



**Fish and Fish Habitat Assessment
of the Niaqunguk (Apex) River,
Lake Geraldine, and the Lake
Geraldine Drainage Channel**

FINAL REPORT

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Iqaluit, Nunavut

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Executive Summary

The City of Iqaluit retained Nunami Stantec Ltd. to complete a fish and fish habitat assessment of the Niaqunguk (Apex) River, Lake Geraldine, and the Lake Geraldine Drainage Channel. At the time of the assessment in the late summer of 2016, Arctic char were found in both the Apex River and the Lake Geraldine Drainage Channel. No species at risk were observed or captured during the fisheries assessment.

The Apex River provides good rearing and spawning habitat including overwintering habitat for a resident adfluvial population of Arctic char. The Lake Geraldine Drainage Channel provides moderate quality rearing habitat for small-bodied fish from the Koojesse Inlet upstream to an old dam structure near the hospital. Fish sampling in Lake Geraldine did not capture any fish but sampling effort was limited due to poor weather conditions. It is unlikely that fish are present based on the sampling effort and anecdotal evidence, but further sampling may be required.

Based on the fish present in the Apex River and a review of exp (2014), the Apex River may not meet the required supplemental water needs of the City of Iqaluit within the Fisheries and Oceans Canada (DFO) advised minimum flow standards. Modelling potential changes to downstream habitat availability during projected withdrawal may need to be completed to meet DFO's regulatory requirements. Additional measures to protect the fishery may have to be implemented, depending on potential intake design and flow diversion rates.

Upon review of the fish and fish habitat in the Apex River, the proposed works has the potential to result in serious harm to fish, as defined in the *Fisheries Act*. This depends on the minimum flow that may be required to sustain the resident Arctic char population in the Apex River.

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Abbreviations

asl.....	above sea level
AUP	Animal Use Protocol
CCME.....	Canadian Council of Ministers of the Environment
City	City of Iqaluit
CRA.....	Commercial, Recreational, or Aboriginal
DELT	deformities, erosion of fins, lesions, and tumors
DFO.....	Fisheries and Oceans Canada
DO	dissolved oxygen
GPS.....	global positioning system
LFSP	Licence to Fish for Scientific Purposes
Nunami.....	Nunami Stantec Ltd.

1 INTRODUCTION

The City of Iqaluit (the City) is investigating the use of the Niaqunguk (Apex) River as a secondary water source to supplement water quantity from the City's Lake Geraldine reservoir, their current drinking water source. A supplementary water supply study was recently completed and suggested that the Apex River could provide the required supplemental volumes, assuming all water was available for withdrawal (exp 2014). However, field assessments of fish presence, fish habitat, or fish use had not been completed in the Apex River, or in the Lake Geraldine reservoir, to determine if water withdrawal from the Apex River into Lake Geraldine could cause serious harm to fish, as defined under the federal *Fisheries Act*. To assess potential fish presence and habitat, Nunami Stantec Ltd. (Nunami) was retained by the City in July 2016 to complete a fish and fish habitat assessment at the Apex River, Lake Geraldine, and the Lake Geraldine Drainage Channel (the Project). As outlined in the City's Request for Proposal, the Project objectives were to:

1. Complete a fish and fish habitat assessment of the Apex River and the mouth of the Apex River at Koojesse Inlet
2. Complete a fish and fish habitat assessment of Lake Geraldine and the Lake Geraldine Drainage Channel
3. Prepare a report to discuss the findings of the fish and fish habitat assessments with respect to the *Fisheries Act*, the *Species at Risk Act*, Nunavut Land Claims Agreement, and other applicable legislation

This report provides the results of the fish and fish habitat assessment conducted between August 29 and September 4, 2016, and the regulatory implications, if any, from the assessment results.

1.1 Background

As noted, the City currently withdraws drinking water from a constructed reservoir impoundment at Lake Geraldine that is replenished by run-off from its watershed. The impoundment was constructed to increase water storage capacity and service a community population up to 12,800 (City of Iqaluit 2010). However, the quantity of water within the Lake Geraldine watershed is estimated sufficient to service a population up to 8,300 only (ibid.). For a population above this latter estimate, a secondary water source will be needed to supplement the Lake Geraldine reservoir for the community's future potable water supply.

Iqaluit has been ranked as the fastest growing community in Nunavut, and between 2001 and 2006, was among the top 15 fastest growing communities in Canada (City of Iqaluit 2010). Based on the 2011 Canadian census, the population in Iqaluit was estimated at 6,699 individuals, which represents an 8.3% change over the 2006 population (6,184 individuals) (Statistics Canada 2012). The Nunavut Bureau of Statistics (2016) adjusts population estimates for census under-coverage and has estimated the population of Iqaluit at 7,543 individuals as of mid-2015.

Given the current population estimates, and population projections for the community, there is a need for a secondary, supplementary water source. In their General Plan (City of Iqaluit 2010), the City identified the Apex River as a potential secondary water source and has included both the Lake Geraldine and the Apex River watersheds within their Watershed Protection Area to limit development within the City's current and potential future water supply basins.

The City's current proposal to use the Apex River includes pumping water from the river into the Lake Geraldine reservoir on an as-needed basis. Based on the 28-year hydrologic data record for the Apex River, one withdrawal location has been recommended (site "A2") to provide sufficient minimum and average flow volume to meet the estimated supplementation requirement (exp 2014). The preliminary design includes a 1,400 m pipeline between the Apex River and the Lake Geraldine reservoir, three vertical turbine pumps at the extraction point, and a service road. Water would be pumped from the river over the summer period, from mid-June to early October (approximately 105 days), depending on climate and reservoir water level.

As outlined by exp (2014), the available water quantity in the Apex River can provide the required supplementation volumes for the Lake Geraldine reservoir, based on the 28-year hydrologic data record for the river, and their assumption that there is no requirement to maintain a minimum stream flow; or, that all water flowing in the river is available for withdrawal, if needed. This assumption was based on the understanding that there is no active commercial fishery within the Apex River, and that fishing primarily occurs at the mouth of the river at Koojesse Inlet. However, field studies had not been conducted, with targeted fish collection within the river, to verify this assumption, or the potential for recreational, Aboriginal, or supporting fisheries, considered.

To assess potential impacts to the waterbodies, and the potential regulatory obligations under the *Fisheries Act*, the Nunavut Land Claims Agreement, and other applicable legislation, the City required additional information on existing fish habitat and fish use within both systems. Pending the results of the fish and fish habitat assessments, potential regulatory and/or ecological considerations that may need to be considered for design of the supplementary water supply system may include:

- Presence of commercial, recreational, or Aboriginal (CRA) fisheries or species of special conservation concern
- Establishment of a minimum flow requirement for the Apex River
- Requirement for, and sizing of, intake end-of-pipe screens, and withdrawal flow restrictions
- Potential loss or change of aquatic habitat in either system, from withdrawal/drawdown in the Apex River, and deepening of Lake Geraldine
- Transfer of aquatic species into the Lake Geraldine system and potential effects on existing aquatic biota and habitat

1.2 Study Area

Iqaluit is located on the northern shores of Koojesse Inlet, on south Baffin Island, Nunavut Territory. It is situated within the Northern Arctic ecozone and the Meta Incognita Peninsula ecoregion (ESWG 1995). Iqaluit experiences cool temperatures throughout the year with a mean annual temperature around -9°C, a mean July temperature around 8°C, and a mean January temperature around -27°C (Environment and Climate Change Canada 2016). Total annual precipitation is typically around 400 mm with near equal contributions from snow and rain (approximately 229 and 197 mm, respectively) (ibid.). Elevations in the Iqaluit area range from sea level at Koojesse Inlet to approximately 120 m above sea level (m asl) (Natural Resources Canada 1999). The Iqaluit area is characterized by a near-continuous cover of shrub tundra vegetation consisting of dwarf birch (*Betula nana*), willow (*Salix* spp.), northern Labrador tea (*Rhododendron groenlandicum*), mountain avens (*Dryas* spp.), and heath (*Vaccinium* spp.) (ESWG, 1995). Continuous permafrost with low to medium ice content is typical (ibid.).

The three waterbodies included in the study are shown in Figure 1-1. The Apex River lies on the east side of Iqaluit. It is approximately 8 km in length with headwater elevations up to 365 m asl, and has a catchment area of approximately 60 km² (Obradovic 1986). The proposed A2 water withdrawal location on the Apex River is shown on Figure 1-1.

Lake Geraldine lies on the northeast side of Iqaluit and is 1 km west of the Apex River. In 2006, the spillway elevation of the Lake Geraldine dam was raised by approximately 2 m to increase storage capacity of the reservoir (City of Iqaluit, 2007). From a 2008 bathymetric study, Lake Geraldine has an estimated shoreline perimeter of 3.5 km, a surface area of 0.29 km², a maximum depth of 12 m, and a volume of 1.3 million cubic metres (Mm³) (Budkewitsch 2011). Golder (2013) augmented the 2008 bathymetry data to account for the increased storage capacity and water level elevation to the spillway elevation (111.3 m asl), and volume estimates for Lake Geraldine are now 1.89 Mm³. The lake's drainage channel is approximately 2 km in length and originates from the reservoir dam, on the lake's southwest shore; the drainage channel flows through Iqaluit to Koojesse Inlet.



Overview of the Apex River, Lake Geraldine, and the Lake Geraldine Drainage Channel

Figure 1-1

2 METHODS

This section reviews the methods followed during the Project to meet study objectives, and includes the permitting, background data research, and field data collection activities.

2.1 Permitting

To conduct fish collection during the field program, two permits were obtained from Fisheries and Oceans Canada (DFO), including a Licence to Fish for Scientific Purposes (LFSP; No. S-16/17-1043-NU), and an Animal Use Protocol (AUP; No. FWI-ACC-2016-047). Permitting activities were completed as a priority task after Project award as the licensing process can take up to three months. Nunami applied for the permits in mid-July 2016, and after follow-up with DFO and the Amarok Hunters and Trappers Association, received the two permits by August 18, 2016.

2.2 Background Data Research

An electronic search and review of reports and current conditions in the Apex River, Lake Geraldine, and/or the Lake Geraldine Drainage Channel was conducted. Members of the Amarok Hunters and Trappers Association were asked to provide information on these systems; however, they were not available at the time of the request to provide supplemental information. In addition, Nunami spoke with Mr. Richard Janusz of DFO regarding potential DFO concerns about the City's proposed water supplementation project, use of the Apex River, and of Lake Geraldine.

2.3 Field Data Collection

The field program was completed over the period from August 29 to September 05, 2016, inclusive. The field program included fish and fish habitat assessment work under the terms of the DFO LFSP and the AUP, as noted above.

Sampling site locations were selected based on the requirement to assess fish presence or absence, and the requirement to assess the habitat at the proposed water intake locations. Sites were selected above barriers from Koojesse Inlet and at locations that appeared to contain habitat that Arctic char (*Salvelinus alpinus*) may utilize. Sampling locations in the Lake Geraldine Drainage Channel were selected based on existing known barriers and suitable looking reaches determined through the desktop assessment. One site on the Lake Geraldine Drainage Channel was identified as an electrofishing site based on local residents' observations of fish.

2.3.1 General Procedures

2.3.1.1 *Fish Sampling*

Backpack electrofishing was conducted on the Apex River and Lake Geraldine Drainage Channel where water depths and substrate compaction allowed. Backpack electrofishing was conducted using a Smith-Root LR-24 electrofisher powered by a 24 V battery with duty cycle (%), frequency (Hz), voltage (v) and time (seconds) recorded for each sampling event. On Lake Geraldine, modified Fyke nets and Gee-style minnow traps baited with cat food were set in nearshore areas to capture small fish species and juvenile char. Fish sampling methods included the collection of the following:

- Species ID
- Length (mm)
- Weight (g)
- Visual inspection for parasites
- Deformities, erosion of fins, lesions, and tumors (DELT)

Fish were released live, when possible. If fish were to be sacrificed, additional information was to be obtained from key large-bodied species (e.g., Arctic char) including sex and estimates of maturity, and bodies sent to DFO for analysis.

2.3.1.2 *Fish Habitat*

Channel and wetted widths, water depths, and bank heights were measured with a rangefinder, surveyor's tape, or meter stick. Bed and bank materials, bank stability, bank slopes, cover, vegetation, and fish habitat were estimated visually. In situ water chemistry (i.e., pH [± 0.2 unit], temperature [$\pm 0.2^\circ\text{C}$], conductivity [$\pm 5\%$ of reading], and dissolved oxygen [± 0.4 mg/L]) were measured using a hand-held YSI Professional Plus Water Quality Meter.

Habitat characteristics were incorporated into a physical habitat classification system that rates the quality of each macro-habitat type based on physical features (e.g., depth, cover, substrate) with respect to the life requirements of fish species (e.g., rearing, spawning, overwintering) suspected to occur in the waterbody.

Fish habitat suitability for migration, spawning, rearing, and overwintering for each watercourse was rated (i.e., good, moderate, poor, or none) by the suitability to support migration, spawning, rearing, and overwintering by fish species (as outlined by Scott and Crossman 1998). Field personnel rated watercourses for each of the four categories as nil, poor, moderate, or good for fish species categories: forage fish (small-bodied species such as sticklebacks), and harvested fish (large-bodied species characterized by their importance in recreational and subsistent fisheries such as Arctic char).

2.3.2 Waterbody-Specific Procedures

2.3.2.1 *Apex River*

At each target site, fish habitat was assessed along 100 m reaches. Along each 100 m reach, five transects were established to collect habitat data at 0 m, 25 m, 50 m, 75 m, and 100 m. The following data was collected at each transect:

- General channel morphology
- Channel width
- Wetted width
- Water depth at 0.25, 0.5 and 0.75 of wetted width
- Substrate composition
- Bank description (i.e., height, slope, and stability)
- Functional cover type and abundance
- Riparian vegetation composition
- Global positioning system (GPS) recordings and photographs

The channel was also assessed for potential seasonal and permanent barriers to migration from fish travelling up from Koojesse Inlet. This qualitative assessment of a watercourse's effectiveness as fish habitat is used in conjunction with quantitative data collected on-site to achieve a comprehensive assessment of fish habitat.

Fish sampling was conducted at each site along the full 100 m reach. Fish were collected using a variety of methods, including backpack electrofisher and angling.

2.3.2.2 *Lake Geraldine Drainage Channel*

A fish habitat assessment was completed along the entire 2 km reach of the Lake Geraldine Drainage Channel, from Lake Geraldine downstream to Koojessee Inlet. Transects were established at significant features and habitat type changes along the channel. The data collected along each transect was identical to that conducted on the Apex River (Section 2.3.2.1). Fish sampling was conducted at three 100 m sub-reaches along the Lake Geraldine Drainage Channel using a backpack electrofisher.

In addition to the transect-based assessment, qualitative habitat mapping was conducted along the entire length of the Lake Geraldine Drainage Channel to include potential important habitat features that may exist between transects, including passage barriers. Pending discussions with regulators on the water supplementation from the Apex River, habitat information from the Lake Geraldine Drainage Channel could be used towards developing a compensation/offsetting plan, if mitigation of potential effects at the Apex River is not feasible.

2.3.2.3 *Lake Geraldine*

Habitat was assessed at randomly selected locations on Lake Geraldine based on several sites stratified over various depth zones, based on available bathymetry data (i.e., Budkewitsch 2011; Golder 2013). Observations of mesohabitat, including vegetation, substrate, and shoreline features were documented. In addition, the following data was collected at regular locations along each transect:

- Dissolved oxygen
- Temperature measurements
- GPS recordings and photographs

To identify potential fish presence, fish sampling was conducted on Lake Geraldine using a variety of methods close to shore, including: angling, minnow traps, and fyke nets. Minnow and fyke nets are non-destructive methods of capturing fish and were left overnight to increase sampling effort and the potential for capturing fish. Multi-mesh gill nets were used in deeper areas. During the day, gill nets were set for a short duration (i.e., one to four hours) to minimize harm or death of fish. As no motors are allowed on Lake Geraldine, gill nets were set using a non-motorized boat (i.e., an inflatable zodiac or canoe).

3 RESULTS

The following sections provide the results of the fish and fish habitat assessments in the Apex River, Lake Geraldine Drainage Channel, and Lake Geraldine.

3.1 Apex River

The Apex River originates northeast of Iqaluit and flows into the Koojesse Inlet in the community of Apex. Historical monthly flow data for the Apex River (Water Survey of Canada [WSC] Station No. 10UH002) are available from 1973 to 2016 (WSC 2016). Mean monthly discharge in the Apex River, averaged among years, is lowest over the winter ($0.001 \text{ m}^3/\text{s}$, when not completely frozen) and highest in June and July (2.69 and $1.56 \text{ m}^3/\text{s}$, respectively).

During the field program, the primary water level at WSC Station No. 10UH002 fluctuated from a low of 0.799 m on September 4, 2016, to a high of 1.015 m on September 5, 2016, with this higher level likely the result of rainfall occurring the day before.

Figure 3-1 identifies the sampling locations on the Apex River, as well as features of interest.



Sample Sites on the Apex River

3.1.1 Fish Presence

As identified on Figure 3-1, backpack electrofishing was conducted within four separate 100 m reaches of the Apex River:

- AR-01: Upstream of the Bypass Road in Apex, approximately 350 m upstream from Koojesse Inlet (19V 527094 m E 7067317 m N)
- AR-02: Upstream of the lower canyon approximately, 1.8 km from Koojesse Inlet (19V 526584 m E, 7068527 m N)
- A1: Reach A1 upstream of the Road to Nowhere (19V 526480 m E, 7070000 m N)
- A2: At the potential water withdrawal site A2 (19V 526300 m E, 7069250 m N)

Catch efficiency may have been reduced in reach A1 due to the difficulty in sampling the deep water, presence of large boulders, and low conductivity.

Table 3-1 Electrofishing Effort in the Apex River

Reach	Length (m)	Average Channel Width (m)	Time (s)	Voltage (V)	Frequency (Hz)	Duty Cycle (%)	Fish Captured
AR-01	100	20.8	803	650	30	22	0
AR-02	100	29	541	800	30	22	0
A1	100	26.7	532	800	30	22	0
A2	100	16.2	683	800	30	22	7 ARCH

Seven Arctic char (*Salvelinus alpinus*) were captured in the Apex River at the proposed water withdrawal site A2 (Table 3-2), which is immediately downstream of a section where the Apex River widens into a small lake locally known as the “Swimming Lake” (Figure 3-1).

Table 3-2 Arctic Char Captured in the Apex River at Reach A2

Species	Length (mm)	Weight (g)	Notes
Arctic char	223	107.1	Appears to be female with spawning colours beginning to appear
Arctic char	218	114.9	Appears to be male with a kype and spawning colours beginning to appear
Arctic char	183	72.4	No comment
Arctic char	163	54	No comment
Arctic char	166	52.1	No comment
Arctic char	159	49.9	No comment
Arctic char	106	15.1	No comment

The size range of the char captured appears to indicate more than one age class present in the Apex River at A2. In addition, larger char were observed in the river upstream of the Swimming Lake at the base of a series of small waterfalls that might restrict upstream passage. These small-sized char are believed to be

resident char (i.e., do not migrate to/from Koojesse Inlet) due to the waterfall at the downstream end of the Apex River that creates a barrier to upstream fish movement (see Section 3.1.2).



Photo 3-1 Two of the Largest Arctic Char (223 mm [top] and 218 mm [bottom]) Captured in the Apex River on September 1, 2016; Both Showing Signs of Spawning Colours

3.1.2 Fish Habitat

In situ water chemistry was recorded during the assessment (Table 3-3) at each of the four sample reaches. Dissolved oxygen (DO) is an important water quality parameter that was measured in the field and is a part of the *Water Quality Guidelines for the Protection of Aquatic Life*, produced by the Canadian Council of Ministers of the Environment (CCME 2014). Dissolved oxygen concentrations were above 9.5 mg/L, which is within the CCME guidelines for early life stages of cold water fish species (i.e., at least 9.5 mg/L). The pH measurements were within the CCME guidelines acceptable range of 6.5 to 9.0.

Other water quality parameters, such as water temperature (°C) and specific conductivity (µS/cm) measured at the time of assessment were within the CCME *Water Quality Guidelines for the Protection of Freshwater Aquatic Life* (CCME 2014). exp (2014) recorded similar results in the field program in 2013.

Table 3-3 In Situ Water Chemistry in the Apex River

Parameter	A1	A2	AR-01	AR-02
Date/Time	Aug 31, 2016/ 17:00	Sep 1, 2016/ 11:30	Aug 31, 2016/ 15:30	Sep 1, 2016/ 15:30
Temperature (°C)	9.7	6.2	9.8	6.7
Dissolved oxygen (% saturation)	84	83.2	83.8	83.1
Dissolved oxygen (mg/L)	9.55	10.31	9.51	10.16
Specific conductivity (µS/cm)	52.2	54.5	55	55
pH	6.79	6.70	7.13	6.88

At the mouth of the Apex River, exposed bedrock shelves create a series of waterfalls, the largest being over 2 m in height (Photo 3-2). This waterfall creates a barrier to upstream fish movement at the community of Apex, approximately 350 m upstream from the Koojesse Inlet. The lowest reach assessed, AR-01 (Figure 3-1), is just upstream this waterfall, near the Bypass Road in the community of Apex.



Photo 3-2 Fish Passage Barrier (Waterfall) at the Community of Apex; Northwest Aspect

3.1.2.1 AR-01—Apex River at Apex

A summary of habitat data surveyed at AR-01 is provided in Appendix A, with fish habitat codes in Appendix B. The river at AR-01 is approximately 15 to 25 m wide with depths over 0.6 m. The substrate consists of coarse materials such as cobbles and boulders, that can withstand the higher gradient and

faster water. Boulders provide cover for fish from predators and from the water velocities. In addition to cover from boulders, water depth between the boulders and slight overhanging banks would also provide cover (Photo 3-3). The river channel is stable, with large boulders forming stable banks and preventing bed erosion.



Photo 3-3 Looking Upstream at Reach AR-01; North Aspect

In the lower part of the AR-01 reach, Bypass Road (Photo 3-4) creates a “choke point” impounding the river during higher flows, resulting in the deposition of smaller substrate sizes, including fine materials.



Photo 3-4 Looking Downstream in Reach AR-01 at the Impoundment Created by Bypass Road in Apex; South Aspect

Between reach AR-01 and reach AR-02, the Apex River flows through a steep canyon, where the Water Survey of Canada flow gauging station is located (Photo 3-5). Through the canyon, the river has a steeper, cascade and rapids habitat type, but there do not appear to be any barriers to fish passage.



Photo 3-5 Water Survey of Canada Gauge in the Apex River Lower Canyon; West Aspect

3.1.2.2 *AR-02—Apex River upstream of the lower canyon*

A summary of habitat data surveyed at AR-02 is provided in Appendix A, with fish habitat codes in Appendix B. The Apex River in reach AR-02 is a transition from lake type habitat to river type habitat, where a small bedrock shelf forms a gradient break between two lower gradient areas (Photo 3-6). The river is 13 to 39 m in width, with depths ranging from 0.06 to 0.78 m. Substrates range from mainly boulders at the downstream end of the reach, to an assortment of small gravels and fines in the lower gradient portions at the upstream part of the reach. The banks are well vegetated with grass and ground cover, with some exposed coarse materials including boulders and cobble.



Photo 3-6 Reach AR-02 Looking Downstream at the Bedrock Outcrop; South Aspect

Approximately 2 km from Koojesse Inlet, the Apex River flows through a wide flat valley, upstream of the lower canyon. As the river flows through the lower gradient valley bottom, the river widens and forms a series of small lakes (Photo 3-7). The lakes are approximately 500 m long and at places, as wide as 100 m.



Photo 3-7 Looking Downstream at the Low Gradient Valley Lakes on the Apex River; Southeast Aspect

These lakes appear to be deeper than 2 m with substrates ranging from fine materials to boulders. Reach AR-02 is at the outlet of these lakes, where the river slope begins to steepen as the river flows into the lower canyon.

3.1.2.3 *A2—Potential Diversion Site on the Apex River*

A summary of habitat data surveyed at A2 is provided in Appendix A, with fish habitat codes in Appendix B. The reach at the potential diversion site, identified as “A2”, is at the upstream end of the flat valley where the Apex River forms the series of small lakes. At A2, the river is in a well-defined channel, with a slightly steeper gradient between 1% and 5%. The channel in the A2 reach ranges from 13 to 38 m wide with some ponded water on the west bank. Water depths were up to 0.75 m in this reach. The substrate ranges from large gravels and cobble to boulders. Most cover for fish is in the form of deeper pockets of water behind instream boulders and along overhanging sections of bank.

At the upstream end of reach A2, the river flows from a small lake locally known as the “Swimming Lake”. The lake is approximately 35 m wide and 50 m long, with depths exceeding 2 m. Substrates are smaller gravels and cobbles near the lake’s outlet, with cobbles and boulders. The lake has bedrock outcroppings forming cover at the upstream end, and is protected by a valley wall on the east. Habitat in the lake would consist of cover from depth as well as bedrock and boulder structures on the bed and around the edges. Arctic char were observed in the “Swimming Lake” and in the river immediately upstream of the lake.



Photo 3-8 Reach A2 Looking Upstream Towards the "Swimming Lake"; Northeast Aspect



Photo 3-9 Looking Upstream from Reach A2 into the "Swimming Lake"; Northeast Aspect

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Upstream of the "Swimming Lake", the river is confined in a tighter steep valley with bedrock outcrops creating a series of cascade and rapid sections (Photo 3-10 to Photo 3-12). Substrates are large coarse materials and exposed bedrock. There are a series of cascades forming drops that may limit upstream fish movement, although they do not appear to be high enough to be complete barriers. The presence of scour pools for resting and jumping, small bypass channels, and stepped drops along the edge of the cascade, likely provide passage through the canyons.



NOTE: Fish observed in the pool below the falls

Photo 3-10 Cascade Upstream of the "Swimming Lake" (19V 526407 m E, 7069344 m N)



Photo 3-11 Looking Upstream in the Cascade on Apex River (19U 526526 m E, 7069570 m N)



Photo 3-12 Looking Upstream at Cascade on Apex River (19U 526526 m E, 7069570 m N)

3.1.2.4 A1—Upstream of the “Road to Nowhere” on the Apex River

A summary of habitat data surveyed at A1 is provided in Appendix A, with fish habitat codes in Appendix B. The reach identified as A1 is upstream of the Road to Nowhere crossing, and had originally been considered as a potential water diversion location on the Apex River. A1 is upstream of the canyon section identified in Section 3.1.2.3. The “Road to Nowhere” crosses the Apex River immediately downstream of A1. A slight

impoundment caused by the road has resulted in a smaller substrate size at the lower end of the A1 reach, with fine materials dominating. Boulders present along the east side of the river provide cover. Under the bridge on the Road to Nowhere, the constriction increases the water velocity and a coarse substrate was observed, consisting of boulders and cobble. Between the “Road to Nowhere” and the canyon downstream, there is a sand pit adjacent to the river that is a source of sediment input (Photo 3-13)



**Photo 3-13 Sand Pit Adjacent to the Apex River, downstream of Reach A1
(19V 526467.94 m E, 7069819.72 m N)**

The reach at A1 consists of boulder garden/run habitat along much of the channel length and width, with a narrow riffle zone along the east bank (Photo 3-14). The channel width varies from 25 to 32 m wide, with a wetted width from 22 to 32 m. The channel has depths ranging up to 1.38 m recorded in between large boulders that have a diameter of 1.5 m (Photo 3-15). The dominant substrate is large boulders, followed by cobbles. The banks are stable and vegetated by grasses. Although fish were not captured in this reach it appears that it could provide good fish habitat for fish, with high amounts of cover between the boulders. There are also riffles along the east bank adjacent to steep banks providing cover and potential food production.



Photo 3-14 Looking Downstream at the Road to Nowhere Bridge from the Mid-Section of Reach A1



NOTE: Recorded depth at this transect was 1.38 m between the boulders

Photo 3-15 Mid-Reach of A1 showing the Large Boulders and Deep Interstitial Spaces

3.2 Lake Geraldine Drainage Channel

The Lake Geraldine Drainage Channel flows approximately 2 km through the city from Lake Geraldine to Koojesse Inlet. It is a small perennial stream, modified by the urban interface, while retaining sections of natural stream form. The channel is a notable feature in Iqaluit, and is crossed by roads and trails, eight times along its 2 km length (see Table 3-4 and Figure 3-2).

Table 3-4 Man-Made Features along the Lake Geraldine Drainage Channel

Feature No.	Feature	Location (in UTM 19 V)	Notes
1	Sinaa Road Crossing	524114.64 m E, 7068411.83 m N	Two circular culverts, 1,100 mm dia and 800 mm dia, no drop
2	Nipisa Street Crossing	524186.05 m E, 7068498.85 m N	Three 1,200 mm dia culverts, 14 m long with gabion wall headwall at inlet. Flow through one pipe only
3	Queen Elizabeth Road Crossing	524261.72 m E, 7068684.52 m N	Five pipes, three 1,650 mm dia oval culverts, with two 620 mm dia circular overflow pipes above them 0.22 m drop from culvert into 0.29 m pool may be barrier to small fish or at some flow levels
4	Pedestrian Crossing near Paunna Road	524313.69 m E, 7068819.42 m N	Two 1,550 mm dia culverts, 7 m long, half buried in the substrate
5	Astro Hill Road Crossing	524302.97 m E, 7068975.12 m N	Clear span bridge structure, 13 m wide over a channel with 7 m wide bankful Unstable bank on downstream left
6	Astro Hill Pedestrian Crossing	524210.46 m E, 7069099.66 m N	Two 1,300 mm dia culverts, 7 m long with one 400 mm dia overflow pipe
7	Overhead Pipe Crossing	524118.39 m E, 7069199.35 m N	Footings constructed of wooden cribs on rock riprap, encroaching on channel width
8	Road to Apex Crossing	524080.36 m E, 7069242.08 m N	Two 2,200 mm dia culverts, 22 m long
9	Old Dam Structure	524099.06 m E, 7069449.71 m N	Concrete dam, over 1 m drop. Complete barrier, no flow over structure—water flows through rock debris under structure
10	Saputi Road Crossing	524132.93 m E, 7069756.41 m N	Two 1,500 mm dia oval pipes, 80 m long, steep installation



Sources: Base Data - Government of Canada; Thematic Data - Stantec Ltd.

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Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Sample Sites on the Lake Geraldine Drainage Channel and Lake Geraldine

The overall habitat available in the channel is considered good for juvenile Arctic char. There are riffles with areas of gravels and cobbles that would support the production of aquatic invertebrates, as well as some deeper pools, boulder cover, and cascade/step pool habitats. There is good cover in the form of boulders and undercut banks through the entire length. The substrates range from fines to large boulders and bedrock outcrops.

Figure 3-2 identifies the sampling locations on the Lake Geraldine Drainage Channel, as well as features of interest.

3.2.1 Fish Presence

Arctic char were identified in the Lake Geraldine Drainage Channel during the field assessment (Photo 3-16) at locations from the Koojesse Inlet upstream to a series of barriers at an old dam structure near the hospital above the Road to Apex.

Backpack electrofishing was conducted in three separate 100 m reaches of the Lake Geraldine Drainage Channel:

- DC-01: 100 m upstream of the Queen Elizabeth Road Crossing in Apex, approximately 500 m upstream from Koojesse Inlet (19V 524313 m E, 7068838 m N)
- DC-02: Above the old dam structure at (19V 524099 m E, 7069449 m N) approximately 1.3 km from Koojesse Inlet
- DC-03: Upstream of the Road to Apex crossing approximately, 1 km from Koojesse Inlet (19V 524085 m E 7069271 m N)

Table 3-5 Electrofishing Effort in the Lake Geraldine Drainage Channel

Reach	Length (m)	Average Channel Width (m)	Time (s)	Voltage (V)	Frequency (Hz)	Duty Cycle (%)	Fish Captured
DC-01	100	6.1	686	450	30	20	0
DC-03	100	3	698	450	30	20	2 ARCH
DC-02	100	3	580	450	30	20	0

Two juvenile Arctic char were captured upstream of the Road to Apex, near the hospital. The larger Arctic char was 113 mm long and weighed 18.5 g, the smaller was 94 mm long and 11.3 g (Photo 3-16).

Arctic char were also observed, but not captured, downstream of the sampling reaches, in a pool below the crossing on Sinaa Road and in the step-pool habitat above Nipisa Street (Figure 3-2).



Photo 3-16 Arctic Char Captured in the Lake Geraldine Drainage Channel (113 mm), August 30, 2016

3.2.2 Fish Habitat

The Lake Geraldine Drainage Channel was surveyed from the mouth at the Koojesse Inlet upstream to the dam on Lake Geraldine. Based on the fisheries assessment, there are no barriers to fish movement in the Lake Geraldine Drainage Channel from the Koojesse Inlet up to a dam structure near the hospital, which is a barrier to fish (Table 3-4).

In situ water chemistry was recorded upstream of the Queen Elizabeth Road Crossing (Table 3-6). Dissolved oxygen was measured at 9.79 mg/L, which is within the CCME guidelines for early life stages of coldwater fish species (9.5 mg/L). The pH was measured at 6.5, which is just at the CCME guidelines acceptable range of 6.5 to 9.0.

Other water quality parameters, such as water temperature (°C) and specific conductivity (µS/cm) measured at the time of assessment were within the CCME *Water Quality Guidelines for the Protection of Freshwater Aquatic Life* (CCME 2014).

Table 3-6 In Situ Water Chemistry in the Lake Geraldine Drainage Channel

Parameter	Drainage Channel
Date/Time	30 Aug 2016 / 13:30
Temperature (°C)	7.5
Dissolved oxygen (% saturation)	81.6
Dissolved oxygen (mg/L)	9.79
Specific conductivity (µS/cm)	120.6
pH	6.48

The lower 700 m section of the Lake Geraldine Drainage Channel, below the bridge to the Astro Hill Complex, is heavily influenced by the urban setting, with five culvert stream crossings (Table 3-4), sections of gabion walls, and channelized stream form. The lower section has a channel that ranges from 2 to 8 m wide, with depths up to 0.29 m. Most of the lower section is shallow, with depths less than 0.1 m between areas with pools. The overall gradient is relatively steep, over 5%, although water velocity in steep sections is moderated by the step-pool morphology and presence of large boulders. Boulders, cobbles, and gravel formed most the substrate in step pool and riffle channel types. Pools behind boulders and scour pools below culverts created fish cover, while the small pools, eddies, and turbulent water surface provided additional cover in the steeper step pool morphology (Photo 3-17). Small drops in the step pools are likely passable to fish and there are alternative flow paths bypassing many of the drops observed.



Photo 3-17 Looking Downstream (Southwest) to Queen Elizabeth Road (Reach DC-01) at Step-Pool Morphology in the Lake Geraldine Drainage Channel

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The culvert under Queen Elizabeth Road has a 0.22 m drop into a 0.29 m deep pool that might pose a partial passage barrier for small fish at low flows, but is unlikely a complete barrier.

The upper 1.3 km section from the bridge at the Astro Hill Complex Road, upstream to Lake Geraldine, is in a wider valley, with less urban encroachment. The riparian area is more intact, consisting of grasses and low shrubs, with occasional boulders and bedrock outcrops. The channel widths vary from 2 to 7 m with water depths observed up to 0.28 m. The channel is more entrenched, with stable steeper banks than in the lower section. Instream cover consists of overhanging banks, boulders, and turbulent water.

Upstream of the Astro Hill Complex Road there are three roads crossing the upper portion of the Lake Geraldine Drainage Channel, including a set of culverts near the Frobisher Inn for pedestrian use (Table 3-4 and Figure 3-2). The slightly meandering channel through the meadow northeast of the Astro Hill Complex (Photo 3-18) is typical of an Arctic stream, with entrenched flow, braiding, and cobble and fine substrates with boulder features. Channel widths in this section are approximately 6 m, with wetted widths being 4 m. Water depths ranged from 0.07 to 0.28 m. There is good cover present from overhanging banks and deep spaces between boulders. Fish were observed at the upstream end of this section, in the pool below the Road to Apex Crossing.



Photo 3-18 Lake Geraldine Drainage Channel Looking Downstream (Southwest) at the Astro Hill Complex

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Upstream of the Road to Apex, the channel becomes steeper again, with step-pool morphology and small cascades creating scour pools and turbulent water cover. Arctic char were observed in these pools and two were captured at this location (Reach DC-03) while electrofishing. The channel is slightly narrower at 5 m, with a wetted width of 3 m. Water depths range from 0.08 to 0.27 m in the scour pools. Cobbles dominate the substrate with boulder features and grassed banks. Low shrubby vegetation overhangs some of the pool habitat. The channel upstream, becomes steeper and eventually a series of waterfalls and an old dam structure near the hospital create a complete fish passage barrier (Photo 3-19 and Photo 3-20).



Photo 3-19 Small Waterfalls and Old Dam on the Lake Geraldine Drainage Channel Near the Hospital



Photo 3-20 Looking Downstream at Steep Step-Pool Channel to the Road to Apex from the Old Dam Structure

Above the old dam structure near the hospital, the channel ranges from 2 to 5 m wide, with more bedrock outcrops constricting the channel form and creating small drops (Photo 3-21). Water depths in pools below bedrock ledges were measured at 0.27 m near the transects. Substrates range from fines to boulders, with gravels and cobbles dominating. The channel flows through a narrow canyon, limiting the meanders and channel braiding.



Photo 3-21 Looking Downstream on the Lake Geraldine Drainage Channel Towards the Hospital

The Saputi Road crossing is another complete passage barrier and creates a small ponded area upstream of the road (Photo 3-22). A tributary flows from the west, entering the Lake Geraldine Drainage Channel at the pond upstream of Saputi Road. From the pond near the Saputi Road Crossing upstream to the dam, the channel flows through a large boulder field from the base of the dam on Lake Geraldine (Photo 3-23). Portions of this channel have no apparent surface flow. At high water levels, flows in the Drainage Channel come from the Lake Geraldine dam spillway (Photo 3-24).



Photo 3-22 Looking Upstream on the Lake Geraldine Drainage Channel Towards Saputi Road



Photo 3-23 Boulder Field Downstream of Lake Geraldine Dam



Photo 3-24 Spillway on the Lake Geraldine Reservoir Dam

3.3 Lake Geraldine

Lake Geraldine is 0.29 km² in area and is up to 12 m deep. The updated volume of the lake is estimated at 1,890,000 m³ (Golder 2013), with approximately 93% of the lake being less 8 m deep. A detailed bathymetric plan is available from Budkewitsch et al. (2011) and Golder (2013).

The fishing effort in Lake Geraldine was restricted due to poor weather conditions, including high winds that restricted safe boat access. Fish were not captured with the sampling effort that occurred. Lake Geraldine appears to have the habitat to support stickleback and Arctic char species, although discussion with Operations Staff at the City's Water Treatment Facility, which withdraws water from Lake Geraldine using an unscreened intake pipe, suggests that fish are not present in the lake.

3.3.1 Fish Presence

A total of 57 hours of minnow trapping effort, 19 hours of effort with a Fyke net, and 3 hours of gill netting effort was accomplished from August 29, 2016 to August 31, 2016. In addition, 2 hours of angling effort occurred on September 4, 2016 along the northeast shoreline. Figure 3-2 identifies the sampling locations on Lake Geraldine.

Three Gee-style minnow traps were baited with cat food and set along 150 m of the southeast shoreline. The minnow traps were set overnight from approximately 1500 hours on August 29, 2016 to 1000 hours on August 30, 2016, approximately 19 hours each. No fish were captured, but amphipods and caddisfly larvae were found in the traps.

A modified fyke net was set at 1600 hours on August 29, 2016, in a bay on the southwest shore of Lake Geraldine, located at 19V 524567.82 m E, 7069891.19 m N. The guide nets extended approximately 20 m into the lake, at a depth of just over 2 m. The first square frame in the throat of the net was set approximately 1 m deep, with water just reaching the top of the frame. The area around the net was chummed with canned sardines (two cans), and cat food was floated into the throat of the net. The net was pulled at approximately 1100 hours on August 30, 2016, after about 19 hours of set time. No fish were captured.

On August 31, 2016 a gill net was set at approximately 1000 to 1300 hours from 19V 524633 m E, 7069922 m N to 19V 524684 m E, 7069937 m N. The net was a five-panel multi-mesh net, 2 m high by 45.7 m long, with each panel being 9.1 m long. Mesh sizes were: 19, 25, 38, 64, 88, and 114 mm. The net was set about 40 m from the shore with the small mesh in the shallower zone (approximately 2 m), closer to shore, and extending into over 6 m of depth. No fish were caught during the three-hour net set. Wind conditions during the remainder of the week prevented boat use on the lake for the remainder of the assessment period.

3.3.2 Fish Habitat

In situ surface water chemistry was recorded from the southwest shore of the lake (Table 3-7), at a depth of 0.2 m, approximately 180 m southeast of the dam at 19V 524588 m E, 7069903 m N. Dissolved oxygen measured at the surface (0.2 m depth) was 8.96 mg/L, which is below the CCME guidelines for early life stages of cold water fish species (9.5 mg/L) but above the CCME guidelines for other life stages of cold water fish species (6.5 mg/L). The pH at the surface was measured at 6.23, which is below the CCME guidelines acceptable range of 6.5 to 9.0.

Other water quality parameters, such as water temperature (°C) and specific conductivity (µS/cm) measured at the time of assessment were within the CCME *Water Quality Guidelines for the Protection of Freshwater Aquatic Life* (CCME 2014).

Table 3-7 In Situ Water Chemistry in the Lake Geraldine

Parameter	Lake Geraldine
Date/Time	August 29 2016 / 15:00
Temperature (°C)	10.2
Dissolved oxygen (% saturation)	81.5
Dissolved oxygen (mg/L)	9.16
Specific conductivity (µS/cm)	20.2
pH	6.23

The habitat along the shore of Lake Geraldine consisted of exposed bedrock, boulders, and cobble substrates, with low shrubs and grasses on the banks. The shoreline along the west side of the lake drops off to a depth between 1 and 2 m rapidly from the bank. Photo 3-25 and Photo 3-26 show typical sections of the western Lake Geraldine shoreline. Amphipods, chironomids, and tricoptera larva were also observed in the shallow margins of the lake.



Photo 3-25 Lake Geraldine Looking Northeast from South of the Dam; Note the Cobble/Boulder Substrate and the Steep Drop-Off



Photo 3-26 Looking South across Lake Geraldine from the North Side; Note Smaller Gravel Substrate with Cobble and Boulders

3.4 Species at Risk

No aquatic Species at Risk were captured during the field assessment or are known to exist in the Apex River, Lake Geraldine, or the Lake Geraldine Drainage Channel (Government of Canada 2016).

4 DISCUSSION

The Apex River and the Lake Geraldine Drainage Channel provide habitat for Arctic char. No Species at Risk were observed or captured during the fisheries assessment, but Arctic char were caught and threespine stickleback (*Gasterosteus aculeatus*) and ninespine stickleback (*Pungitius pungitius*) fish species may be present. There is no record of fish in Lake Geraldine. Fish sampling conducted in Lake Geraldine during the Project did not capture any fish but sampling effort was restricted due to poor weather conditions; the sampling, therefore, could not provide a high level of confidence for determining the absence or presence of fish. However, operators of the City's Water Treatment Facility have no record of fish entering their unscreened water intake from Lake Geraldine.

4.1 Assessment of Fishery

Evans et al. (2001) report that Arctic char are known to travel upstream through riffles 0.10 to 0.15 m deep and jump waterfalls as high as 1.5 m, although the rocks at the base of the drop may limit opportunity for the Arctic char to jump. Juvenile Arctic char will remain in freshwater creeks and lacustrine systems, moving to deeper lacustrine areas to overwinter each season, and potentially migrating to the sea at one to eight years of age (Evans et al. 2001; Richardson et al. 2002). Scott and Crossman (1998) indicate that Arctic char from the Frobisher Bay (i.e., Iqaluit) area of Nunavut are under 90 mm when they are four years of age and younger, around 130 mm at five years, 139 mm at six years, around 172 mm at seven years, and around 302 mm at eight years of age. Evans et al (2001) identify that juvenile Arctic char feed on plankton and invertebrates along shallow shorelines of lakes, and in water up to 0.30 m deep in streams.

In lake habitats, adult Arctic char are known to spawn in lacustrine gravel and cobble substrates approximately 1 to 11 m deep, as well as in areas with emergent aquatic vegetation (Richardson et al. 2001). In riverine habitats, Arctic char are known to spawn on gravels below rapids in rivers and streams, 0.5 to 1.5 m deep (Evans et al. 2002), although spawning substrates vary from sand to large gravels. If the river is known to freeze during the winter, Arctic char may not spawn in typical river habitats, and migrate to lakes instead (Evans et al. 2002).

Threespine and ninespine stickleback, which could be prey for Arctic char, are known to move into shallow streams during the spring and summer and move back into deeper lakes to overwinter (Evans et al. 2002; Scott and Crossman 1998). Threespine stickleback spawn from July to August (Evans et al. 2002), building a nest in slower areas of the watercourse with sand, debris, gravel, or vegetation. Male stickleback will construct a nest in shallow vegetation or in crevices between boulders in the summer. The females will deposit the egg in the nest and the male will fertilize and guard the eggs until the young hatch (Evans et al. 2002). Ninespine stickleback appear to use more vegetation and slower shallower areas (Evans et al. 2002; Richardson et al. 2001).

4.1.1 Apex River

The Apex River is isolated from upstream fish movement from the Koojesse Inlet because of the waterfall barrier near the inlet, but contains a resident population of Arctic char and habitat quality to support the lifestages of Arctic char.

The overall habitat available in the Apex River and small lakes formed by the Apex River in its valley is considered excellent for young of year and juvenile Arctic char, as well as good for adult char. There are riffles with good areas of gravels and cobbles that would support the production of aquatic invertebrates, as well as some deep pools and runs, wide impounded areas and lakes, and cascade/step pool habitats. There is good cover in the form of boulders and undercut banks through the entire area, and depth in the lakes. The substrates ranged from fines to large boulders and bedrock outcrops.

The waterfall near the mouth of the Apex River is over 2 m in height, with rocks at the base that would prevent fish from migrating upstream from the Koojesse Inlet. Below the waterfall, there is approximately 150 m of steep, rocky channel that would provide habitat for fish from the Koojesse Inlet. The bedrock outcrops and boulder and cobble substrates could provide rearing habitat and cover for fish.

Arctic char were captured at the proposed withdrawal location A2, upstream of the barrier at the mouth of the Apex River, indicating that there is a resident char population in the Apex River. There is no known CRA fishery on the Apex River, and this may be due to the small size of char individuals of this resident char population. While stickleback were not captured, suitable habitat exists, but access may be limited by the higher gradient sections of the river. There is a potential that stickleback species may exist in the lakes in the flat valley downstream of A2, but none were observed during surveys along the shorelines.

Both lacustrine and riverine spawning habitats are available in the Apex River, above the waterfall at Apex. Overwintering habitat in the main channel of the Apex River may be limiting due to water depths, with the deepest location sampled around 1.5 m deep. There may be other deep areas within the channel, but they may only provide limited overwintering for adult Arctic char. The Swimming Lake, and lakes downstream would provide deeper habitats that would be suitable for overwintering but bathymetric data are needed to confirm this. Adult and juvenile Arctic char are known to migrate to lakes to overwinter (Evans et al. 2001; Richardson et al. 2002; Scott and Crossman 1998). With the short distance to the lakes in the valley along the Road to Nowhere, overwintering habitat would not be limiting for the local Apex River Arctic char population, nor potential lacustrine stickleback populations.

4.1.2 Lake Geraldine Drainage Channel

The Lake Geraldine Drainage Channel is connected to Koojesse Inlet and provides rearing habitat for Arctic char juveniles that likely move up into the Lake Geraldine Drainage Channel during the open water season.

Habitat in the Lake Geraldine Drainage Channel provides rearing habitat for juvenile Arctic char. The lack of deep water areas limits the habitat use to small-bodied fish such as stickleback and juvenile Arctic char, and may limit the use of the Lake Geraldine Drainage Channel to the summer season. The presence of large boulders, scour pools, and bank and instream cover provides good habitat for rearing Arctic char that may move upstream from Koojesse Inlet. These fish likely move out to the Inlet before the Drainage

Channel freezes in the fall. It is unlikely that the Lake Geraldine Drainage Channel has deep enough water to prevent freezing, which would limit spawning and overwintering habitat for Arctic char.

The low water and high number of culvert crossings in the Lake Geraldine Drainage Channel may limit upstream fish movement during low water in the late summer season and the culverts may be fish passage barriers during high flow events. Migration habitat is considered poor, but no complete barriers exist below the dam structure near the hospital. Adjacent to the hospital, the old dam structure and small waterfalls are complete barriers to fish moving upstream. While stickleback were not captured, suitable habitat exists, but access may be limited by the drops at the culverts, passage through the culverts, and higher velocity areas of the channel, including the step-pools.

4.1.3 Lake Geraldine

Lake Geraldine would provide suitable habitat for life stages of land-locked Arctic char. Suitable rearing habitat is found in the boulders and bedrock outcrops of the nearshore areas. The lake is deep enough to support an overwintering population of Arctic char if dissolved oxygen levels remain within the CCME *Water Quality Guidelines for the Protection of Freshwater Aquatic Life* (CCME 2014). Lacustrine spawning habitats would be available in Lake Geraldine over submerged substrates.

Fish were not captured in Lake Geraldine, although the sampling effort may be inconclusive to determine presence or absence. Lake Geraldine appears to have the habitat to support stickleback or Arctic char species if they were present, although the sampling effort and discussion with Operations Staff at the City's Water Treatment Facility does not indicate that fish are present in the lake. In addition to the absence of fish noted by staff at the Water Treatment Facility, Budkewitsch et al. (2011) only noted invertebrates during underwater video sessions used during their lake analysis. Although it is unlikely that fish are present based on the sampling effort and anecdotal evidence, further sampling may be required to obtain more conclusive evidence.

If fish were present in Lake Geraldine, fish could not move downstream from Lake Geraldine into the Koojesse Inlet. During high flow events, fish could get washed downstream over the spillway, but could not continue further to Koojesse Inlet, via the Lake Geraldine Drainage Channel, due to areas with no surface flows downstream of the Lake Geraldine dam, and the presence of a boulder field between the dam and the ponded area upstream of Saputi Road.

5 IMPLICATIONS FOR PERMITTING AND MITIGATIVE STRATEGIES

The Apex River is a fish-bearing waterbody. As such there will be permitting requirements with respect to minimizing harm to fish and fish habitat.

The *Fisheries Act* applies to projects that have the potential to cause serious harm to fish that are part of, or support, a CRA fishery. DFO has developed a Self-Assessment Tool (DFO 2014), and *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2013a), to aid in the assessment of the potential for projects to cause serious harm to fish.

The federal *Fisheries Act* prohibits unauthorized work, undertaking, or activity that results in serious harm to fish that are part of a CRA fishery, or to fish that support such a fishery. As outlined in section 2(1) of the *Fisheries Act*, “Fish includes: (a) parts of fish, (b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and (c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals”.

Serious harm is defined as “the death of fish or any permanent alteration to, or destruction of, fish habitat” (DFO 2013a). The *Fisheries Act* also prohibits the deposition of a deleterious substance of any type, in water frequented by fish, or in any place under any conditions where the deleterious substance may enter such water. A deleterious substance is defined as “any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water” (DFO 2013a). Common types of deleterious substances include but are not limited to: sediment, excess nutrients, contaminants, pesticides, and industrial and municipal waste discharges. Under the *Fisheries Act*, there is a duty to notify and report serious harm to fish or a deleterious substance deposit in a fish-bearing water bodies.

The Arctic char captured in the Apex River may be considered part of a CRA fishery because Arctic char are a regulated sport fish in Nunavut; however, this population of char is not known to be fished, likely due to the small size of char in the river. The proposed work on the Apex River and associated construction activities have the potential to cause serious harm to fish and fish habitat from:

- Sedimentation and erosion
- Accidental spill or release of deleterious substances
- Disruption of fish movement and use
- Project-related fish mortality
- Habitat alteration and changes to hydraulic characteristics of the waterbody, including:
 - Direct infill of habitat from the intake construction
 - Reduction of available habitat downstream of the intake

- Change to channel morphology, as well as composition and size of bed materials
- Changes in the bank configuration and stability

DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2013c) provide guidelines to follow when working in and around water to reduce the potential for harm to fish and protect the aquatic environment; these are provided in Appendix C. Additional measures to protect the fishery may have to be undertaken depending on potential intake design and flow diversion rates.

If serious harm to the fishery is determined by DFO, the City would be responsible for providing measures to counterbalance unavoidable serious harm to fish resulting from the work with the goal of maintaining or improving the productivity of the affected CRA fishery (Clarke and Bradford 2014).

5.1 Instream Flows

Arctic char were captured at the proposed water intake location, A2. In a previous study investigating the potential availability of water for the project, exp (2014) assumed that there would be no requirement to maintain a minimum flow in the Apex River and that available flows at A2 could be used for supplementing the City's water supply. However, due to the presence of Arctic char in the Apex River, which may be considered a CRA fishery, considerations with regards to minimum flow requirements should be made. DFO (2013b), the *Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada*, recommends that, to avoid serious harm, diversions from a riverine ecosystem should not exceed $\pm 10\%$ of instantaneous flow, or that any diversions should not reduce instantaneous flow below 30% of MAD. The most restrictive of the two, at any given time, is typically applied.

A previous water balance study conducted by Golder, identified in exp (2014), presented the City's three potential annual volumetric water supplementation requirements based on various climate scenarios: (1) 845,000 m³, (2) 1,328,000 m³, and (3) 1,853,000 m³. The average three-month total volume available from the Apex River at A2 was determined to be 8,500,000 m³. exp (2014) indicated that minimum flows in July, August, and September are variable, and may not meet the required supplemental volume, but additional water diverted during adjacent months could make up for the deficits, assuming all water would be available for withdrawal.

The data available for the Apex River were reanalyzed based on the DFO (2013b) guidance for water withdrawal. Table 5-1 presents the updated flow analysis at the proposed A2 location using the data available for the Apex River WSC hydrometric station (No. 10UH002). There are 32 years of data available for this station over two operational periods, 1973 to 1995 and 2006 to 2015. Following the exp (2014) report, the Apex River station daily flow data were scaled by 0.83 to estimate flows at the proposed intake location, to account for the smaller drainage at the proposed A2 location relative to the WSC station (i.e., the A2 location is upstream of the WSC station). The MAD was calculated using the scaled flow data and multiplied by 0.3 to determine one of the flow criteria in the DFO guidance. The volume of flow available for withdrawal was evaluated to assess if the daily flow satisfied either the 10% withdrawal rate or 30% MAD requirements, whichever is more conservative. Table 5-1 presents the data on an annual basis, compared to the monthly basis presented in exp (2014). An additional difference with the exp (2014) analysis is that the entire open water flow period was analyzed.

Figure 5-1 provides an example of how the available water flow for withdraw was determined, following the DFO (2013b) guidance, from the Apex River; 2008 is used as an example year. The total volume of water that flowed through the A2 location in 2008 was 14,134,077 m³, which is slightly larger than the average total annual volume of flow at A2 over the period of record, which was 13,391,185 m³. The MAD for 2008 was 0.95 m³/s and 30% of this is 0.29 m³/s, which is represented on Figure 5-1. Although the flow record begins on May 17, 2008, flows remain below the 30% MAD threshold until May 25, 2008 at which time 10% of the flow can be withdrawn. The allowable flow to be withdrawn is the portion of the hydrograph between the solid black line (scaled discharge at A2) and the red dotted line (discharge not available), an amount that is equivalent to 10% of the daily discharge. The light green line (plotted on the secondary y-axis) represents the cumulative volume allowed to be withdrawn following DFO (2013b) guidance. The volume withdrawn increases until July 24, 2008 when flows become less the 30% MAD and no water withdrawals can be done. Flows remain below this threshold until July 30, 2008, when flows return to levels above 30% MAD and water can be withdrawn again. Withdrawal continues until flows again fall below 30% MAD on October 6, 2008 and remain so for the remainder of the year. The last flow recorded in 2008 occurred on November 6, 2008.

Figure 5-1 also illustrates the three supplementation scenarios. Comparing these volume requirements with the cumulative flow volume available reveal that, during 2008, supplementation volume needs under Scenarios 1 and 2 could be met, but requirements under Scenario 3 could not. This method for determining flow volumes was repeated for each year that data was available, the results of which are presented in Table 5-1.

Based on the DFO (2013b) criteria assessed using data from the existing period of record, Scenario 1 flow needs would have been met 81% of the time, Scenario 2 flow needs would be met 51% of the time, and Scenario 3 flow needs would be met only 16% of the time, using historic Apex River flows. An additional analysis was undertaken to determine at what withdrawal rate (i.e., percentage of available flow), based on the historic information, could the city meet their supplemental flow requirements. These results are also presented in Table 5-1. It should be noted that although the rate shown maybe 10% of the Apex River flow rate, it is actually slightly greater than 10% and therefore would not have passed the DFO (2013b) withdrawal criteria guidance.

Table 5-1 Historical Monthly Volumes in the Apex River at the Proposed A2 Location and the Potential to meet the City of Iqaluit's Water Needs following the DFO Instream Flow Guidelines (DFO 2013b)

Year	Mean Annual Discharge (m³/s)	30% of Mean Annual Discharge (m³/s)	Total Volume Available for Withdrawal per Year (m³)	Available Flow Meets Supplemental Scenarios?			Percent (%) Withdrawal of Available Flow Required to Meet Supplemental Scenarios¹		
				No. 1 845,000 m³	No. 2 1,328,000 m³	No. 3 1,853,000 m³	No.1	No. 2	No. 3
1973	1.83	0.55	1,828,756	yes	yes	no	met	met	10
1974	0.99	0.30	838,901	no	no	no	10	16	22
1975	0.98	0.29	885,442	yes	no	no	met	15	21
1976	1.38	0.41	1,189,752	yes	no	no	met	11	15
1977	0.74	0.22	577,905	no	no	no	14	23	32
1978	2.67	0.80	1,432,232	yes	yes	no	met	met	13
1979	1.33	0.40	1,002,806	yes	no	no	met	13	18
1980	0.66	0.20	557,001	No	no	no	15	24	33
1981	0.93	0.28	631,245	No	no	no	13	20	29
1982	0.75	0.22	967,022	yes	no	no	met	14	19
1983	1.09	0.33	1,000,511	yes	no	no	met	13	18
1984									
1985	1.31	0.39	1,745,147	yes	yes	no	met	met	11
1986	1.93	0.58	2,218,992	yes	yes	yes	met	met	met
1987	2.02	0.61	2,055,517	yes	yes	yes	met	met	met
1988	1.23	0.37	1,633,750	yes	yes	no	met	met	11
1989	0.93	0.28	1,151,164	yes	no	no	met	11	16
1990	1.44	0.43	1,753,315	yes	yes	no	met	met	11
1991	0.88	0.26	1,175,331	yes	no	no	met	11	16
1992	0.93	0.28	1,104,437	yes	no	no	met	12	17
1993	0.81	0.24	900,179	yes	no	no	met	15	20
1994	0.99	0.30	1,594,079	yes	yes	no	met	met	12
1995	0.83	0.25	865,134	yes	no	no	met	15	21

Table 5-1 Historical Monthly Volumes in the Apex River at the Proposed A2 Location and the Potential to meet the City of Iqaluit's Water Needs following the DFO Instream Flow Guidelines (DFO 2013b)

Year	Mean Annual Discharge (m³/s)	30% of Mean Annual Discharge (m³/s)	Total Volume Available for Withdrawal per Year (m³)	Available Flow Meets Supplemental Scenarios?			Percent (%) Withdrawal of Available Flow Required to Meet Supplemental Scenarios ¹		
				No. 1 845,000 m³	No. 2 1,328,000 m³	No. 3 1,853,000 m³	No.1	No. 2	No. 3
1996-2005									
2006	1.11	0.33	699,694	no	no	no	12	19	26
2007	1.15	0.35	1,792,879	yes	yes	no	met	met	10
2008	0.95	0.29	1,402,995	yes	yes	no	met	met	13
2009	1.27	0.38	1,697,502	yes	yes	no	met	met	11
2010	1.04	0.31	1,915,306	yes	yes	yes	met	met	met
2011	1.24	0.37	1,531,697	yes	yes	no	met	met	12
2012	1.29	0.39	1,695,243	yes	yes	no	met	met	11
2013	1.55	0.46	1,942,535	yes	yes	yes	met	met	met
2014	1.30	0.39	1,914,775	yes	yes	yes	met	met	met
2015	0.68	0.21	798,226	no	no	no	11	17	23
Max	2.67	0.80	2,218,992	–	–	–	15	24	33
Min	0.66	0.20	557,001	–	–	–	10	11	10
Avg.	1.20	0.36	2,218,992	–	–	–	13	16	18

Notes:

¹ Withdrawal rate presented is the percentage of available flow needed to meet each supplemental scenario, while maintaining DFO (2013b) guidance on 30% of the MAD; 'met' indicates the supplemental scenario volume is met within DFO (2013b) guidance on 10% of available flow and 30% of MAD.

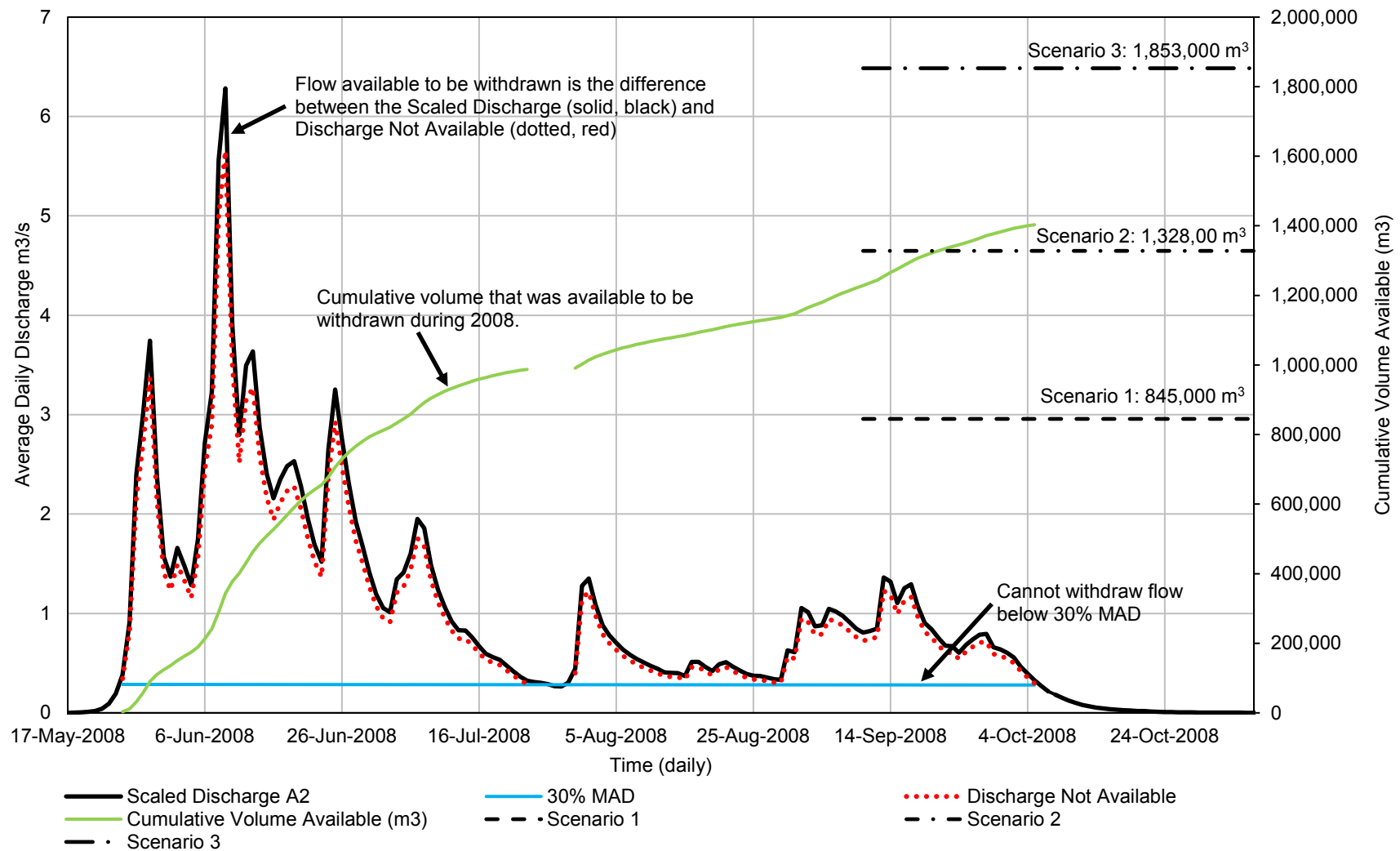


Figure 5-1 Example Withdrawal Scheme at the Proposed Apex River Withdrawal Location A2, using 2008 Flow Data, and based on DFO (2013b) Water Withdrawal Guidance

The exp (2014) analysis assumed a constant flow withdrawal. The analysis conducted in this report would require that the withdrawal be actively managed in order that the minimum flow standards be maintained in the river (i.e., withdrawal rate scaled to available instantaneous flow). It should also be noted that the flows presented in Table 5-1 are mean daily flows and not the instantaneous flows as recommended by DFO; instantaneous flows are not available online from the WSC. Additionally, the analysis has been conducted using historical data and this data cannot be used as a predictor of future flows.

Given the presence of Arctic char in the Apex, a limit will likely be applied to the volume of water withdrawn from the Apex River to minimize harm to fish and fish habitat. Using DFO's current guidance on water withdrawal, the Apex River does not meet the required supplemental water needs of the City over the existing period of record.

Apex River water withdrawal from A2 at a rate above DFO's current guidance could result in a reduction of flow, which might result in lowering the volume and water level of the downstream lakes and, a reduction of available fish habitat in the river downstream of A2, specifically the approximately 2.5 linear km of river downstream from A2 to the waterfall. Water withdrawal and reductions in flows may also affect fish use of the freshwater/saltwater interaction in Koojesse Inlet at the Apex River mouth, however given the large tides in Koojesse Inlet (e.g., 11 to 12 m), this effect may be nominal. Water withdrawal from A2 would not affect identified overwintering habitat in the "Swimming Lake" as A2 is located downstream of this lake.

Therefore, to withdraw more than 10% of the instantaneous flow, or to reduce flow in the river below 30% of the mean annual discharge (i.e., exceed DFO's current guidance), additional evaluation will be required to assess the potential impacts of the City's water requirements on fish habitat, which may require modelling potential changes in downstream habitat availability with required withdrawal rate(s). If, after further study, it is shown that withdrawal from the Apex River is unlikely to avoid causing serious harm to fish and fish habitat, formal approval by DFO will be required, which may include habitat offsetting as part of the supplementation project's mitigations.

5.2 Intake Design and Other Mitigations

Due to the presence of juvenile Arctic char at the proposed intake location A2, the intake should be screened and sized based on DFO's screening guidelines (DFO 2013a) to prevent the entrainment and impingement of Arctic char on the intake screen.

With rain events, it appears that the river quickly becomes turbid, as observed during rain on 05 September 2016 (Photo 3-12). A likely contributor to the increase in suspended sediments is the exposed fine soils found at the apparent sand pit near the Road to Nowhere, west of Reach A1 (Photo 3-13). This indicates that the construction in the area should have sediment and erosion control measures to reduce the potential movement of sediment overland into the Apex River.

Measures to prevent the release of deleterious substances should be undertaken at the intake location to reduce potential changes to the habitat, including affecting the productivity, temperature, and chemical characteristics of the water.

6 CONCLUSION

At the time of the assessment, Arctic char were found in both the Apex River and the Lake Geraldine Drainage Channel. Fish were not captured in Lake Geraldine, although the sampling effort may be inconclusive to determine presence or absence. Based on the sampling effort and anecdotal evidence, it is unlikely that fish are present in Lake Geraldine, but further sampling may be required by DFO to increase the certainty on the absence of fish. It is unlikely that fish could move downstream from Lake Geraldine into the Koojesse Inlet via the Lake Geraldine Drainage Channel.

Upon review of the fish and fish habitat in the Apex River, the Lake Geraldine Drainage Channel, and the proposed withdrawal works, there is potential that the City's water supplementation project will potentially result in serious harm to fish and fish habitat in the Apex River. Given the Arctic char in the Apex River, the likely application of withdrawal limits, and a review of exp (2014), the Apex River may not meet the required supplemental water needs of the City within DFO's current guidance on water withdrawals. Additional measures to protect the fishery may have to be undertaken depending on potential intake design and flow diversion rates. In addition, modelling potential changes to downstream habitat availability with projected water withdrawal rate(s) may need to be completed to assess potential impacts of water withdrawal and meet DFO's regulatory requirements.

If the proposed supplementation project is approved and moved forward to construction, DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2013a) should be followed when working in and around water to reduce the potential for harm to fish and protection of the aquatic environment. If, after further study and modelling, the proposed supplementation project is shown unlikely to avoid causing serious harm to Apex River fish and fish habitat, the City should submit a formal request to DFO for review.

7 CLOSURE

Nunami Stantec Ltd. has prepared this report for the sole benefit of the City of Iqaluit (the City) for the purpose of documenting fish and fish habitat conditions in the Niaqunguk (Apex) River, Lake Geraldine, and the Lake Geraldine Drainage Channel, during late summer 2016. The report may not be relied upon by any other person or entity, other than for its intended purposes, with the express written consent of Nunami Stantec Ltd. and the City. Any use of this report by a third party, or any reliance on decisions made based upon it, are the responsibility of such third parties.

The information provided in this report was compiled from existing documents and data provided by the City, and by field data compiled by Nunami Stantec Ltd. This report represents the best professional judgement of our personnel available at the time of its preparation. Nunami Stantec Ltd. reserves the right to modify the contents of this report, in whole or in part, to reflect any new information that becomes available. If any conditions become apparent that differ significantly from our understanding of conditions presented in this report, we requested that we be notified immediately to reassess the conclusions provided herein.

Respectfully Submitted,

NUNAMI STANTEC LIMITED

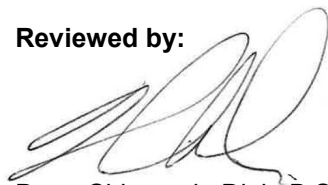


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APPENDIX A

Apex River Fish Habitat Summary Sheets

UTM Location:	19V 527094 m E 7067317 m N	Survey Date:	September 2, 2016
Legal Location:	00-00-000-00W4M	Water Body Class:	Perennial
Crew Initials:	PH, RS	Restricted Activity Period:	n/a

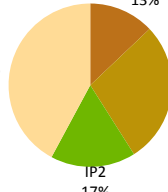
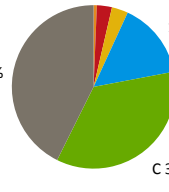
Physical Channel Transect Data											Habitat Inventory / Reach Data			
Transect # (Location)		0m	25m	50m	75m	100m	n/a		Instream Cover (%):		96	Overhead Cover (%):		6
Channel Width (m)		25	19	21	29	23			Dom. Instream Cover:		BL	Dom. Overhead Cover:		UB
Wetted Width (m)		24	18	14	25	23			Subdom. Instream Cover:		DC	Subdom. Overhead Cover:		GF
Depth at LDB + 25% (m)		0.19	0.25	0.58	0.15	0.39			Maximum Depth (m)		0.7	Dom. Aquatic Veg. Type:		-
Depth at LDB + 50% (m)		0.17	0.33	0.40	0.48	0.06			Habitat Distribution  Substrate Composition 					
Depth at LDB + 75% (m)		0.26	0.66	0.37	0.45	0.36								
Max. Depth (m)		0.42	0.68	0.58	0.55	0.43								
Gradient (%)		1	3	5	3	4								
Dominant Habitat Unit		RF	BG	BG	BG	BG								
Stream Bed														
Substrate (% of Transect Area)	Organics	0	0	0	0	0								
	Fines	10	0	0	0	0								
	Small Gravel	0	0	0	0	0								
	Large Gravel	10	10	10	10	5								
	Cobble	60	30	50	30	25								
	Boulder	20	60	40	50	70								
	Bedrock	0	0	0	0	0								
Embeddedness		L	N	N	N	N								
Bank Measurements		Left	Right	Left	Right	Left	Right	Left	Right	Left	Right			
Bank Height (m)		0.38	0.13	0.30	0.40	0.15								
Bank Slope (°)		75	75	90	90	75	45	80	45	90	90			
Bank Stability		S	S	S	S	S	S	S	S	S	S			
Dom. Bank Material		BL	C	BL	BL	BL	BL	BL	BL	BL	BL			
Subdom. Bank Material		O	F	O	O	C	C	O	O	O	O			
Dom. Riparian Veg.		G	G	G	G	G	G	G	G	G	G			
Subdom. Riparian Veg.		N	N	N	N	N	N	N	N	N	N			
Water Quality Data														
Time of Day (HH:MM):		15:30		Pattern:		ST								
Water Temperature (°C):		9.8		Islands:		I								
Dissolved Oxygen (mg/L):		9.35		Bars:		N								
Sp. Conductivity (µs/cm):		55.0		Coupling:		DC								
pH:		7.13		Confinement:		NA								
Turbidity (NTU):		n/a		Flow Stage:		Moderate								
Fish Habitat Assessment Ratings														
		Forage		Coarse		Sportfish								
Spawning:		Good		Good		Good								
Overwintering:		Poor		None		None								
Rearing:		Moderate		Moderate		Good								
Migration:		Moderate		Moderate		Good								



Photo 1: Looking downstream at bottom half of reach. Bypass Road in distance



Photo 2: Looking upstream from center of reach.

Fish Sampling Data									
Method		Effort		Species	Efish Catch	Trap Catch	Efish CPUE	Trap CPUE	Rel. Abundance
					(n)	(n)	(#fish/100s)	(#fish/hr)	(% of total)
Backpack Electrofisher (EB)		803	(s) (hr)		NO FISH CAPTURED				
Electrofisher Settings									
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)						
650	30	22	100						

General Comments

Downstream end of reach is impounded by the Bypass Road crossing. Steep run with boulder garden at the upstream 2/3 of the reach. Island separating a small channel on the east from the main channel. No fish observed.

UTM Location: 19V 526584 m E 7068527 m N

Survey Date: August 31, 2016

Legal Location: 00-00-000-00W4M

Water Body Class: Perennial

Crew Initials: PH, RS

Restricted Activity Period: n/a

Physical Channel Transect Data

Transect # (Location)	0m	25m	50m	75m	100m	n/a
Channel Width (m)	13	30	28	39	37	
Wetted Width (m)	12	29	27	39	36	
Depth at LDB + 25% (m)	0.46	0.15	0.34	0.06	0.07	
Depth at LDB + 50% (m)	0.42	0.26	0.23	0.16	0.57	
Depth at LDB + 75% (m)	0.26	0.07	0.28	0.06	0.48	
Max. Depth (m)	0.78	0.41	0.61	0.33	0.69	
Gradient (%)	5	2	1	1	1	
Dominant Habitat Unit	BG	RF	P2	RF	FL	

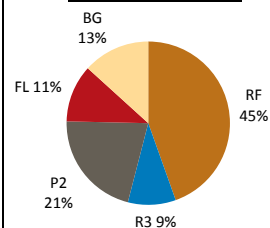
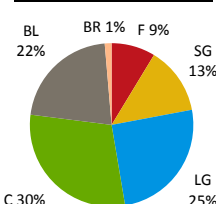
Stream Bed

Substrate (% of Transect Area)	0m	25m	50m	75m	100m
Organics	0	0	0	0	0
Fines	0	0	40	0	0
Small Gravel	0	0	30	20	5
Large Gravel	10	50	10	30	30
Cobble	20	20	10	40	40
Boulder	60	30	10	10	10
Bedrock	10	0	0	0	0
Embeddedness	N	M	M	M	M

Bank Measurements	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Bank Height (m)	0.47	0.27	0.26	0.19	0.25							
Bank Slope (°)	90	90	90	75	90	75	90	90	90	75		
Bank Stability	S	S	S	S	S	S	S	S	S	S		
Dom. Bank Material	BL	O	O	O	F	O	O	F	F	F		
Subdom. Bank Material	O	F	LG	LG	C	F	F	C	C	C		
Dom. Riparian Veg.	G	G	G	G	G	G	G	G	G	G		
Subdom. Riparian Veg.	N	N	N	N	N	N	N	N	N	N		

Habitat Inventory / Reach Data

Instream Cover (%):	45	Overhead Cover (%):	4
Dom. Instream Cover:	BL	Dom. Overhead Cover:	UB
Subdom. Instream Cover:	DC	Subdom. Overhead Cover:	GF
Maximum Depth (m)	0.7	Dom. Aquatic Veg. Type:	-

Habitat Distribution

Substrate Composition

Water Quality Data

Time of Day (HH:MM):	15:30
Water Temperature (°C):	6.7
Dissolved Oxygen (mg/L):	10.16
Sp. Conductivity (µs/cm):	55.0
pH:	6.88
Turbidity (NTU):	n/a

Channel Characteristics

Pattern:	ST
Islands:	I
Bars:	N
Coupling:	DC
Confinement:	NA
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage	Coarse	Sportfish
Spawning:	Good	Moderate	Good
Overwintering:	Poor	Poor	Poor
Rearing:	Good	Good	Good
Migration:	Good	Good	Good



Photo 1: Looking upstream from center of reach AR-02



Photo 2: Looking downstream from center of reach AR-02

Fish Sampling Data

Method	Effort	Species	Efish Catch (n)	Trap Catch (n)	Efish CPUE (#fish/100s)	Trap CPUE (#fish/hr)	Rel. Abundance (% of total)
Backpack Electrofisher (EB)	541 (s) (hr)	NO FISH CAPTURED					-
Electrofisher Settings							
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)				
800	30	22	100				

General Comments

Transition from lake type habitat to river type habitat, where a small bedrock shelf forms a gradient break between two lower gradient areas. The upstream portion of the river is a flat, considered a taylor from the upstream wide area, or inline "lake".

UTM Location:	19V 526300 m E, 7069250 m N	Survey Date:	September 1, 2016
Legal Location:	00-00-000-00W4M	Water Body Class:	Perennial
Crew Initials:	PH, RS	Restricted Activity Period:	n/a

Physical Channel Transect Data											Habitat Inventory / Reach Data						
Transect # (Location)		0	25	50	75	100	n/a					Instream Cover (%):		79	Overhead Cover (%):		9
Channel Width (m)		38	26	13	13	15						Dom. Instream Cover:		BL	Dom. Overhead Cover:		UB
Wetted Width (m)		24	16	13	13	15						Subdom. Instream Cover:		DC	Subdom. Overhead Cover:		GF
Depth at LDB + 25% (m)		0.28	0.33	0.32	0.19	0.17						Maximum Depth (m)		0.8	Dom. Aquatic Veg. Type:		-
Depth at LDB + 50% (m)		0.16	0.48	0.42	0.24	0.11											
Depth at LDB + 75% (m)		0.15	0.44	0.11	0.22	0.12											
Max. Depth (m)		0.75	0.50	0.51	0.30	0.32											
Gradient (%)		1	2	<1	1	1											
Dominant Habitat Unit		RF	RF	RF	RF	RF											
Habitat Distribution																	
Substrate Composition																	
BG 30% RF 48% FL 8% R2 13% BL 29% LG 24% C 45%																	
Water Quality Data																	
Channel Characteristics																	
Time of Day (HH:MM): 11:30																	
Pattern: SI																	
Water Temperature (°C): 6.2																	
Islands: O																	
Dissolved Oxygen (mg/L): 10.31																	
Bars: MD																	
Sp. Conductivity (µs/cm): 54.5																	
Coupling: DC																	
pH: 6.70																	
Confinement: CO																	
Turbidity (NTU): n/a																	
Flow Stage: Moderate																	
Fish Habitat Assessment Ratings																	
Forage																	
Coarse																	
Sportfish																	
Spawning: Moderate																	
Moderate																	
Overwintering: Moderate																	
Poor																	
Rearing: Good																	
Good																	
Migration: Good																	
Good																	



Photo 1: Looking upstream through A2



Photo 2: Looking downstream at reach A2 from the outlet of the Swimming Lake

Fish Sampling Data						
Method	Effort	Species	Efish Catch	Trap Catch	Efish CPUE	Trap CPUE
Backpack Electrofisher (EB)	632 (s) (hr)	ARCTIC CHAR	(n) 7	(n)	(#fish/100s) 1.11	(#fish/hr)
Electrofisher Settings				Rel. Abundance		
Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)	(% of total)		
800	30	22	100	100.0%		

General Comments

Deeper run downstream of the Riffle/boulder garden at the bottom of the reach. The upstream end of the reach could be defined as a flat, or the "tailout" of the Swimming Lake, which is immediately upstream of reach A2. Arctic char were noticed to be hiding in the larger pools scoured behind clusters of boulders, areas where the depression was deeper than the average bed depth.

UTM Location:	19V 526480 m E, 7070000 m N	Survey Date:	September 2, 2016
Legal Location:	00-00-000-00W4M	Water Body Class:	Perennial
Crew Initials:	PH, RS	Restricted Activity Period:	n/a

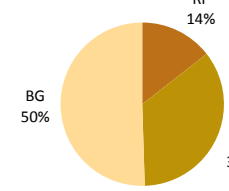
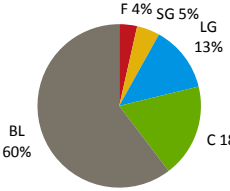
Physical Channel Transect Data											Habitat Inventory / Reach Data			
Transect # (Location)	0	25	50	75	100						Instream Cover (%):	135	Overhead Cover (%):	4
Channel Width (m)	25	25	28	32	32						Dom. Instream Cover:	BL	Dom. Overhead Cover:	GF
Wetted Width (m)	25	25	22	30	32						Subdom. Instream Cover:	DC	Subdom. Overhead Cover:	UB
Depth at LDB + 25% (m)	0.30	0.42	0.26	0.22	0.22						Maximum Depth (m)	1.4	Dom. Aquatic Veg. Type:	-
Depth at LDB + 50% (m)	0.41	0.10	1.2	0.98	0.51						Habitat Distribution			
Depth at LDB + 75% (m)	0.42	0.29	0.61	0.07	0.95						Substrate Composition			
Max. Depth (m)	0.66	0.70	1.4	1.1	0.76						 			
Gradient (%)	1	1	1	1	1						Water Quality Data			
Dominant Habitat Unit	R2	BG	BG	BG	BG						Channel Characteristics			
Stream Bed											Time of Day (HH:MM):	17:00	Pattern:	SI
Organics	0	0	0	0	0						Water Temperature (°C):	9.7	Islands:	O
Fines	40	0	0	20	20						Dissolved Oxygen (mg/L):	9.55	Bars:	MD
Small Gravel	5	20	0	5	5						Sp. Conductivity (µs/cm):	52.2	Coupling:	DC
Large Gravel	5	30	10	5	5						pH:	6.79	Confinement:	CO
Cobble	10	20	10	10	20						Turbidity (NTU):	n/a	Flow Stage:	Moderate
Boulder	40	30	80	60	50						Fish Habitat Assessment Ratings			
Bedrock	0	0	0	0	0							Forage	Coarse	Sportfish
Embeddedness	VH	H	M	H	H						Spawning:	Good	Good	Good
Bank Measurements	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Overwintering:	Good	Poor	Poor
Bank Height (m)	0.31	0.30	0.22	0.19	0.22						Rearing:	Good	Moderate	Good
Bank Slope (°)	90	45	90	25	90	90	90	80	90	90	Migration:	Good	Good	Good
Bank Stability	S	S	S	S	S	S	S	S	S	S				
Dom. Bank Material	C	F	BL	O	O	BL	F	F	F	O				
Subdom. Bank Material	O	O	O	O	O	O	O	O	O	O				
Dom. Riparian Veg.	G	G	G	G	G	G	G	G	G	G				
Subdom. Riparian Veg.	S	S	S	S	S	S	S	S	S	S				



Photo 1: Looking upstream at A1 from the Road to Nowhere.



Photo 2: Looking downstream through A1 at the Road to Nowhere

Fish Sampling Data														
Method				Effort		Species		Efish Catch	Trap Catch	Efish CPUE	Trap CPUE	Rel. Abundance		
								(n)	(n)	(#fish/100s)	(#fish/hr)	(% of total)		
Backpack Electrofisher (EB)				532	(s)	NO FISH CAPTURED						-		
				(hr)										
Electrofisher Settings														
Volts		Freq. (Hz)		Duty Cycle (%)		Dist. (m)								
800		30		22		100								

General Comments

Large boulders were submerged with deep spaces between them providing excellent cover, but making electrofishing unproductive.

APPENDIX B

Fish and Fish Habitat Codes

B.1 Summary Data Sheet Habitat Codes

The following habitat descriptions and codes have been adapted from Alberta Transportation (2009) and RIC (2001).

Table B-1 Substrate Classifications for Stream Bed and Banks

Code	Substrate	Size Range
O	Organics	NA
F	Fines	<2 mm
SG	Small gravel	2–16 mm
LG	Large gravel	17–64 mm
C	Cobble	65–256 mm
BL	Boulder	>256 mm
BD	Bedrock	N/A

Table B-2 Embeddedness

Code	Class	Description
N	Non-embedded	All rock substrates (i.e., gravel, cobble, boulders)
L	Low embeddedness	<25% embedded
M	Medium embeddedness	25–50% embedded
H	High embeddedness	51–75% embedded
VH	Very high embeddedness	>75% embedded

Table B-3 Bank Stability

Code	Description
S	Stable
MS	Moderately stable
US	Unstable

Table B-4 Riparian Vegetation

Code	Description
N	None
G	Grass
S	Shrub
C	Coniferous
D	Deciduous forest
M	Mixed coniferous and deciduous forest
W	Wetland (e.g., muskeg, marsh, swamp, or bog)

Table B-5 Instream and Overhead Cover Types

Code	Description
AV	Aquatic vegetation
BL	Boulders
DC	Depth or clarity (turbid) of water
OV	Overhanging vegetation
UC	Undercut bank
WD	Woody debris

Table B-6 Stream Channel Pattern

Code	Description
ST	Straight
SI	Sinuuous
IR	Irregular, wandering
IM	Irregular, meandering
ME	Regular meanders
TM	Torturous meander

Table B-7 Channel Islands

Code	Type	Description
N	None	No islands in channel
O	Occasional	No overlapping islands, average spacing less than 10 channel widths
I	Infrequent	Infrequent overlapping, average spacing less than 10 channel widths
F	Frequent	Not overlapping, average spacing less than 10 channel widths
S	Split	Islands overlap frequently or continuously, usually two or three flow branches
AN	Anatomizing	Continuously overlapped islands, with multiple flow branches

Table B-8 Sediment Bars

Code	Type	Description
N	None	No bars present
SD	Side bar/point bar	Sediment deposition intermittent along the sides of the stream
DG	Diagonal bar	Mid-stream sediment deposition diagonally aligned to stream axis
MD	Mid-channel bar	Mid-stream deposition aligned parallel to stream axis
SP	Span	Sediment deposition continuous along the sides of the stream
BR	Braided	Sediment deposition forms a number of small channels separated by bars

Table B-9 Coupling

Code	Type	Description
DC	Decoupled	Sediment mobilized on the hill slope by a land-slide normally would not enter the stream channel
PC	Partially coupled	A portion of the sediment mobilized on the hill slope by a landslide enters the stream channel
CO	Coupled	Sediment mobilized on the hillslope by landslide activity directly enters the stream channel

Table B-10 Confinement

Code	Type	Description
EN	Entrenched	Entrenched channels are confined by fluvial eroded gullies or valleys or bedrock walls
CO	Confined	Confined channels are prevented or restricted from lateral migration by the valley walls
FC	Frequently Confined	Frequently confined channels are restricted from lateral migration by the valley walls, but are able to store sediments on a valley flat (typically < channel width)
OC	Occasionally Confined	Occasionally confined channels are able to store sediments on a valley flat (typically 1-10 channel widths)
UN	Unconfined	Unconfined channels are not restricted from lateral migration by the valley walls
N/A	Not Applicable	Confinement is not always applicable to every stream reach, such as a channel flowing across a fan or cone onto a valley flat

Table B-11 Flow Stage

Type	Description
Dry	Water not present
Pooled	Water only present as unconnected pools or standing in bottom depressions; no flow
Low	Water flowing as threads within the channel; most bed material is exposed and little of the lower banks are wet
Moderate	Water flowing throughout the normal bed and in contact with the lower portions of banks; some bars are exposed
High	Water fills most of the channel and is in contact with the middle and upper portions of banks
Flood	Water is bankfull or over banks and into the floodplain

Table B-12 Habitat Unit Classification for Small Streams

Habitat Unit	Class	Code	Description
Falls		FA	Highly turbulent whitewater caused by water free-falling over a vertical drop. Falls formed from a full spanning flow obstruction, often bedrock. Slope < 100%.
Cascade		CA	Series of small falls or steps and pools; stepped longitudinal profile. Substrate of bedrock or boulder accumulations. Highly turbulent, high velocity, > 7% slope, mainly whitewater.

Fish and Fish Habitat Assessment of the Niaqunguk (Apex) River, Lake Geraldine, and the Lake Geraldine Drainage Channel

Appendix B: Fish and Fish Habitat Codes

September 2017

Table B-12 Habitat Unit Classification for Small Streams

Habitat Unit	Class	Code	Description
Rapid		RA	Steps and pocket pools common, cobble/boulder substrate with some exposed boulders at lower flows. Considerable turbulence, some whitewater, fast velocity (> 0.5 m/s), 4–7% slope.
Chute		CH	Area of channel constriction, usually due to bedrock intrusions; associated with channel deepening and increased velocity.
Riffle		RF	Partially to totally submerged pebble to cobble substrate, causing moderate turbulence and ripples, little to no whitewater (some whitewater at points of constriction), moderate velocity (0.2–0.5 m/s), usually < 0.5 m depth, 1–4% slope.
Run			Runs are typically deep, slow to swift flowing sections (> 0.2 m/s), with gravel to boulder substrate. Defined thalweg, moderate slope and with no surface turbulence. Run units are differentiated into three classes, based on depth.
	1	R1	Deepest run (> 1 m), slow to fast water velocity, coarse substrate (cobble to boulder), high instream cover from substrate and depth.
	2	R2	Moderate depth (0.6–1.0 m), slow to fast water velocity, coarse substrate (cobble to boulder), moderate instream cover from substrate and depth.
	3	R3	Shallowest depth (0.3–0.6 m), slow to fast water velocity, coarse substrate (gravel to cobble), low instream cover.
Glide		GL	Glides are shallow (< 0.3 m deep), wide, slow flowing (< 0.2 m/s), non-turbulent and lack a defined thalweg. Substrate is usually silt/sand but may sometimes consist of gravel to small cobble. Featureless with low instream cover.
Flat		FL	Area characterized by low velocity and near-uniform flow; differentiated from pool habitat by high channel uniformity; more depositional than R3 habitat.
Sheet		ST	Shallow water reach that flows uniformly over smooth bedrock. Non-turbulent.
Pool			Pools are deeper and wider than channel units immediately above or below it and are usually formed by the scouring or plunging action of water. Sub-surface velocities are slow although water surface may be fast. Substrate usually composed of fines or small gravel.
	1	P1	High quality pool habitat based on depth and size. High instream cover from instream features (i.e., logs/boulders) and depth (> 1.2 m) provides overwintering habitat.
Pool (cont.)	2	P2	Shallower than P1 (0.6–1.2 m deep), moderate to high instream cover, provides juvenile and adult fish rearing habitat during open water.
	3	P3	Shallow (< 0.6 m deep) and small, low instream cover. May not be suitable for overwintering or adult holding habitat but may provide rearing habitat for juvenile fish during open water.
Step pool		SP	Series of pools separated by short riffles or cascades. Generally found in high gradient, confined mountain streams dominated by boulder substrate. The length of the turbulent water cannot exceed the mean wetted width; otherwise, classify the pools and turbulent water separately.
Impoundment			Includes pools and impoundments formed behind complete or nearly complete channel blockage. Four types of dams are: beaver, debris, landslide, or weir (man-made). Dams tend to accumulate more sediment/organic debris than scour pools. Identify as class 1, 2 or 3 using pool criteria.

Fish and Fish Habitat Assessment of the Niaqunguk (Apex) River, Lake Geraldine, and the Lake Geraldine Drainage Channel

Appendix B: Fish and Fish Habitat Codes

September 2017

Table B-12 Habitat Unit Classification for Small Streams

Habitat Unit	Class	Code	Description
	1	IP1	> 1.2 m deep
	2	IP2	0.6–1.2 m deep
	3	IP3	< 0.6 m deep
Dam	Beaver	BD	Structures causing complete or nearly complete channel blockage. Three types of dams are: beaver, debris (including landslides), and man-made (including weirs). Dams tend to accumulate more sediment/organic debris than scour pools.
	Debris	DD	
	Man-made	MD	
Backwater		BW	Shallow pool habitat found along channel margins, caused by eddy scour (exhibits reverse flow direction) around a boulder, root wad, or log obstruction. Substrate is typically small (silt to small cobble) and the velocity slower than the main channel.
Snye		SN	Discrete section of non-flowing water connected to a flowing channel only at its downstream end; generally formed in a side channel or behind a peninsula.
Boulder garden		BG	Substantial occurrence of large boulders providing significant instream cover; always in association with an overall channel unit such as a riffle (RF/BG) or run (e.g., R1/BG).
Swale		SW	Round bottomed drainage; has connectivity upstream and downstream with little to no flow. Bank heights and channel width poorly defined or absent. Large amounts of vegetation sometimes present.
Marshy flat		MF	Wetland-like habitat with connectivity upstream and downstream. Water movement present within habitat unit but to a lesser degree than a swale. Can have high amounts of vegetation such as <i>Carex</i> spp and cattails.
Wetland		WL	With respect to fish and fish habitat: no connectivity upstream or downstream. Does not contribute to a fishery.
Dugout		DU	Artificial water body with no connectivity upstream or downstream. Does not contribute to a fishery.
Dry		DR	Area within a watercourse that is dry at the time of assessment.

Table B-14 Fish Species Codes

Species Common Name	Scientific Name	Species Code
Arctic char	<i>Salvelinus alpinus</i>	ARCH
Ninespine stickleback	<i>Pungitius pungitius</i>	NNST
Threespine stickleback	<i>Gasterosteus aculeatus</i>	THST

APPENDIX C

Measures to Avoid Causing Harm to Fish and Fish Habitat

C.1 Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013a)

SOURCE: <http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/index-eng.html>.

If you are conducting a project near water, it is your responsibility to ensure you avoid causing [serious harm to fish](#) in compliance with the [Fisheries Act](#). The following advice will help you avoid causing harm and comply with the *Act*.

PLEASE NOTE: This advice applies to all project types and replaces all “Operational Statements” previously produced by DFO for different project types in all regions.

Measures

Project Planning/Timing

- Time work in water to respect [timing windows](#) to protect fish, including their eggs, juveniles, spawning adults and/or the organisms upon which they feed.
- Minimize duration of in-water work.
- Conduct instream work during periods of low flow, or at low tide, to further reduce the risk to fish and their habitat or to allow work in water to be isolated from flows.
- Schedule work to avoid wet, windy and rainy periods that may increase erosion and sedimentation.

Site Selection

- Design and plan activities and works in waterbody such that loss or disturbance to aquatic habitat is minimized and sensitive spawning habitats are avoided.
- Design and construct approaches to the waterbody such that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation.
- Avoid building structures on meander bends, braided streams, alluvial fans, active floodplains or any other area that is inherently unstable and may result in erosion and scouring of the stream bed or the built structures.
- Undertake all instream activities in isolation of open or flowing water to maintain the natural flow of water downstream and avoid introducing sediment into the watercourse.

Contaminant and Spill Management

- Plan activities near water such that materials such as paint, primers, blasting abrasives, rust solvents, degreasers, grout, or other chemicals do not enter the watercourse.
- Develop a response plan that is to be implemented immediately in the event of a sediment release or spill of a deleterious substance and keep an emergency spill kit on site.
- Ensure that building material used in a watercourse has been handled and treated in a manner to prevent the release or leaching of substances into the water that may be deleterious to fish.

Erosion and Sediment Control

- Develop and implement an Erosion and Sediment Control Plan for the site that minimizes risk of sedimentation of the waterbody during all phases of the project. Erosion and sediment control measures should be maintained until all disturbed ground has been permanently stabilized, suspended sediment has resettled to the bed of the waterbody or settling basin and runoff water is clear. The plan should, where applicable, include:
 - Installation of effective erosion and sediment control measures before starting work to prevent sediment from entering the water body.
 - Measures for managing water flowing onto the site, as well as water being pumped/diverted from the site such that sediment is filtered out prior to the water entering a waterbody. For example, pumping/diversion of water to a vegetated area, construction of a settling basin or other filtration system.
 - Site isolation measures (e.g., silt boom or silt curtain) for containing suspended sediment where in-water work is required (e.g., dredging, underwater cable installation).
 - Measures for containing and stabilizing waste material (e.g., dredging spoils, construction waste and materials, commercial logging waste, uprooted or cut aquatic plants, accumulated debris) above the high water mark of nearby waterbodies to prevent re-entry.
 - Regular inspection and maintenance of erosion and sediment control measures and structures during the course of construction.
 - Repairs to erosion and sediment control measures and structures if damage occurs.
 - Removal of non-biodegradable erosion and sediment control materials once site is stabilized.

Shoreline Re-vegetation and Stabilization

- Clearing of riparian vegetation should be kept to a minimum: use existing trails, roads or cut lines wherever possible to avoid disturbance to the riparian vegetation and prevent soil compaction. When practicable, prune or top the vegetation instead of grubbing/uprooting.
- Minimize the removal of natural woody debris, rocks, sand or other materials from the banks, the shoreline or the bed of the waterbody below the ordinary high water mark. If material is removed from the waterbody, set it aside and return it to the original location once construction activities are completed.
- Immediately stabilize shoreline or banks disturbed by any activity associated with the project to prevent erosion and/or sedimentation, preferably through re-vegetation with native species suitable for the site.
- Restore bed and banks of the waterbody to their original contour and gradient; if the original gradient cannot be restored due to instability, a stable gradient that does not obstruct fish passage should be restored.
- If replacement rock reinforcement/armouring is required to stabilize eroding or exposed areas, then ensure that appropriately-sized, clean rock is used; and that rock is installed at a similar slope to maintain a uniform bank/shoreline and natural stream/shoreline alignment.

- Remove all construction materials from site upon project completion.

Fish Protection

- Ensure that all in-water activities, or associated in-water structures, do not interfere with fish passage, constrict the channel width, or reduce flows.
- Retain a qualified environmental professional to ensure applicable permits for relocating fish are obtained and to capture any fish trapped within an isolated/enclosed area at the work site and safely relocate them to an appropriate location in the same waters. Fish may need to be relocated again, should flooding occur on the site.
- Screen any water intakes or outlet pipes to prevent entrainment or impingement of fish. Entrainment occurs when a fish is drawn into a water intake and cannot escape. Impingement occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself.
 - In freshwater, follow these measures for design and installation of intake end of pipe fish screens to protect fish where water is extracted from fish-bearing waters:
 - Screens should be located in areas and depths of water with low concentrations of fish throughout the year.
 - Screens should be located away from natural or artificial structures that may attract fish that are migrating, spawning, or in rearing habitat.
 - The screen face should be oriented in the same direction as the flow.
 - Ensure openings in the guides and seals are less than the opening criteria to make “fish tight”.
 - Screens should be located a minimum of 300 mm (12 in.) above the bottom of the watercourse to prevent entrainment of sediment and aquatic organisms associated with the bottom area.
 - Structural support should be provided to the screen panels to prevent sagging and collapse of the screen.
 - Large cylindrical and box-type screens should have a manifold installed in them to ensure even water velocity distribution across the screen surface. The ends of the structure should be made out of solid materials and the end of the manifold capped.
 - Heavier cages or trash racks can be fabricated out of bar or grating to protect the finer fish screen, especially where there is debris loading (woody material, leaves, algae mats, etc.). A 150 mm (6 in.) spacing between bars is typical.
 - Provision should be made for the removal, inspection, and cleaning of screens.
 - Ensure regular maintenance and repair of cleaning apparatus, seals, and screens is carried out to prevent debris-fouling and impingement of fish.
 - Pumps should be shut down when fish screens are removed for inspection and cleaning.
- Avoid using explosives in or near water. Use of explosives in or near water produces shock waves that can damage a fish swim bladder and rupture internal organs. Blasting vibrations may also kill or damage fish eggs or larvae.

- If explosives are required as part of a project (e.g., removal of structures such as piers, pilings, footings; removal of obstructions such as beaver dams; or preparation of a river or lake bottom for installation of a structure such as a dam or water intake), the potential for impacts to fish and fish habitat should be minimized by implementing the following measures:
 - Time in-water work requiring the use of explosives to prevent disruption of vulnerable fish life stages, including eggs and larvae, by adhering to appropriate fisheries [timing windows](#).
 - Isolate the work site to exclude fish from within the blast area by using bubble/air curtains (i.e., a column of bubbled water extending from the substrate to the water surface as generated by forcing large volumes of air through a perforated pipe/hose), cofferdams or aquadams.
 - Remove any fish trapped within the isolated area and release unharmed beyond the blast area prior to initiating blasting
 - Minimize blast charge weights used and subdivide each charge into a series of smaller charges in blast holes (i.e., decking) with a minimum 25 millisecond (1/1000 seconds) delay between charge detonations (see Figure C-1).
 - Back-fill blast holes (stemmed) with sand or gravel to grade or to streambed/water interface to confine the blast.
 - Place blasting mats over top of holes to minimize scattering of blast debris around the area.
 - Do not use ammonium nitrate based explosives in or near water due to the production of toxic by-products.
 - Remove all blasting debris and other associated equipment/products from the blast area.

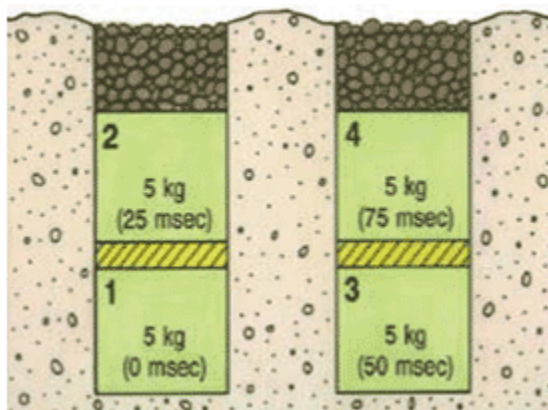


Figure C-1 Sample Blasting Arrangement

Per Fig. 1: 20 kg total weight of charge; 25 msecs delay between charges and blast holes; and decking of charges within holes.

Operation of Machinery

- Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks, invasive species and noxious weeds.

Fish and Fish Habitat Assessment of the Niaqunguk (Apex) River, Lake Geraldine, and the Lake Geraldine Drainage Channel

Appendix C: Measures to Avoid Causing Harm to Fish and Fish Habitat

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- Whenever possible, operate machinery on land above the high water mark, on ice, or from a floating barge in a manner that minimizes disturbance to the banks and bed of the waterbody.
- Limit machinery fording of the watercourse to a one-time event (i.e., over and back), and only if no alternative crossing method is available. If repeated crossings of the watercourse are required, construct a temporary crossing structure.
- Use temporary crossing structures or other practices to cross streams or waterbodies with steep and highly erodible (e.g., dominated by organic materials and silts) banks and beds. For fording equipment without a temporary crossing structure, use stream bank and bed protection methods (e.g., swamp mats, pads) if minor rutting is likely to occur during fording.
- Wash, refuel and service machinery and store fuel and other materials for the machinery in such a way as to prevent any deleterious substances from entering the water.

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