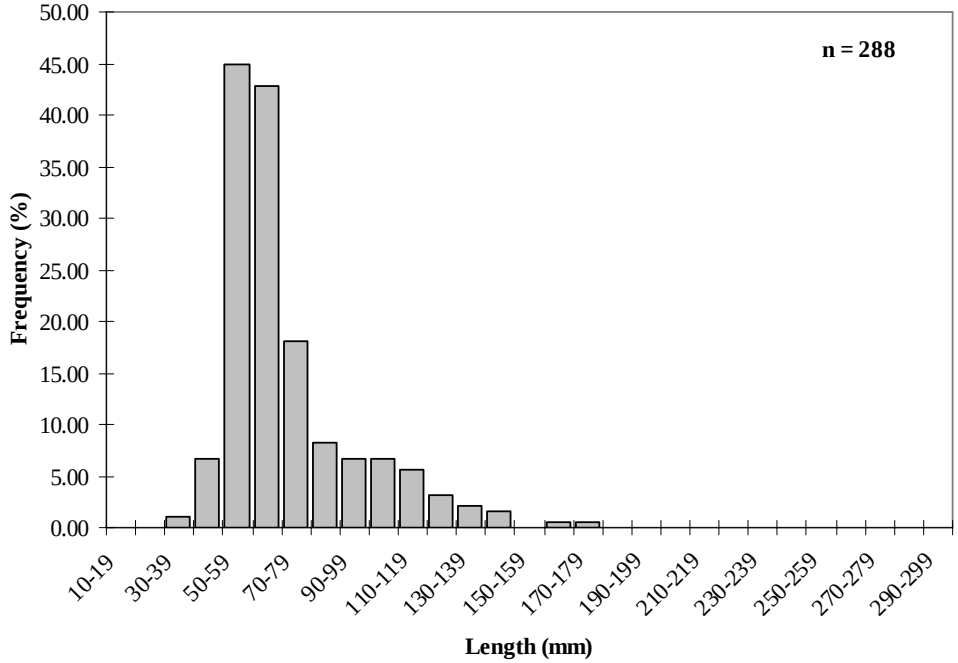

Figure 4.4-26. Length-frequency distributions for Arctic char captured during electrofishing studies in Sheardown Lake Tributary 1, 2006-2008.

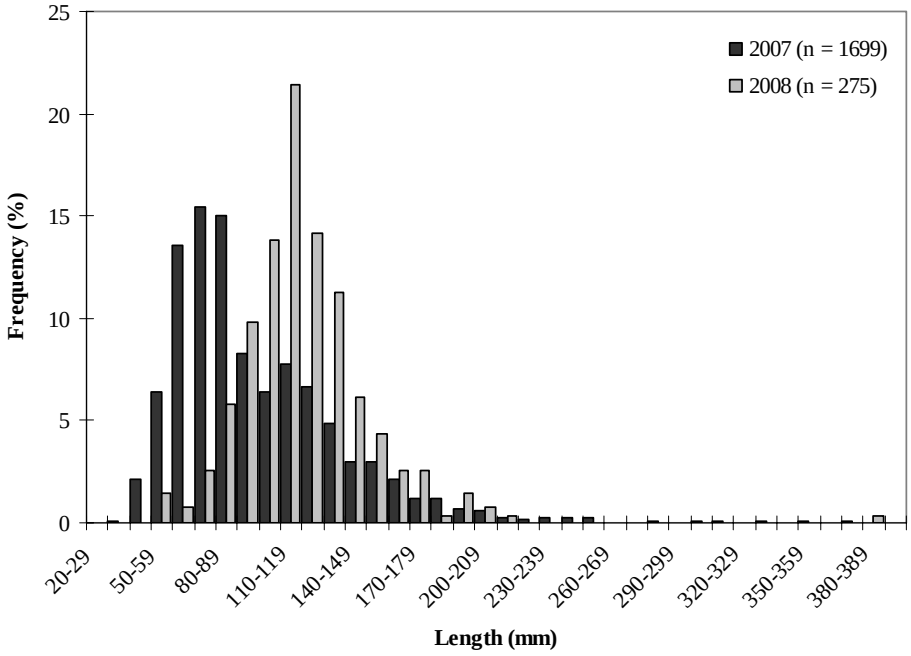

Figure 4.4-27. Length-frequency distributions for Arctic char captured moving downstream in hoop nets set in Camp Lake Tributary 2 during fall 2007 and 2008.

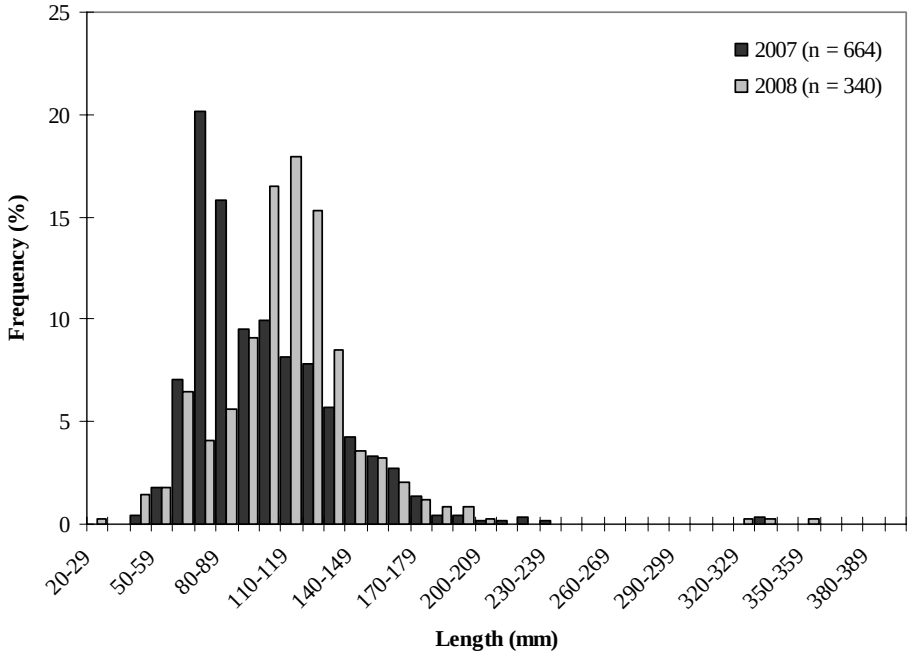

Figure 4.4-28. Length-frequency distributions for Arctic char captured moving downstream in hoop nets set in Sheardown Lake Tributary 1 during fall 2007 and 2008.

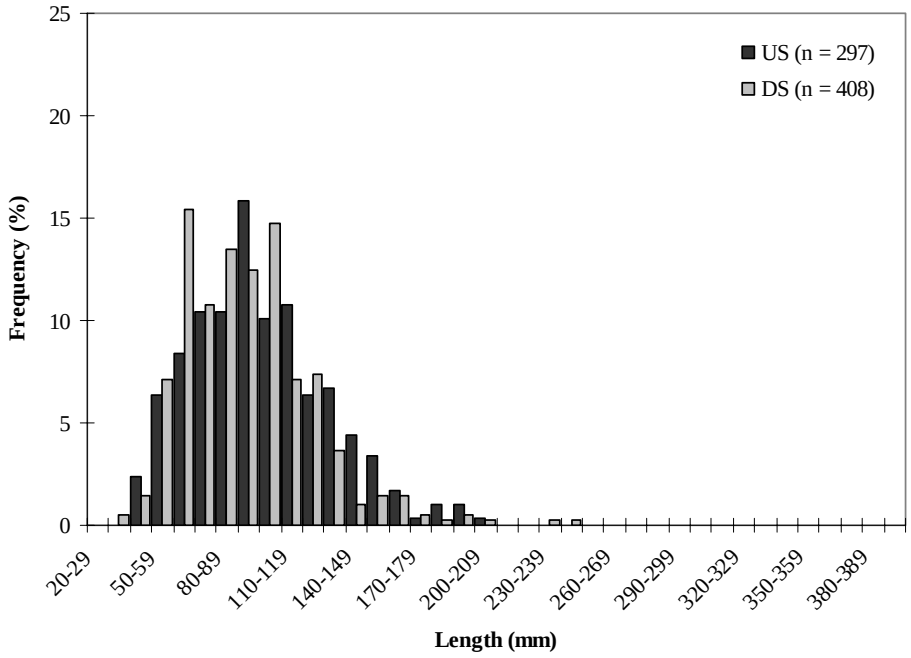

Figure 4.4-29. Length-frequency distributions for Arctic char captured moving upstream and downstream in hoop nets set in Sheardown Lake Tributary 1 during spring 2008.

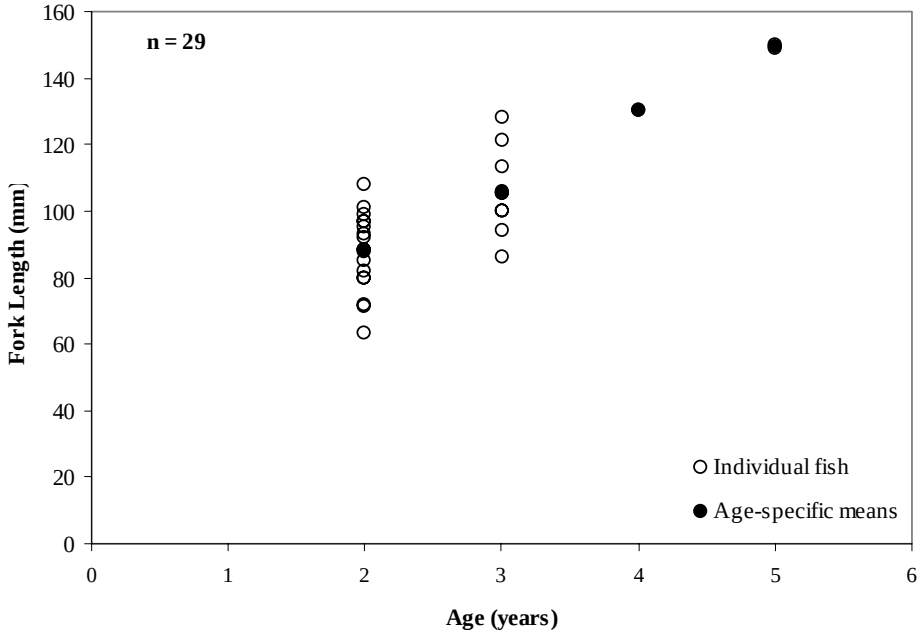

Figure 4.4-30. Age-length relationship for Arctic char captured during electrofishing surveys in the Mary River, 2008.

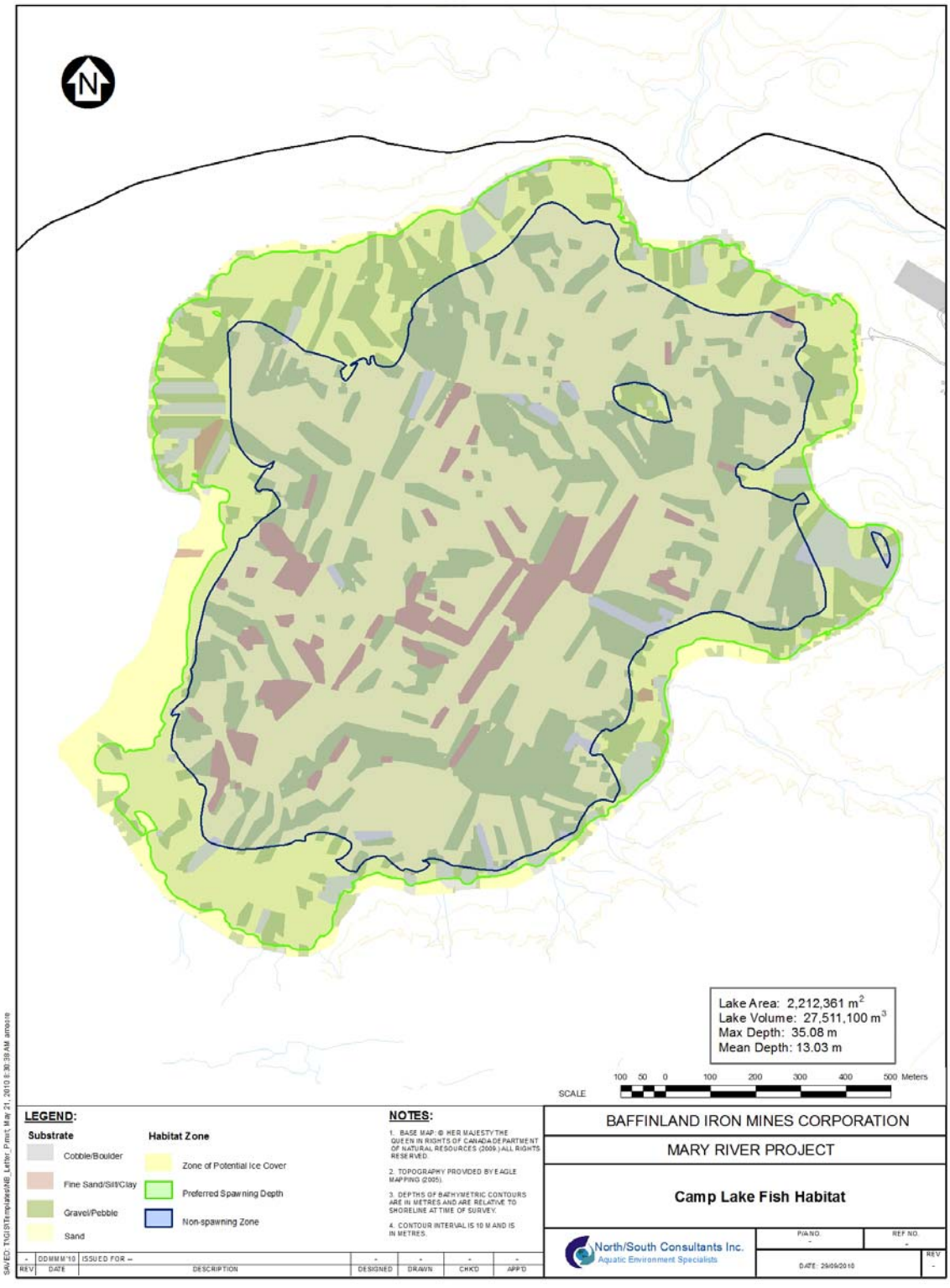

Figure 4.4-31. Map of available fish habitat in Camp Lake.

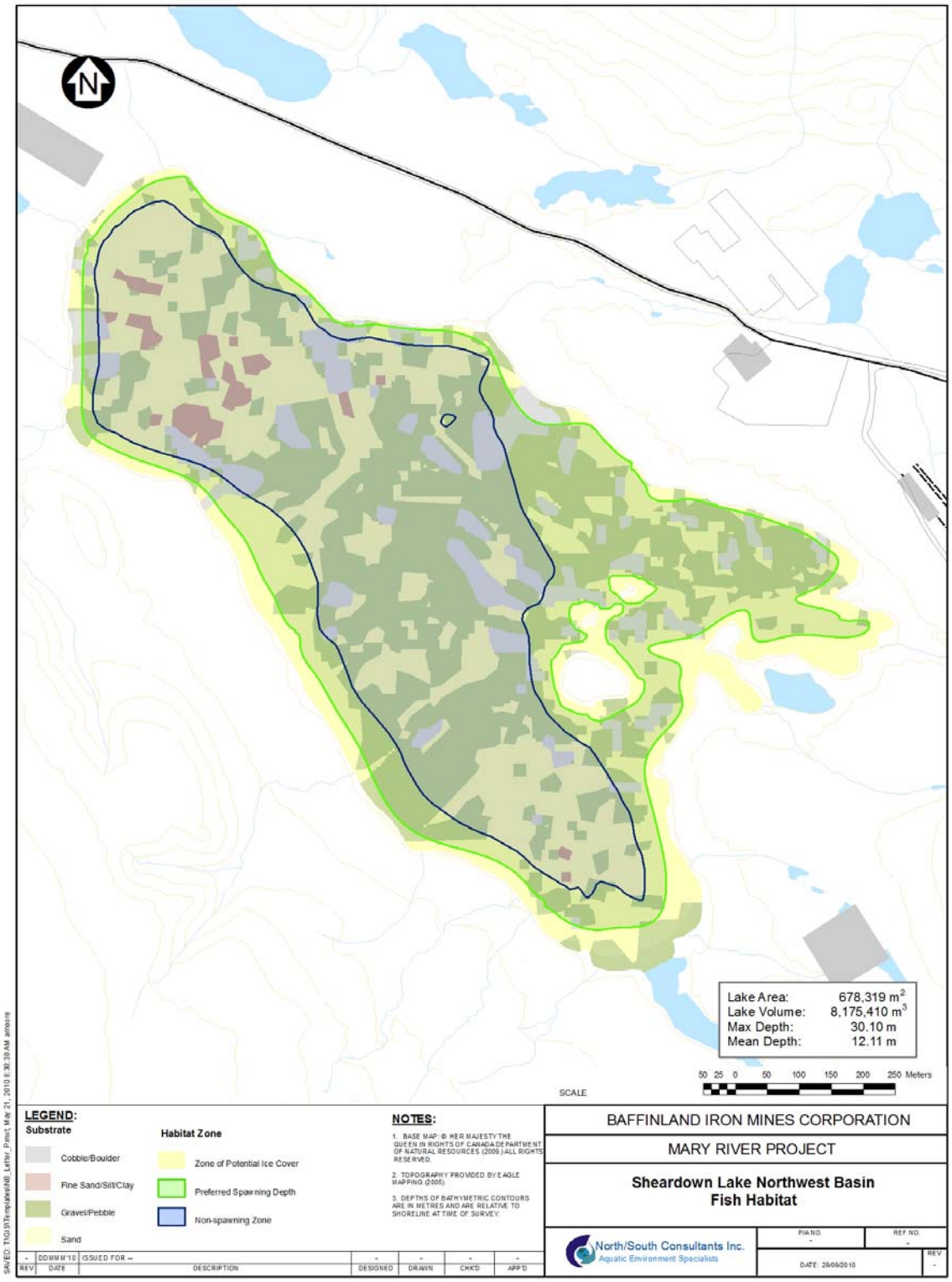

Figure 4.4-32. Map of available fish habitat in the northwest basin of Sheardown Lake.

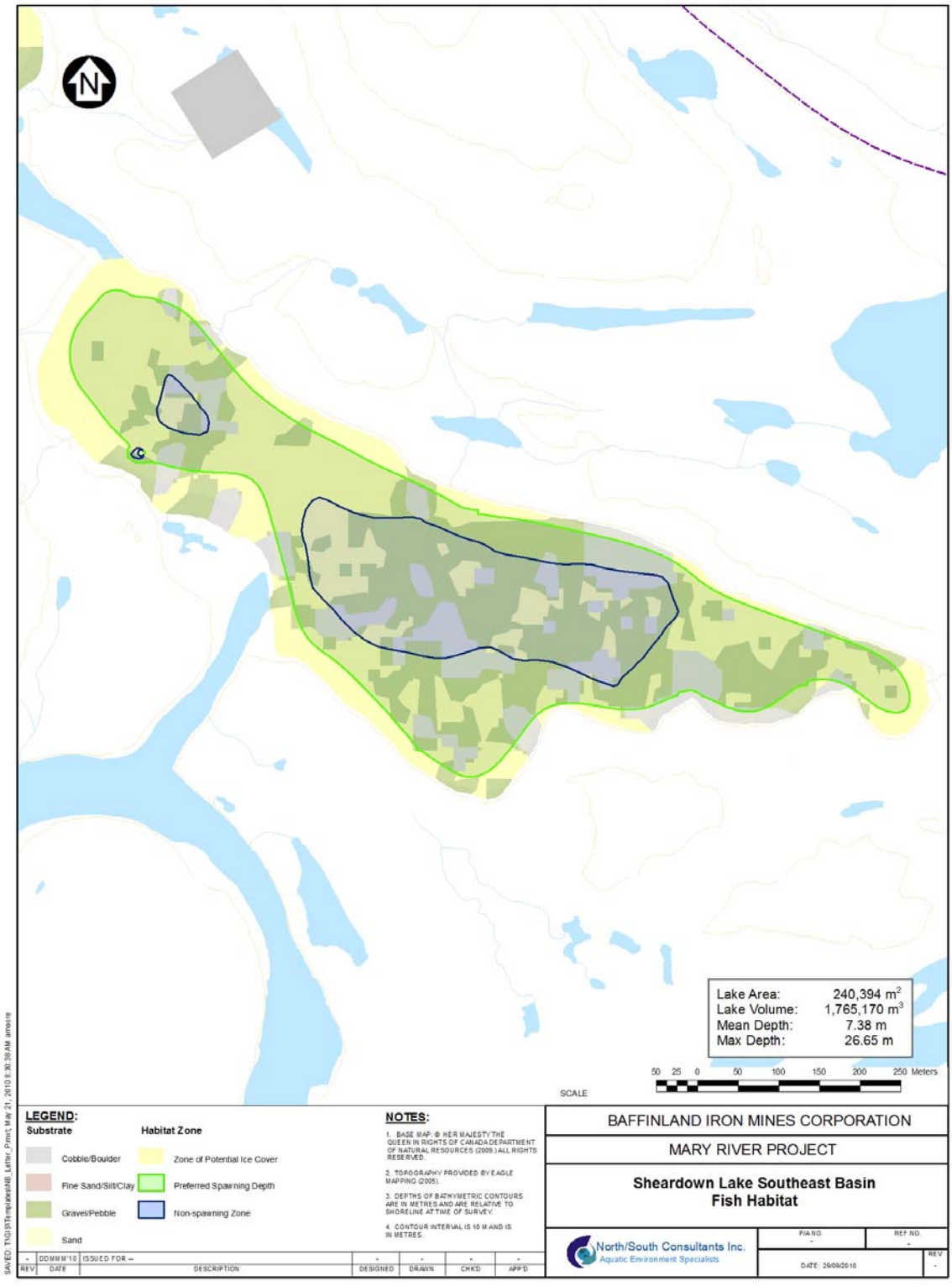

Figure 4.4-33. Map of available fish habitat in the southeast basin of Sheardown Lake.

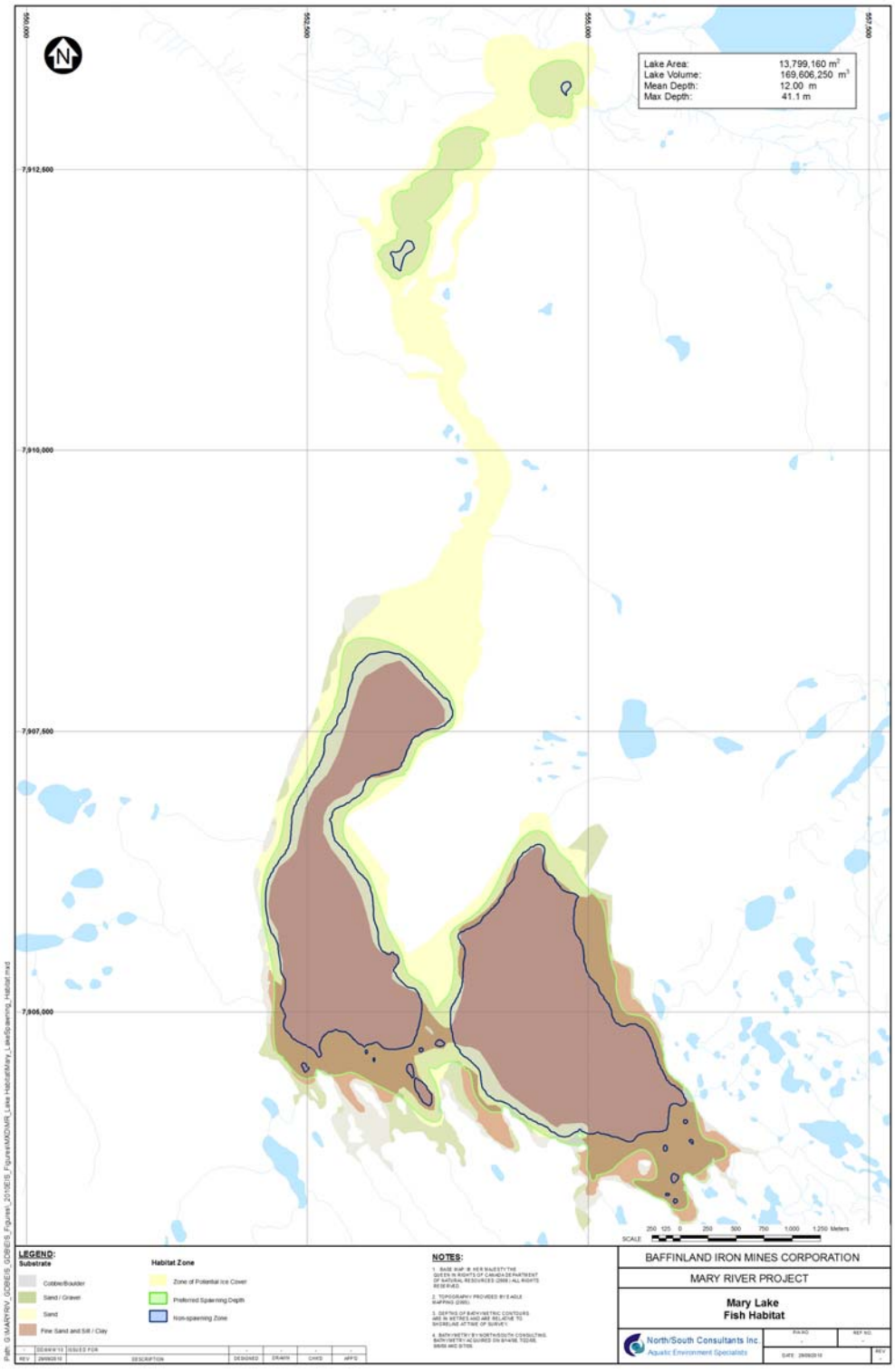

Figure 4.4-34. Map of available fish habitat in Mary Lake.

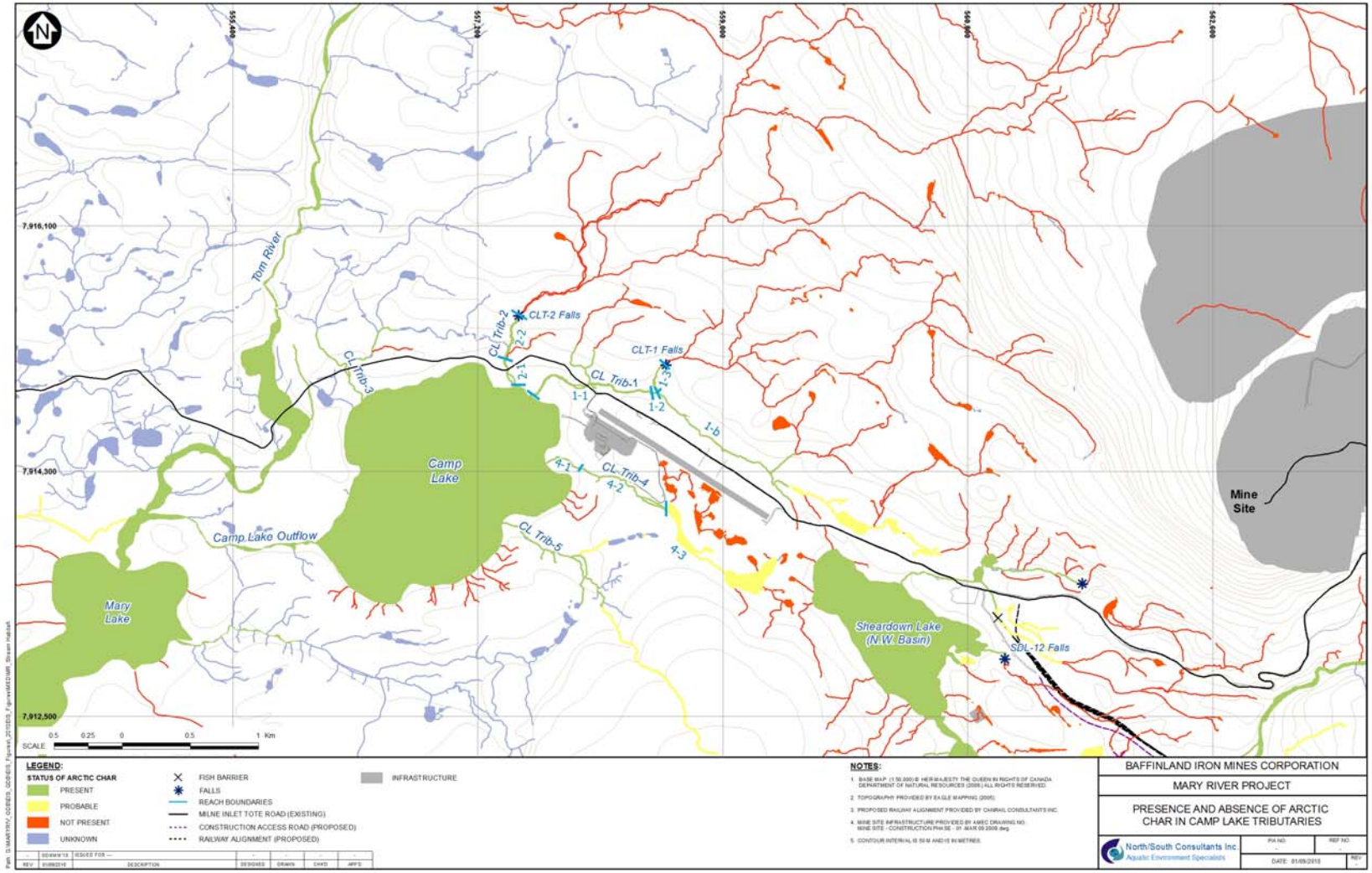

Figure 4.4-35. Map of Arctic char distribution, by reach, in Camp Lake inflows.

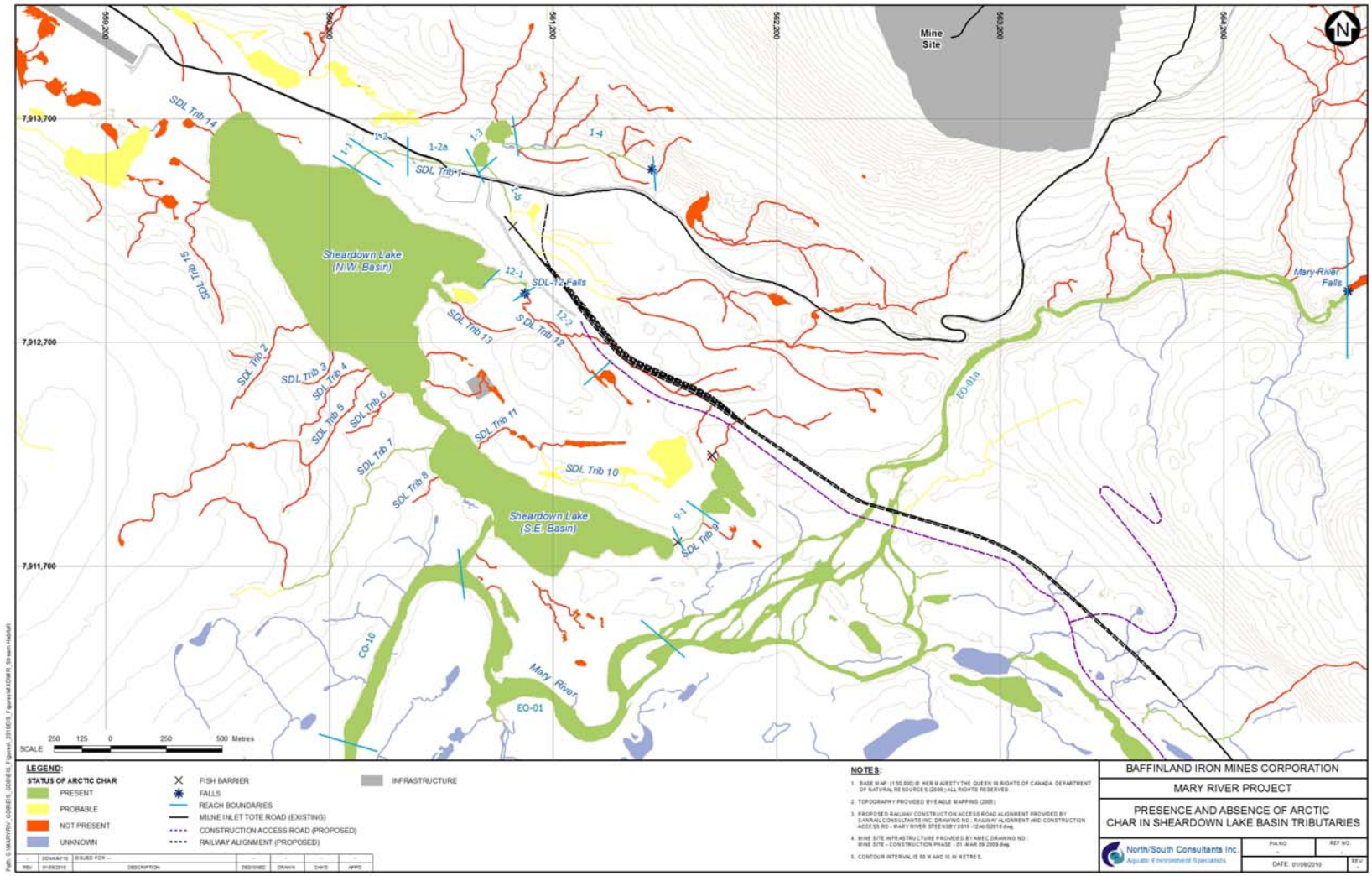

Figure 4.4-36. Map of Arctic char distribution, by reach, in Sheardown Lake inflows.

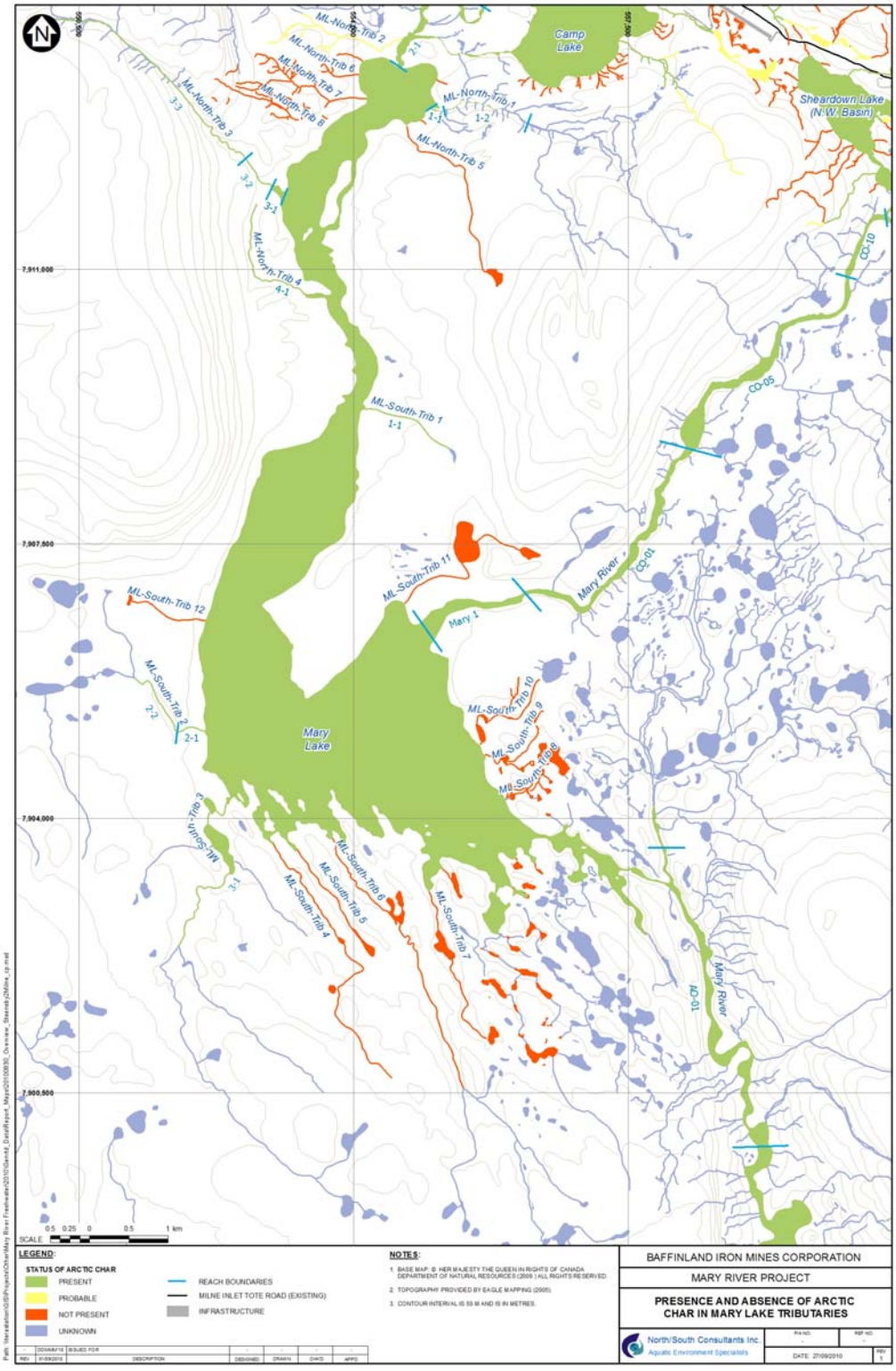

Figure 4.4-37. Map of Arctic char distribution, by reach, in Mary Lake inflows.

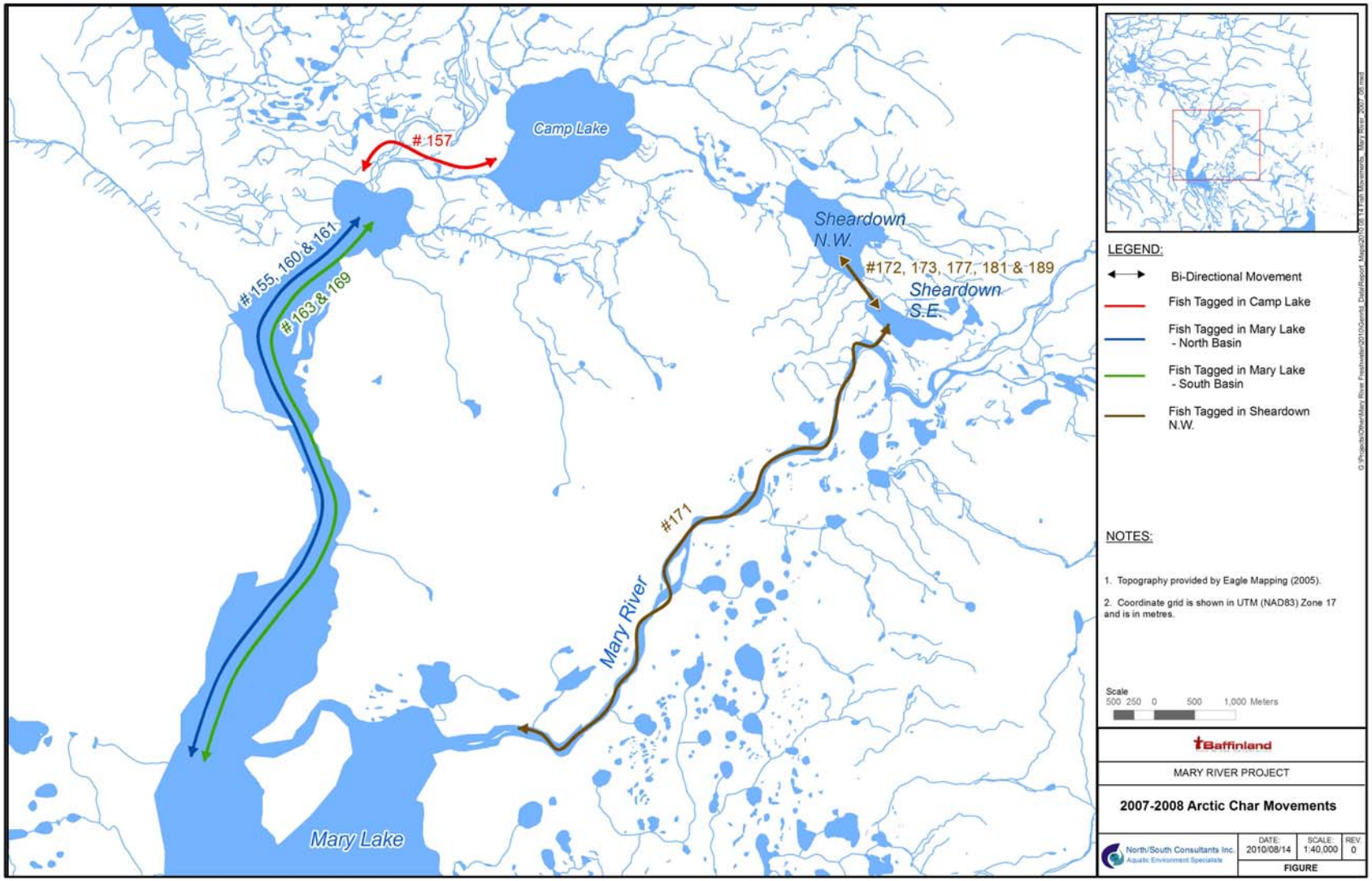

Figure 4.4-38. Movements of Arctic char marked with acoustic tags in the Mine Area, 2007-2008.

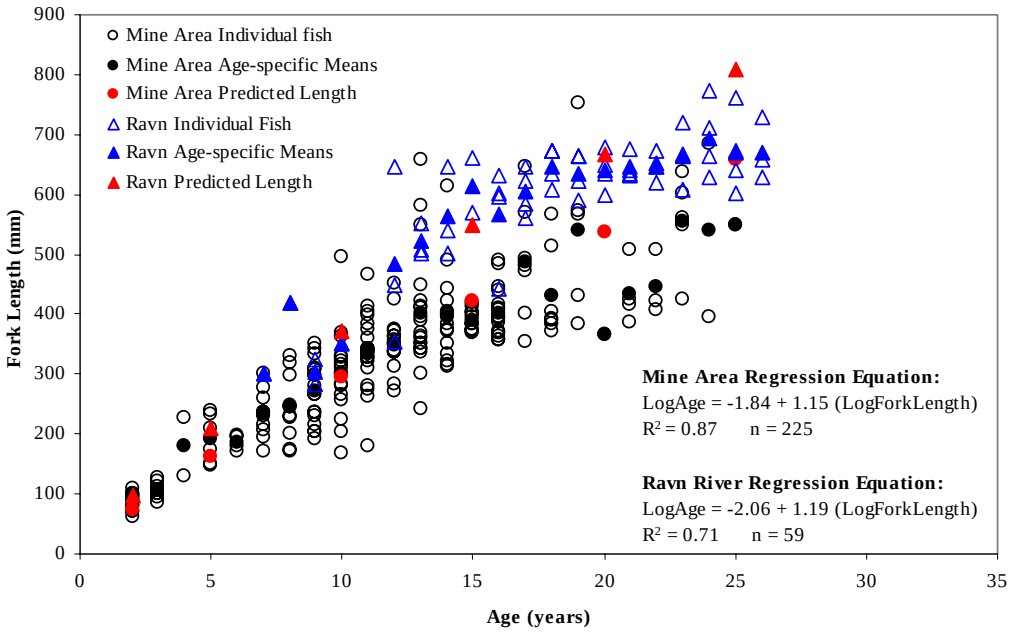

Figure 4.4-39. Age-length relationship for Arctic char captured during fish population investigations in the Mine Area, 2006-2008, compared with data collected from the Ravn River, 1985-86. Red dots and triangles represent the fork lengths predicted from the age-length regression equations for each data set.

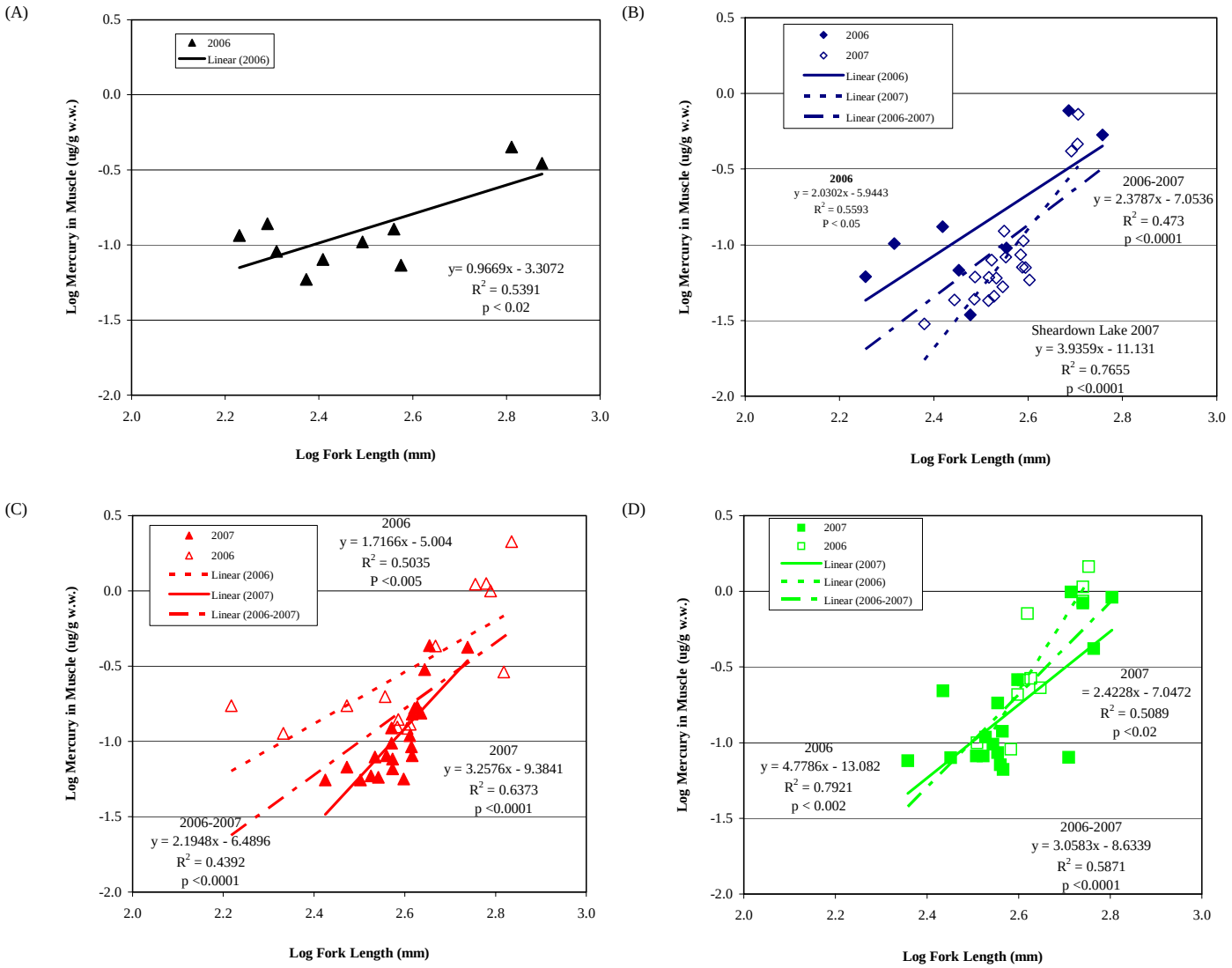

Figure 4.5-1. Regressions between fork length and mercury in muscle tissue of Arctic char from Mine Area lakes: (A) Camp Lake; (B) Sheardown Lake; (C) Mary Lake; and (D) Angajurjualuk Lake.

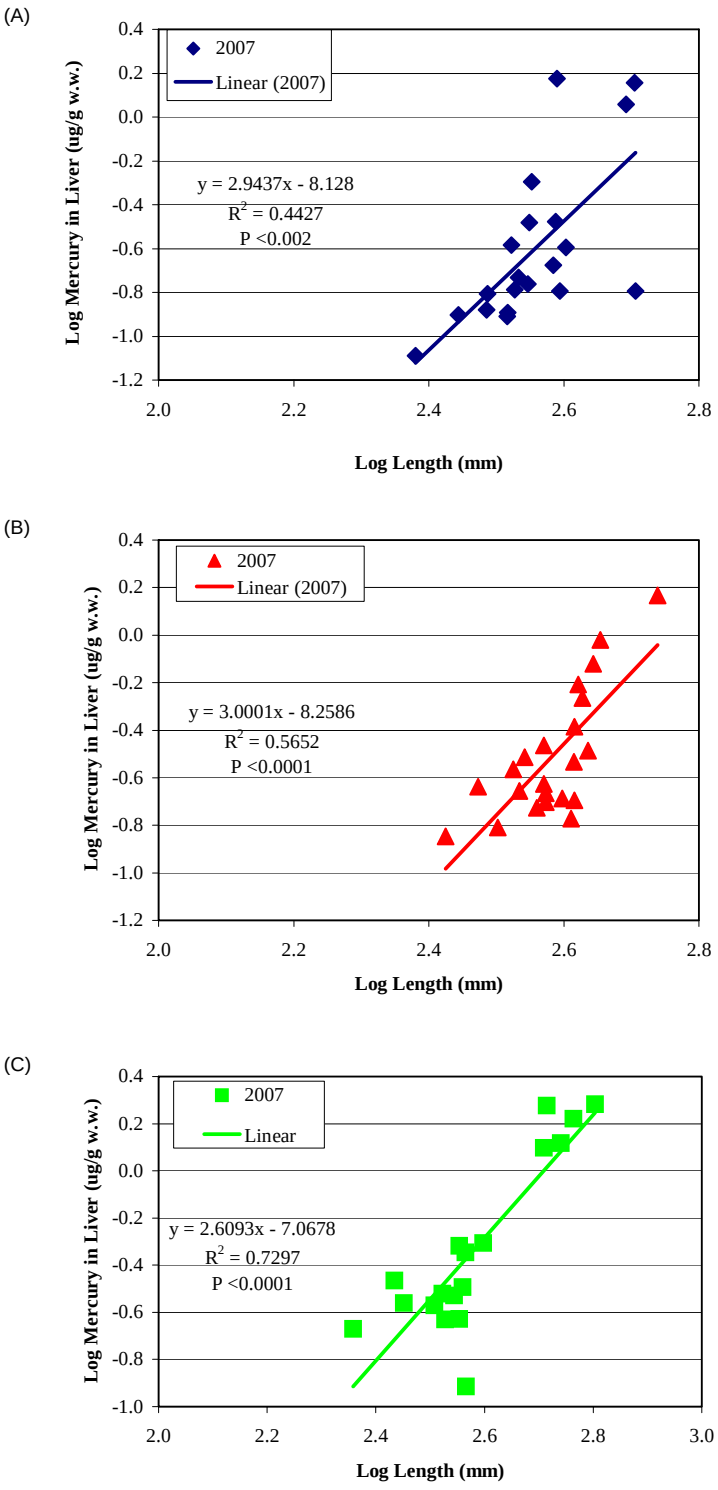

Figure 4.5-2. Regressions between fork length and mercury in liver tissue of Arctic char from Mine Area lakes: (A) Sheardown Lake; (B) Mary Lake; and (C) Angajurjualuk Lake.

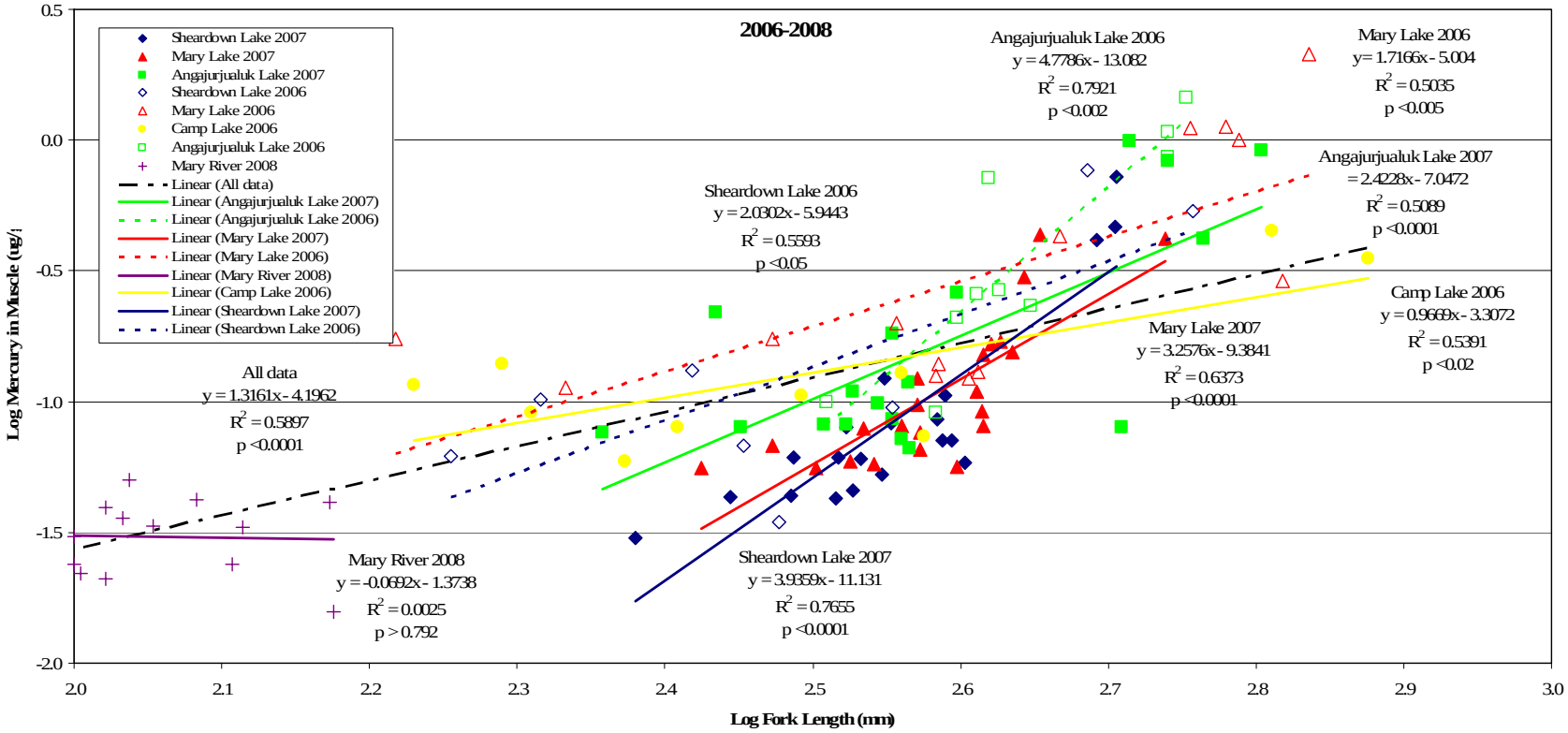

Figure 4.5-3. Regressions between fork length and mercury in muscle tissue of Arctic char from Mine Area lakes and the Mary River.

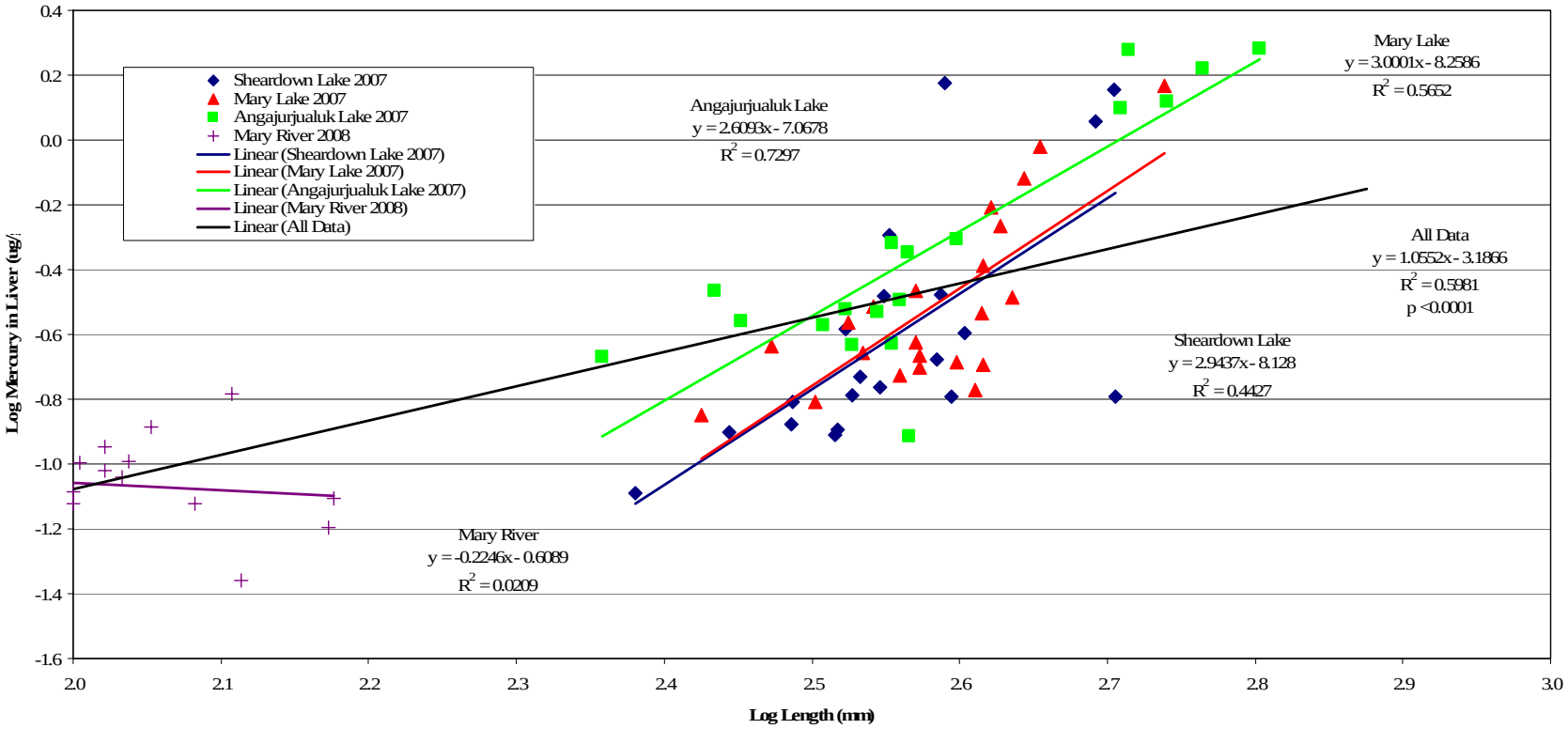

Figure 4.5-4. Regressions between fork length and mercury in liver tissue of Arctic char from Mine Area lakes and the Mary River.

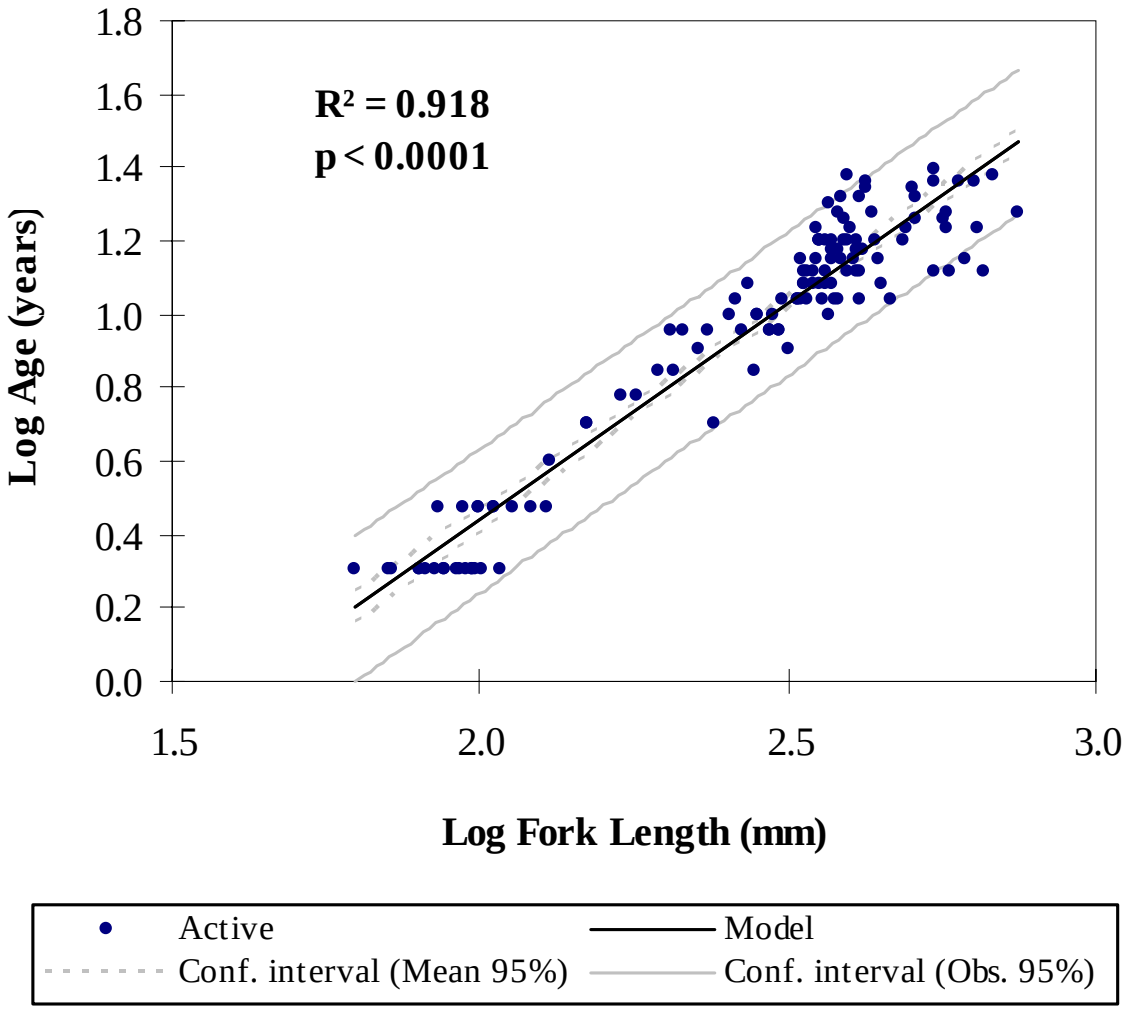

Figure 4.5-5. Regression between Arctic char fork length and age.

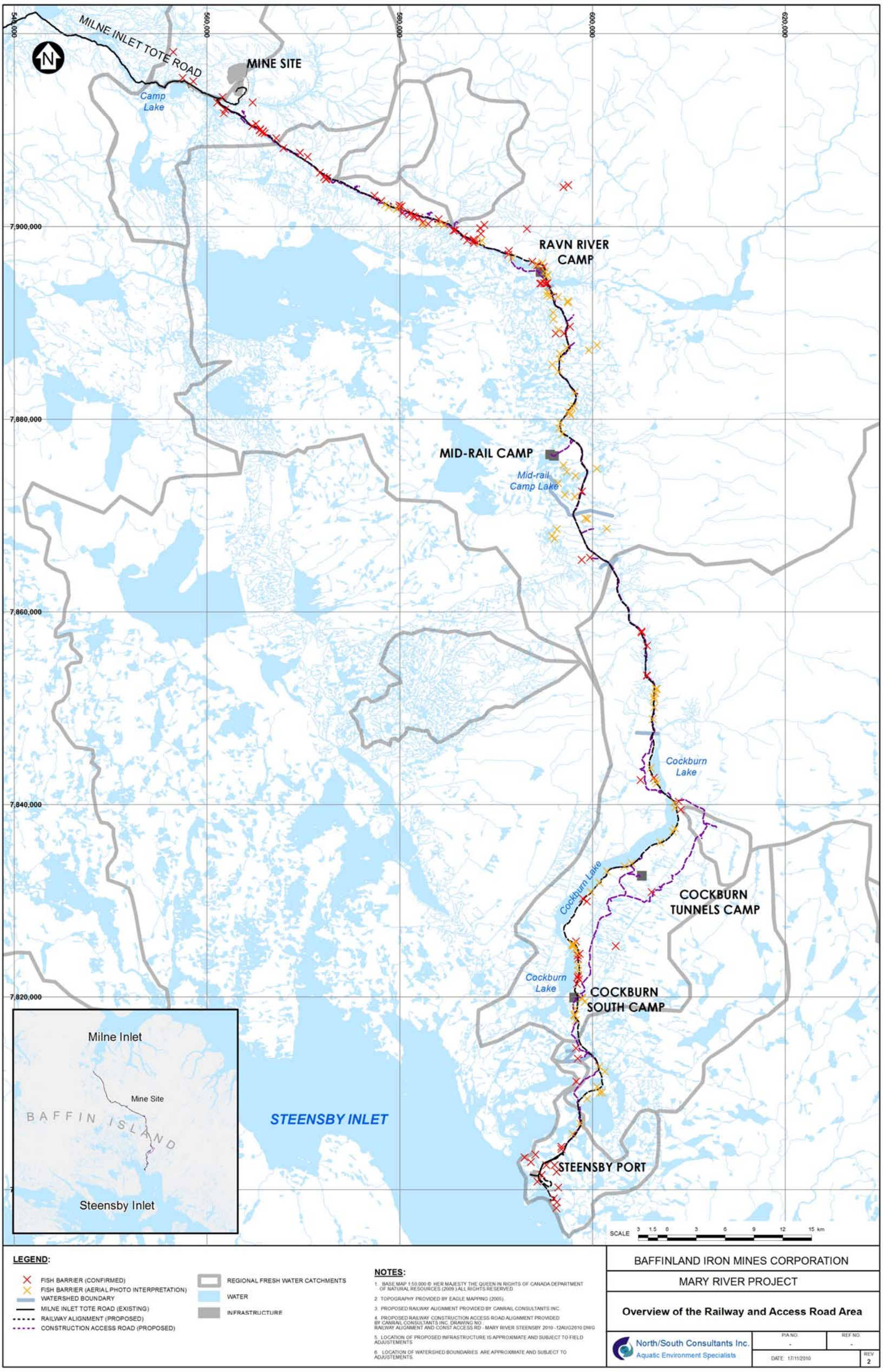

Figure 5-1. Overview of the entire Railway/Access Road Area, including the location of proposed camps.

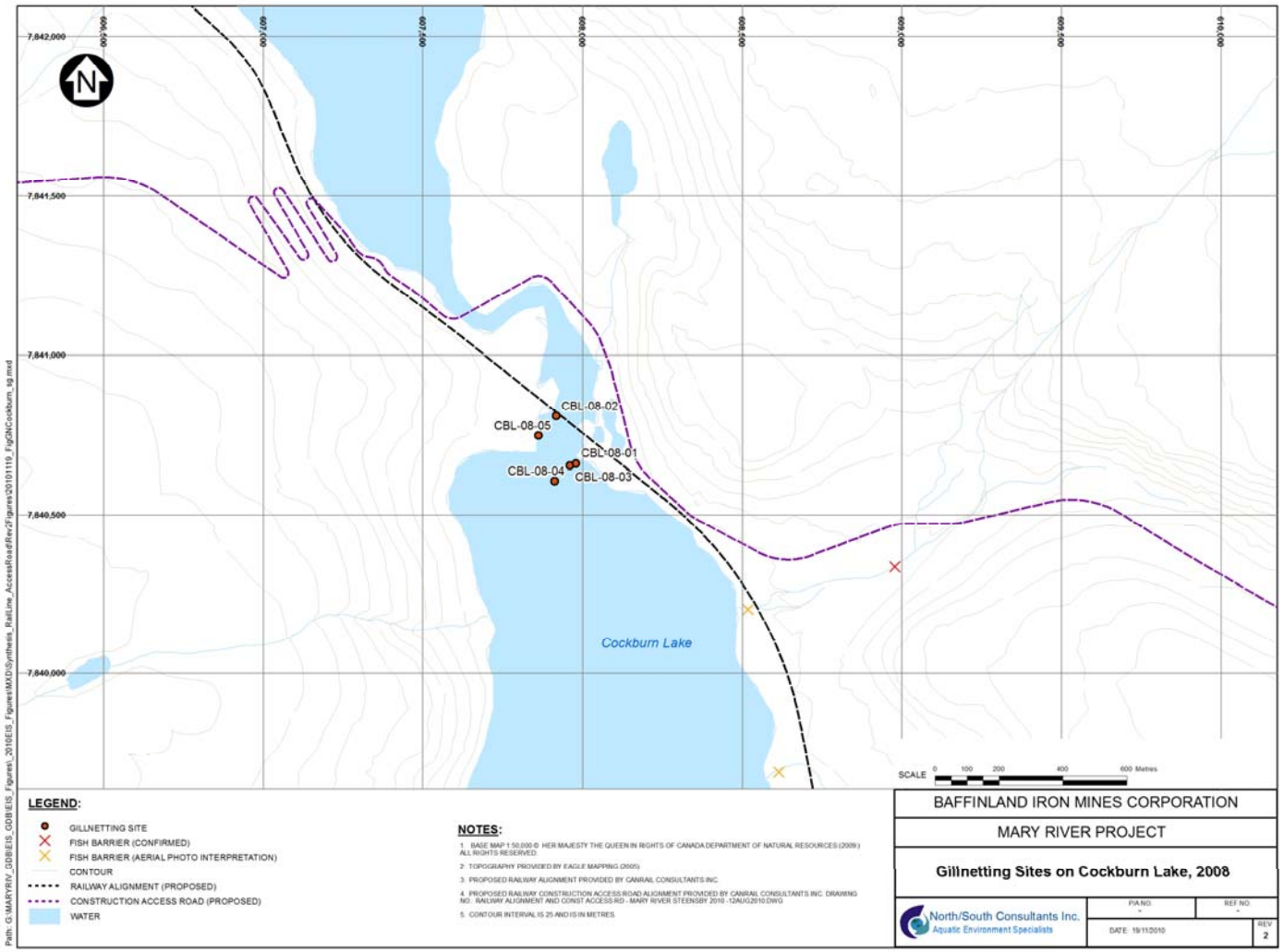

Figure 5.1-1. Location of gillnetting sites in the vicinity of the railway crossing of Cockburn Lake during fall, 2008.

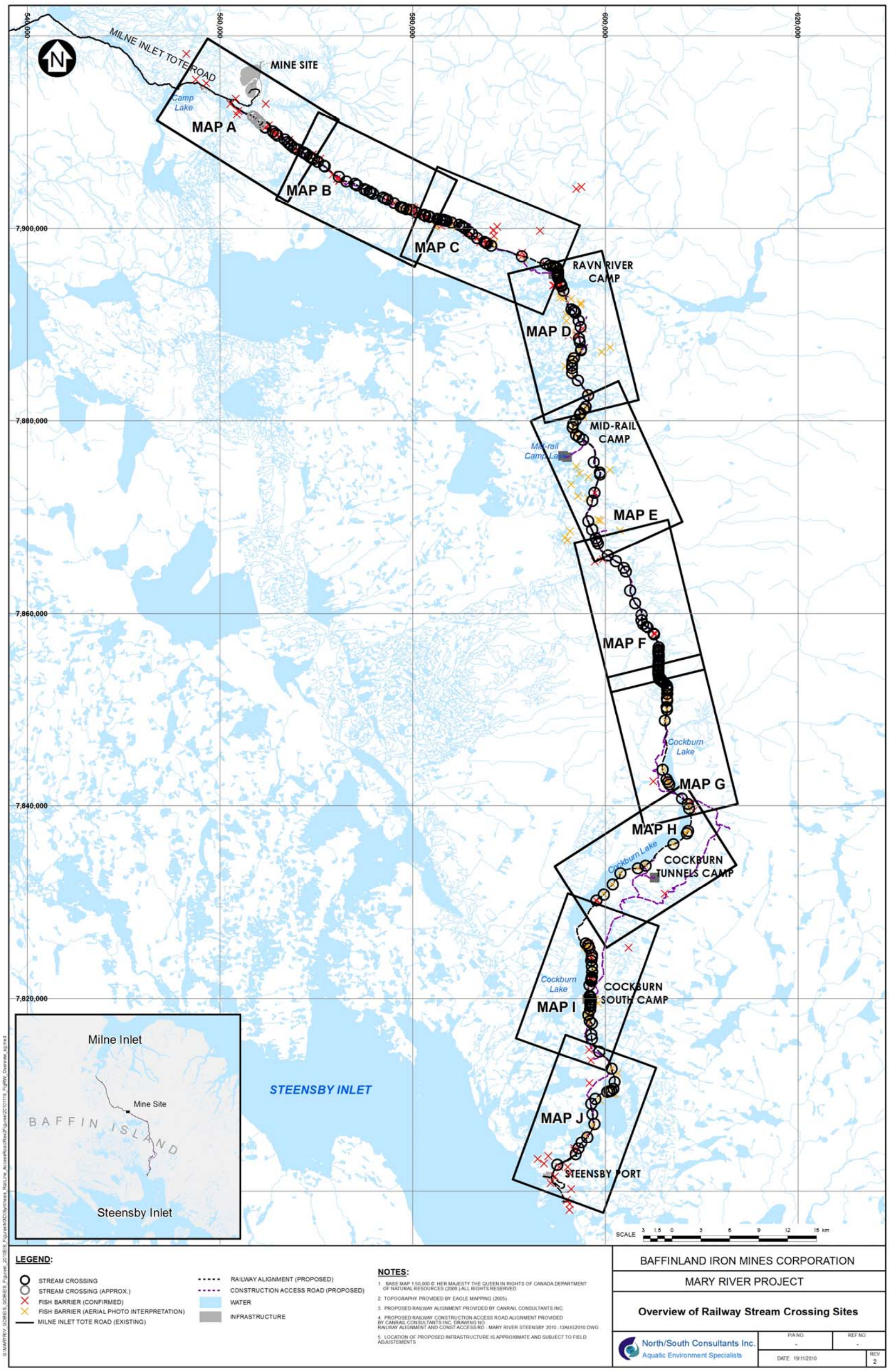

Figure 5.1-2. Overview map of all railway crossings between the Mine Area and Steensby Port.

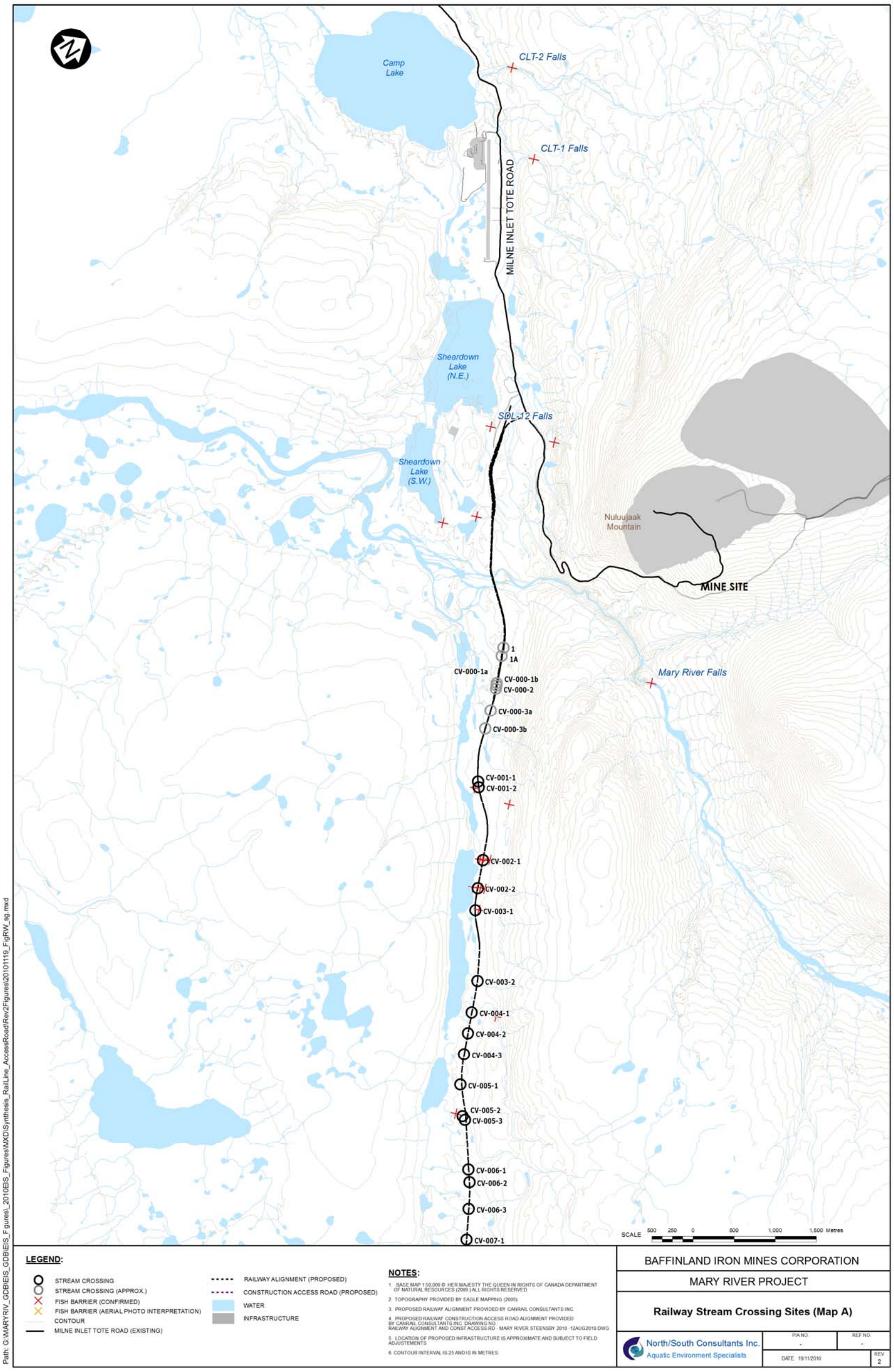

Figure 5.1-3. Detailed map of the first segment of stream crossings (Map A) along the railway alignment.

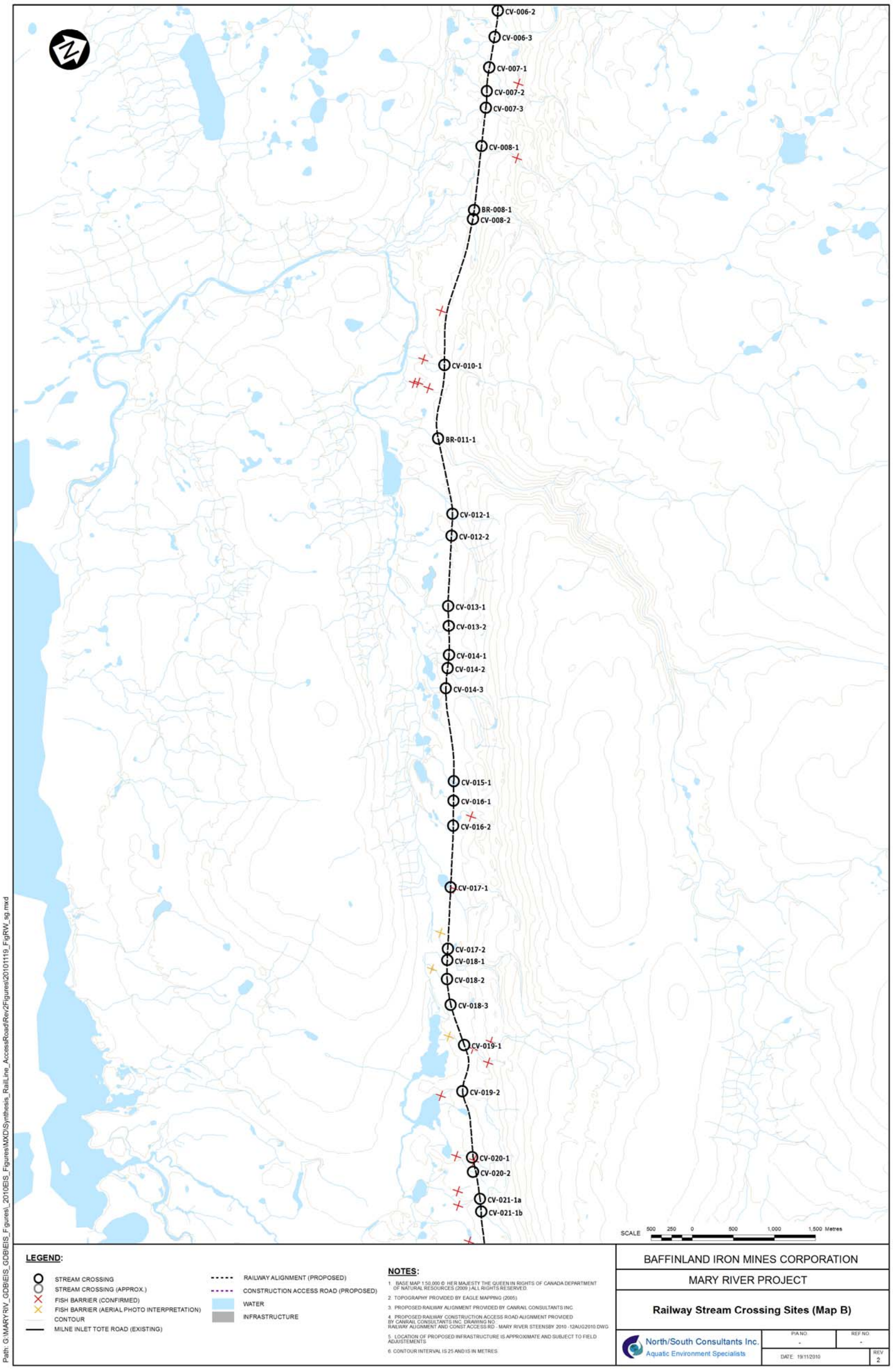

Figure 5.1-4. Detailed map of the second segment of stream crossings (Map B) along the railway alignment.

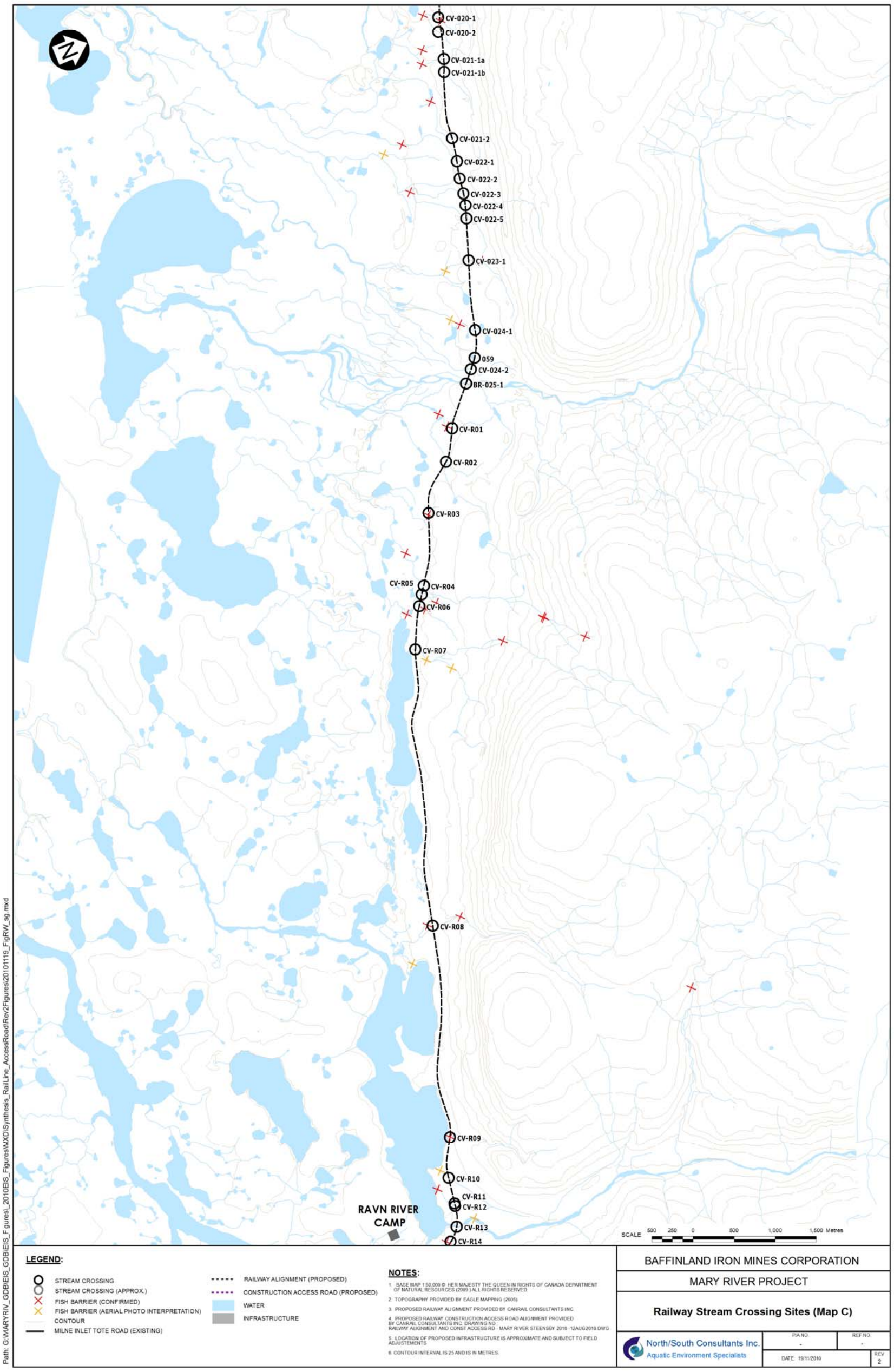

Figure 5.1-5. Detailed map of the third segment of stream crossings (Map C) along the railway alignment.

Figure 5.1-6. Detailed map of the fourth segment of stream crossings (Map D) along the railway alignment.

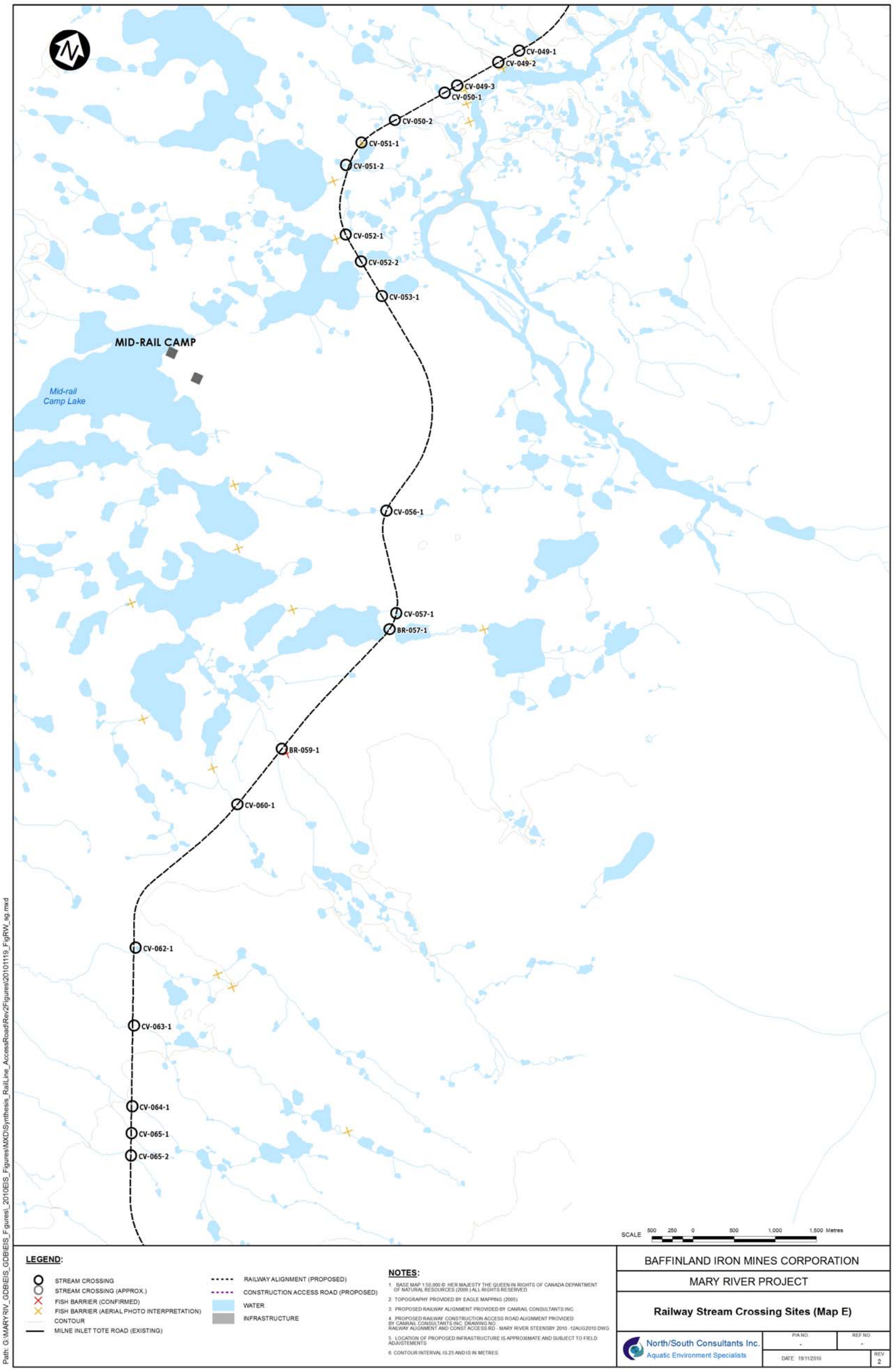

Figure 5.1-7. Detailed map of the fifth segment of stream crossings (Map E) along the railway alignment.

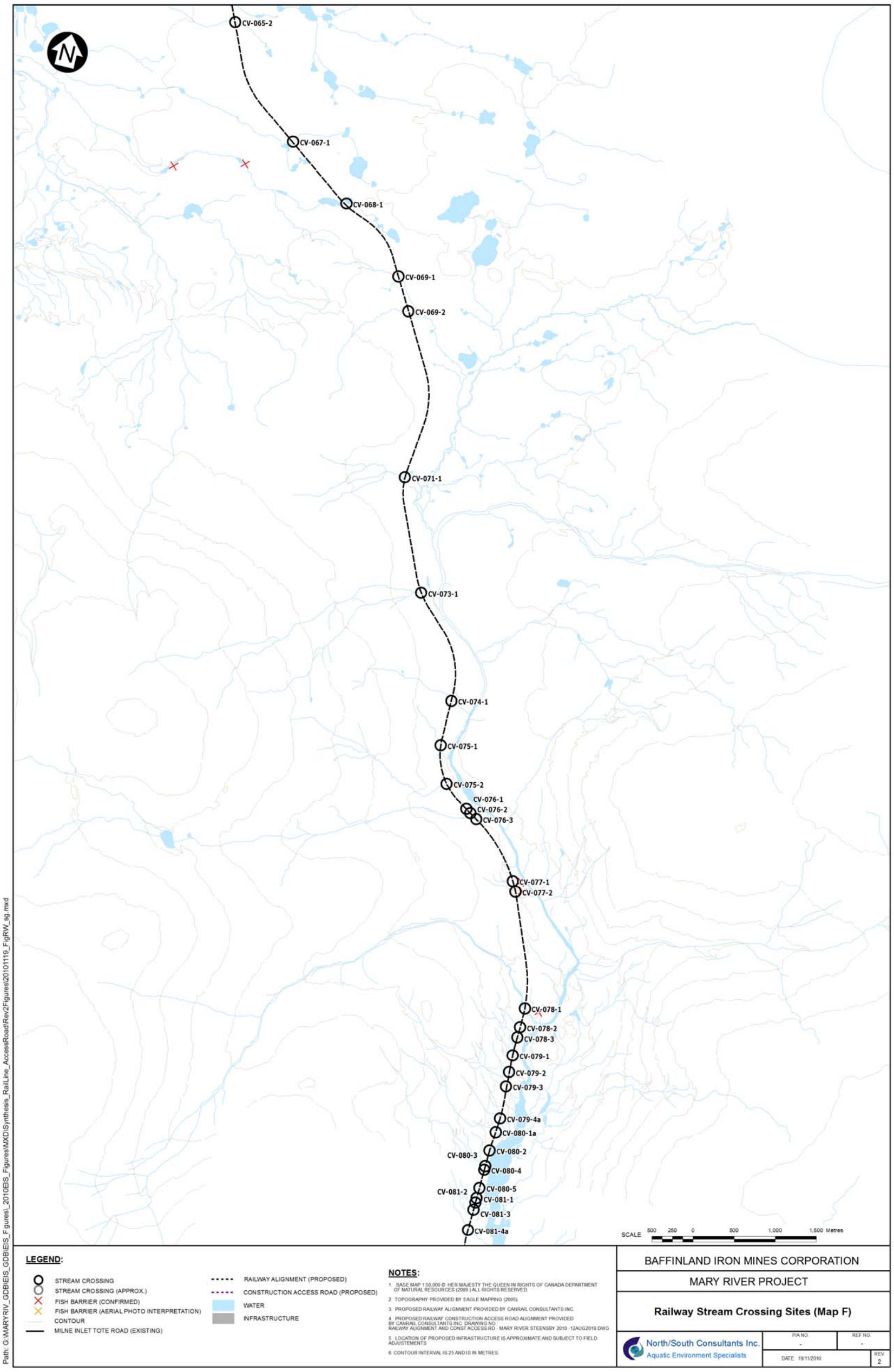

Figure 5.1-8. Detailed map of the sixth segment of stream crossings (Map F) along the railway alignment.

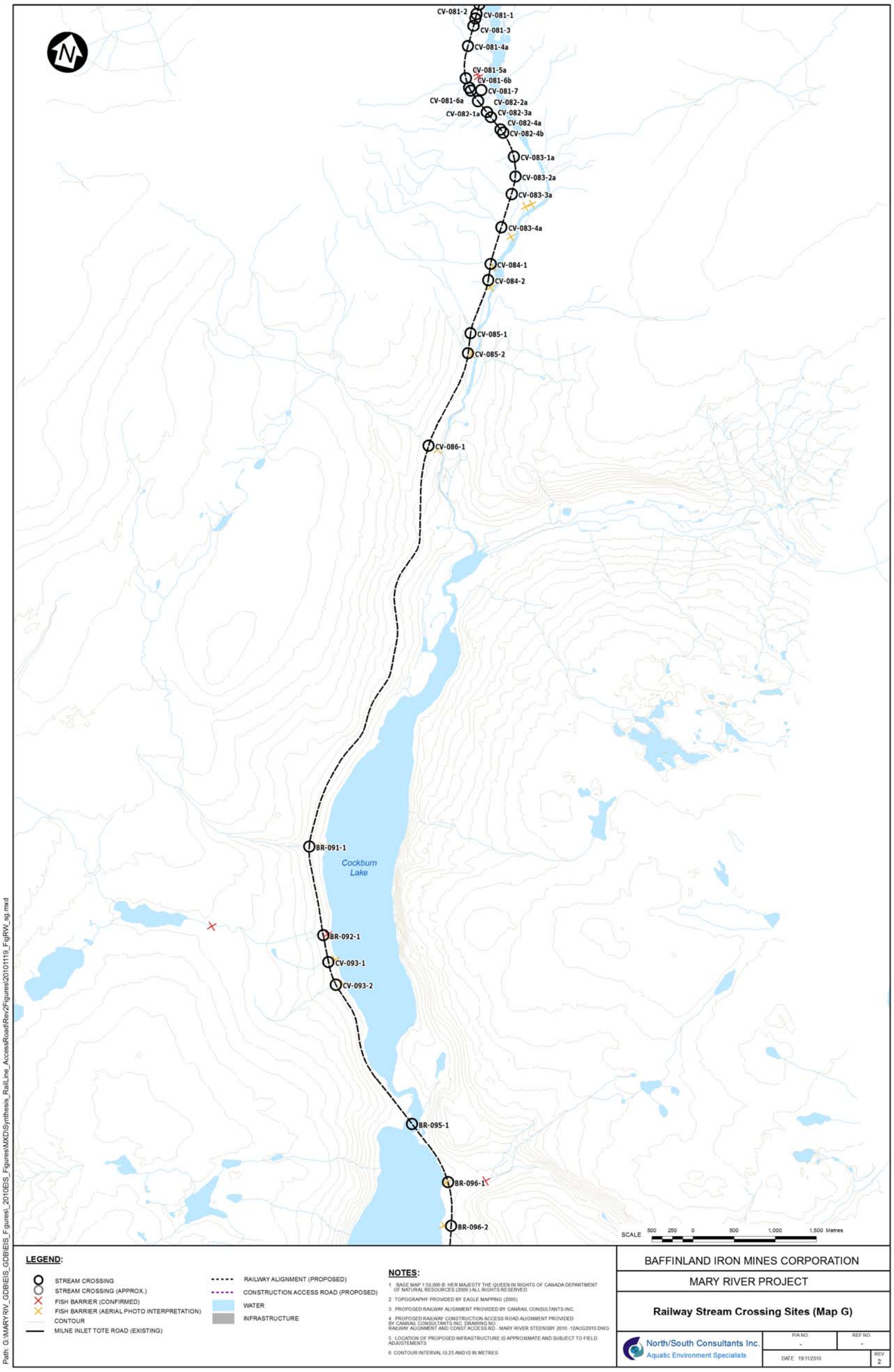

Figure 5.1-9. Detailed map of the seventh segment of stream crossings (Map G) along the railway alignment.

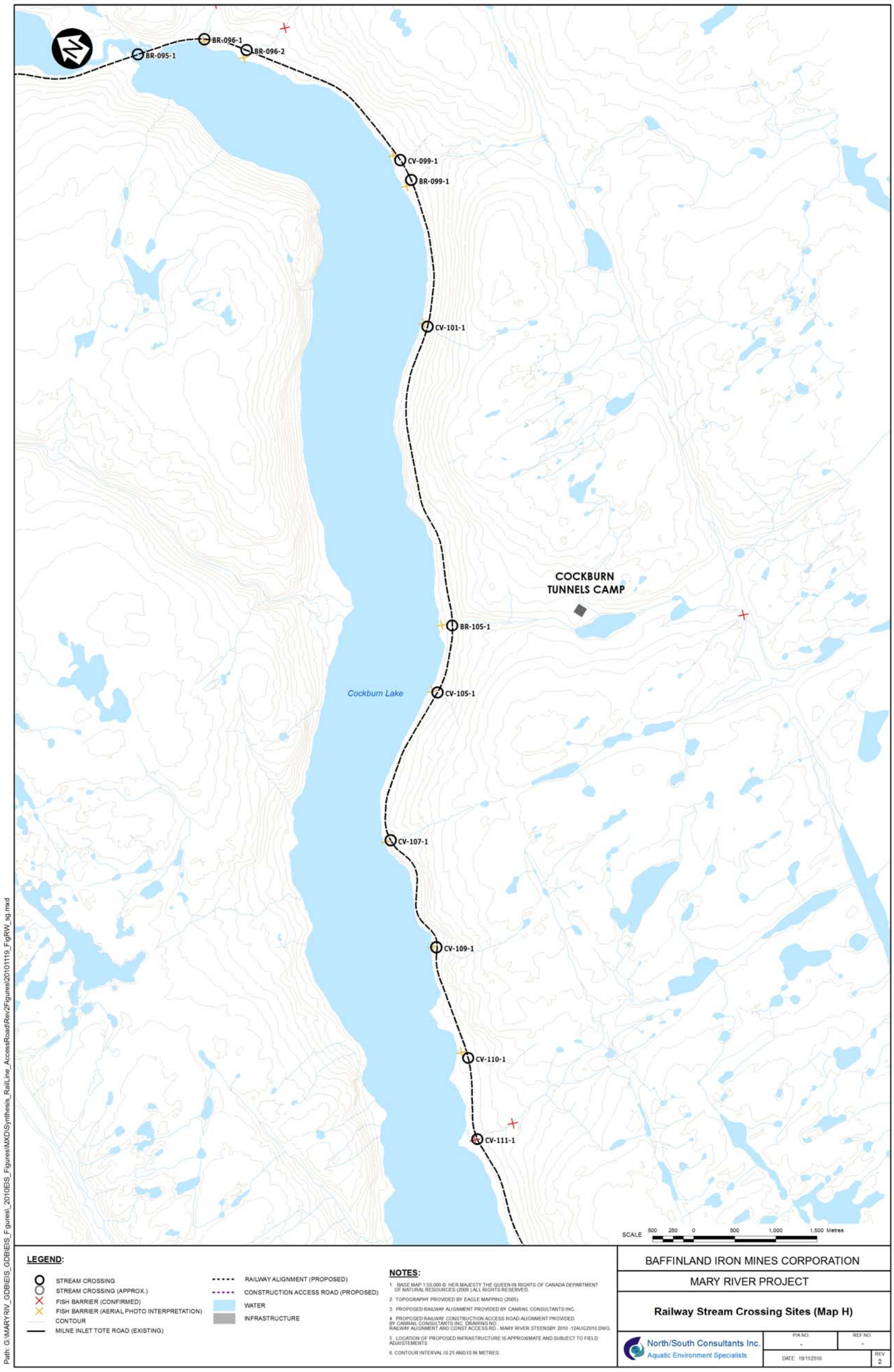

Figure 5.1-10. Detailed map of the eighth segment of stream crossings (Map H) along the railway alignment.

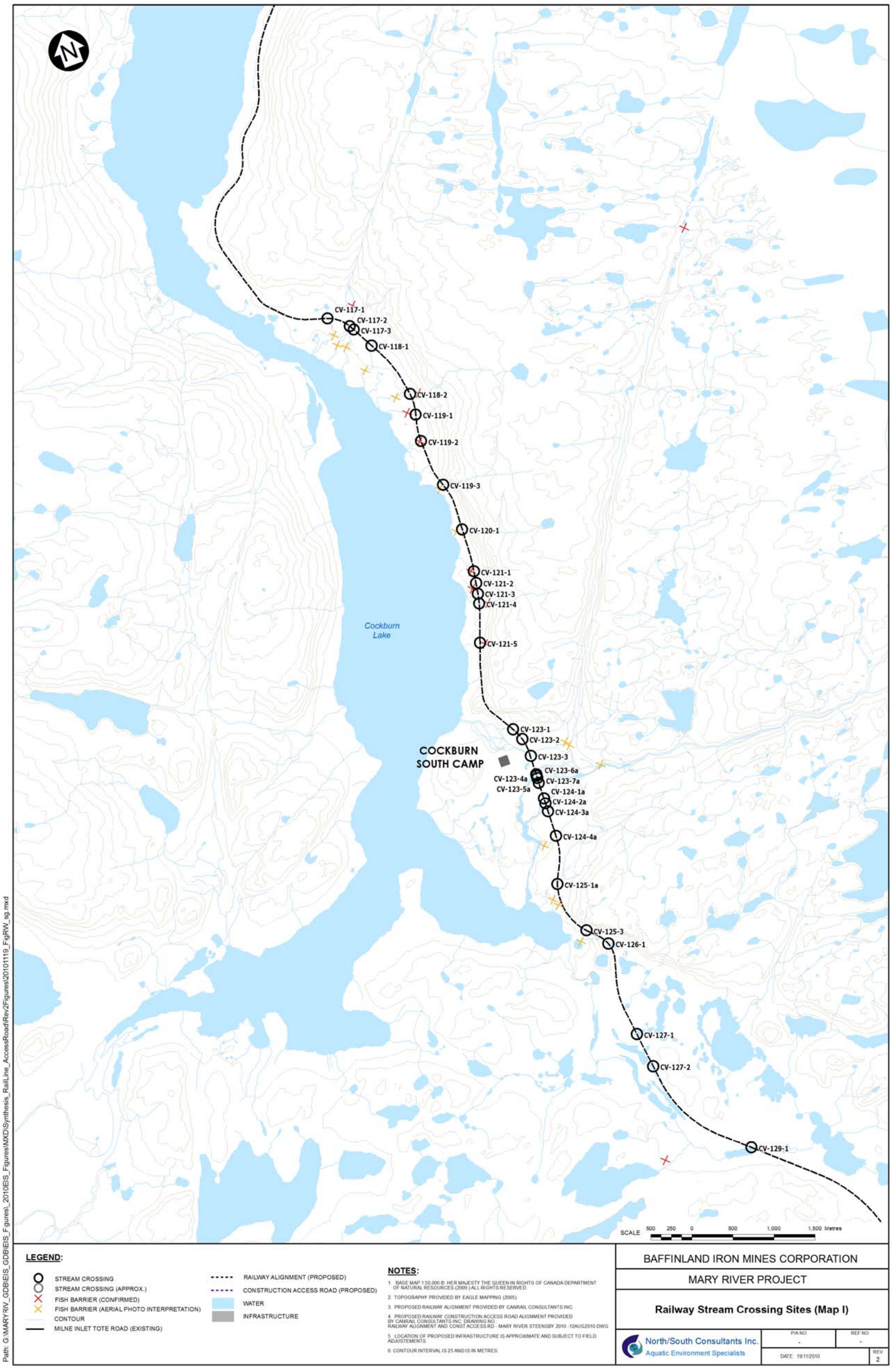

Figure 5.1-11. Detailed map of the ninth segment of stream crossings (Map I) along the railway alignment.

Figure 5.1-12. Detailed map of the tenth segment of stream crossings (Map J) along the railway alignment.

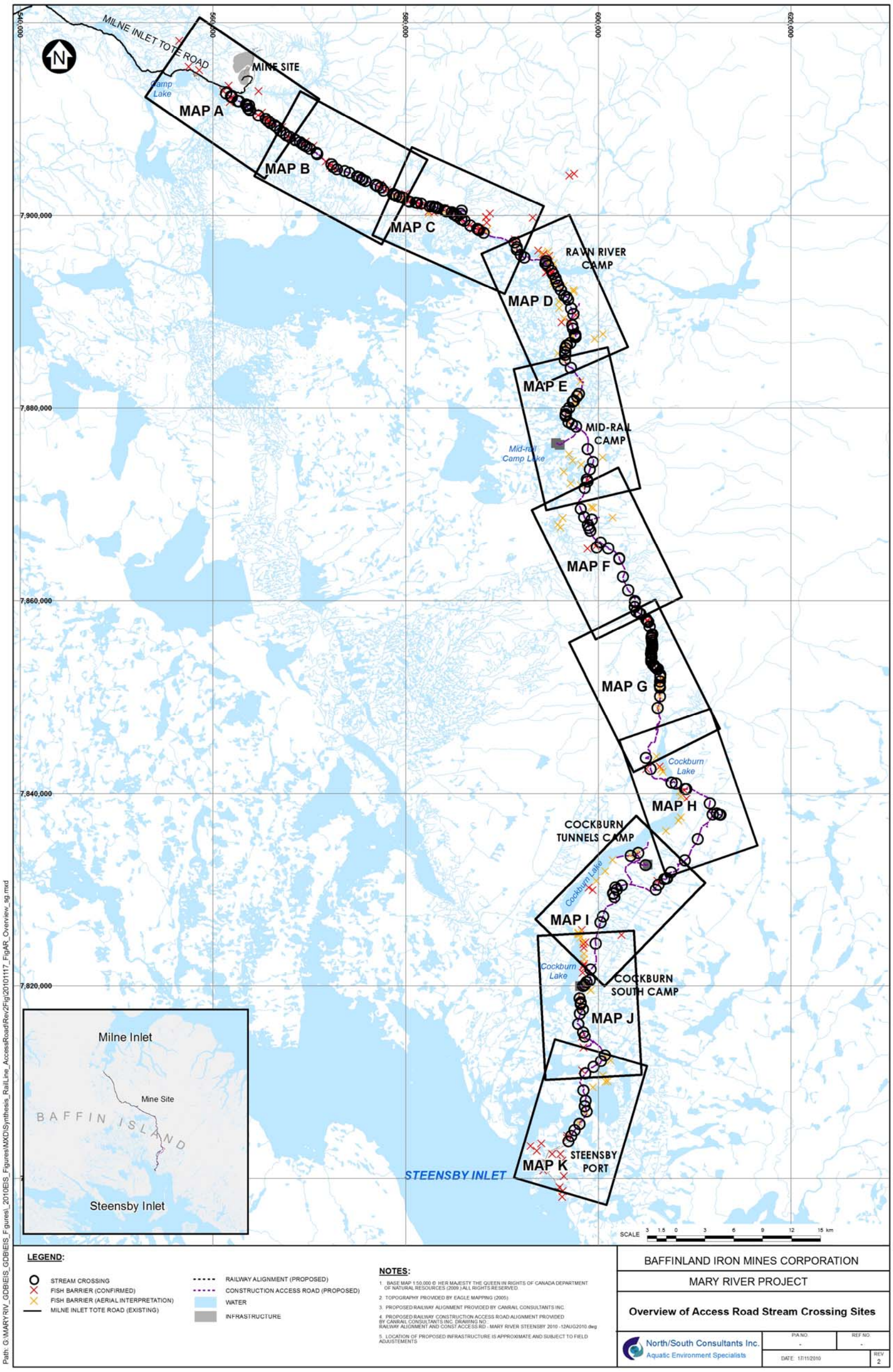

Figure 5.1-13. Overview map of all access road crossings between the Mine Area and Steensby Port.

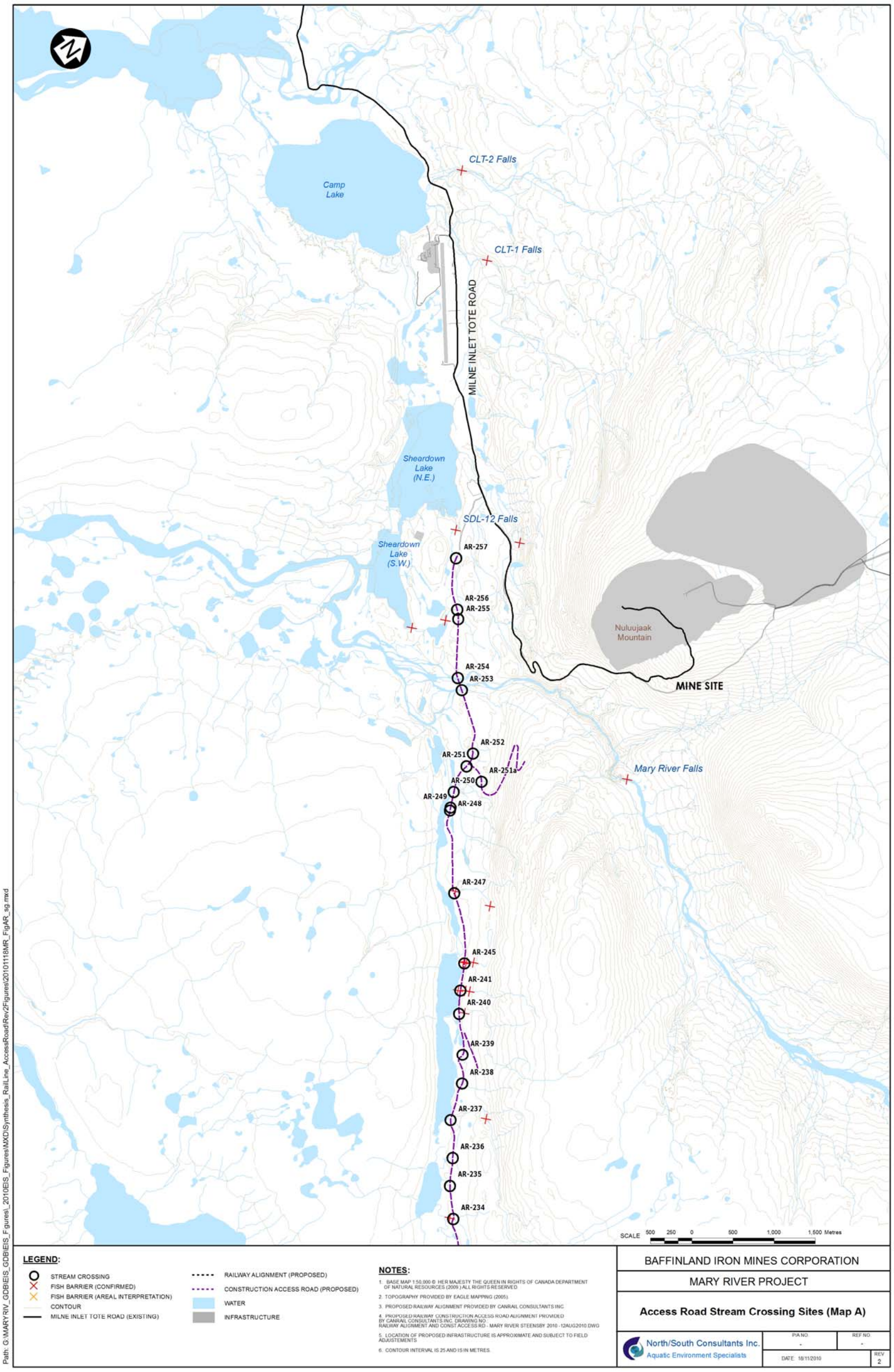

Figure 5.1-14. Detailed map of the first segment of stream crossings (Map A) along the access road alignment.

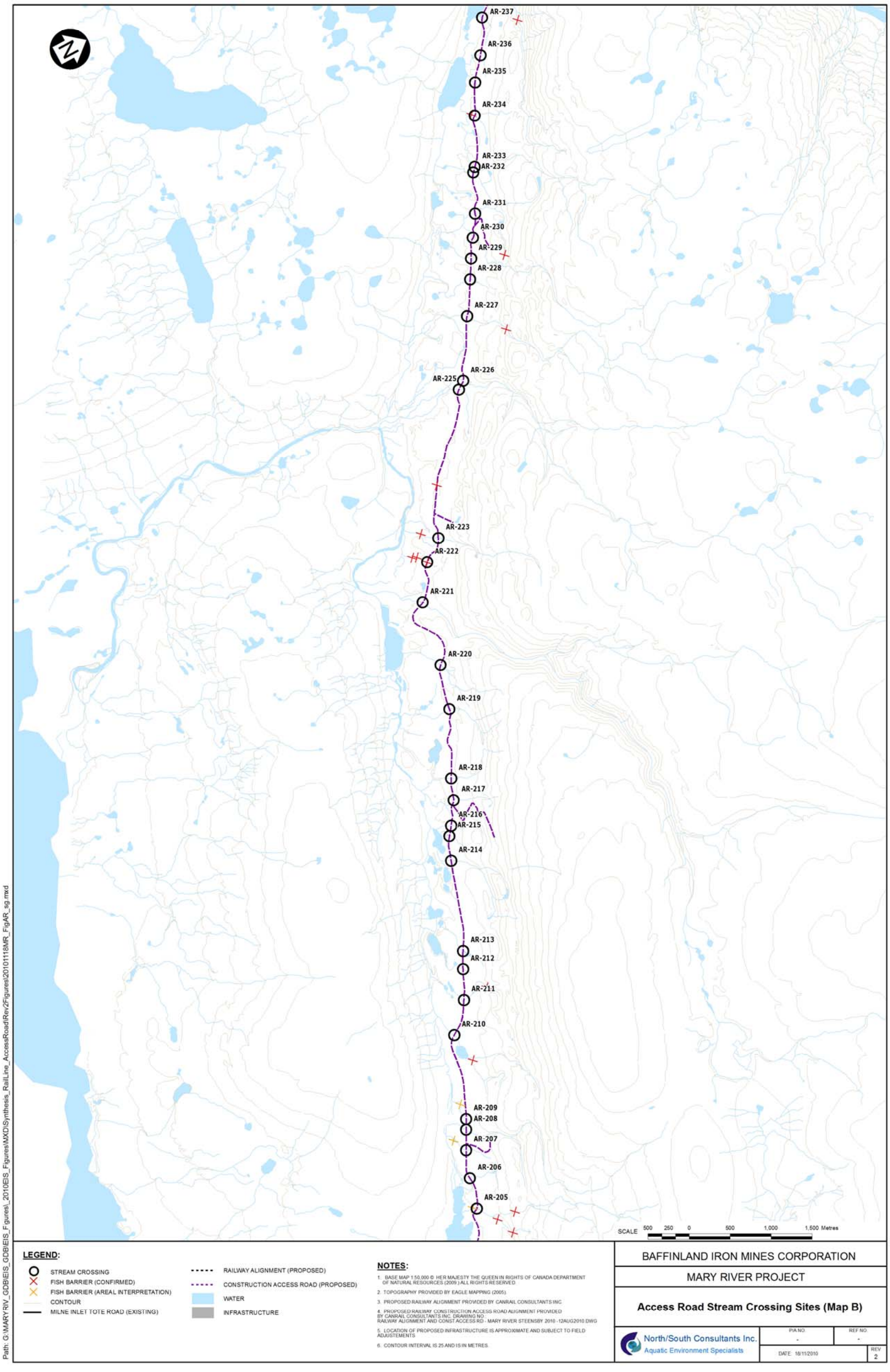

Figure 5.1-15. Detailed map of the second segment of stream crossings (Map B) along the access road alignment.

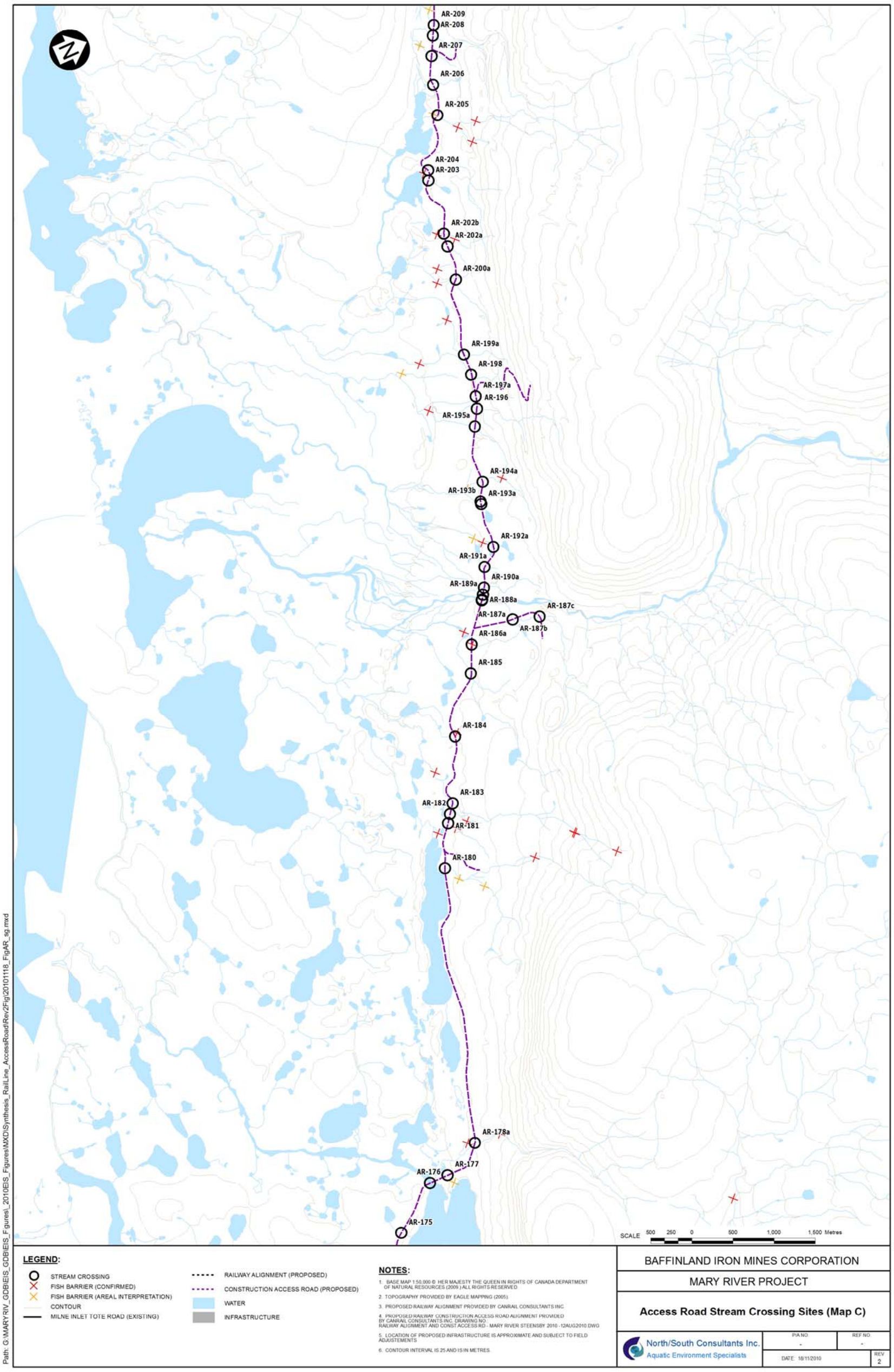

Figure 5.1-16. Detailed map of the third segment of stream crossings (Map C) along the access road alignment.

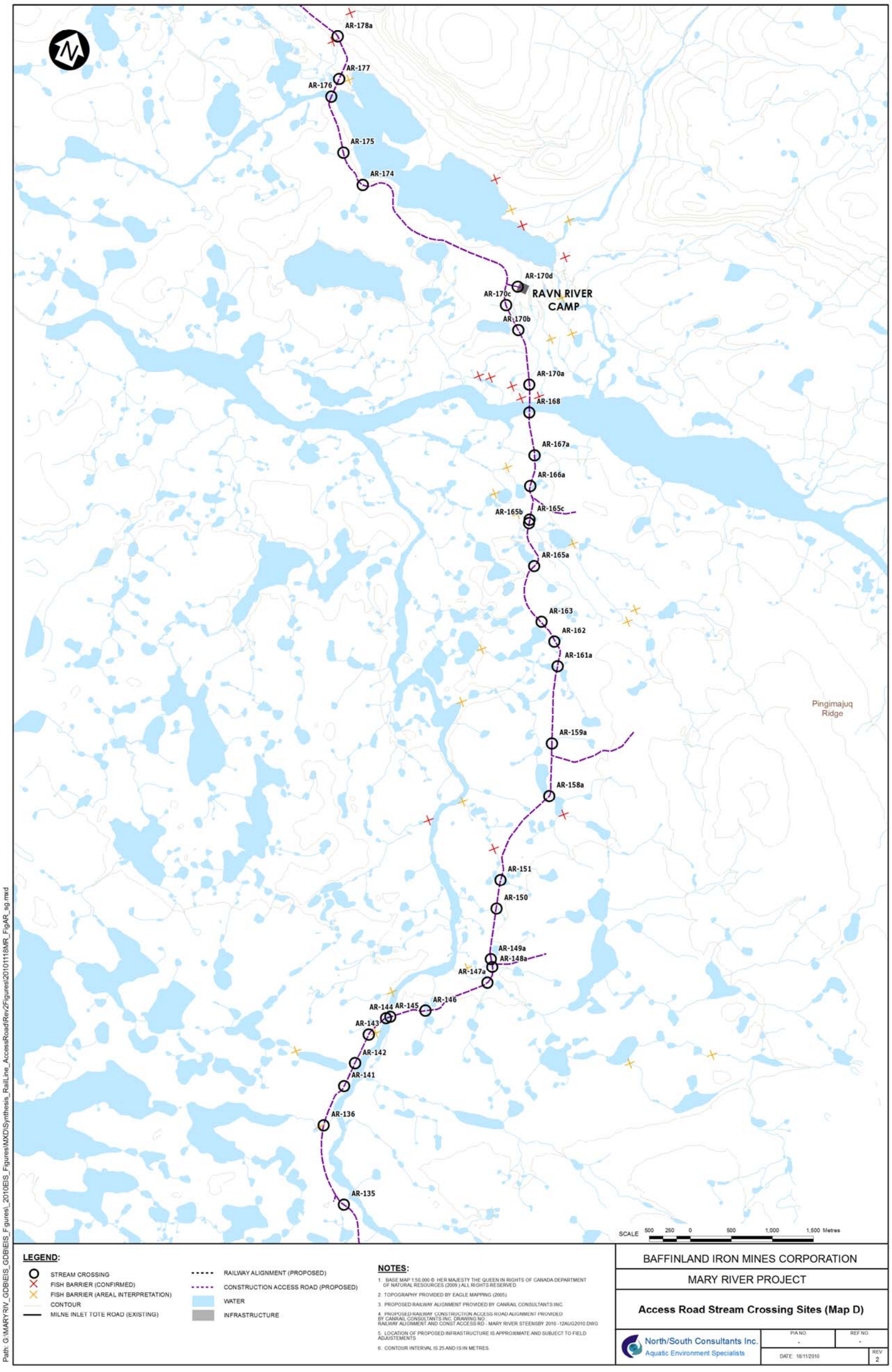

Figure 5.1-17. Detailed map of the fourth segment of stream crossings (Map D) along the access road alignment.

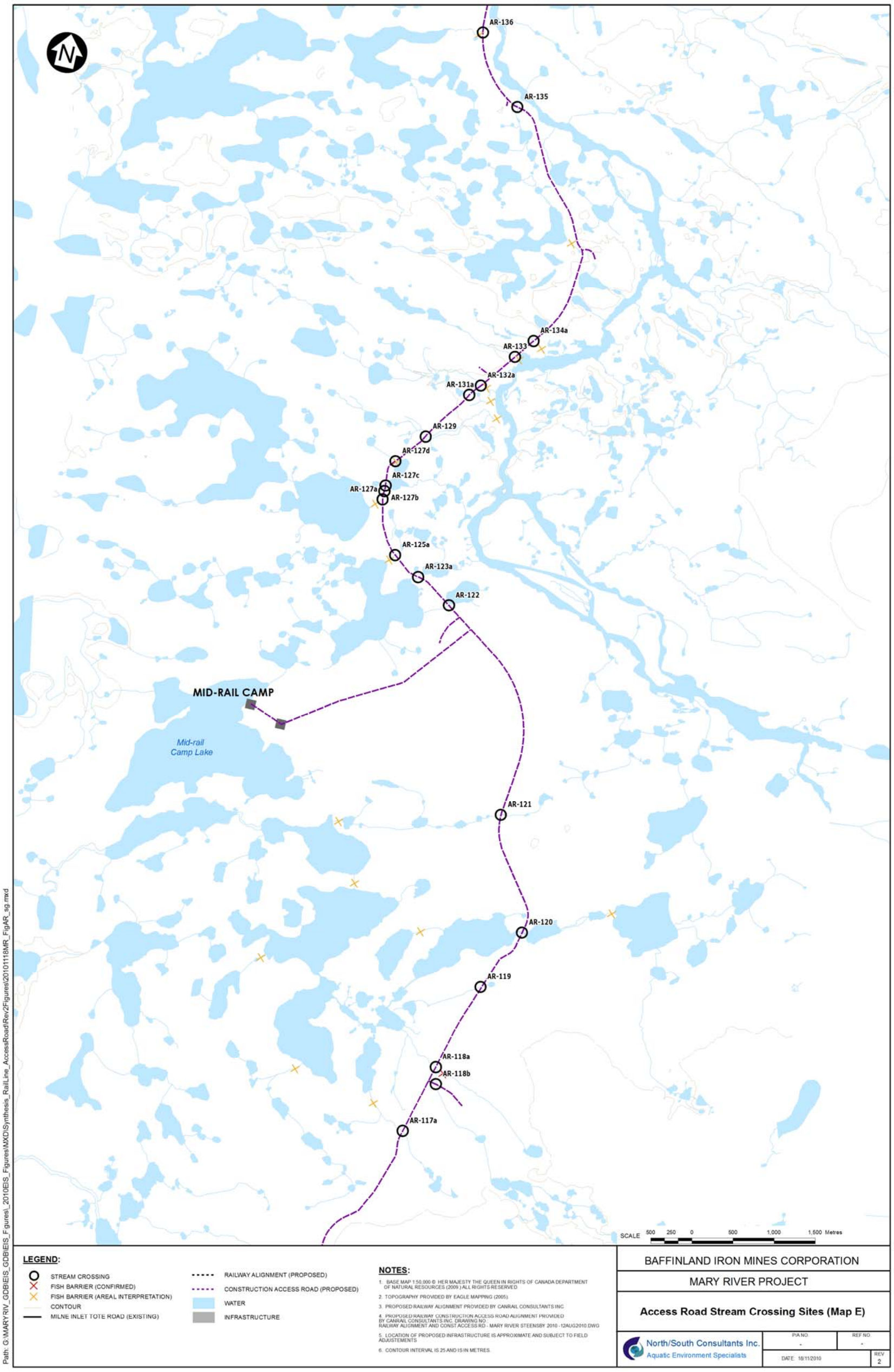

Figure 5.1-18. Detailed map of the fifth segment of stream crossings (Map E) along the access road alignment.

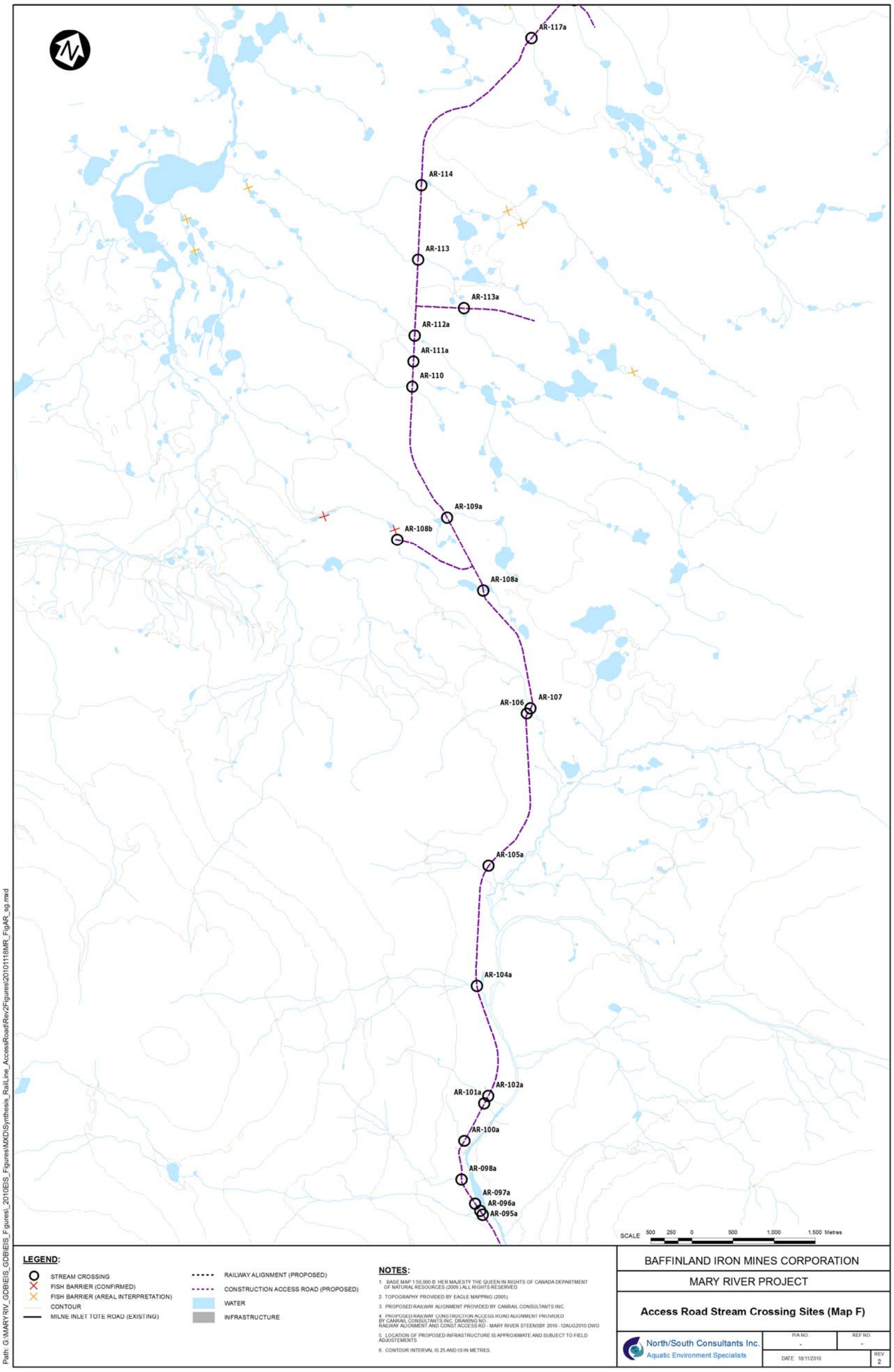

Figure 5.1-19. Detailed map of the sixth segment of stream crossings (Map F) along the access road alignment.

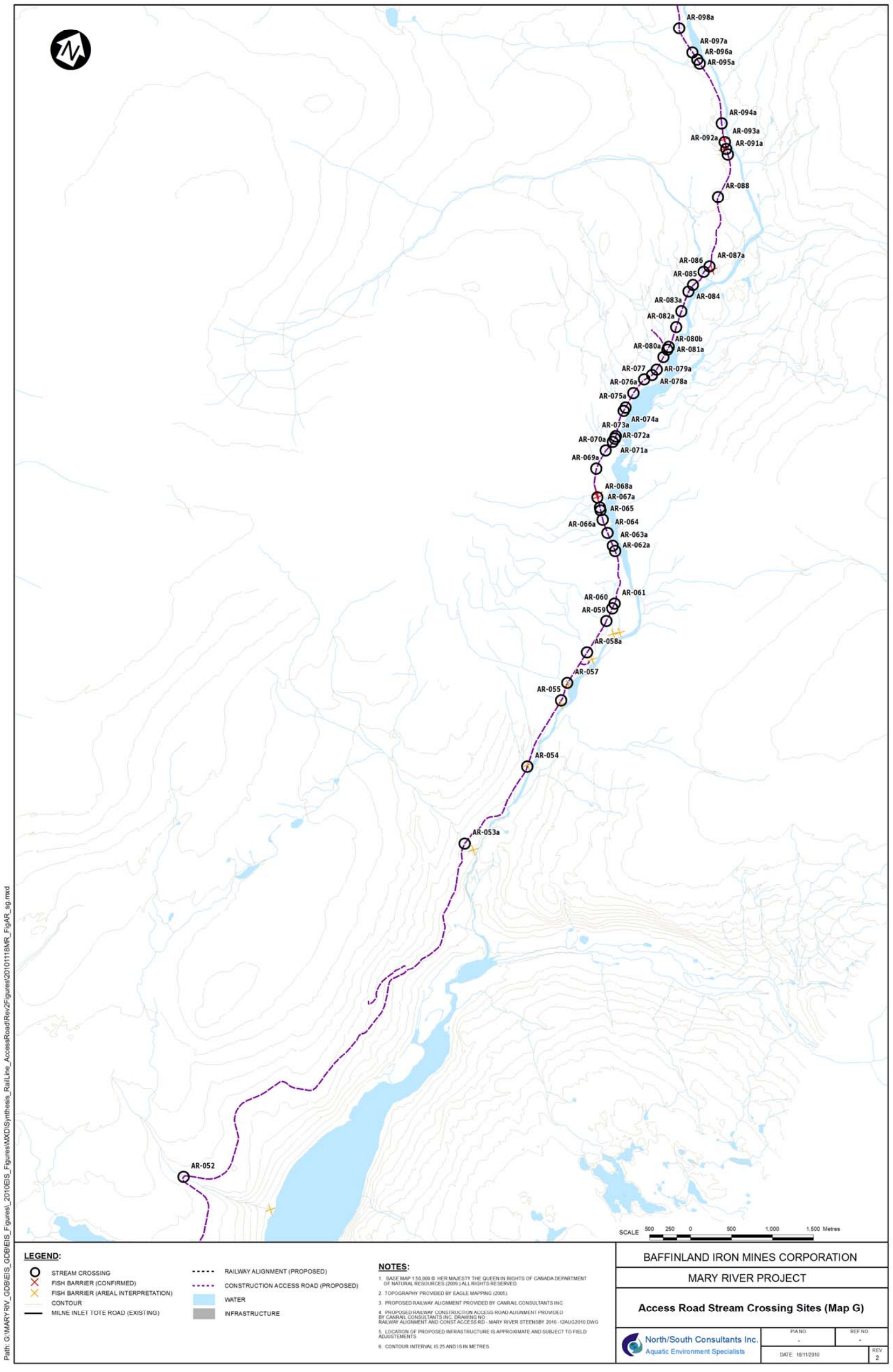

Figure 5.1-20. Detailed map of the seventh segment of stream crossings (Map G) along the access road alignment.

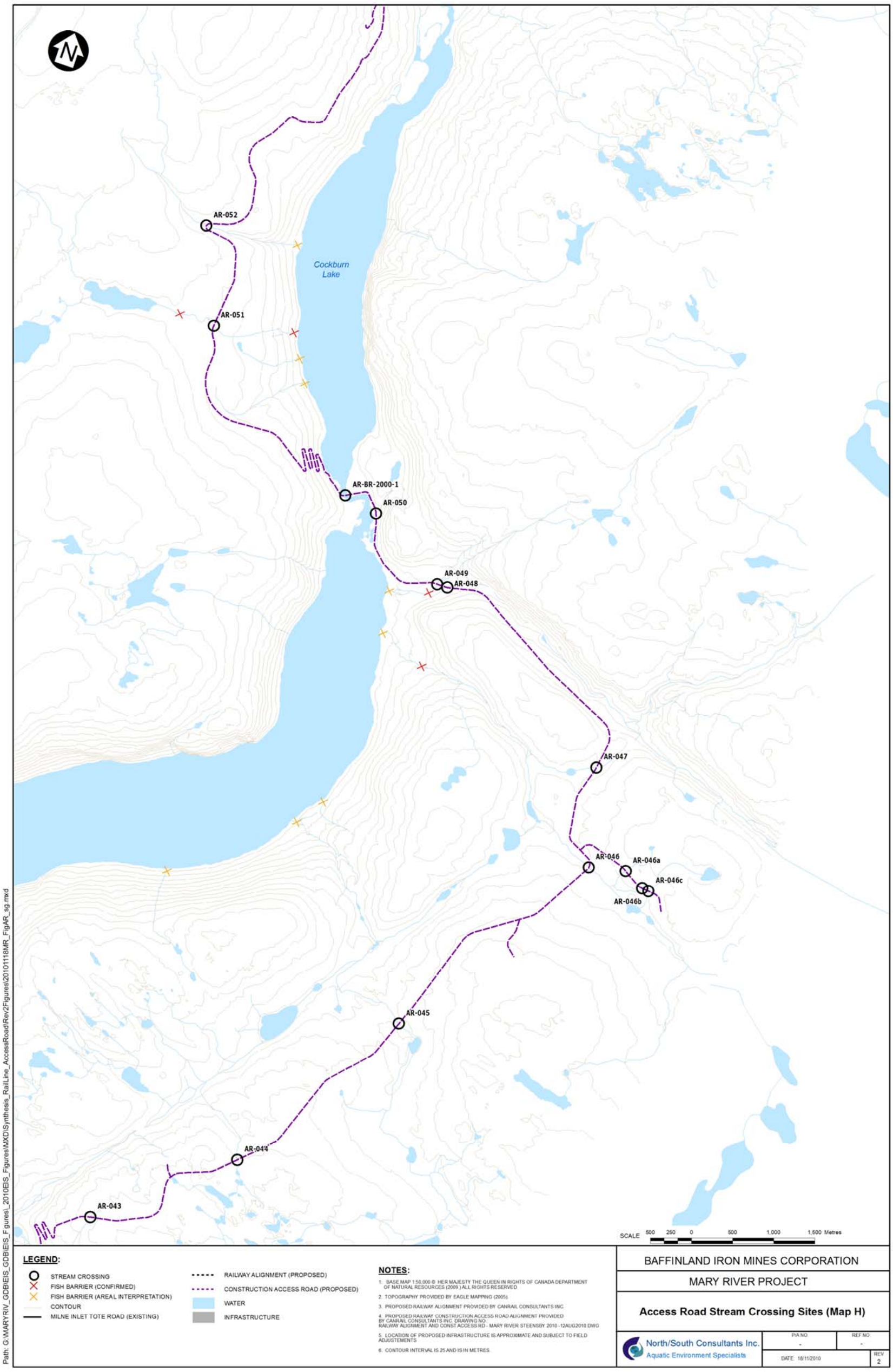

Figure 5.1-21. Detailed map of the eighth segment of stream crossings (Map H) along the access road alignment.

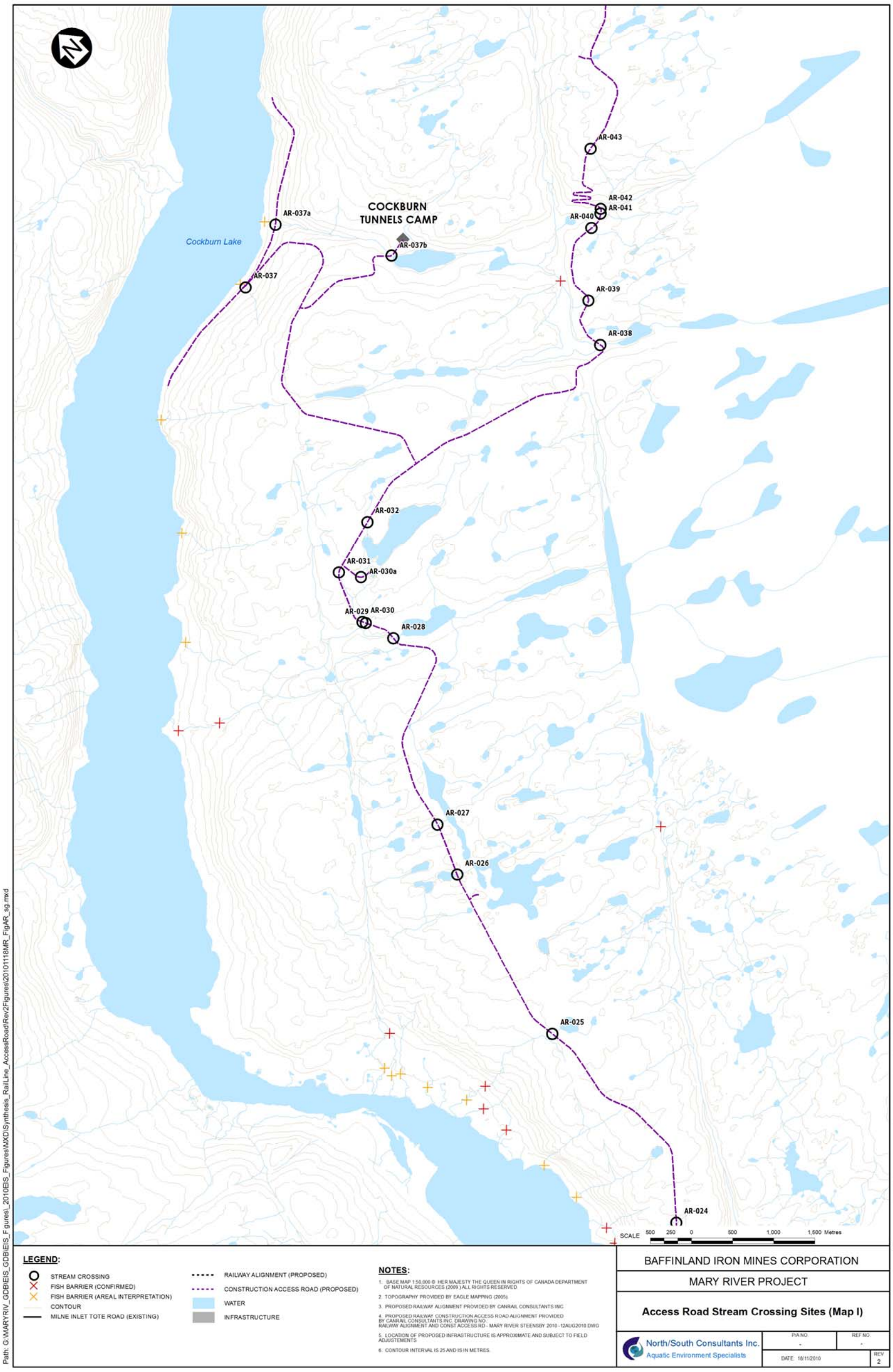

Figure 5.1-22. Detailed map of the ninth segment of stream crossings (Map I) along the access road alignment.

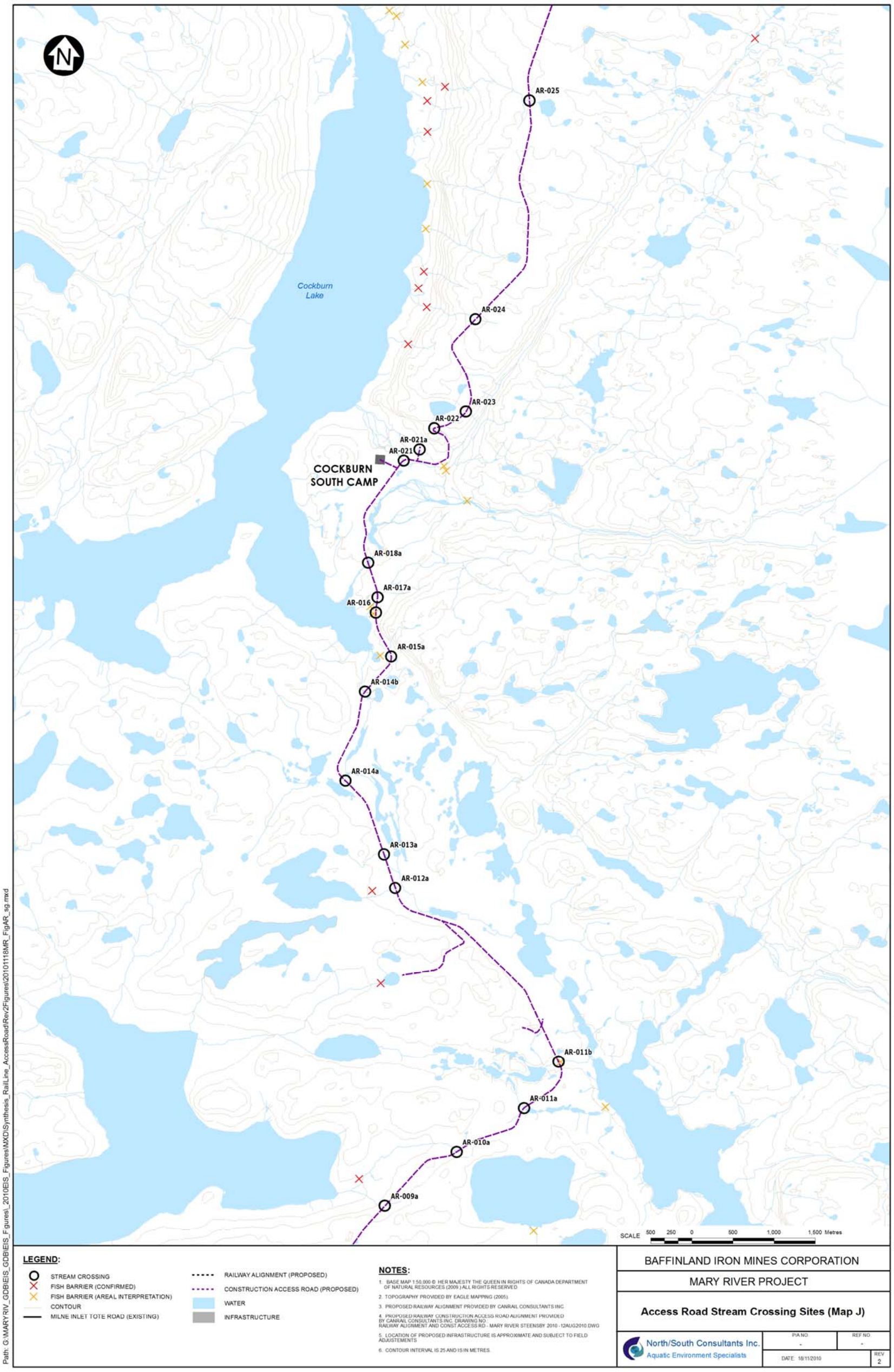

Figure 5.1-23. Detailed map of the tenth segment of stream crossings (Map J) along the access road alignment.

Figure 5.1-24. Detailed map of the eleventh segment of stream crossings (Map K) along the access road alignment.

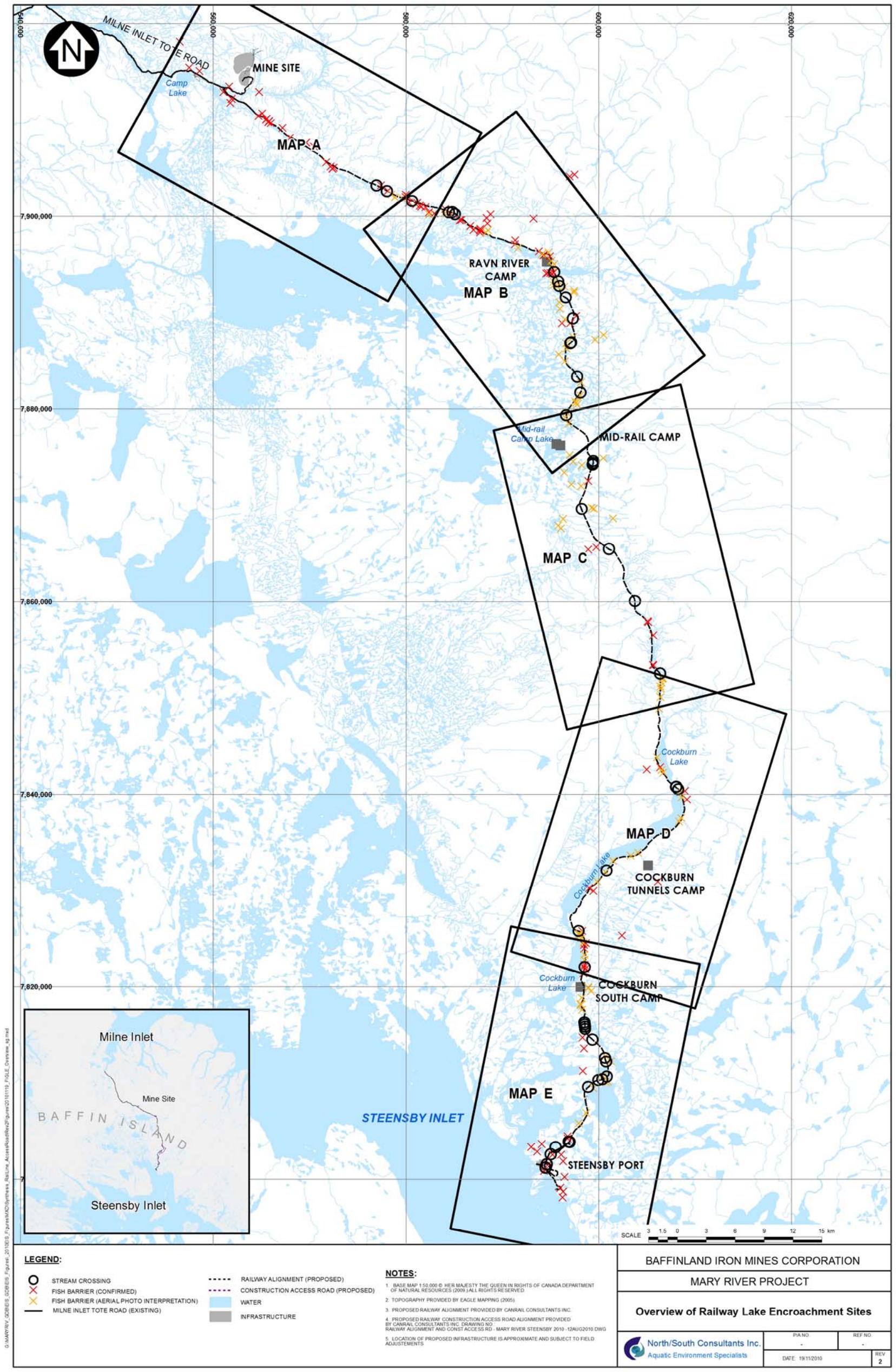

Figure 5.2-1. Overview map of all lake encroachment sites along the railway between the Mine Area and Steensby Port.

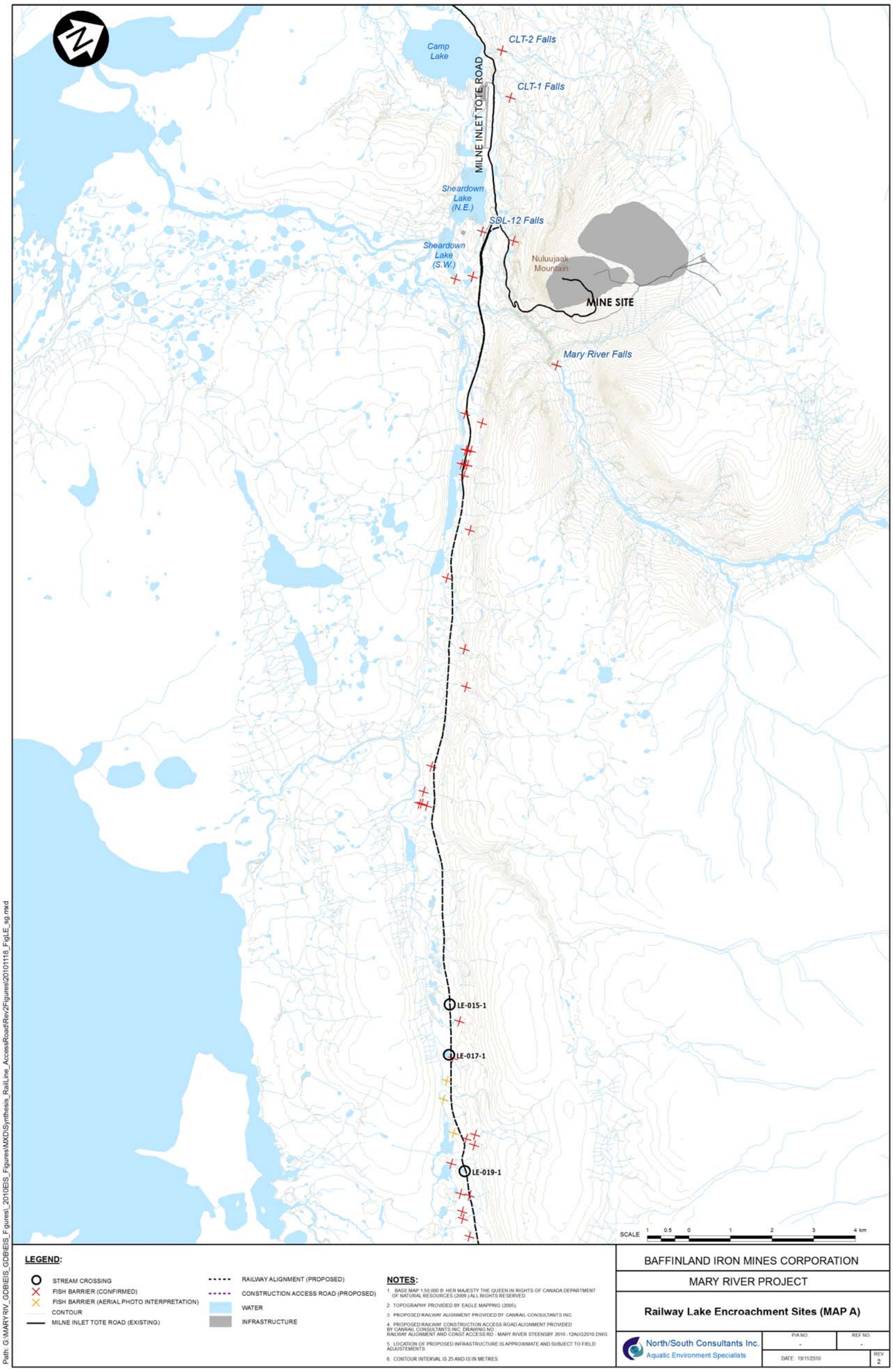

Figure 5.2-2. Detailed map of the first segment of lake encroachment sites (Map A) along the railway alignment.

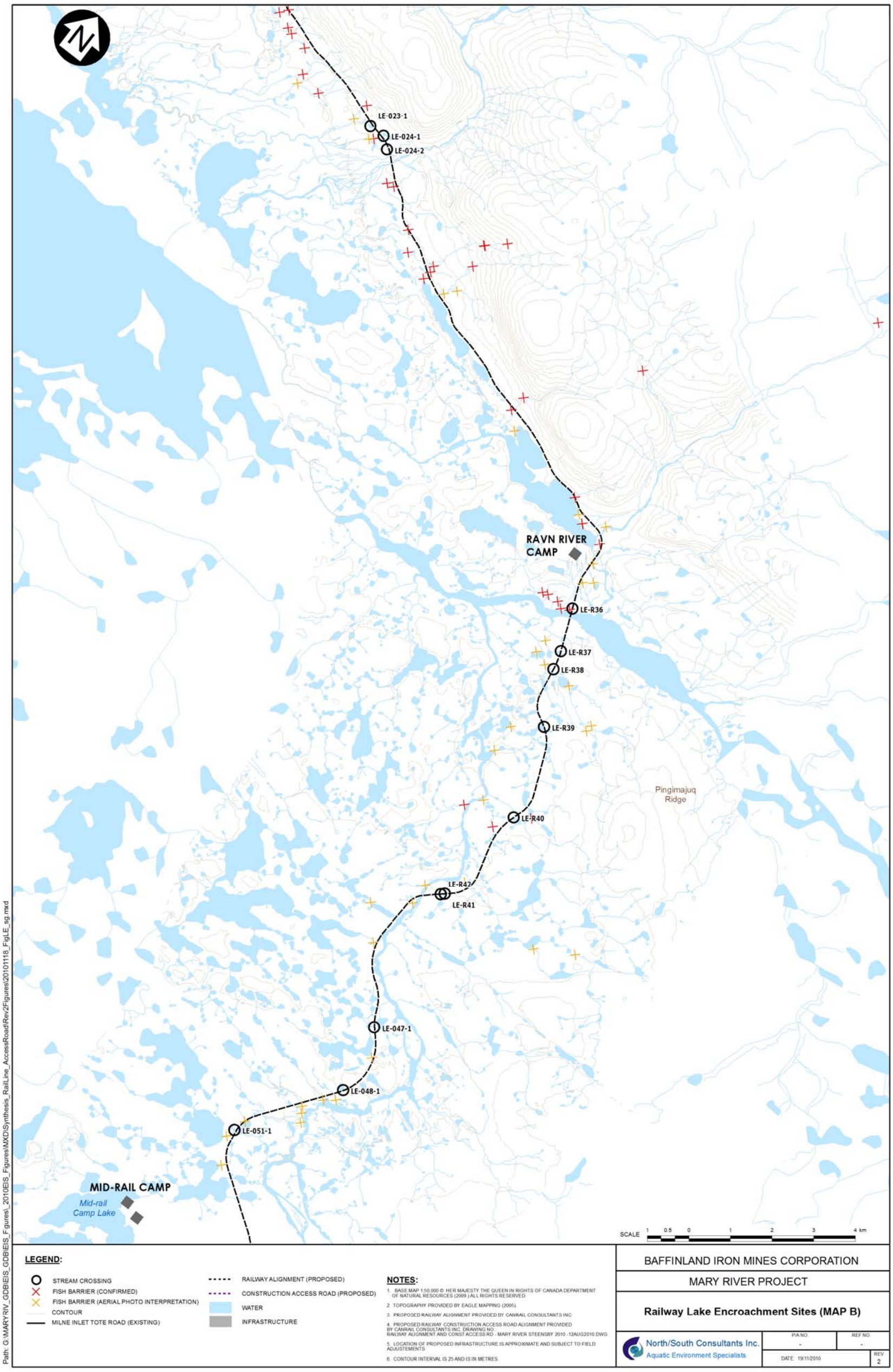

Figure 5.2-3. Detailed map of the second segment of lake encroachment sites (Map B) along the railway alignment.

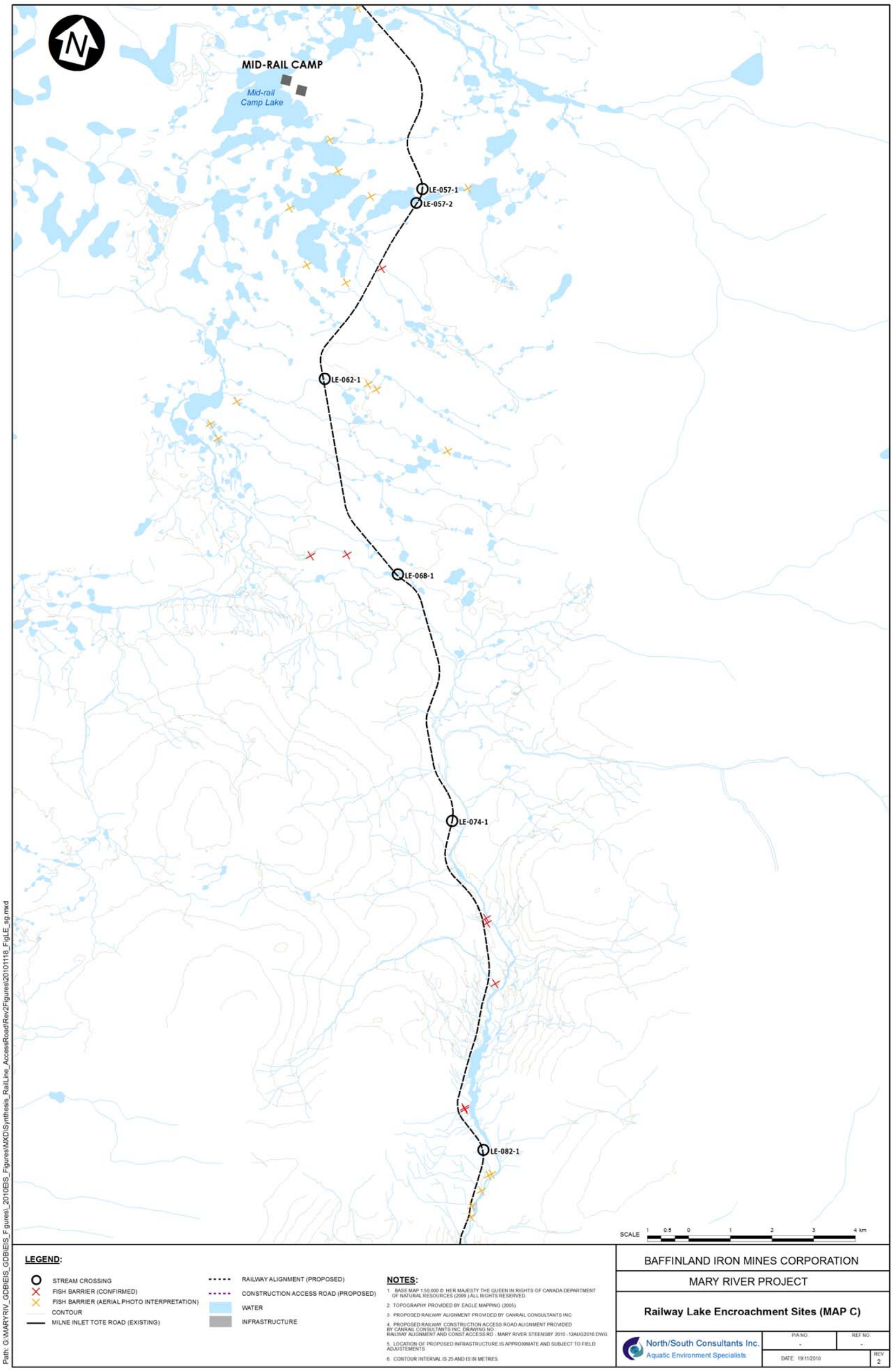

Figure 5.2-4. Detailed map of the third segment of lake encroachment sites (Map C) along the railway alignment.

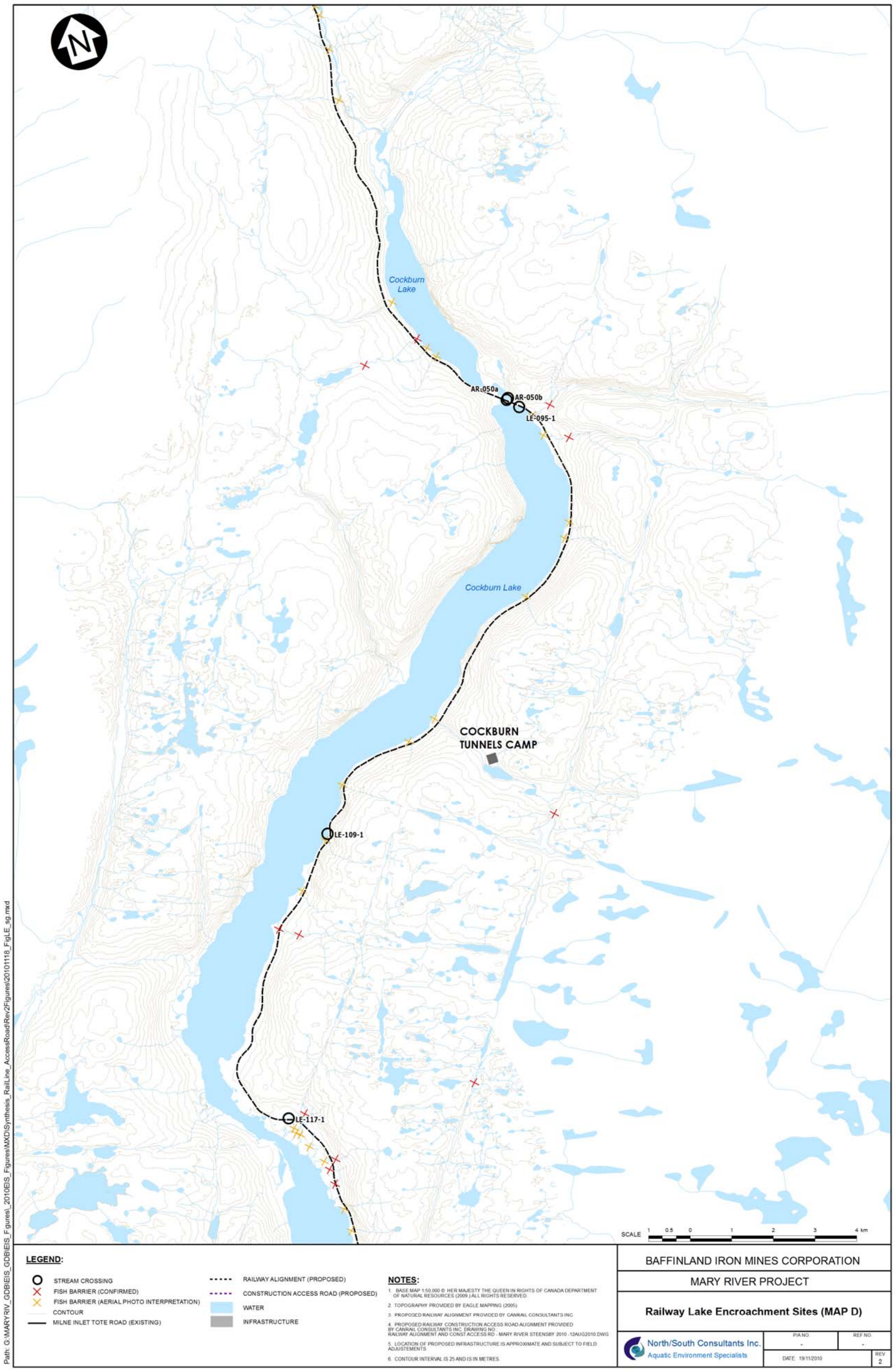

Figure 4.2-5. Detailed map of the fourth segment of lake encroachment sites (Map D) along the railway alignment.

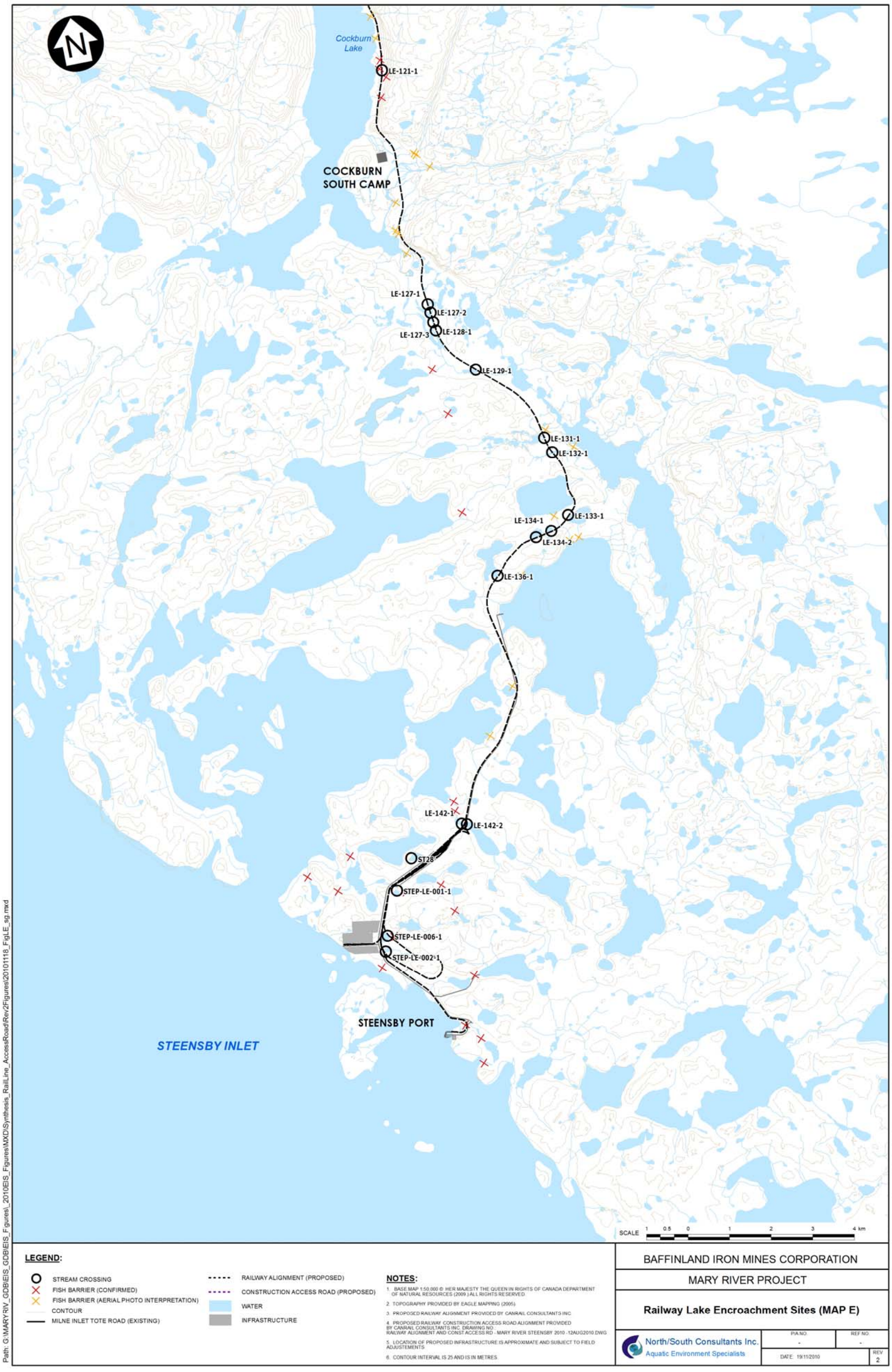

Figure 5.2-6. Detailed map of the fifth segment of lake encroachment sites (Map E) along the railway alignment.

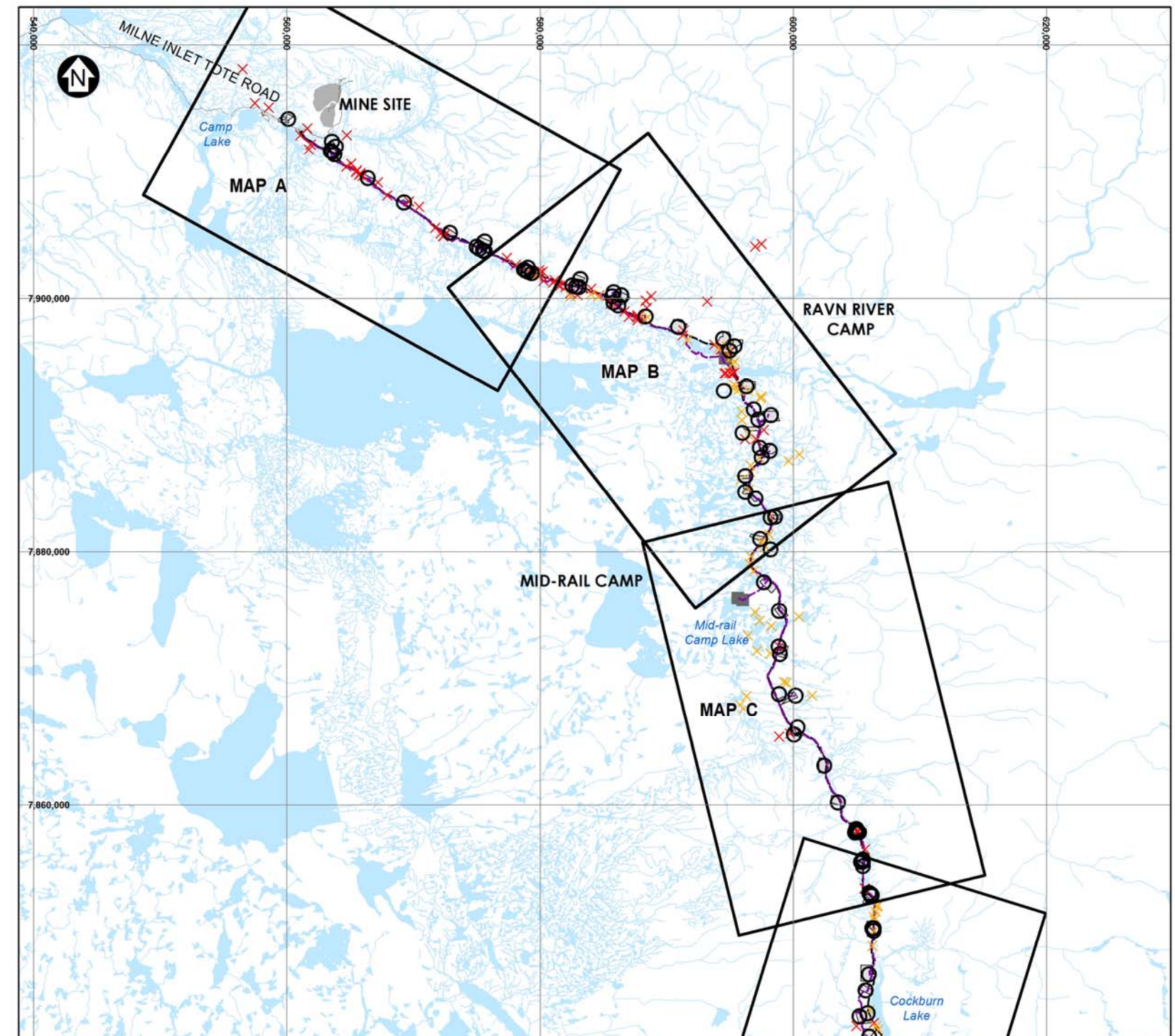

Figure 5.3-1. Overview map of all potential quarry sites in the Railway/Access Road LSA between the Mine Area and Steensby Port.

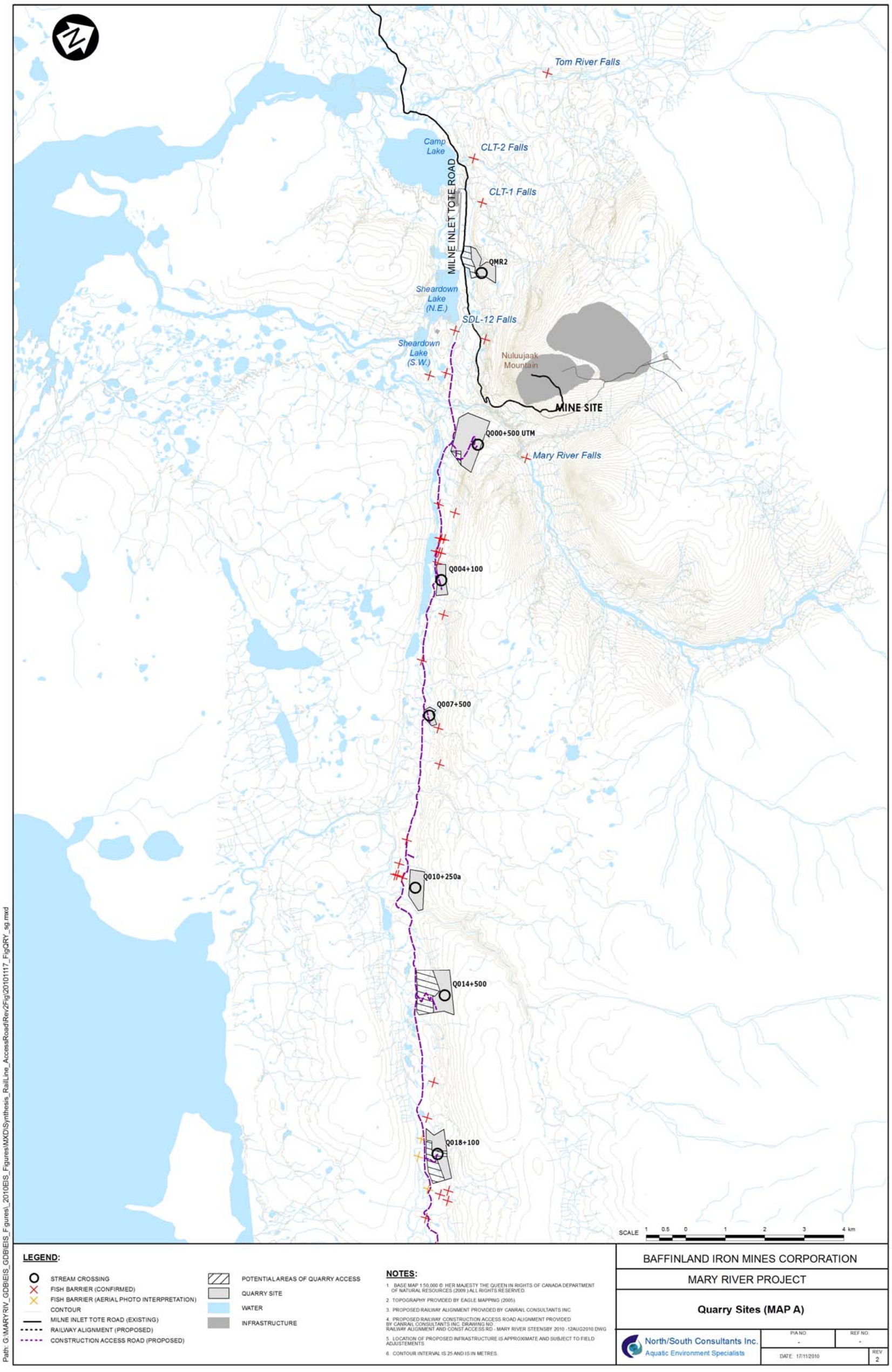

Figure5.3-2. Detailed map of the first segment of potential quarry sites (Map A) along the railway and access road alignments.

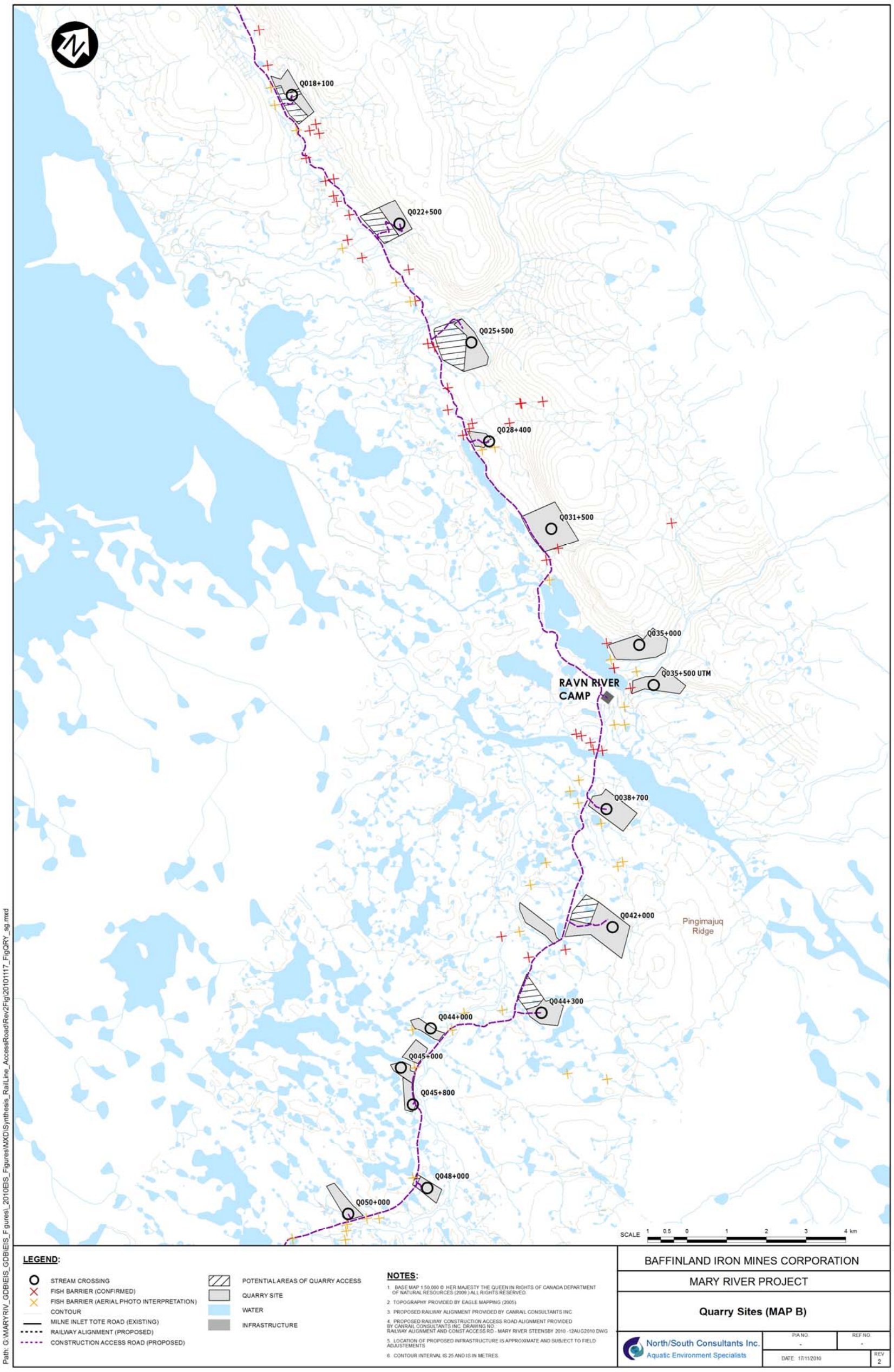

Figure 5.3-3. Detailed map of the second segment of potential quarry sites (Map B) along the railway and access road alignments.

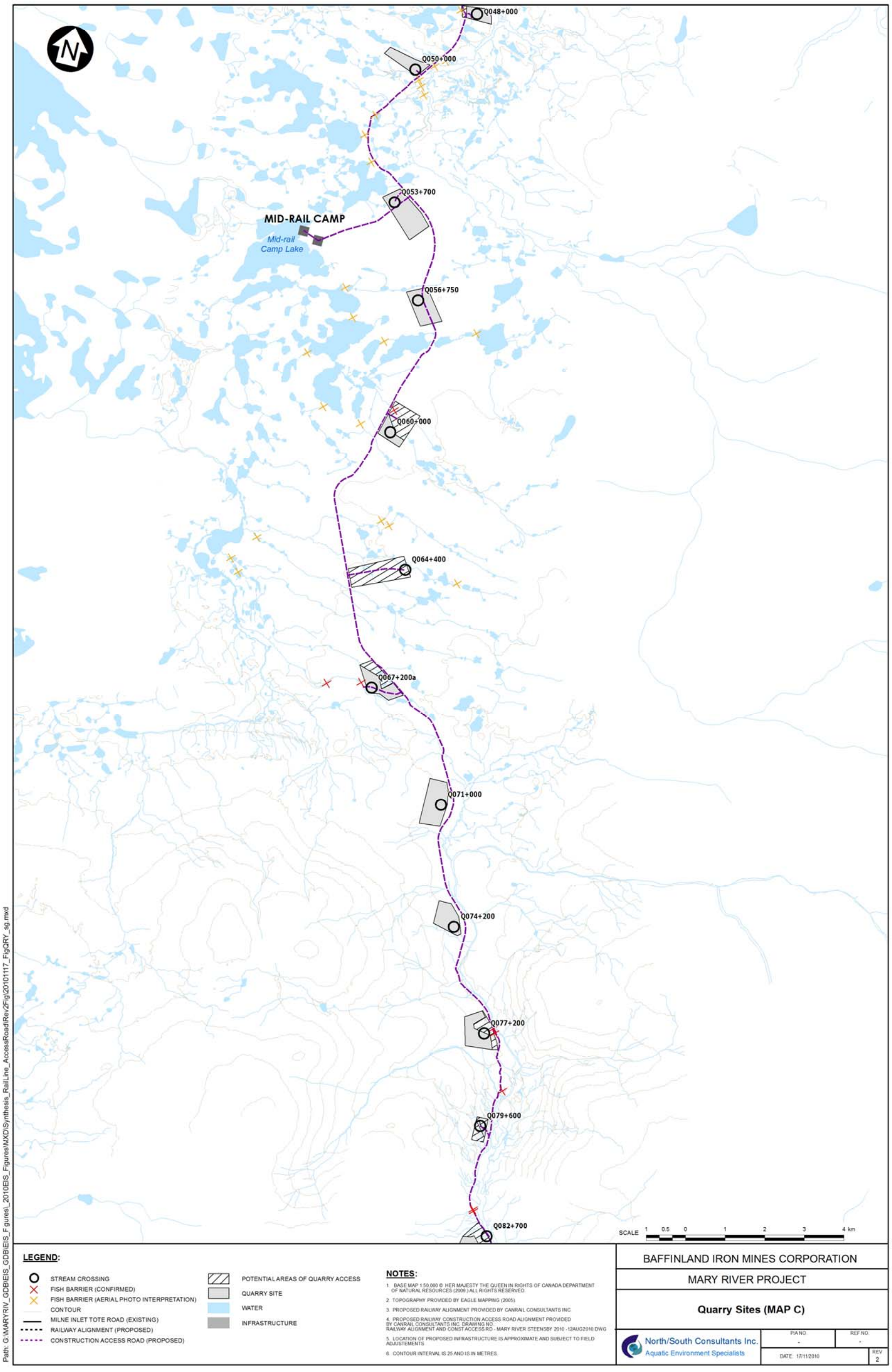

Figure 5.3-4. Detailed map of the third segment of potential quarry sites (Map C) along the railway and access road alignments.

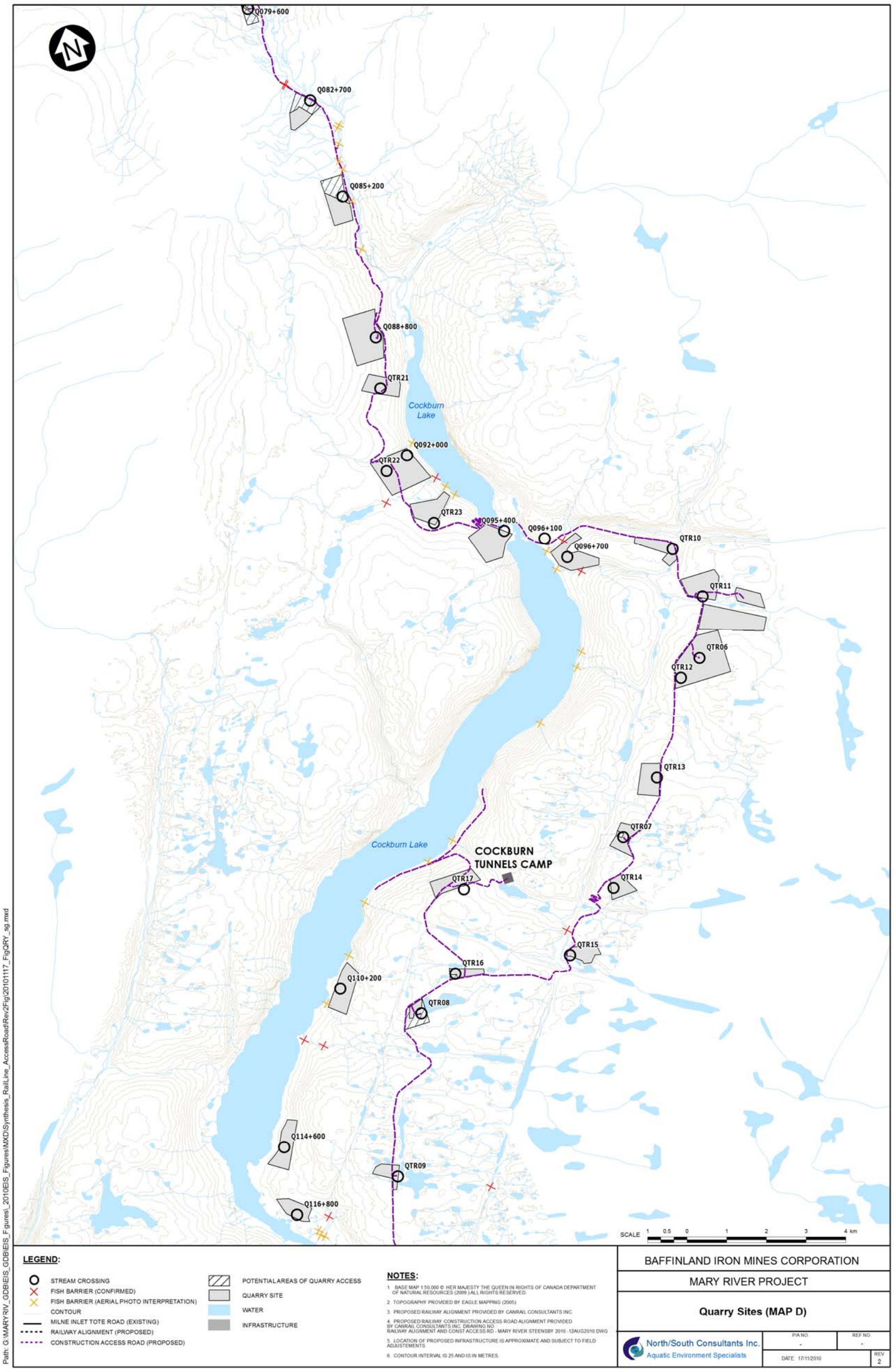

Figure 5.3-5. Detailed map of the fourth segment of potential quarry sites (Map D) along the railway and access road alignments.

Figure 5.3-6. Detailed map of the fifth segment of potential quarry sites (Map E) along the railway and access road alignments.

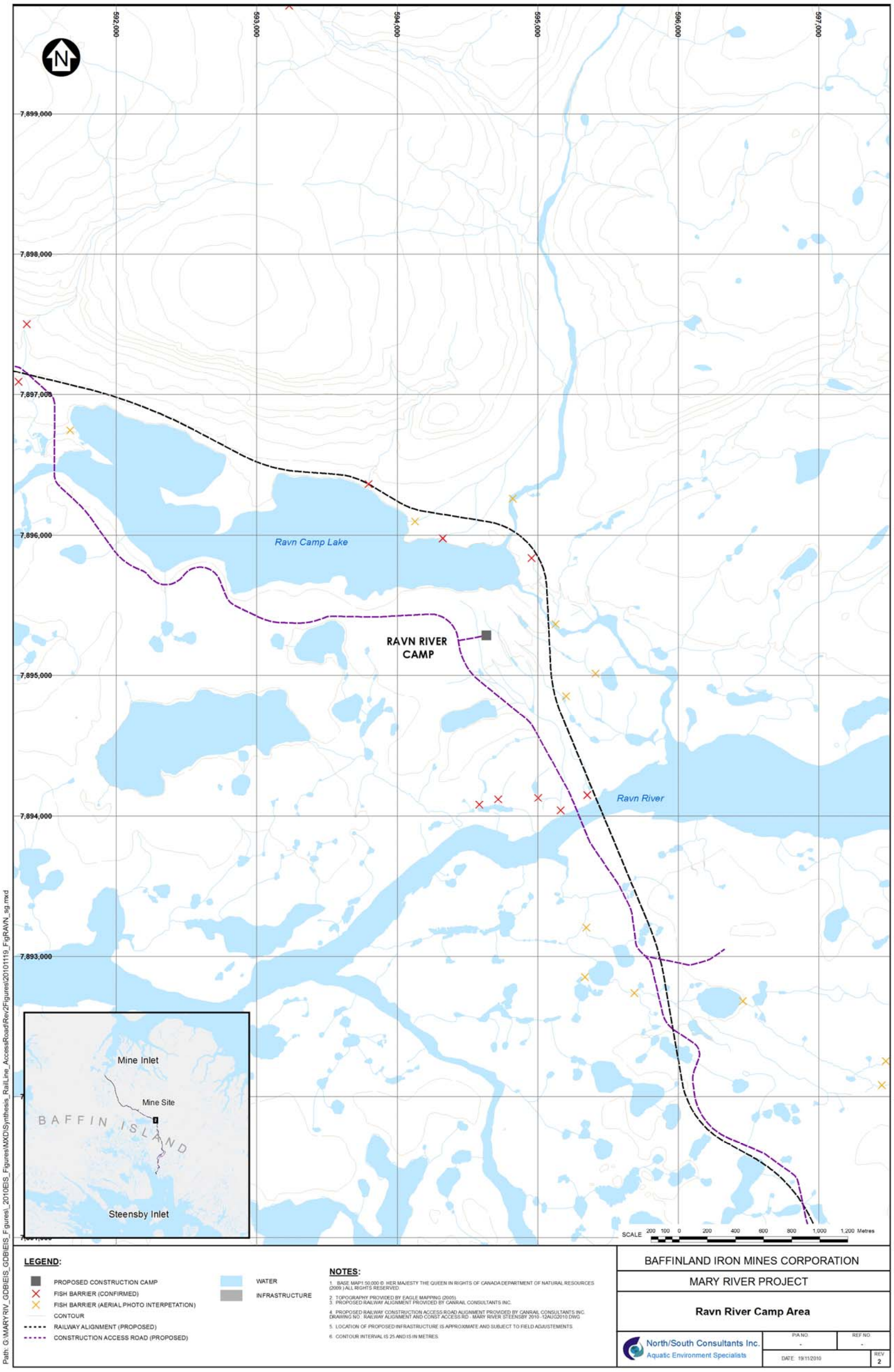

Figure 5.4-1. Map of waterbodies in the vicinity of the proposed Ravn River Camp.

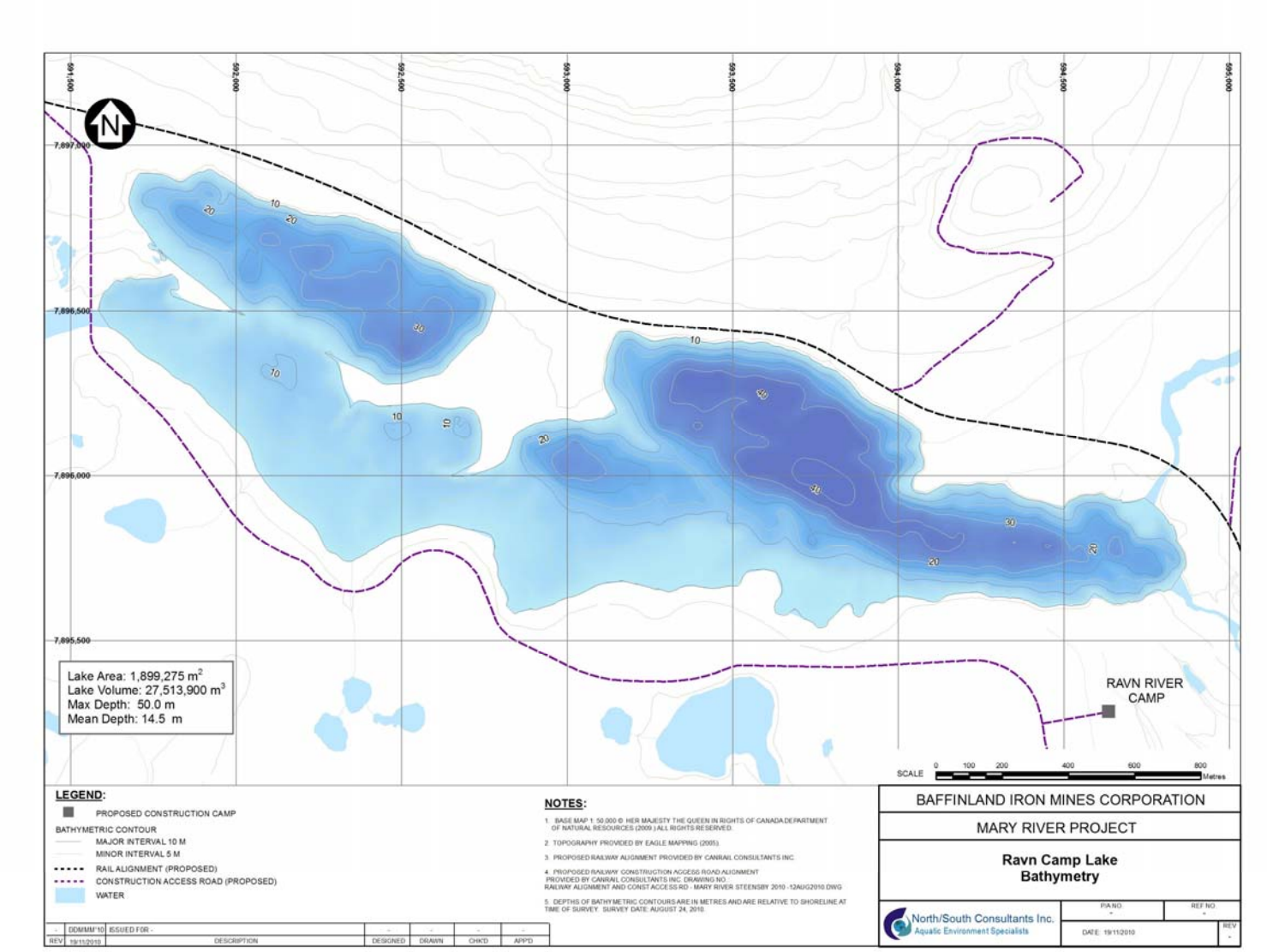

Figure 5.4-2. Bathymetry map of Ravn Camp Lake.

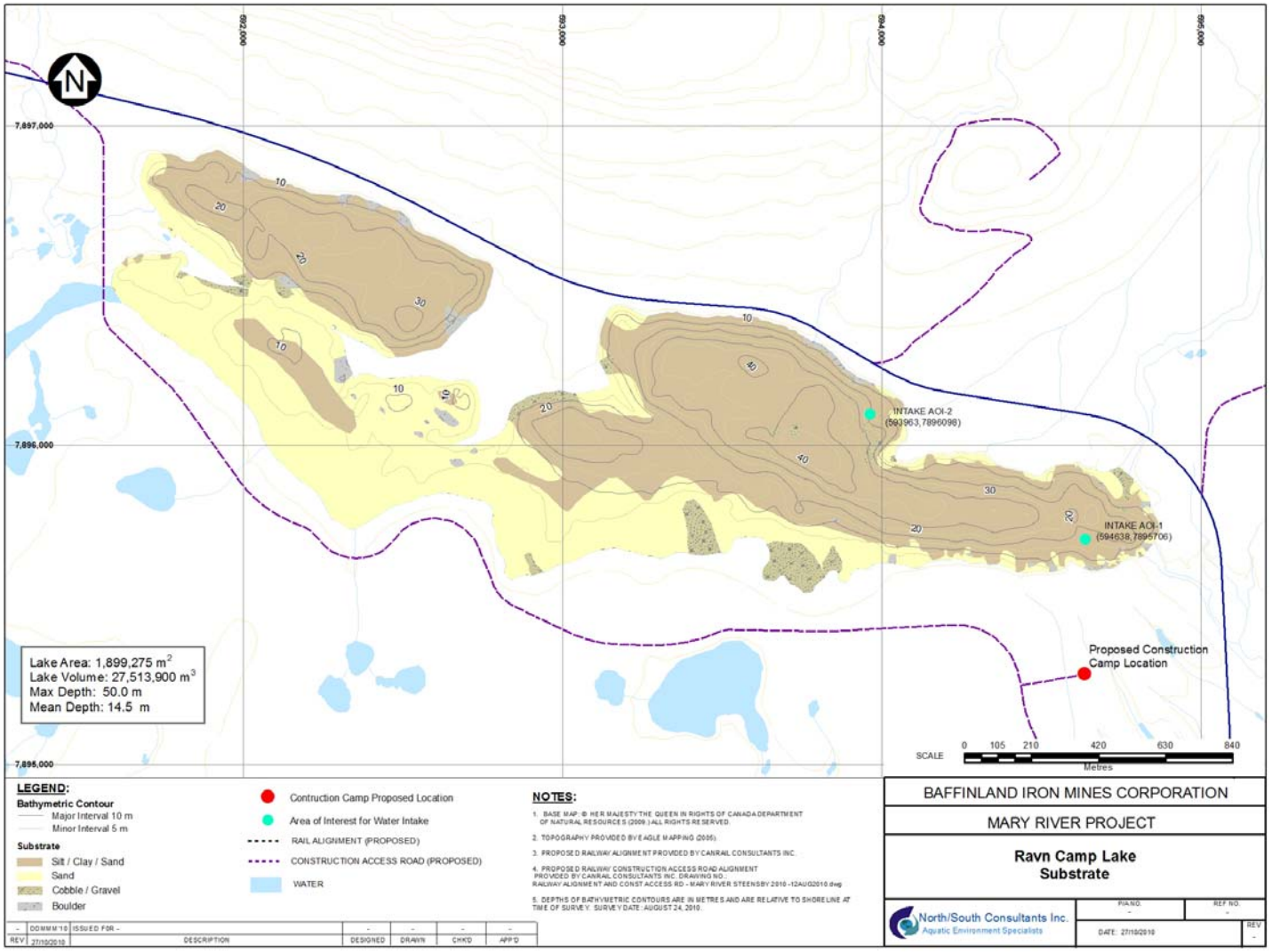

Figure 5.4-3. Substrate and proposed infrastructure map of Ravn Camp Lake.

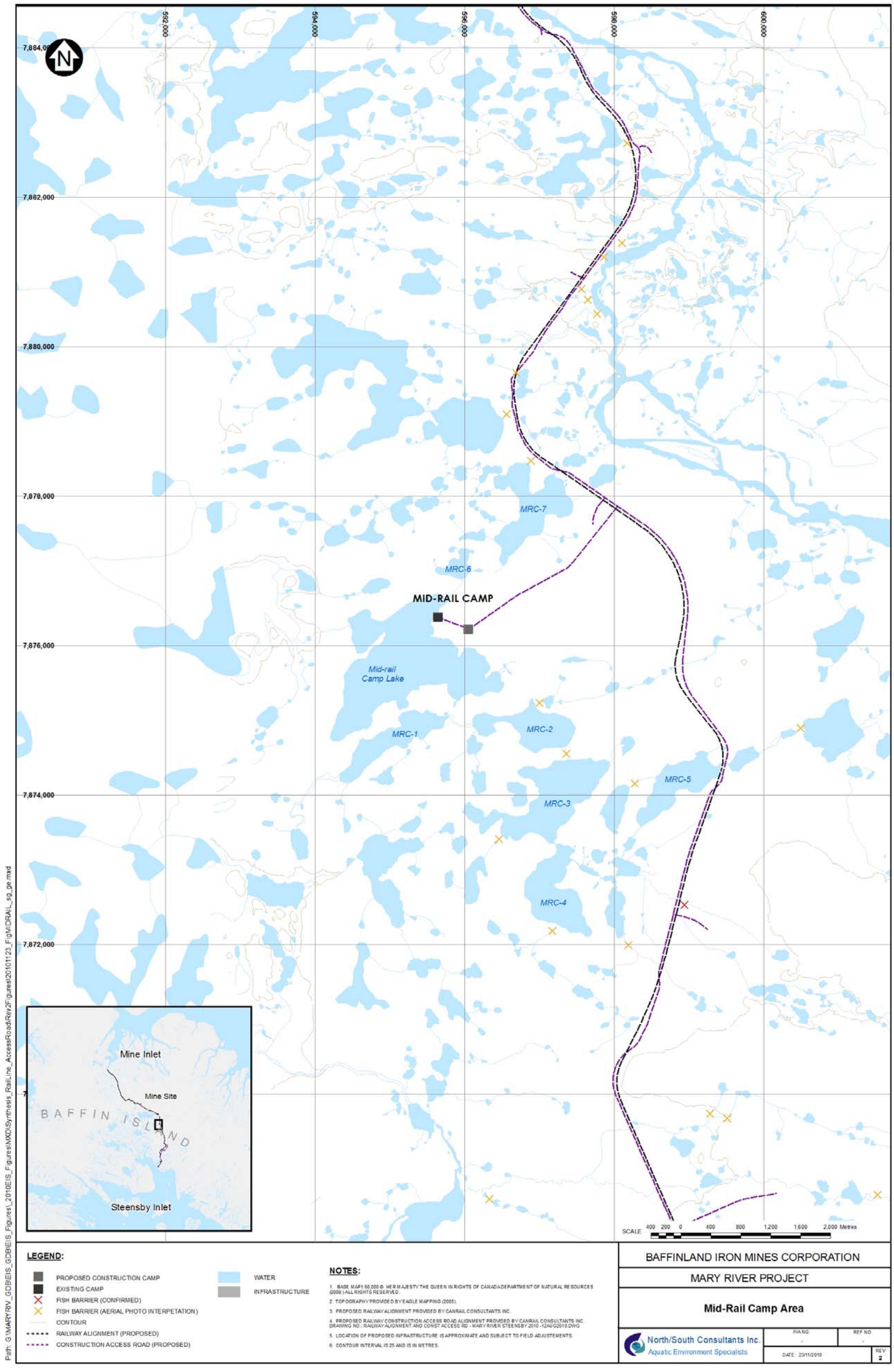

Figure 5.5-1. Map of waterbodies in the vicinity of the proposed Mid-Rail Camp.

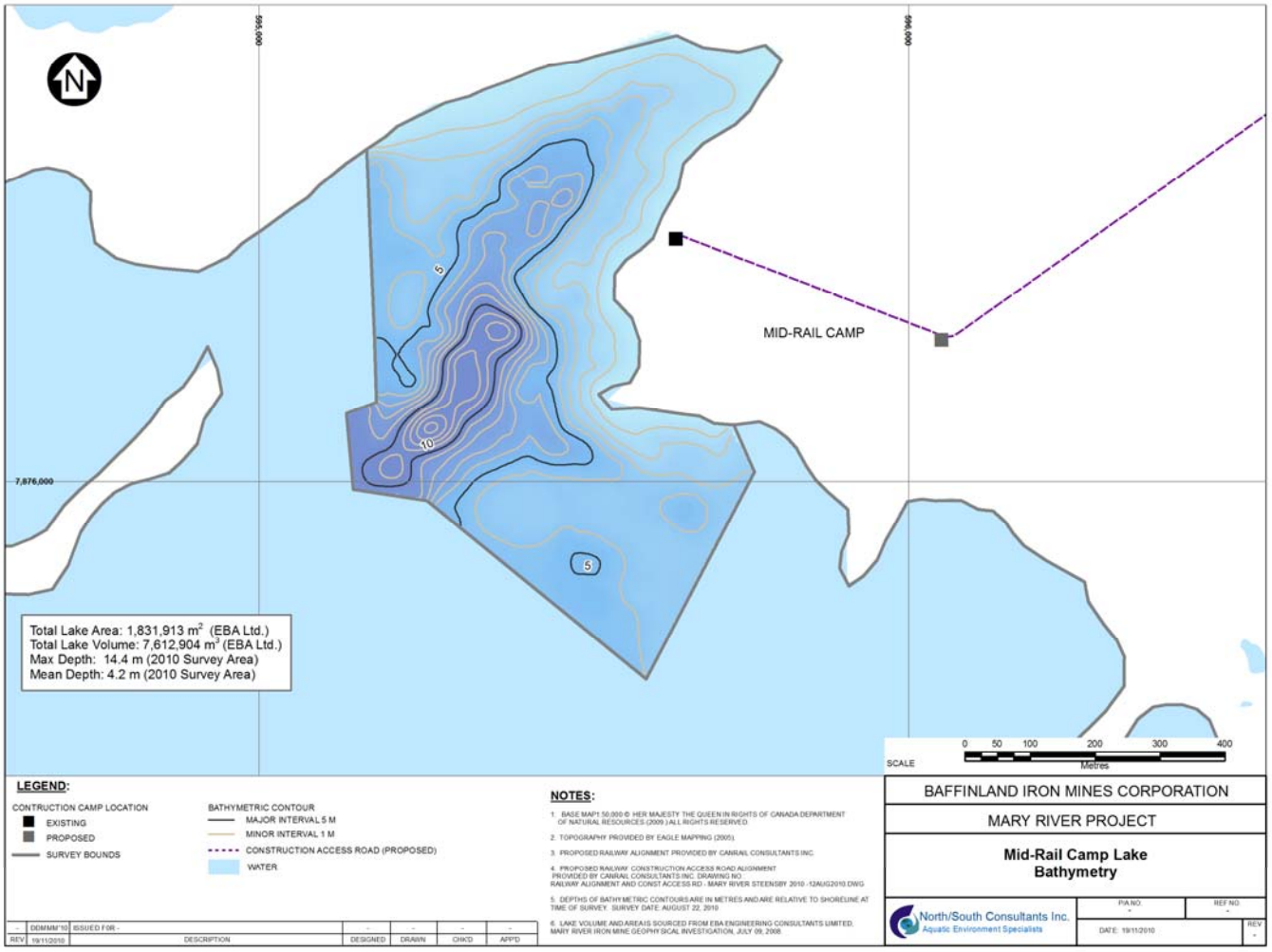

Figure 5.5-2. Bathymetry map of Mid-Rail Camp Lake.

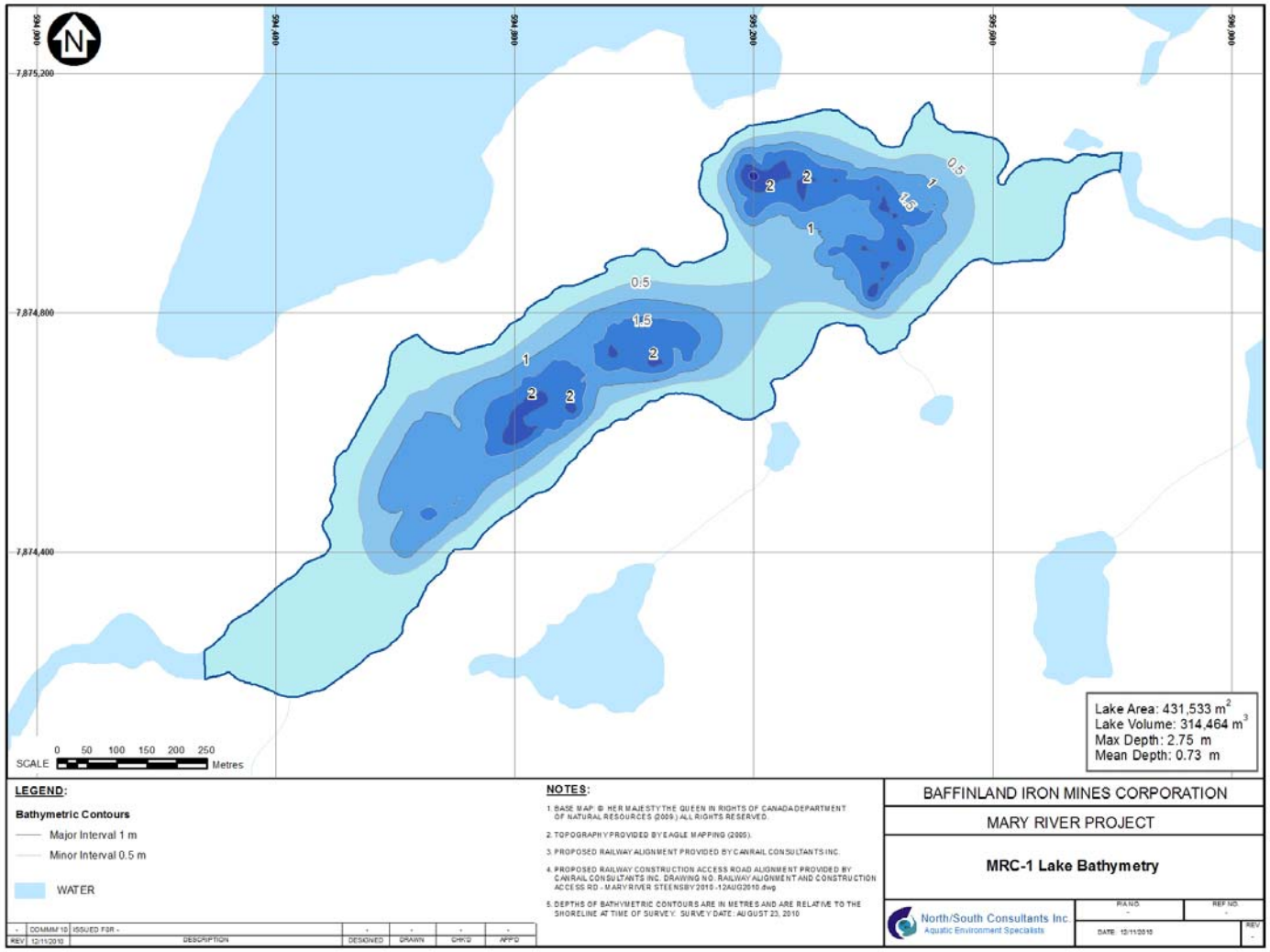

Figure 5.5-3. Bathymetry map of MRC-1 Lake in the vicinity of Mid-Rail Camp.

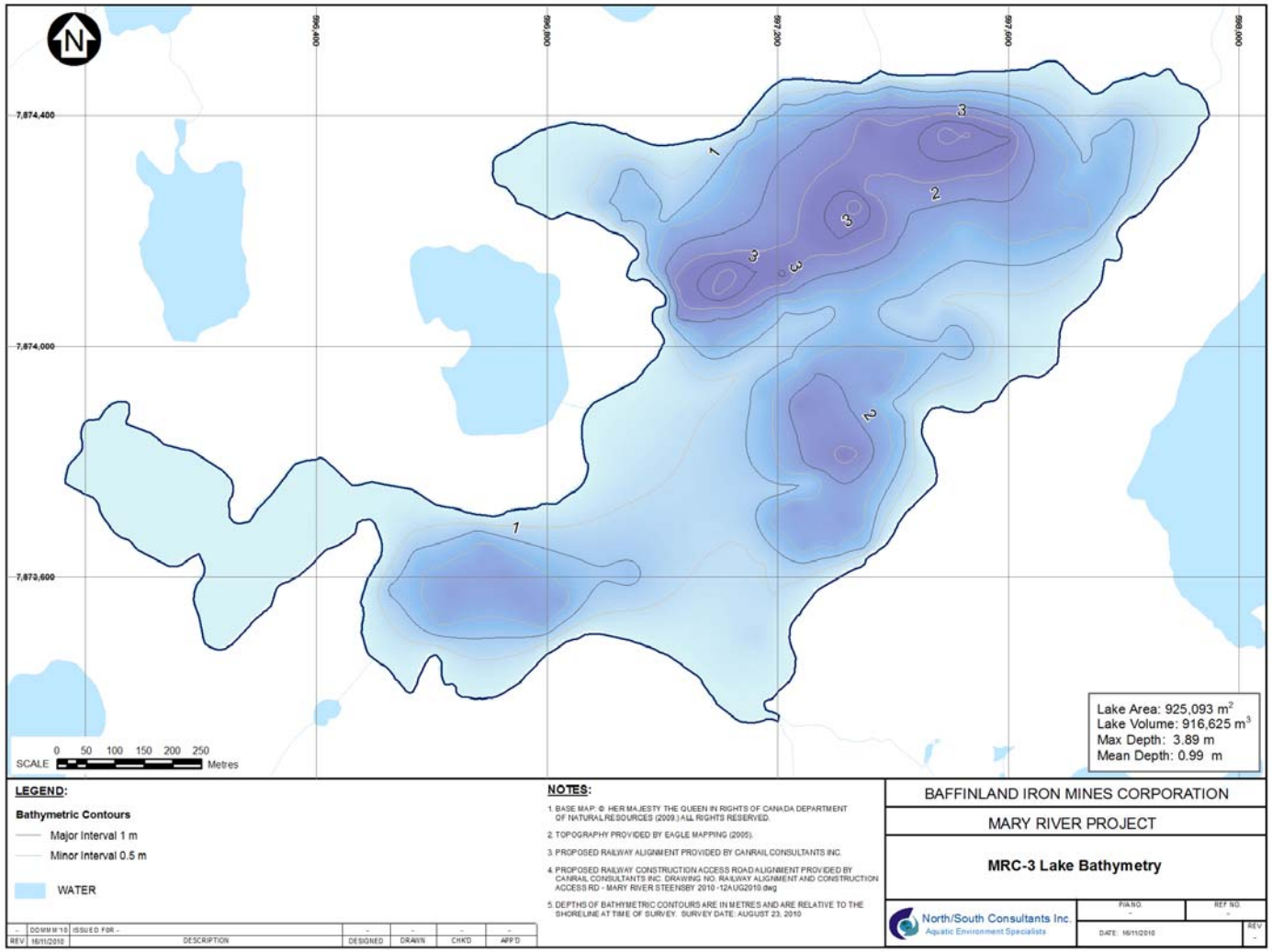

Figure 5.5-4. Bathymetry map of MRC-3 Lake in the vicinity of Mid-Rail Camp.

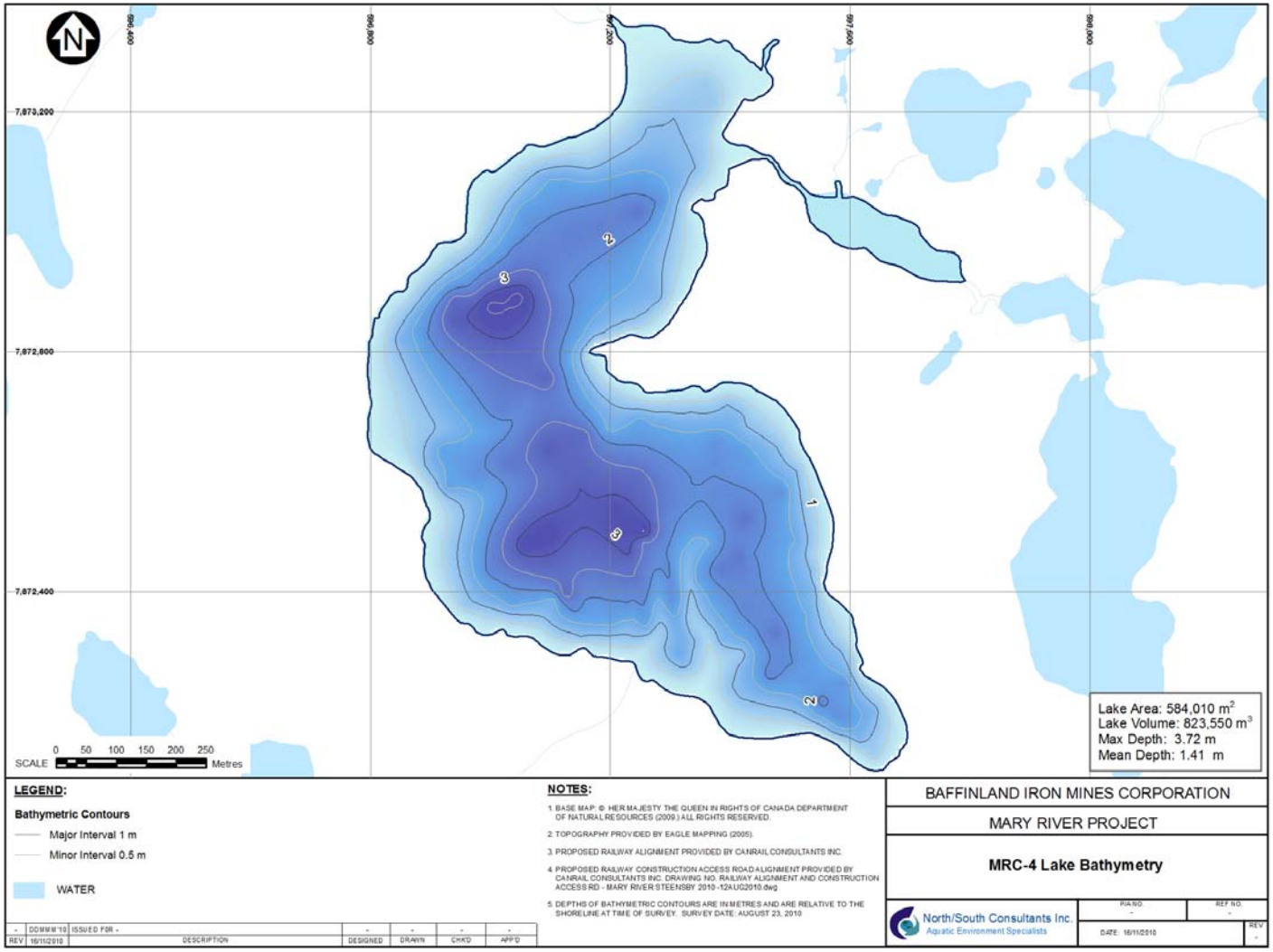

Figure 5.5-5. Bathymetry map of MRC-4 Lake in the vicinity of Mid-Rail Camp.

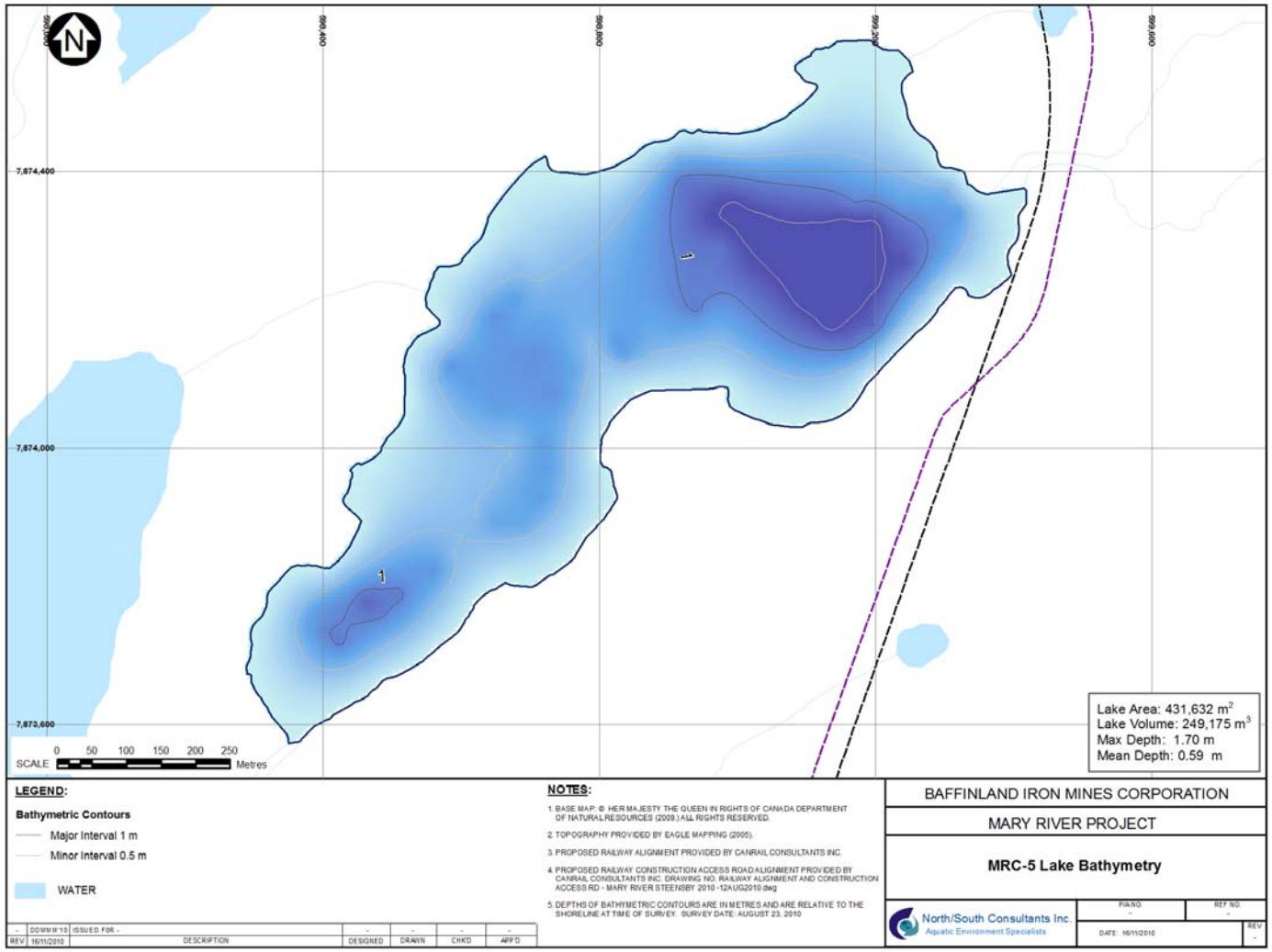

Figure 5.5-6. Bathymetry map of MRC-5 Lake in the vicinity of Mid-Rail Camp.

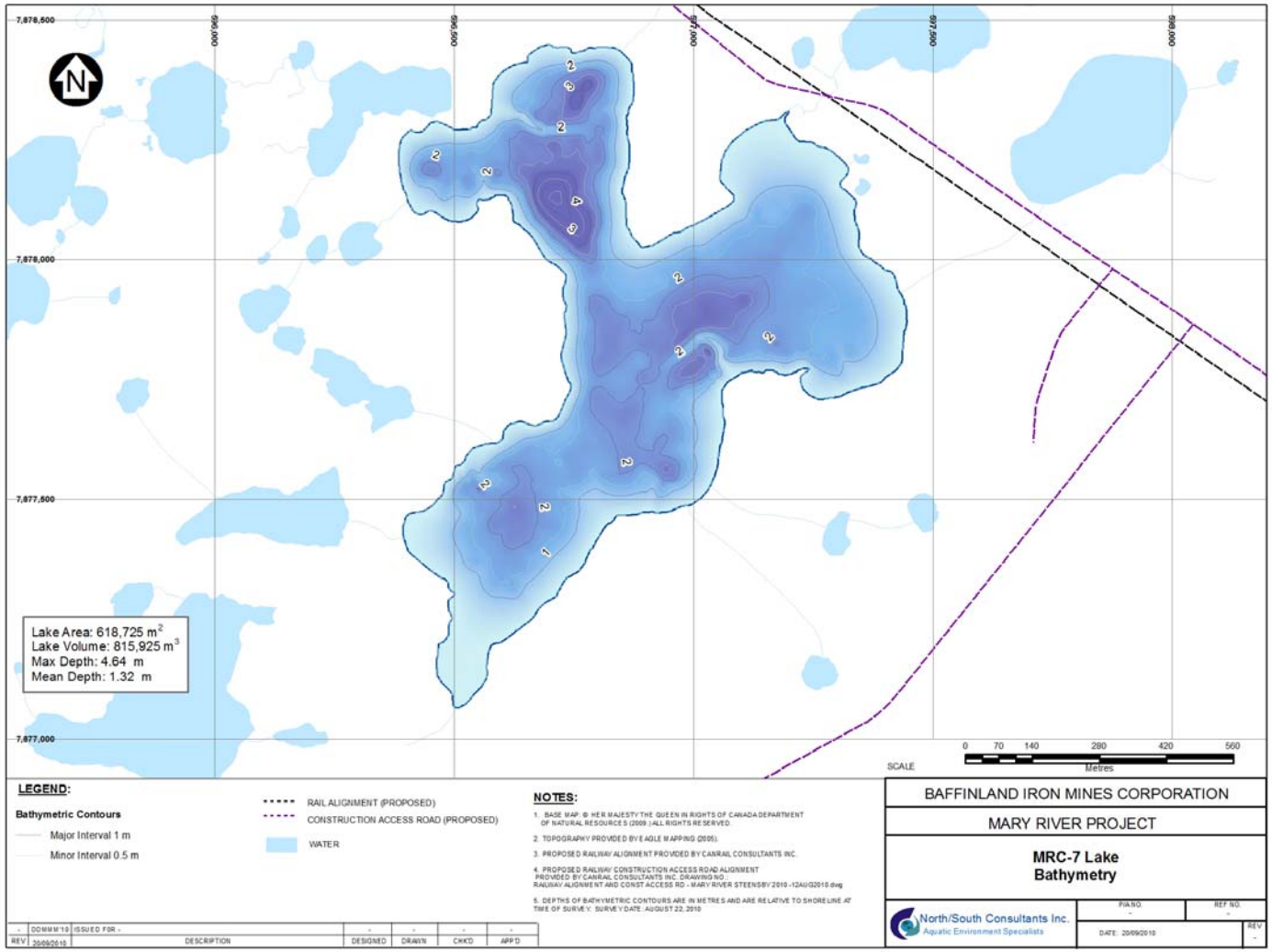

Figure 5.5-7. Bathymetry map of MRC-7 Lake in the vicinity of Mid-Rail Camp.

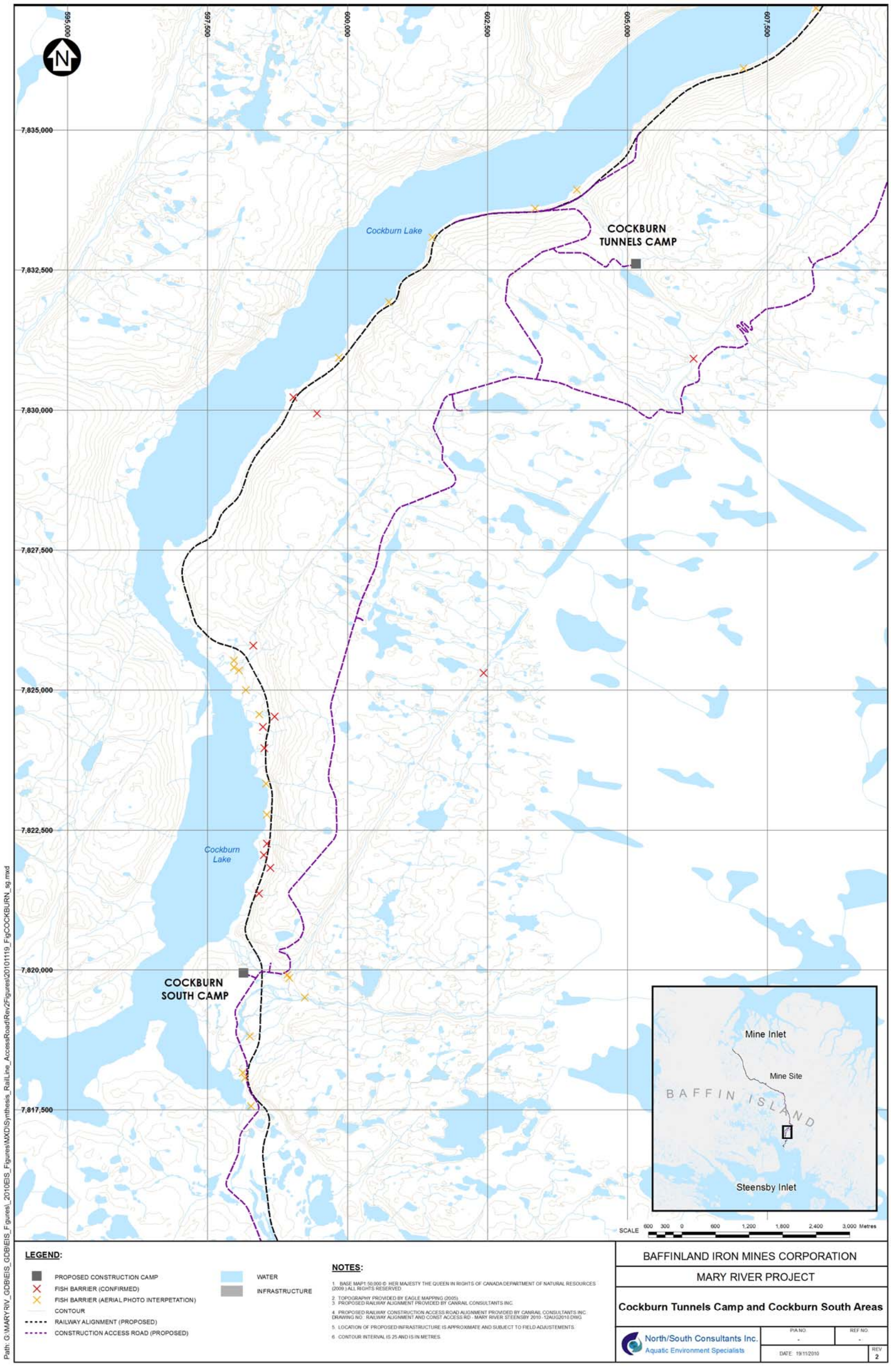

Figure 5.6-1. Map of waterbodies in the vicinity of the proposed Cockburn Tunnels and Cockburn South camps.

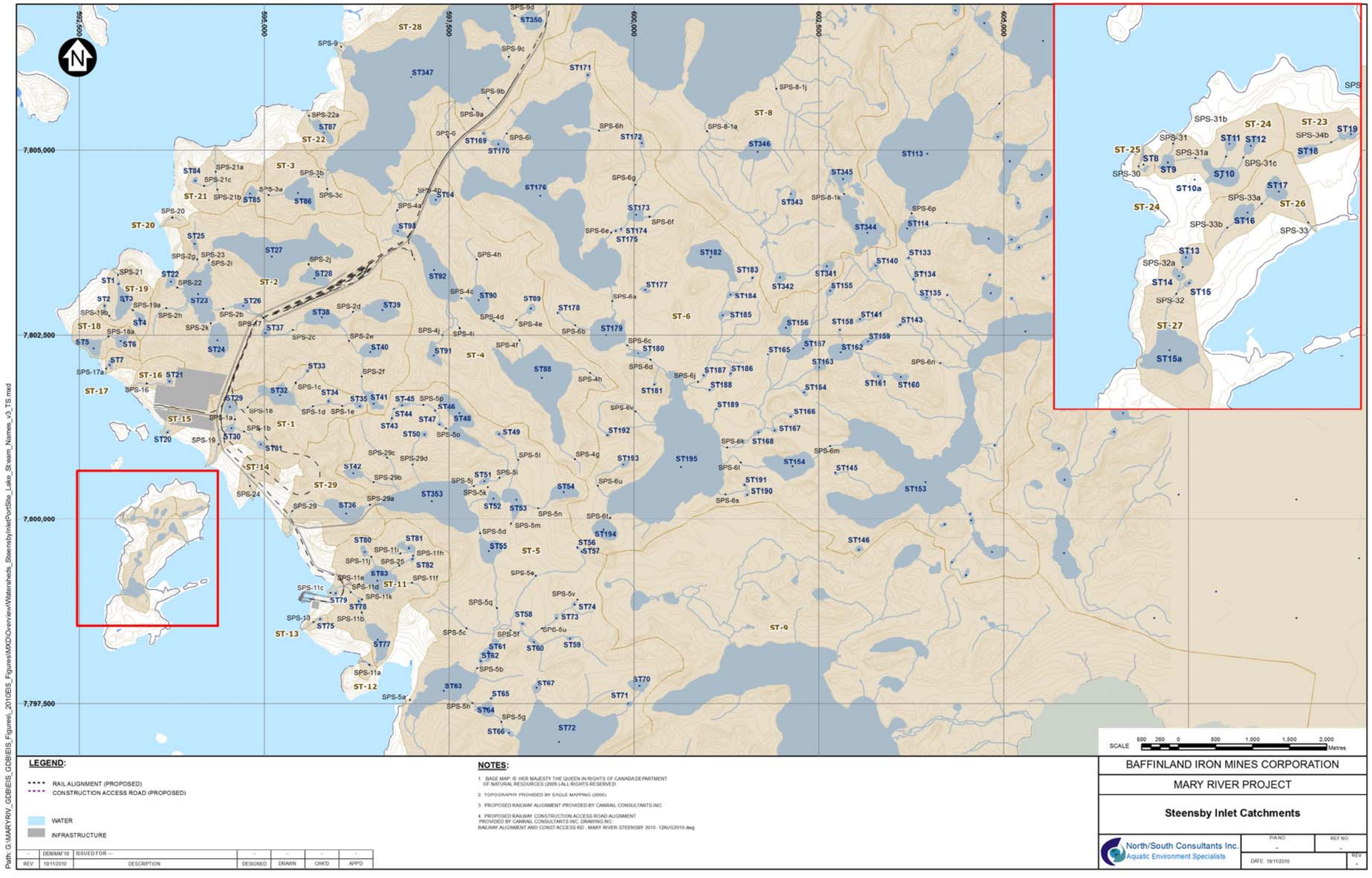

Figure 6-1. Waterbodies and catchments, and proposed infrastructure in the Steensby Port Area.

Figure 6-2.Chlorophyll *a* sampling locations in the Steensby Port Area, open-water season 2008.

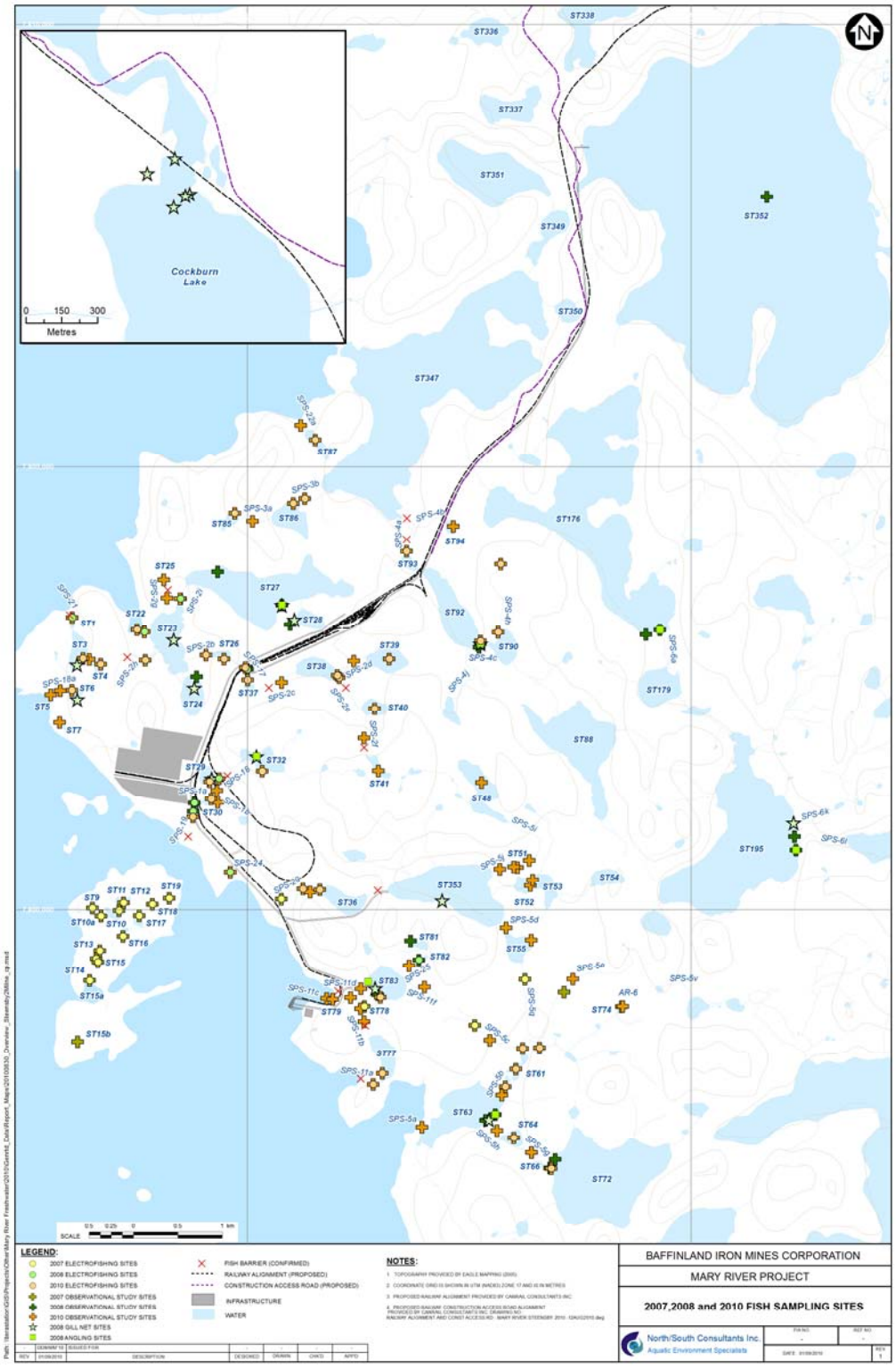

Figure 6-3. Fish population survey locations in the Steensby Port Area, 2007-2010.

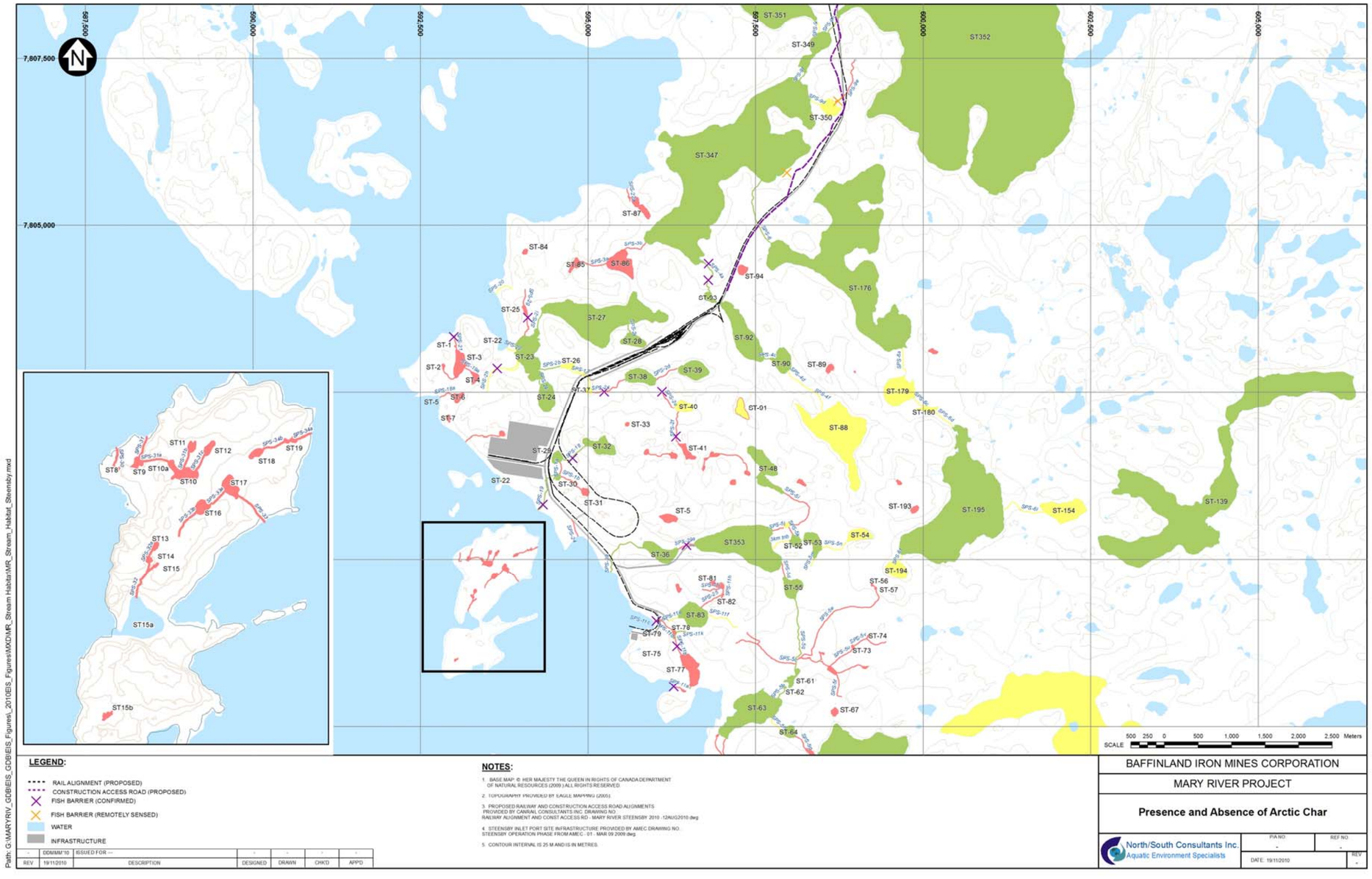

Figure 6-4. Arctic char distribution in the Steensby Port Area. Green = present; yellow = probable, red = not present.

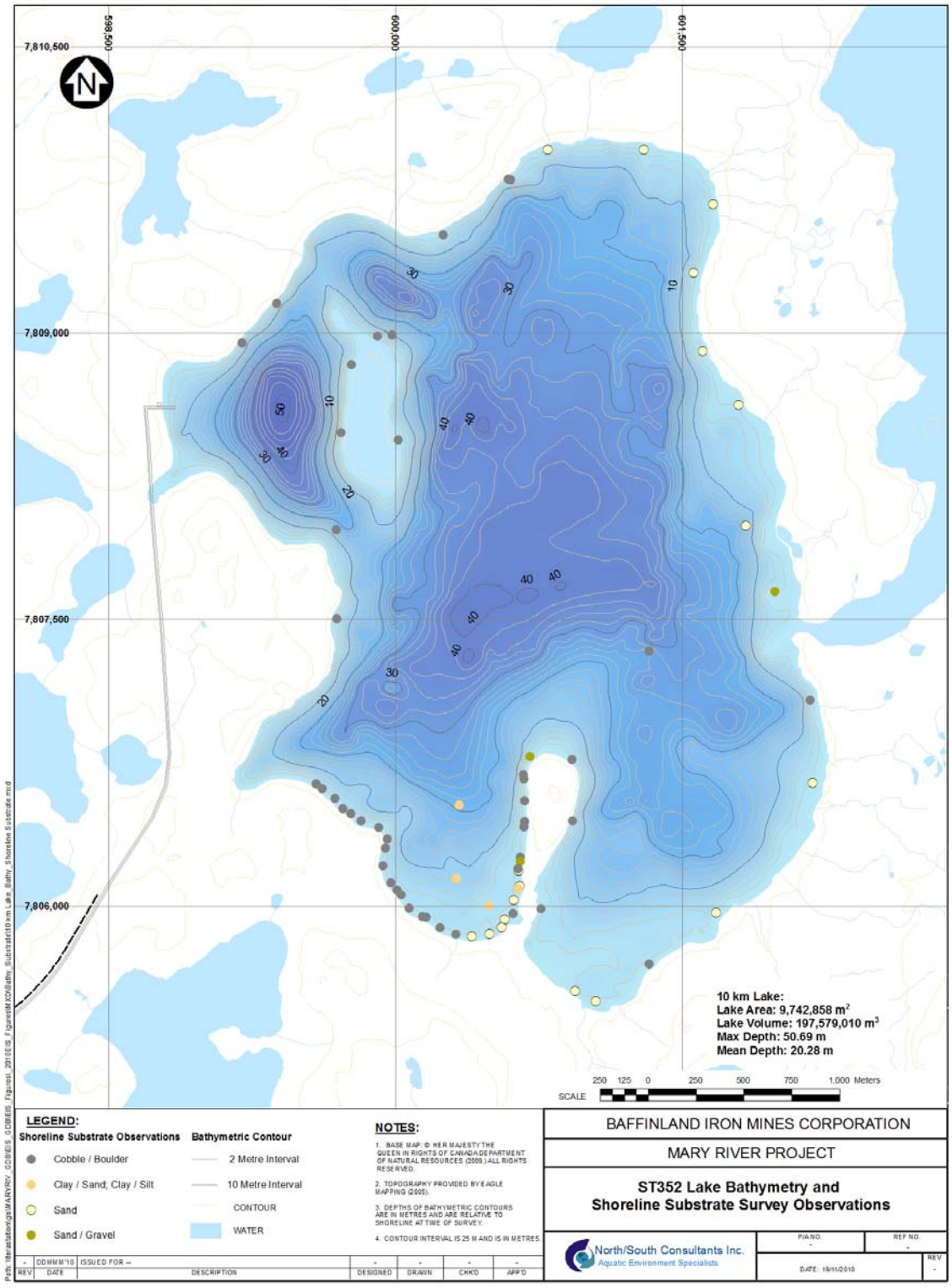

Figure 6-5. Bathymetry and shoreline substrate composition for ST-352 (i.e., 10 km Lake), Steensby Port Area.

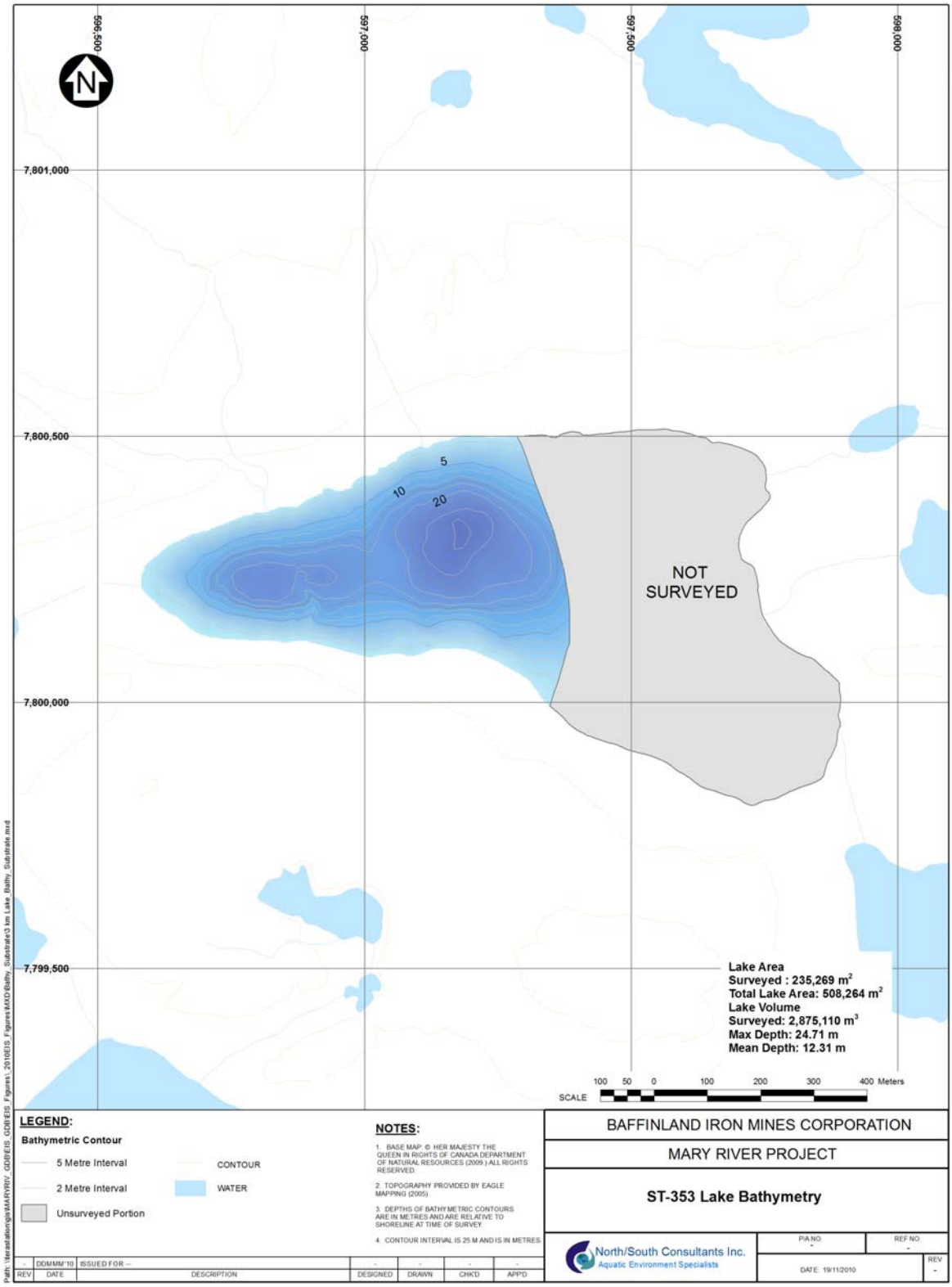

Figure 6-6. Bathymetry for the western portion of ST-353 (i.e., 3 km Lake), Steensby Port Area.

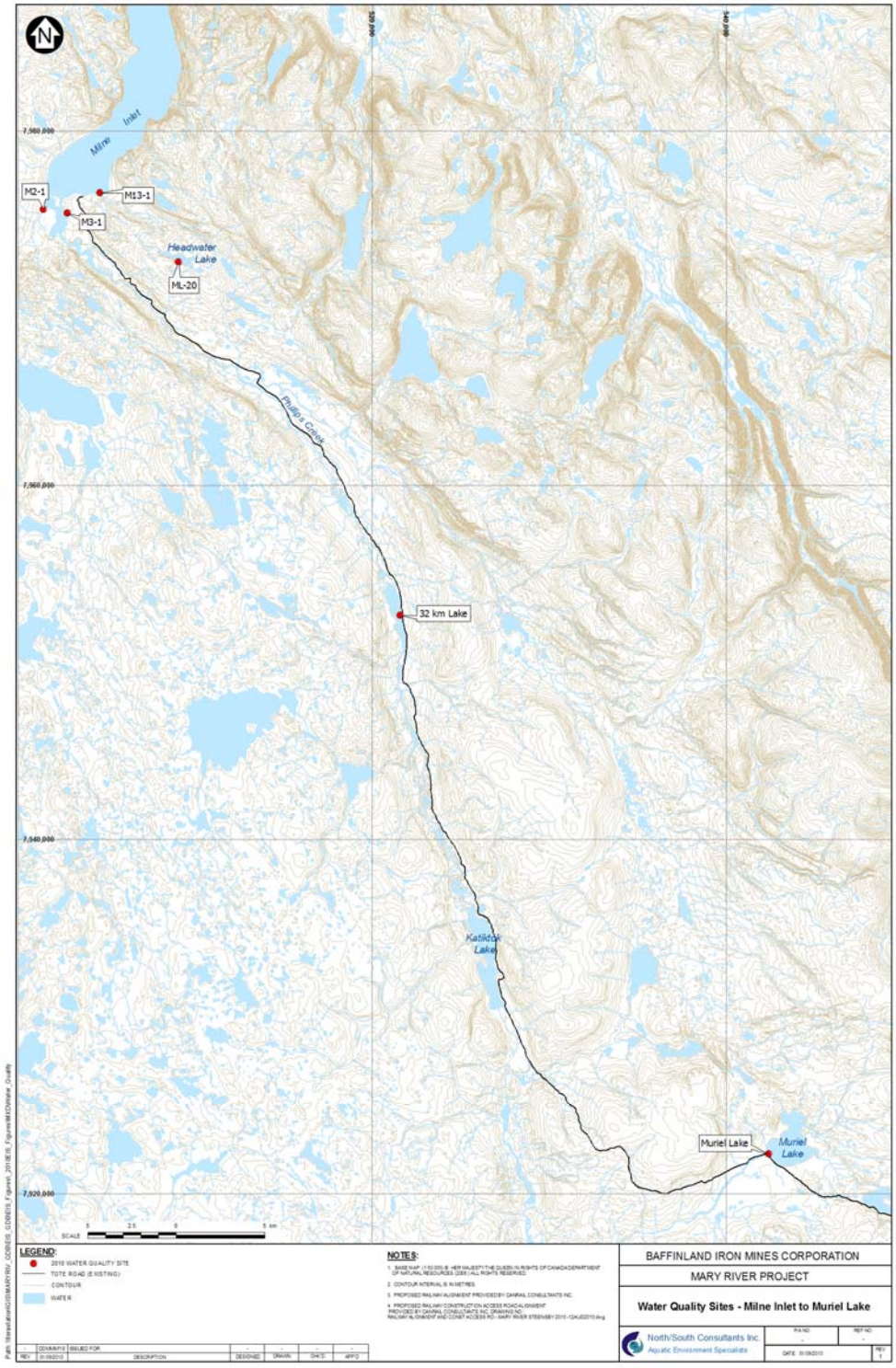

Figure 7-1. Locations of chlorophyll *a* sampling in the Milne Port and Tote Road areas: August 2010.

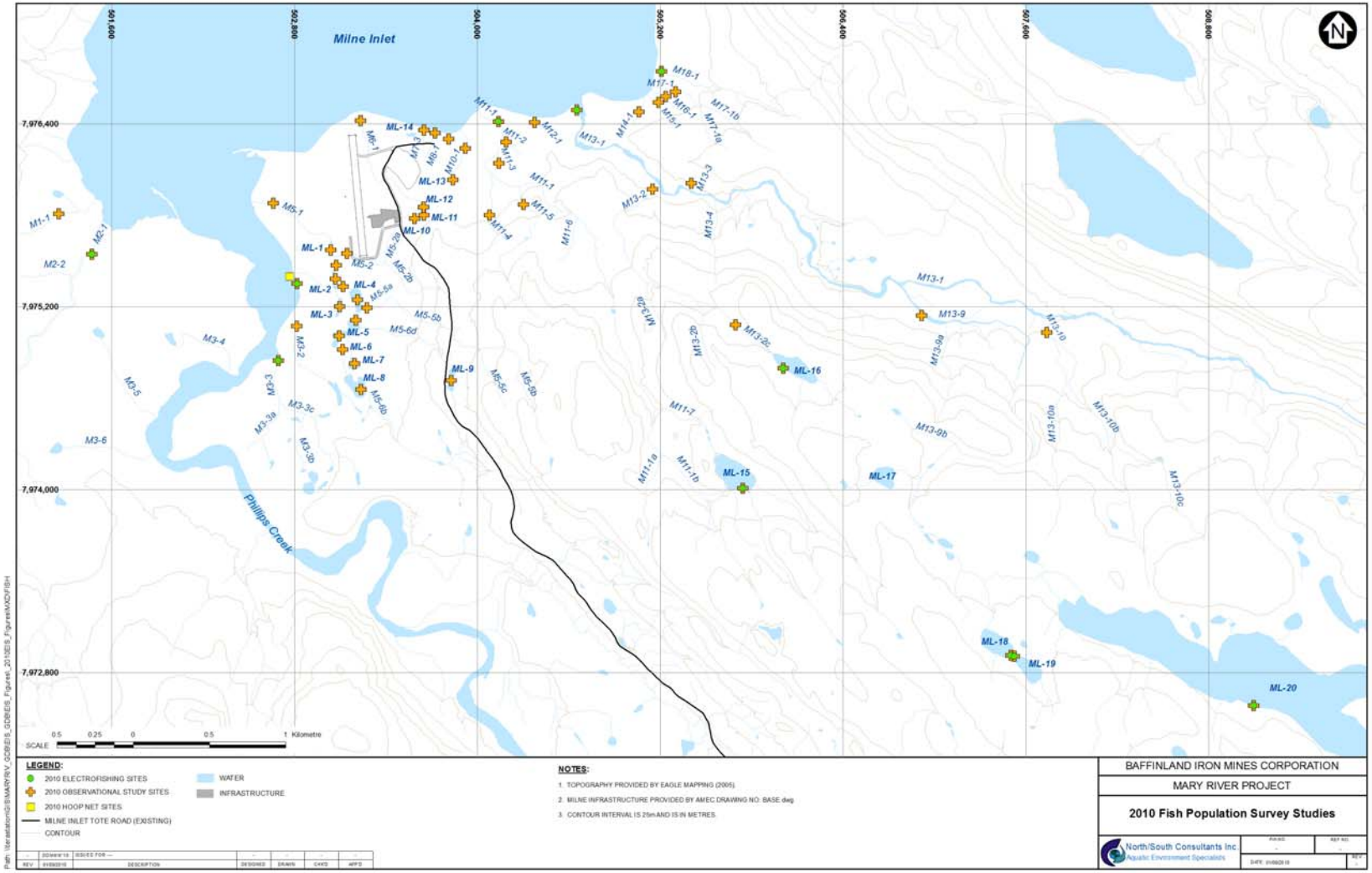

Figure 7-2. Fish population survey sites in the Milne Port Area, 2010.

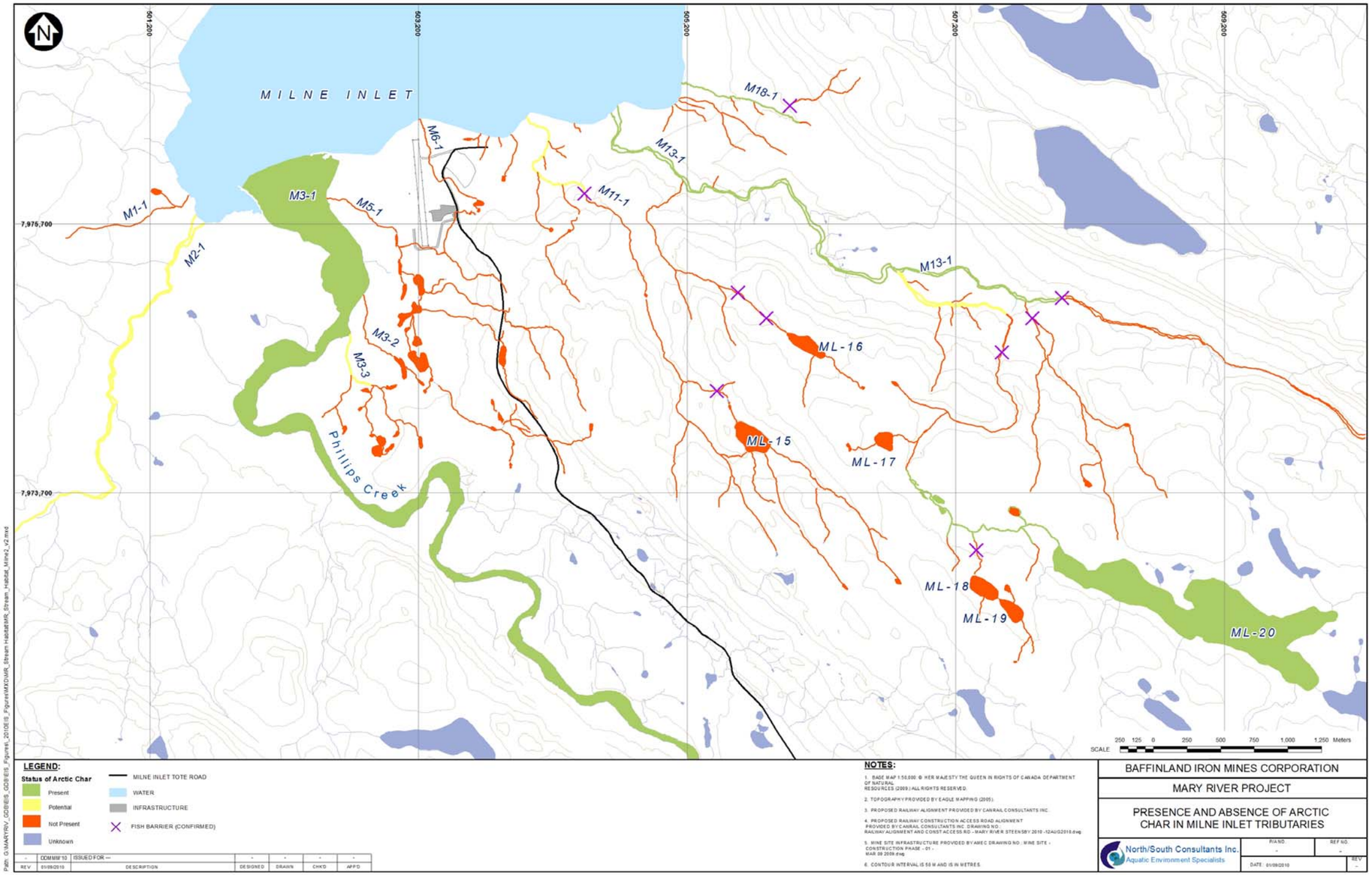

Figure 7-3. Arctic char distribution in waterbodies in the Milne Port Area.

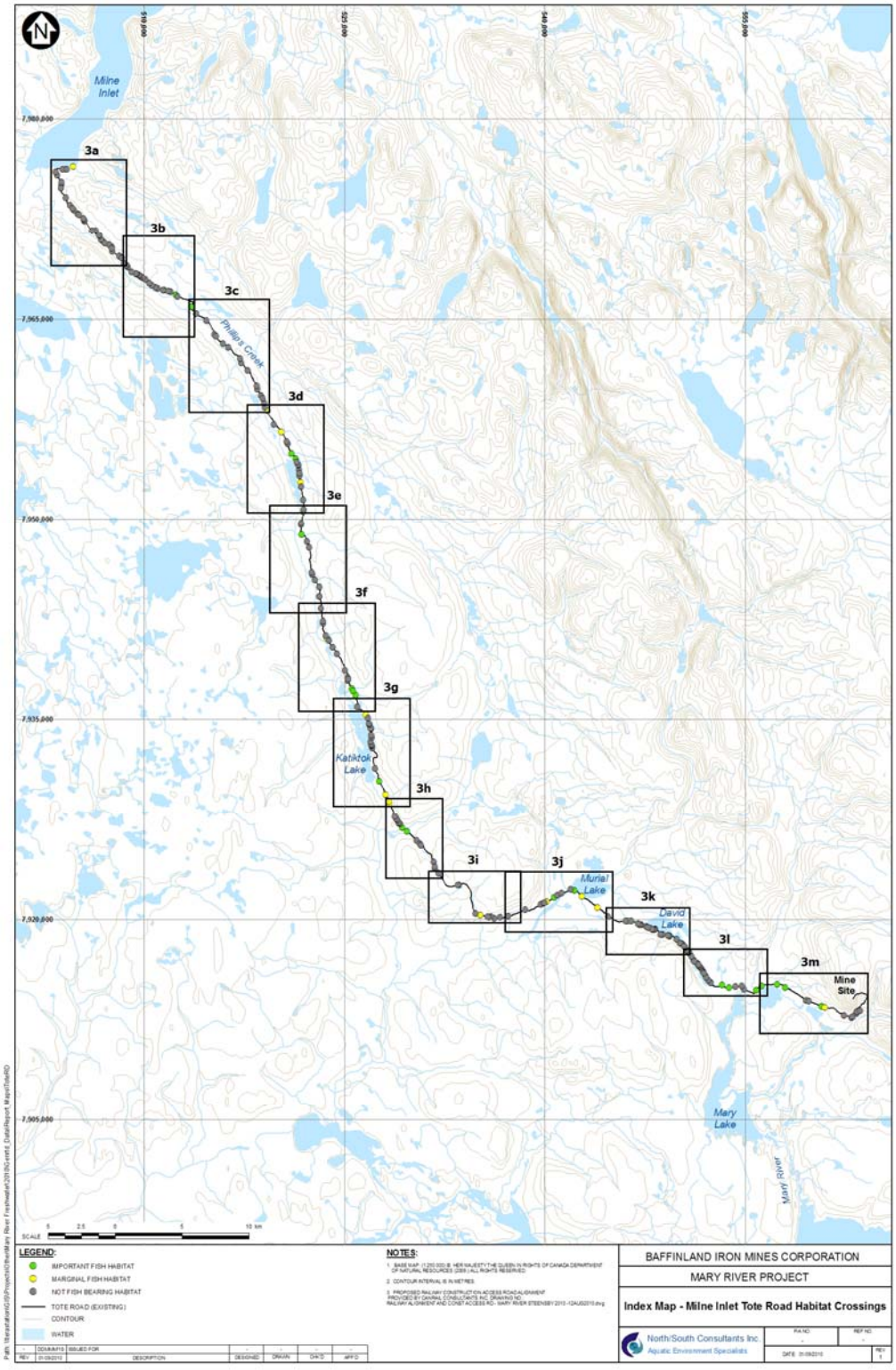

Figure 8-1.The Milne Inlet Tote Road Area

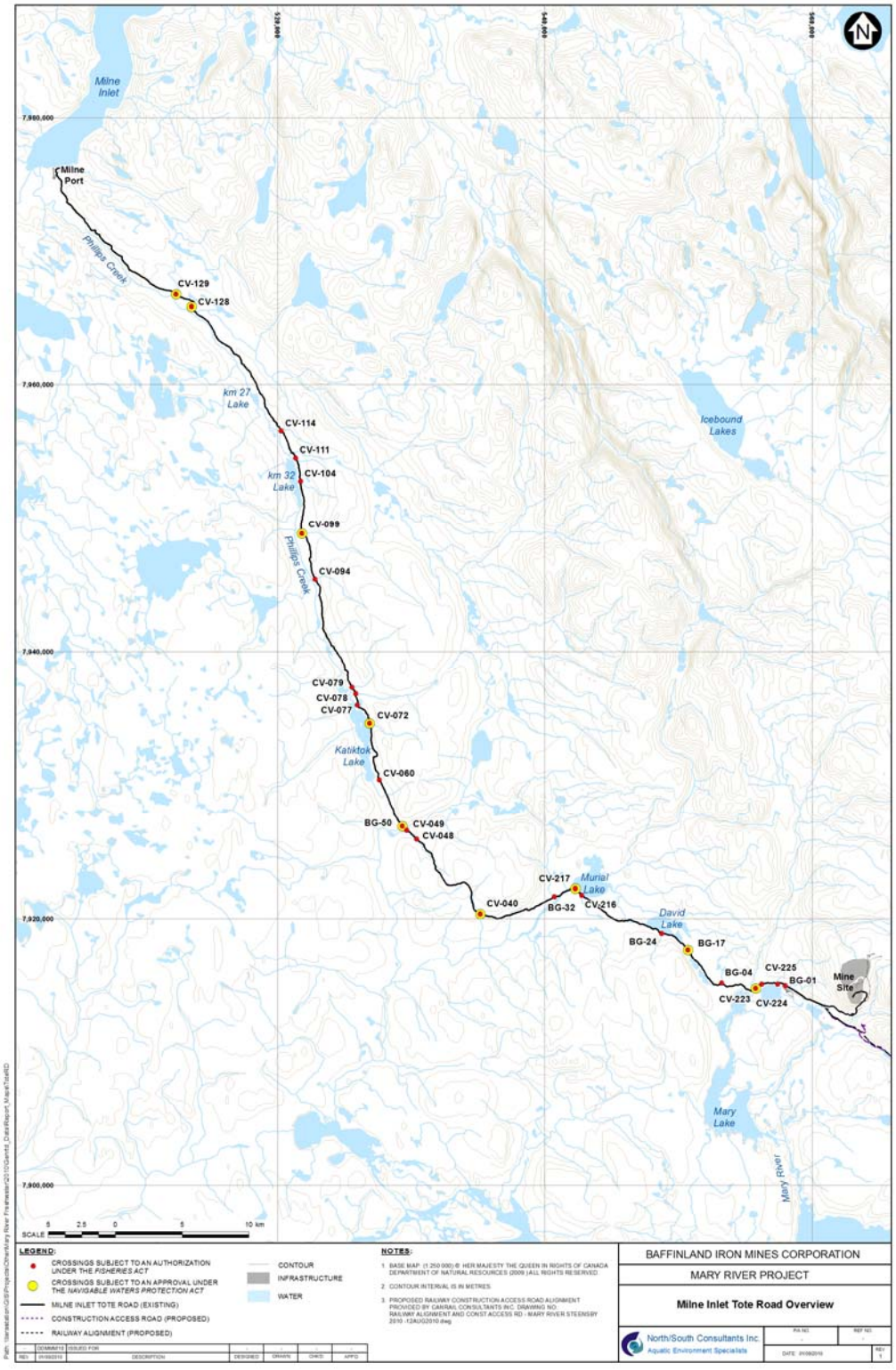

Figure 8-2. DFO Authorization sites along the Milne Inlet Tote Road.

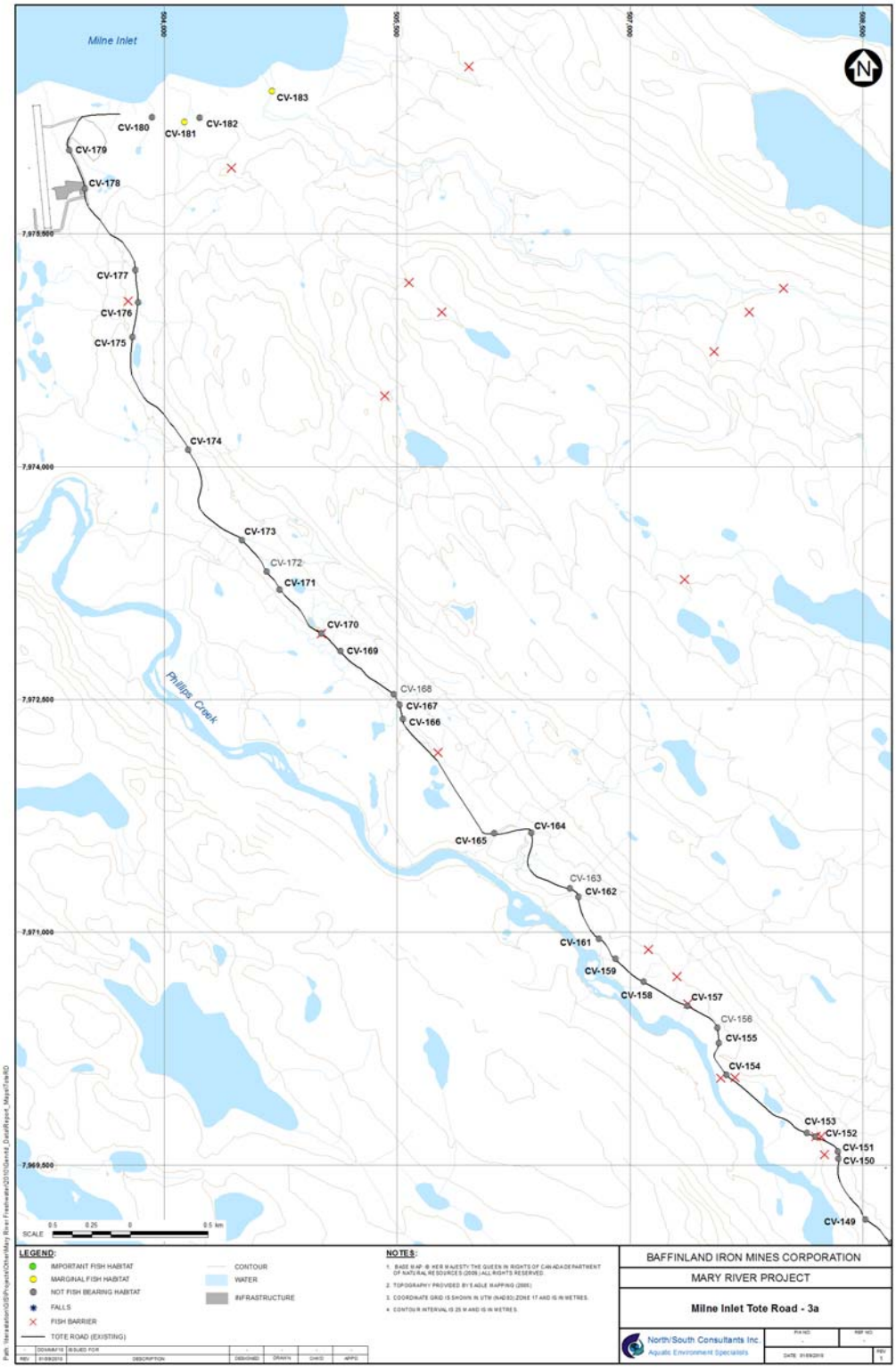

Figure 8-3a. Fish habitat and barriers in watercourses along the Milne Inlet Tote Road.

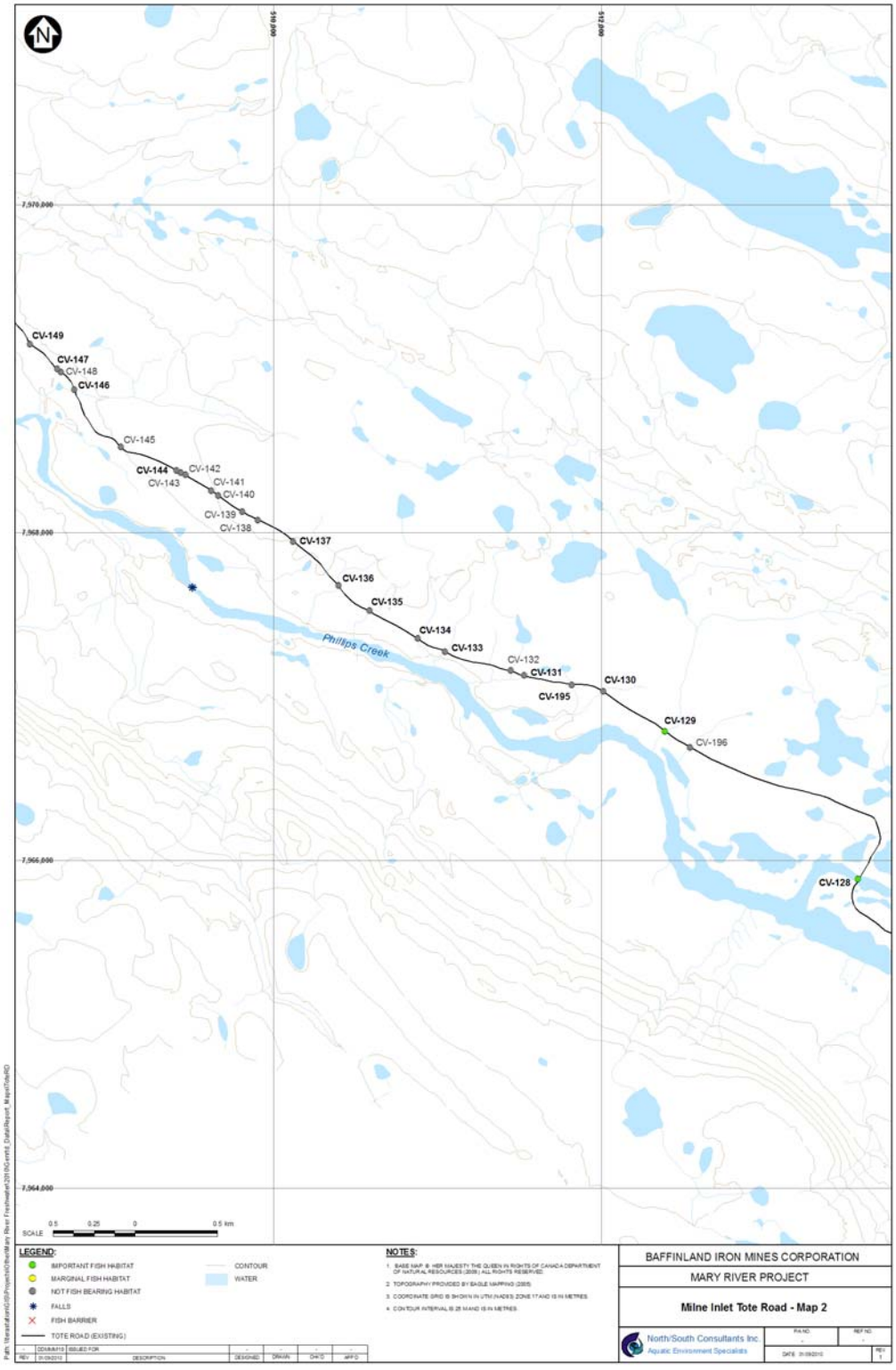

Figure 8-3b. Fish habitat and barriers in watercourses along the Milne Inlet Tote Road.

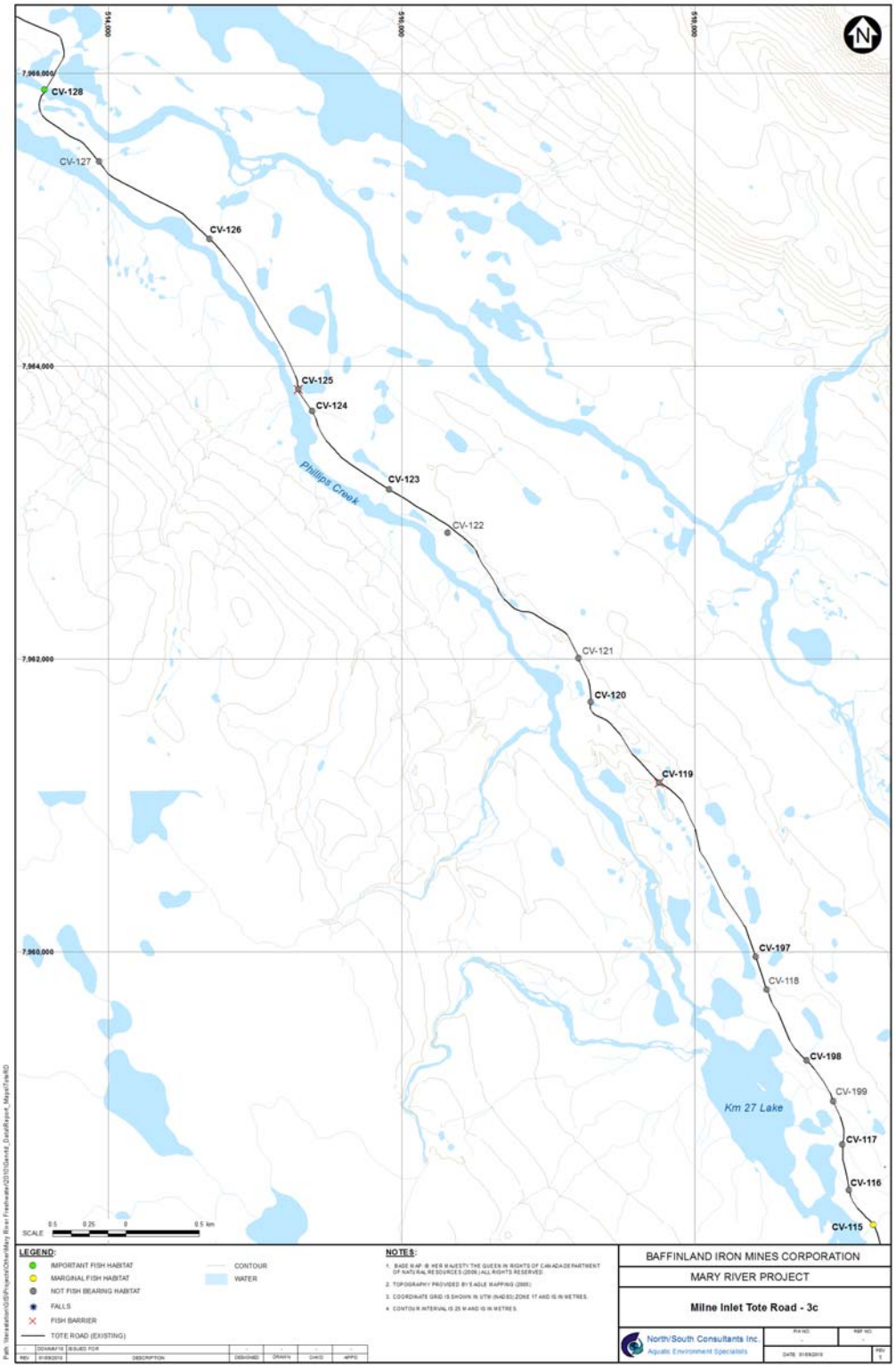

Figure 8-3c. Fish habitat and barriers in watercourses along the Milne Inlet Tote Road.

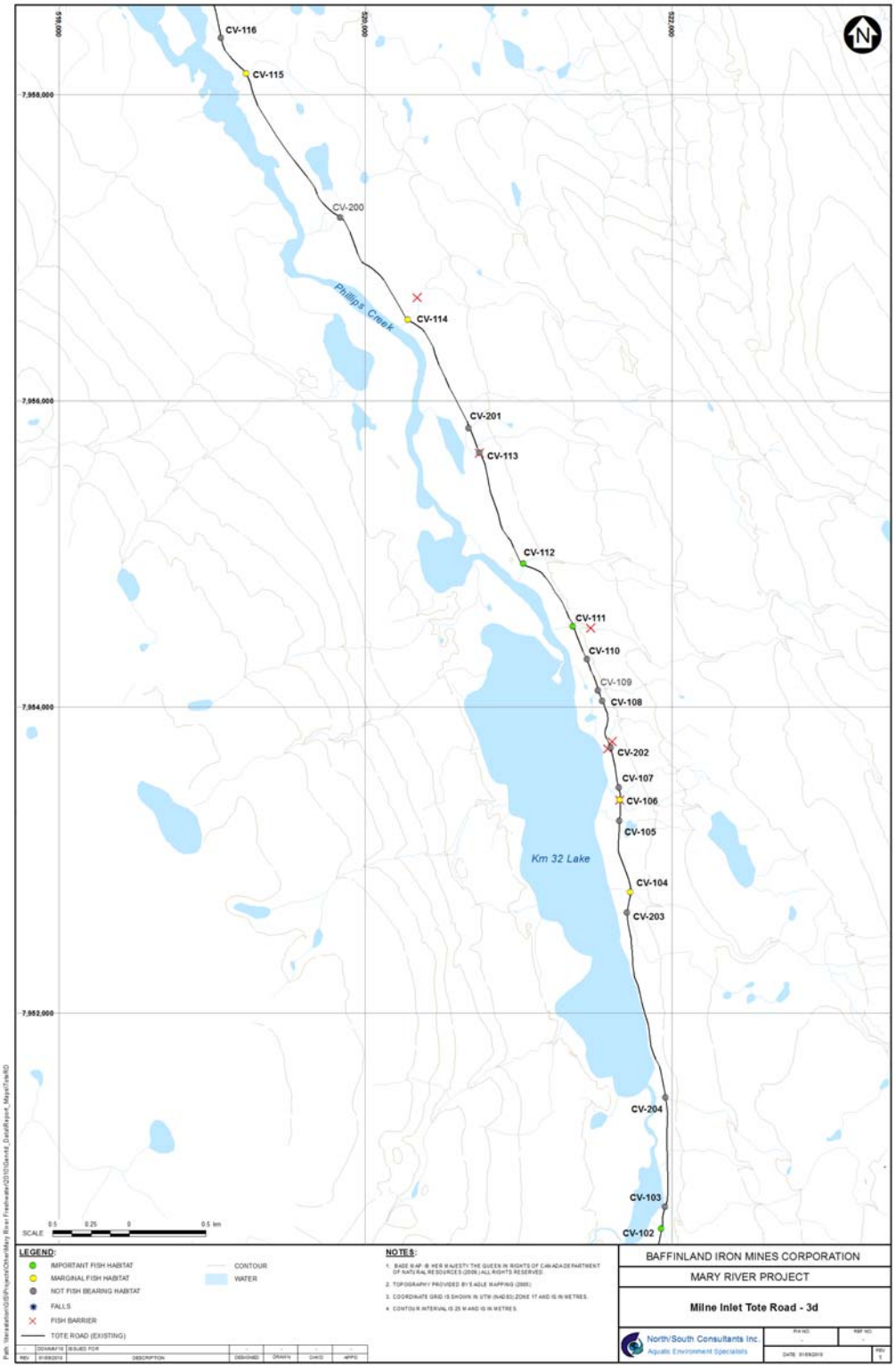

Figure 8-3d. Fish habitat and barriers in watercourses along the Milne Inlet Tote Road.

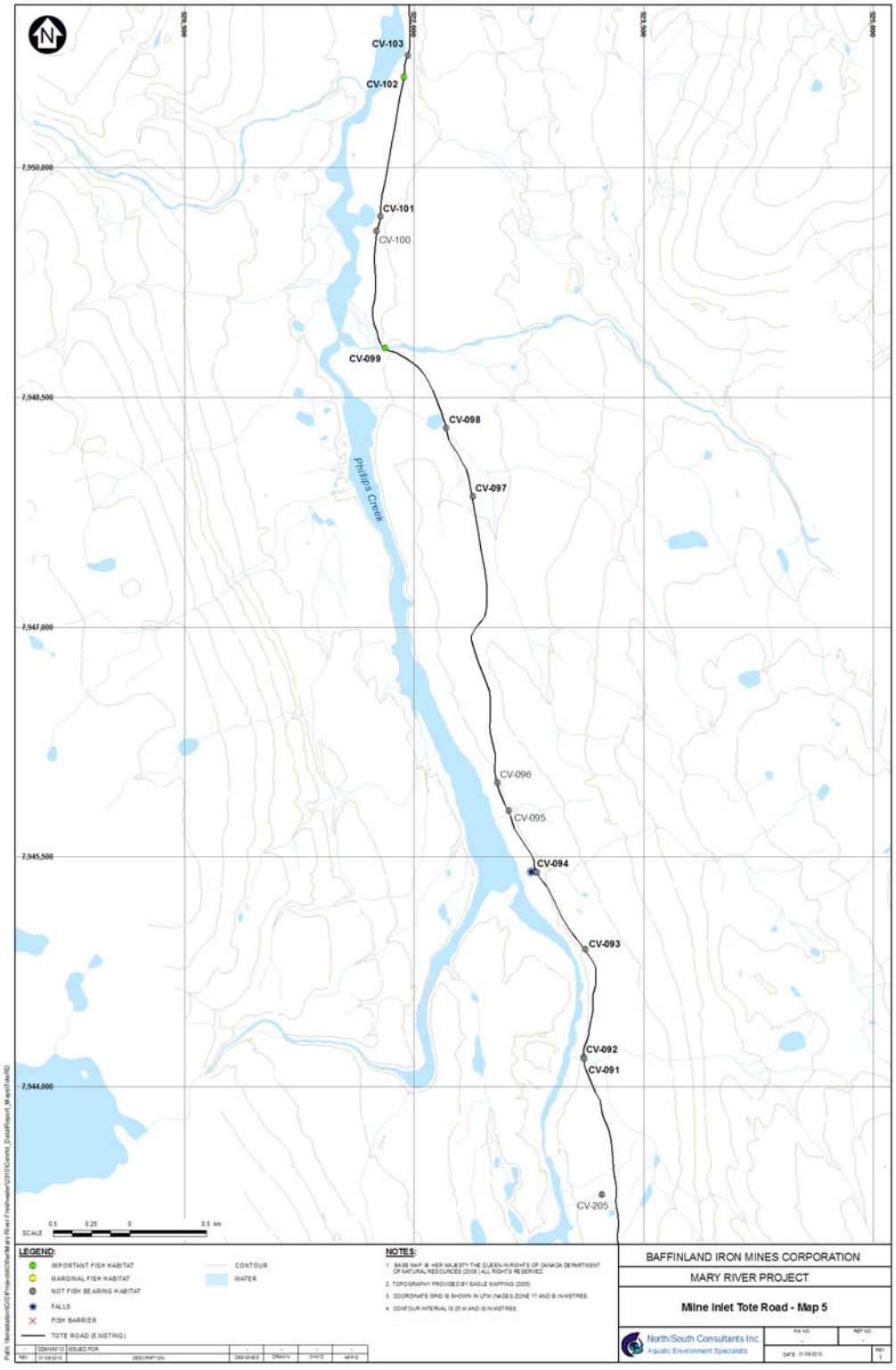

Figure 8-3e. Fish habitat and barriers in watercourses along the Milne Inlet Tote Road

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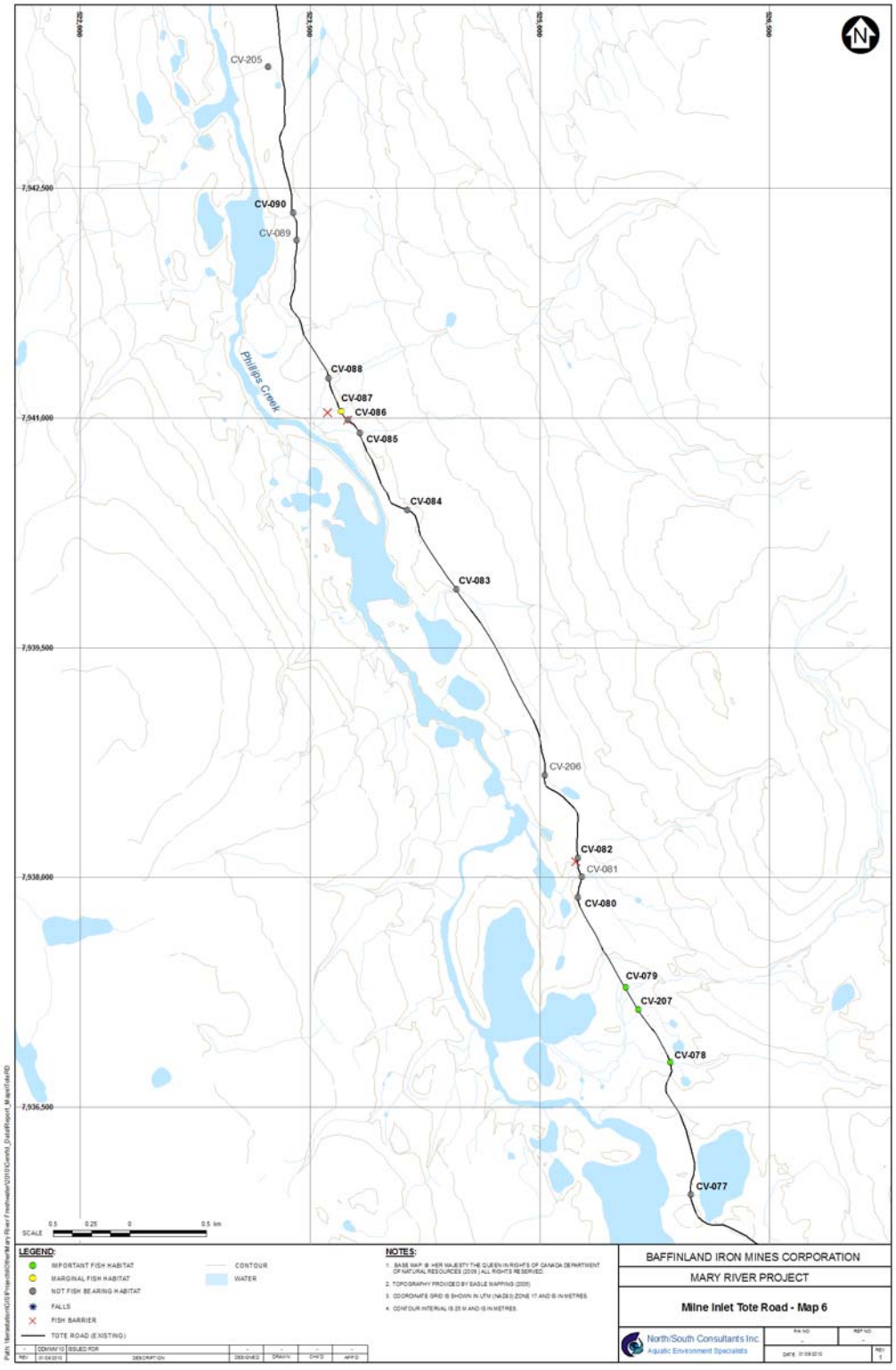

Figure 8-3f. Fish habitat and barriers in watercourses along the Milne Inlet Tote Road.

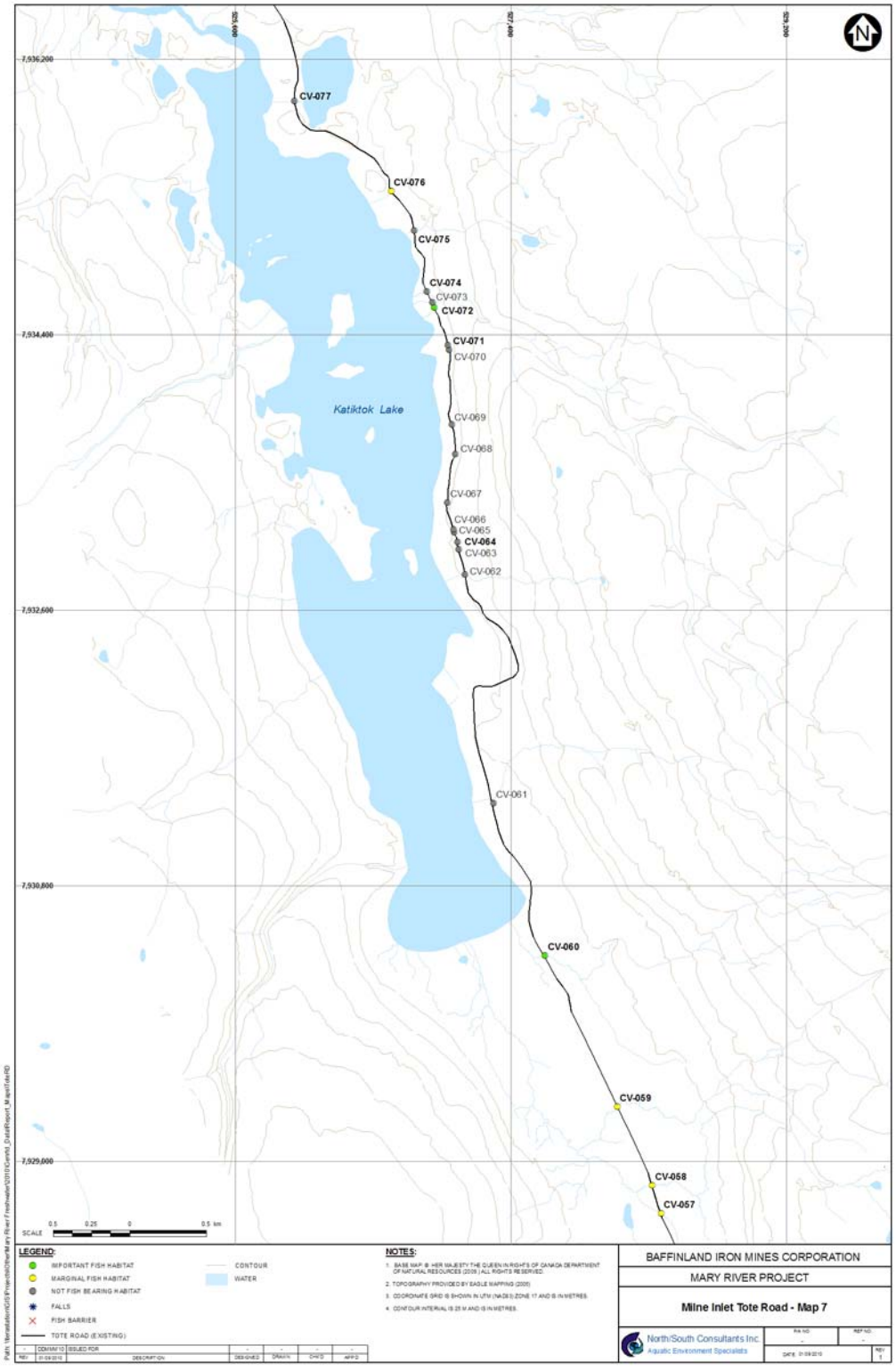

Figure 8-3g. Fish habitat and barriers in watercourses along the Milne Inlet Tote Road.

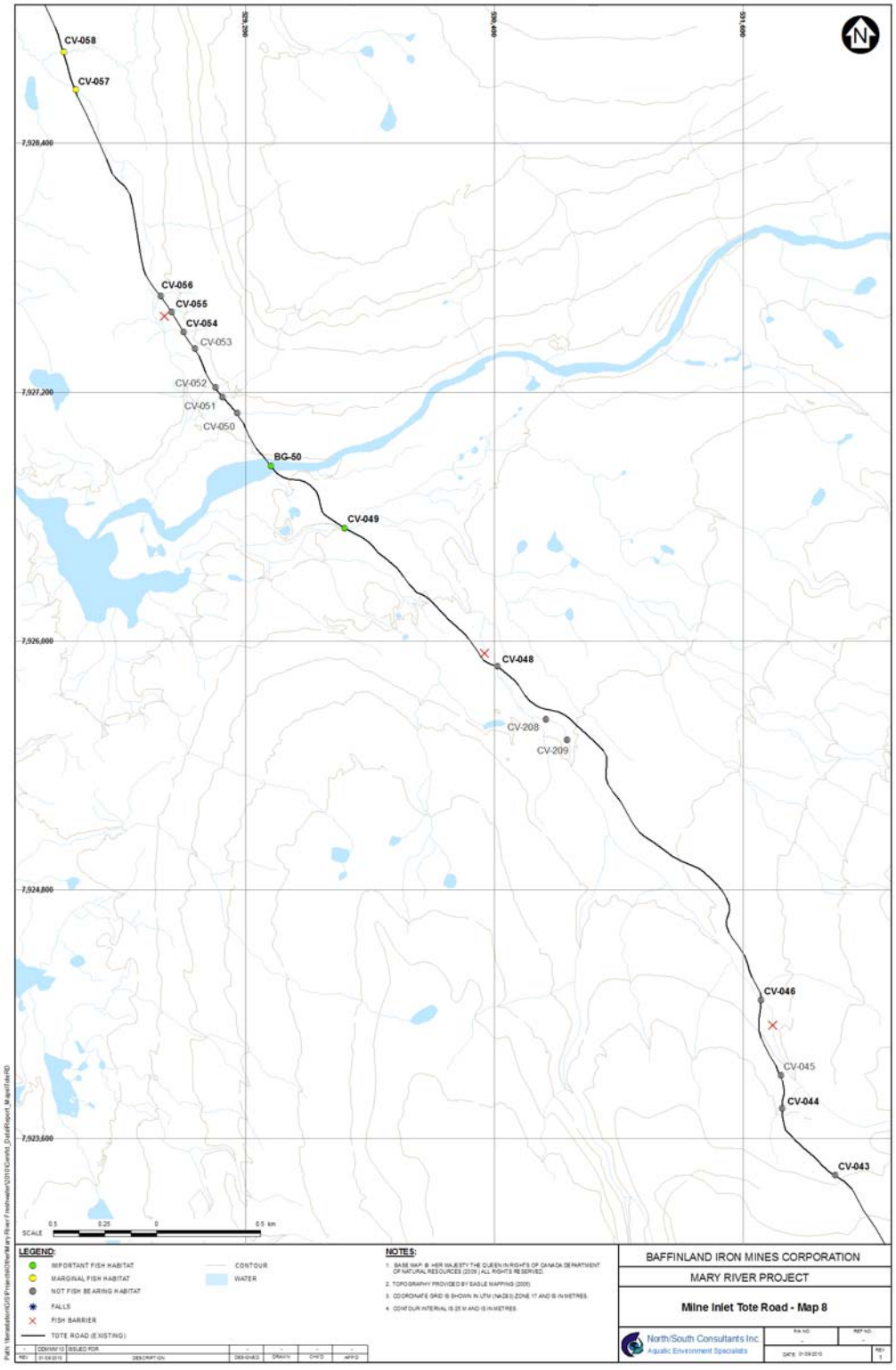

Figure 8-3h. Fish habitat and barriers in watercourses along the Milne Inlet Tote Road.

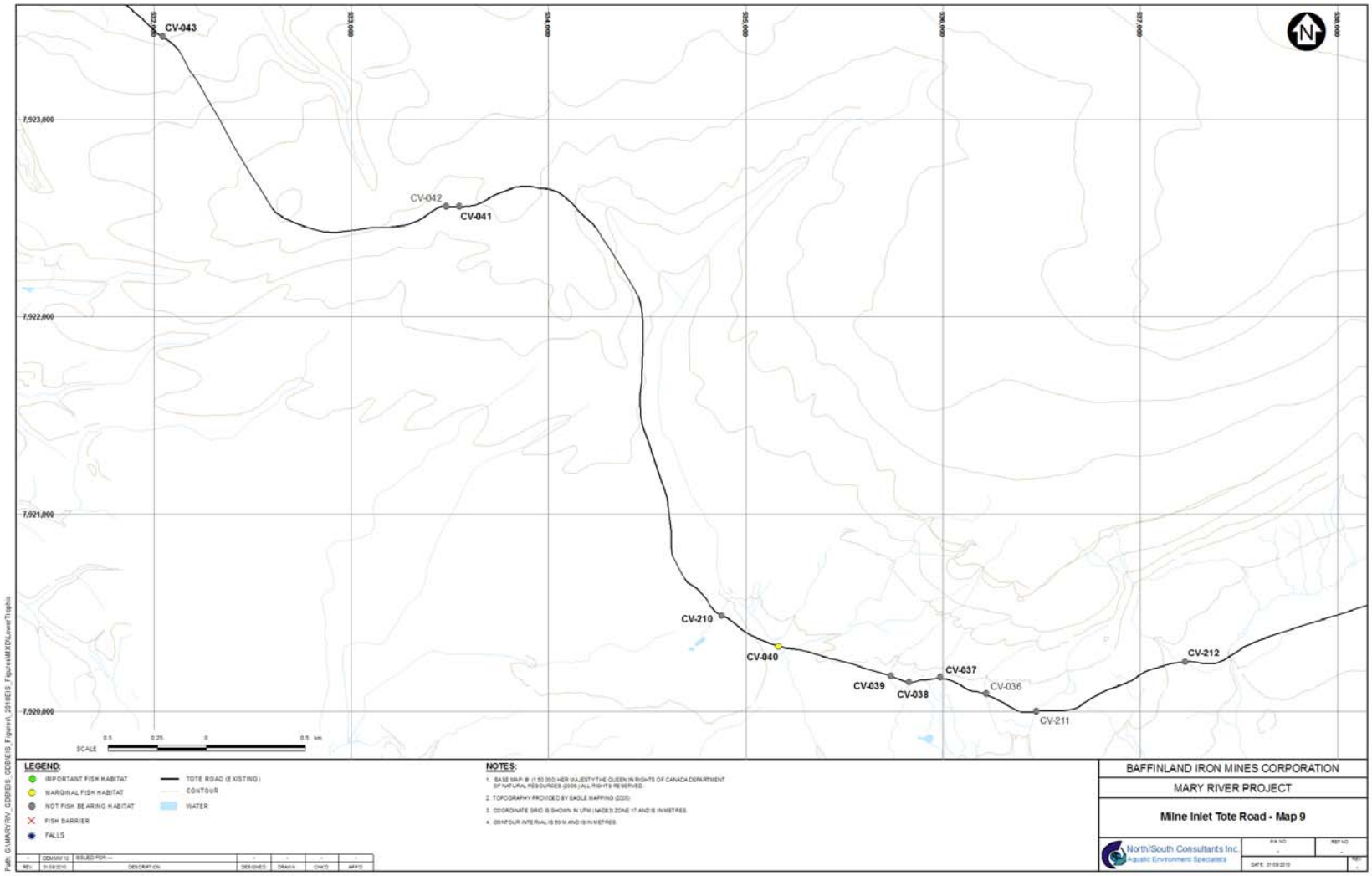

Figure 8-3i. Fish habitat and barriers in watercourses along the Milne Inlet Tote Road.

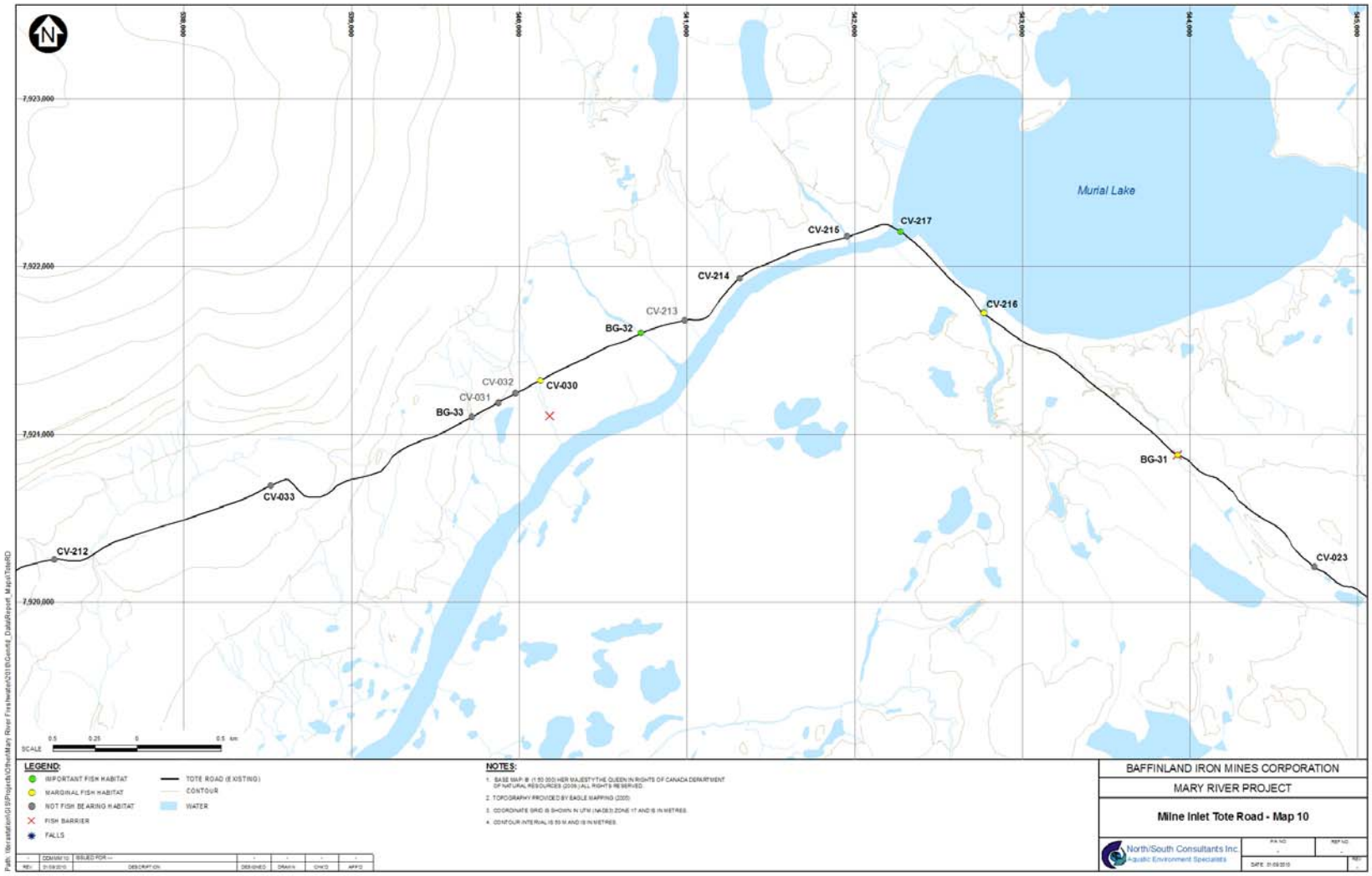

Figure 8-3j. Fish habitat and barriers in watercourses along the Milne Inlet Tote Road.

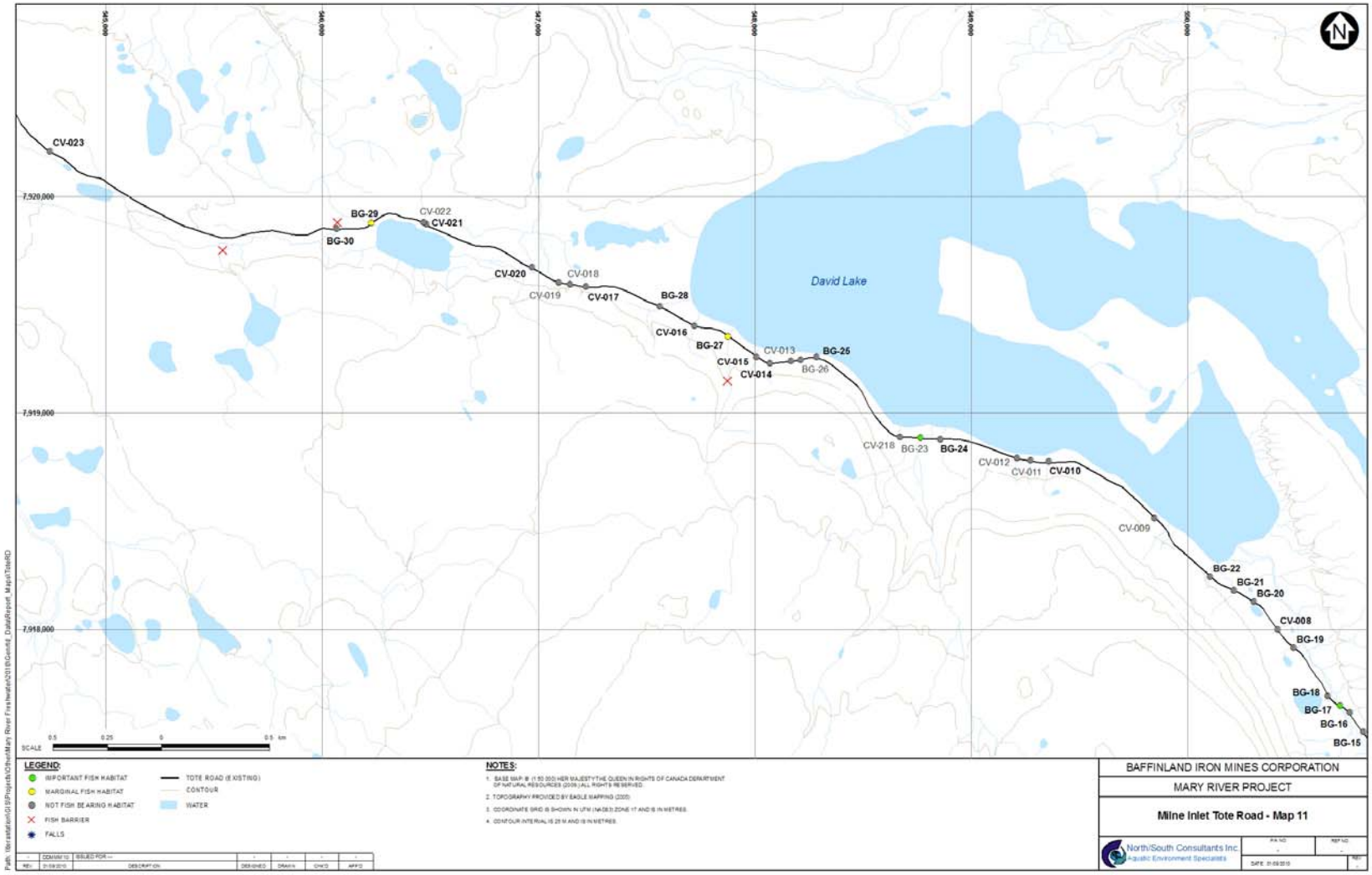

Figure 8-3k. Fish habitat and barriers in watercourses along the Milne Inlet Tote Road.

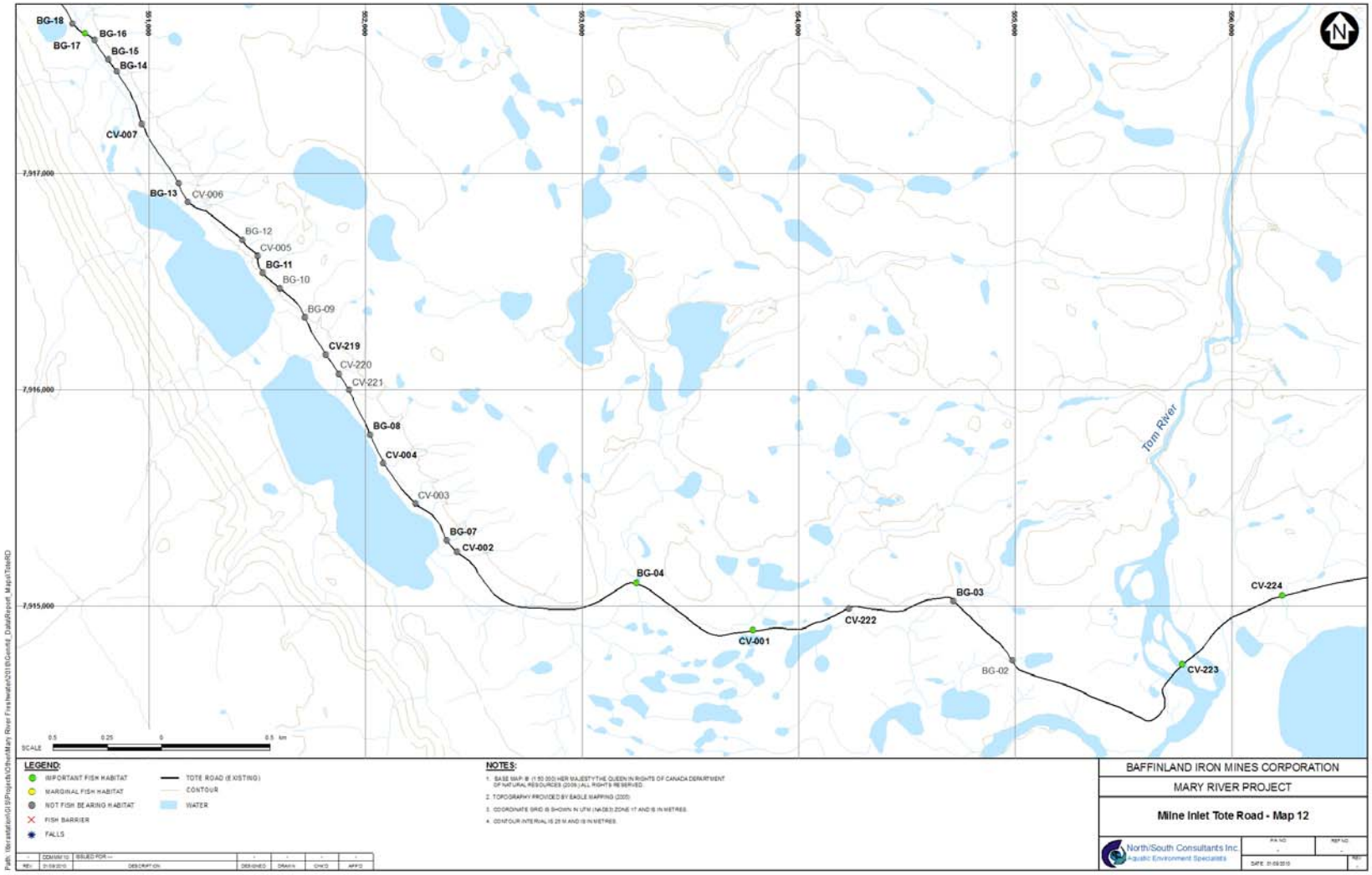

Figure 8-3l. Fish habitat and barriers in watercourses along the Milne Inlet Tote Road.

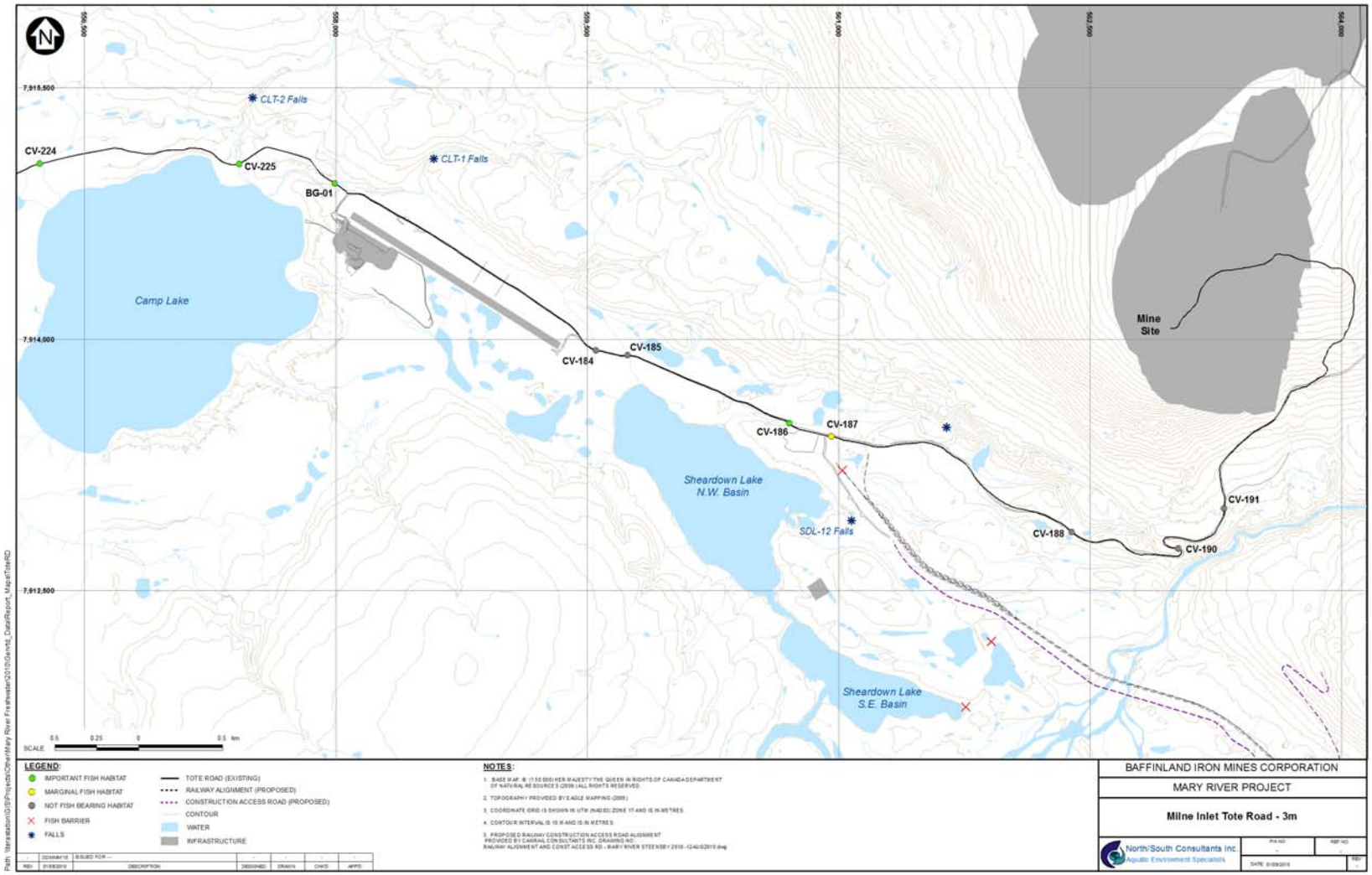

Figure 8-3m. Fish habitat and barriers in watercourses along the Milne Inlet Tote Road.

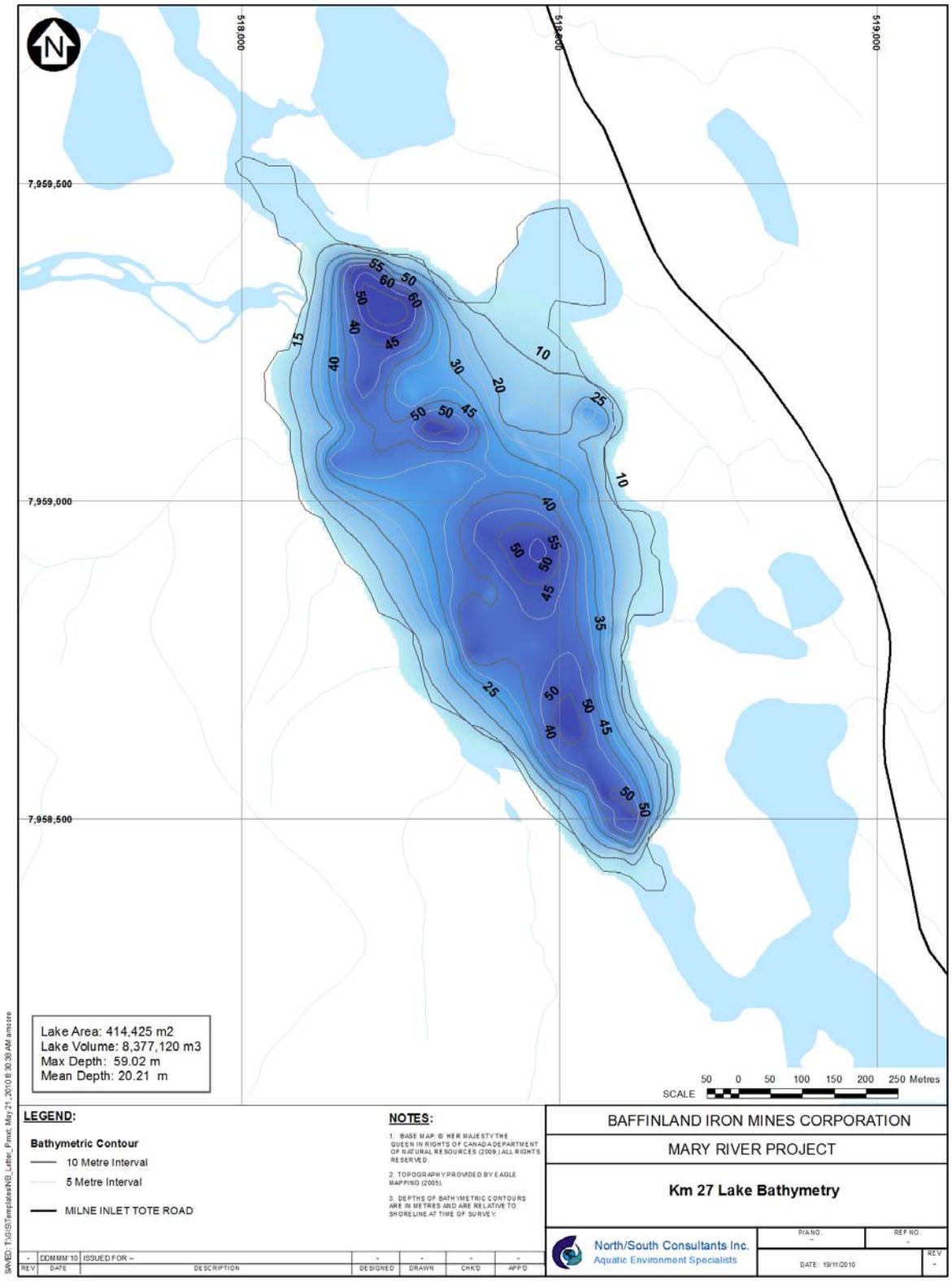

Figure 8-4a. Bathymetry map of Km 27 Lake in the Milne Inlet Tote Road Area.

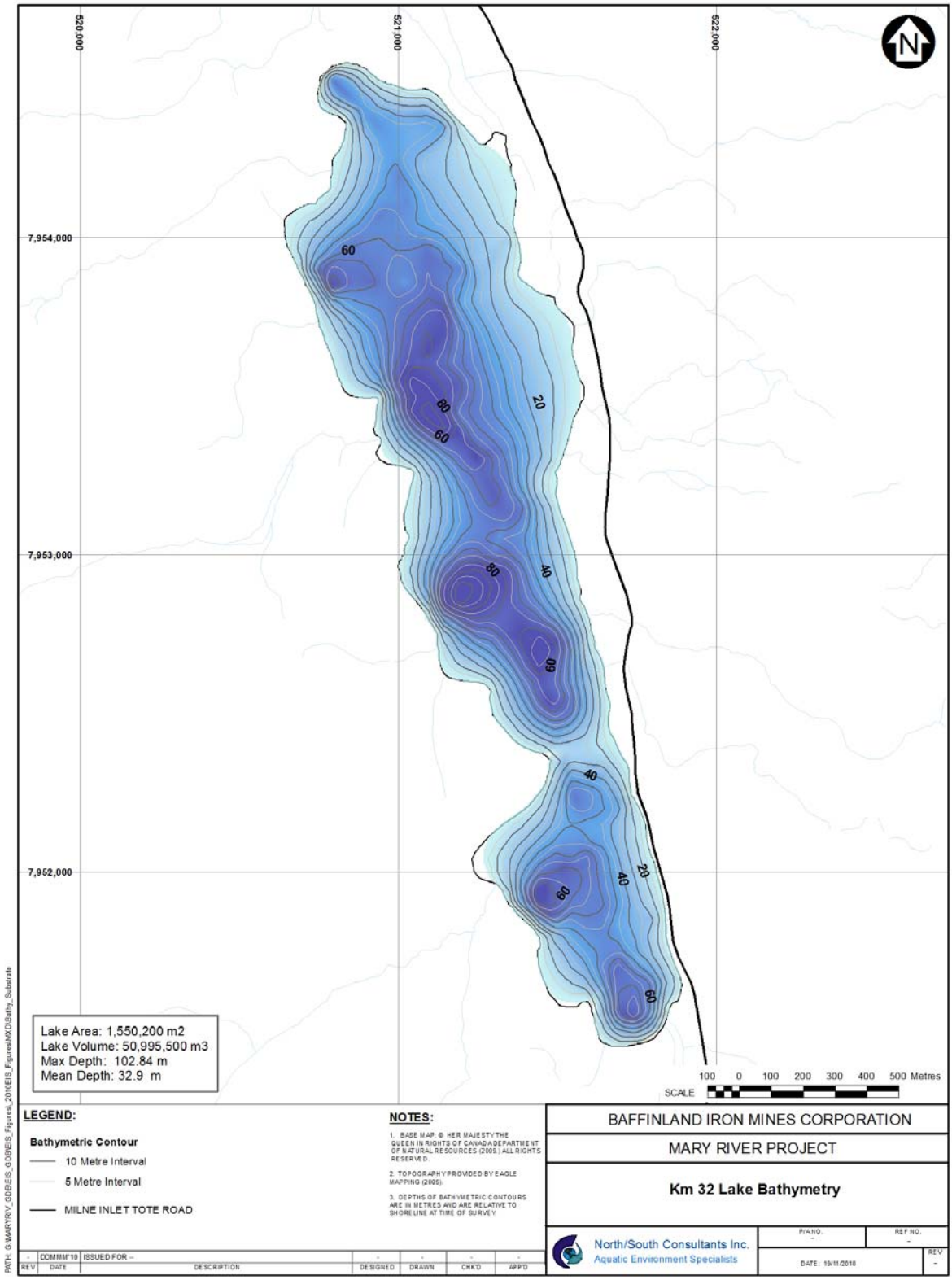

Figure 8-4b. Bathymetry map of Km 32 Lake in the Milne Inlet Tote Road Area.