Fish Habitat Assessment of the Niaqunguk (Apex) River, Nunavut

Prepared for:

City of Iqaluit
Iqaluit, Nunavut

Prepared by:

Nunami Stantec Limited

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Prepared by Doug Chiperzak Digitally signed by Doug Chiperzak Date: 2023.03.02 13:44:36 -07'00'
(signature)

Doug Chiperzak BSc., Dip.
Senior Fisheries Biologist

Reviewed by Clio Bonnett Digitally signed by Clio Bonnett Date: 2023.03.03 13:01:36 -07'00'
(signature)

Clio Bonnett M.Sc., P.Biol., R.P.Bio, P.Geo
Fisheries Biologist

Approved by _____
(signature)

Erica Bonhomme M.Sc., P.Geo
Principal, Environmental Services, Northern Canada

Executive Summary

The City of Iqaluit retained Nunami Stantec Ltd. to complete fish habitat assessments along the Niaqunguk (Apex) River, develop a habitat suitability index for Artic char (*Salvelinus alpinus*), and conduct eDNA samples. The sampling was conducted in support of a monitoring program if supplementary water withdrawal for the Lake Geraldine Reservoir exceeds the allowable 10% instantaneous flow. A field survey was conducted between August 16 to August 20, 2022. Ten 100 m reaches were assessed four upstream of the temporary pumping location, the temporary pumping location, and five downstream of the temporary pumping location.

At each sampled reach habitat features were measured and observed, water quality, and flow measures taken. Areas of river between sampling reaches were walked and habitat features observed and recorded. Fish habitat was rated at each reach by the field biologist for the life history requirements of spawning, rearing, fish passage and overwintering.

A habitat suitability index (HSI) model for Arctic char was adapted from an existing model for Dolly Varden char (*S. malma*) and bull trout (*S. confluentus*) as there was insufficient data in the literature on habitat preferences of Arctic char. The HSI model was applied to the reach at the temporary pumping location (PP-01) and downstream assessed reaches as proposed monitoring locations as a comparison of field assessed habitat ratings.

Water samples were collected at one site upstream of the temporary pumping location for the collection of eDNA to determine the potential for Arctic char upstream of the temporary pumping location. Analysis of the water samples indicated the potential presence of Arctic char at or above the sampling site. No other fish species were identified through the eDNA analysis.

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Abbreviations

City ..... City of Iqaluit
DFO ..... Fisheries and Oceans Canada
DNA ..... Deoxyribonucleic acid
eDNA ..... environmental DNA
HSI ..... habitat suitability index
km ..... kilometre
m ..... metre
MAD ..... Mean annual discharge

Glossary

Fish passage	Features used by fish to migrate through a watercourse or waterbody to access different habitats to carry out additional life stages
Adult foraging	Areas used by adult fish for feeding
Metabarcoding	Used for the identification of species assemblages from DNA barcode genes
Overwintering habitat	Habitat used by fish during the winter, typically when watercourses and waterbodies are ice-covered
Rearing habitat	Habitat used by larval and juvenile fish for feeding and shelter
Spawning habitat	Habitat used by adult fish to carry out spawning activities

1 Introduction

The City of Iqaluit (the City) sources its potable water from Lake Geraldine; however, in recent years, low water levels in the reservoir due to lower levels of precipitation than normal have required the City to divert water from other sources in order to supply the community. The City is permitted to divert water as a supplementary water supply from the Niaqunguk (Apex) River to Lake Geraldine when flows in the Apex River are above 30% mean annual discharge (MAD). During tHSI time, the City is permitted to divert water at a flow rate equal to or less than 10% of the instantaneous flow of the Apex River. The City has determined that increased diversion rates are required in order to continue to supply the community with potable water.

On August 5, 2022, the City of Iqaluit submitted an application for emergency Authorization under the *Fisheries Act* (22-HCAA-02043) to Fisheries and Oceans Canada (DFO) to withdraw water from the Apex River above the allowable limit of 10% instantaneous flow and when conditions are above 30% of the mean annual discharge, as specified in the City's water licence (3AM-IQA1626). The *Fisheries Act* Emergency Authorization was issued on August 12, 2022. A monitoring plan (Nunami Stantec 2022) was developed for water diversion from the Apex River and would be implemented if water is withdrawn over the 10% instantaneous flow level. This monitoring plan was submitted to DFO as part of the application for emergency Authorization. The initial fish and fish habitat assessment was completed in 2016 (Nunami Stantec 2017) and was submitted with the application for emergency Authorization; however, additional recent fish and fish habitat data is required to support ongoing regulatory reviews.

Nunami Stantec Ltd. (Nunami) was retained by the City in July 2022 to develop a revised fish and fish habitat assessment that included:

- Characterization of pre-water diversion fish habitat conditions at proposed monitoring sites along the Apex River
- Develop a habitat suitability index (HSI) model for Arctic char
- Evaluate potential for Arctic char presence above the temporary pumping location using environmental DNA (eDNA)

1.1 Study Area

The Apex River originates at an unnamed lake north of Iqaluit and flows through a tundra landscape into Koojesse Inlet. The Apex River is approximately 8 kilometres (km) in length. A two metre (m) waterfall at the mouth of the Apex River prevents fish from Koojesse Inlet from entering the river. The study area and sampling locations are presented in Figure 1.1.

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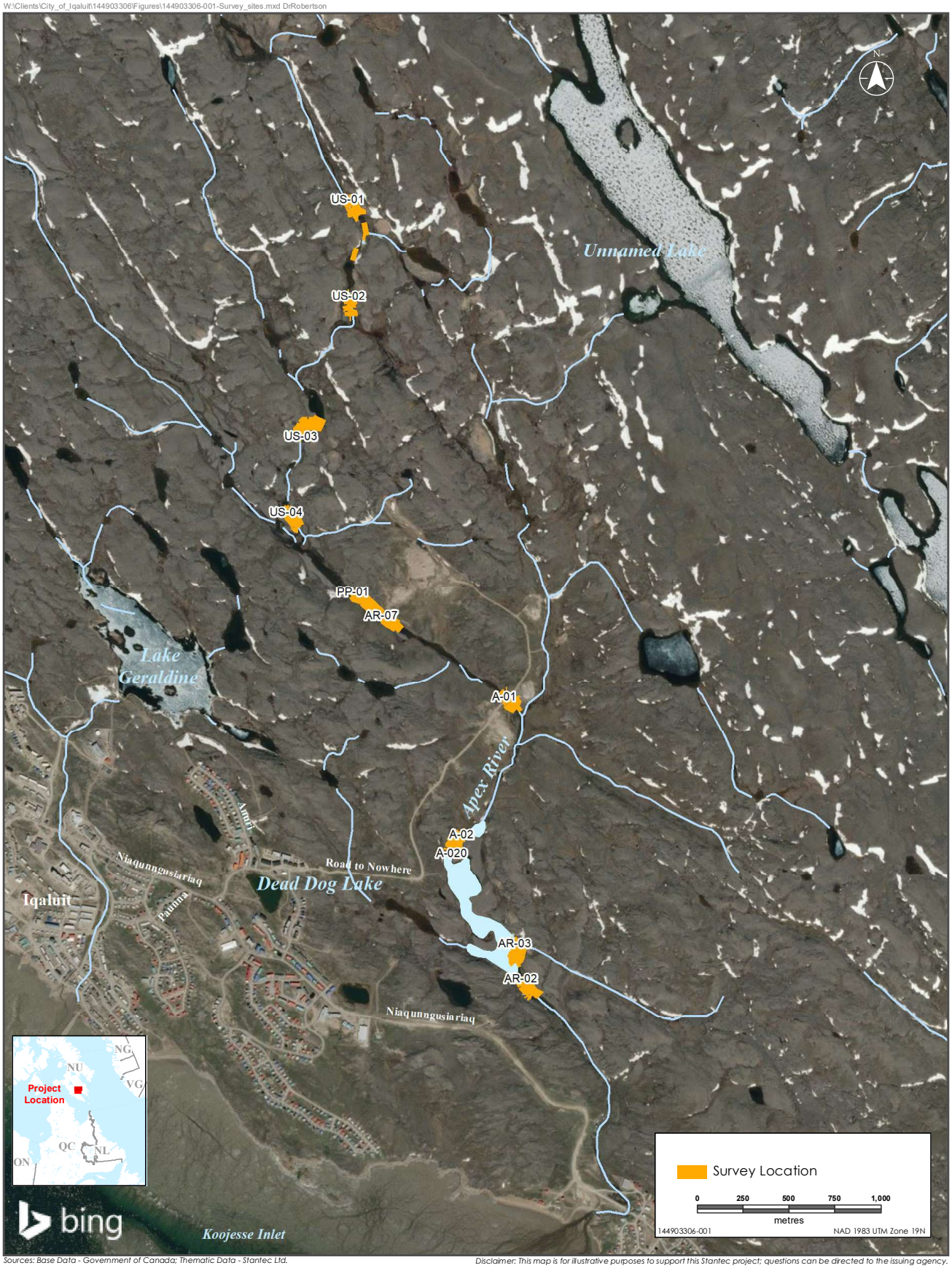

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Survey Locations

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FISH AND FISH HABITAT ASSESSMENT STUDY

Figure 1.1

2 Methods

2.1 HSI Model

Habitat suitability indexes (HSI) are used as a tool used to objectively assess the range of environmental conditions that fully, marginally, or do not meet the life history requirements of a species (Wakeley 1988). The HSI provides a numeric measurement of the habitat variable between 0 (does not meet species requirements) and 1 (fully meets the species requirements) (de Kerckhove et al. 2008) (Table 2.1). Habitat suitability metrics (e.g., water velocity, substrate, and water depth) reflect units that are used in an overall HSI numerical index to describe the suitability of habitat to a specific life stage of Arctic char. The HSI provide environmental-variable suitability values ranging between 0 and 1, where a score of 1 is considered most suitable habitat and a score of 0 is considered least suitable habitat for Arctic char.

The HSI model relies heavily on habitat preferences for Dolly Varden char (*Salvelinus malma*) and bull trout (*S. confluentus*) as they share similar habitat preferences as Arctic char and detailed habitat preference data is lacking on Arctic char in the literature.

The HSI for each 100 m reach was calculated by adding the ranks for each parameter for a life history component modelled and dividing by the number of parameters for that life History component. For example for spawning potential, four habitat parameters (P) were used and therefore the HSI for spawning was calculated as $P_1 + P_2 + P_3 + P_4 / 4$ = HSI for spawning.

Table 2.1 Habitat Ranking

Assigned Rank	Habitat Suitability Rating	Description
1.00	Excellent	Available habitat is highly suitable. No limitations to suitability are identified the life stage under consideration
0.75	Above Average	Available habitat has slight limitations for life stage under consideration.
0.50	Average	Available habitat is capable of supporting life stage under consideration, but may not be most desirable habitat
0.25	Below Average	Moderate to severe limitations in habitat suitability are present for the life stage under consideration.
0.00	Least suitable	Habitat suitability is negligible or nonexistent.

2.2 Fish Habitat

The field survey was conducted between August 16 and August 20, 2022 by a qualified aquatic biologist. At each site (Table 2.2; Figure 1.1), fish habitat was assessed along 100 m reaches. Along each 100 m reach, five transects were established to collect fish habitat data; located at 0 m (i.e., reach ID location), and downstream at 25 m, 50 m, 75 m, and 100 m along each reach. At each transect the following data were collected:

- Date and time;

- general channel morphology;
- channel width;
- wetted width;
- water depth at 0.25, 0.5 and 0.75 of wetted width
- water velocity using a Hach FH950 flow meter;
- water quality (e.g., oxygen, conductivity, and pH);
- substrate composition (visually estimated);
- bank description (i.e., height, slope, and stability);
- functional cover type and abundance;
- riparian vegetation composition;
- global positioning system (GPS) recordings and photographs.

River stretches between sampling sites were walked by the aquatic biologist and habitat characteristics observed and recorded. No measurements were taken between sampled reaches.

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 Arctic char (e.g., rearing, spawning, fish passage, overwintering) suspected to occur in the waterbody. Each life history requirement was rated as good, moderate, poor or none, based on the professional judgement of the fish biologist. In addition, the HSI model (Section 3.1) was also applied for the life requirements (spawning, rearing, foraging, and overwintering) of Arctic char for each assessed site.

Table 2.2 Reach Locations (all locations are in UTM Zone 19 V)

Location Number	Easting	Northing
A-01	526548	7069946
A-02	526260	7069180
AR-02	526625	7068410
AR-03	526559	7068632
AR-07	525871	7070396
PP-01	525736	7070513
US-01	525685	7072648
US-02	525666	7072105
US-03	525419	7071445
US-04	525371	7070950

2.3 eDNA

Five eDNA samples were collected from the US-01 Reach. Samples were collected off the left downstream bank to ensure the crew did not enter the water prior to sample collection to prevent contamination. Nitrile gloves were worn when handling sampling equipment and the filters. Each sample was filtered *in-situ* through a 5 µm pore-size Smith-Root self-preserving eDNA filter. Water was pulled through the filters using a drill-operated Masterflex L/S® Easy-Load® peristaltic pump. Two liters of water were filtered per sample. All samples were labelled, bagged and frozen until they were shipped to NatureMetrics for eDNA metabarcoding species analysis. A negative control filter was prepared by filtering two liters of distilled water. Detailed DNA analysis conducted by NatureMetrics is provided in Appendix A.

3 Results

3.1 HSI

Tables 3.1 to 3.4 provides the HSI model adapted for Arctic char from a HSI model developed by AMEX (2012) for Dolly Varden char.

Table 3.1 Spawning/egg Incubation Habitat

Physical Habitat	Spawning/egg Incubation					References/Notes[1]
	Excellent	Above Average	Average	Below Average	Unsuitable	
HSI Value	**1.00**	**0.75**	**0.50**	**0.25**	**0.00**	
Dominant substrate	gravel	Gravel/cobble	Fine gravel	Cobble/boulder	Rock/bedrock	ADFG 1985 (DV+AC); Griffith 1979 (DV); Leggett 1980 (DV); Kitano and Shimazaki 1995 (DV)
Substrate size (mm)	10-50	50-100	0-10	125-256	≥256	-
Depth-Range (m)	.0.05-0.19	0.19-0.30	0.29-0.40	-	<0.04 >0.40	ADFG 1985 (DV+AC); Armstrong and Morrow 1980 (DV); Griffith 1979 (DV); Hagan and Taylor 2001 (DV); Kitano and Shimazaki 1995 (DV)
Temperature °C	4-12	-	12-15	-	<4, >15	ADFG 1985 (DV+AC); Craig and Poulen 1974 (DV); Griffith 1979 (DV); McPhail 2007 (DV); McPhail and Baxter 1996 (BT)
Water velocity (m/s)	0.1-0.3	0.3-0.6	0.6-1.0	1.0-1.3	>1.3	ADFG 1985(DV+AC); Griffith 1979(DV); Kitano and Shimazaki1995(DV)
Stream morphology	Pool-tails or riffle crests contiguous to holding pools	Riffle-run	Pool-riffle	Runs, pools	-	McCart 1980 (DV)
Additional considerations	Areas of groundwater discharge are considered key habitat spawning					ADFG 1985 (DV+AC); Stewart *et al.* 2007

Notes:
[1] Brackets denote species habitat use information from which HSI was derived from: DV = Dolly Varden; BT = bull trout; AC = Arctic char
"-" no data

Table 3.2 Juvenile Rearing Habitat

Physical Habitat	Juvenile Rearing					References/Notes[1]
	Excellent	Above Average	Average	Below Average	Unsuitable	
HSI Value	1.00	0.75	0.50	0.25	0.00	
Dominant substrate	Gravel-cobble	boulder	-	Fines, debris/organic	Rock/bedrock	Dollof and Reeves 1990 (DV); Griffith 1979 (DV)
Substrate size (mm)	2-256	>256	-	<2, NA	>400	Dollof and Reeves 1990 (DV); Griffith 1979 (DV)
Instream cover	Boulders, undercut banks	Undercut bank	Overhead vegetation + undercut bank	Overhead vegetation, aquatic vegetation, boulder	Cobble	Dollof and Reeves 1990 (DV); Griffith 1979 DV)
Depth-Range (m)	0.16-0.29	0.06-0.10, 0.21-0.39	0.10-0.15	<0.05, 0.40-0.49	≥0.50	Bugert *et al.* 1991 (DV); Dollof and Reeves 1990 (DV)
Gradient (%)	5-7	0-4	8-11	12-18	>18	Bryant *et al.* 2004 (DV)
Water velocity (m/s)	0.06-0.19	0.0-0.09	0.20-0.29	0.30-0.39	>0.40, <0.1	Bugert *et al.* 1991 (DV), Griffith 1979 (DV), Sinnatamby et al. 2012 (AC)
Discharge (m^3/sec)	0.01-0.10	0.10-0.30	0.30-0.50	0.50-0.79	>80	Bryant *et al.* 2009 (DV); Dollof and Reeves 1990 (DV)
Stream morphology	Riffles, riffle/glide, side channels	Run-riffle	Pool	Run-pool	--	Griffith 1979 (DV); McCart 1980 (DV); Smith and Slaney 1980 (DV)

Note:
[1] Brackets denote species habitat use information from which HSI was derived from: DV = Dolly Varden; BT = bull trout; AC = Arctic char

Table 3.3 Adult Foraging

Physical Habitat	Adult Foraging					References/Notes[1]
	Excellent	Above Average	Average	Below Average	Unsuitable	
HSI Value	**1.00**	**0.75**	**0.50**	**0.25**	**0.00**	
Dominant substrate	Cobble-boulder	Gravel	-	Rock	Fines, debris, organic	Stewart *et al.* 2007 (BT)
Cover type	Depth, undercut banks, boulders	Large woody debris, cobble	Overhead vegetation	Aquatic vegetation	Small woody debris	ADFG 1985 (DV+AC); Stewart *et al.* 2007 (BT)
Depth-Range (m)	0.30-0.90	0.20-0.30, 0.90-1.20	>1.2	0.20-0.1	<0.1	Hagan and Taylor 2001 (DV), Stewart *et al.* 2007 (BT)
Temperature °C	4-8	8-12.5	12.5-15	<4, 15-20	>20	McPhail 2007 (DV); McPhail and Baxter 1996 (BT); Stewart *et al.* 2007 (BT)
Water velocity (m/s)	0.22-0.55	-	0-0.22, 0.55-1.46	-	>1.46	Stewart *et al.* 2007 (BT)
Stream morphology	Main channel pools and riffles	Run	Side channel pools-riffles	Flat	Chutes, falls	Hagen 2000 (DV); Murray and Gadboury 2005 (DV+BT)

Note:
[1] Brackets denote species habitat use information from which HSI was derived from: DV = Dolly Varden; BT = bull trout; AC = Arctic char

Table 3.4 Overwintering Habitat

Physical Habitat	Overwintering Habitat					References/Notes[1]
	Excellent	Above Average	Average	Below Average	Unsuitable	
HSI Value	1.00	0.75	0.50	0.25	0.00	
Dominant substrate	Cobble-boulder	Gravel	-	Rock	Fines, debris, organic	Based on rearing substrate use [Stewart *et al.* 2007 (BT)] and use of submerged cover in form of boulders as reported by Heifetz *et al.* 1986 (DV)
Cover	Depth, cobble, boulder	Woody debris,	-	Undercut banks	-	Heifetz *et al.* 1986 (DV)
Depth-Range (m)	0.20-0.60	-	0.05 – 0.20, >0.60	-	<0.05	Derived from data observations of fish in fall or systems where ice cover was not present in winter. Bonneau and Scarnecchia 1998 (BT); Huusko *et al*. 2007 (Salmo spp.); Jakober *et al*. 2000 (BT)
Stream morphology	Deep pools, open areas with groundwater upwelling	Deep Pools	Deep run - glides	Riffles	-	Heifetz *et al.* 1986 (DV); Jakober *et al*. 2000 (BT)

Note:
[1] Brackets denote species habitat use information from which HSI was derived from: DV = Dolly Varden; BT = bull trout; AC = Arctic char

3.2 Fish Habitat

The following provides a summary of the fish habitat at the assessed reaches. Additional habitat details and pictures are provided in Appendix B. Water quality data for all the assessed reaches are provided in Table 3.5 and steam velocities in Table 3.6.

Table 3.5 Water Quality Data by Reach

Reach	Water Clarity	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	Specific Conductivity (µs/cm)	pH
A-01	Clear	9.6	10.71	93.9	66.6	7.79
A-02	Clear	7.5	10.66	89.0	67.8	7.78
AR-02	Clear	8.6	10.38	89.0	68.0	7.64
AR-03	Clear	8.7	10.46	89.9	68.0	7.32
AR-07	Clear	7.0	10.61	87.4	66.7	7.22
PP-01	Clear	7.0	10.59	87.1	67.3	7.12
US-01	Clear	7.8	10.65	89.5	63.1	7.07
US-02	Clear	10.9	10.25	92.8	62.4	7.62
US-03	Clear	8.5	10.45	89.4	66.1	7.11
US-04	Clear	9.4	10.35	90.5	65.7	7.16

Table 3.6 Stream Velocities by Reach

Reach	Minimum m/sec	Maximum m/sec	Average m/sec
A-01	0.045	0.429	0.235
A-02	0.003	0.373	0.124
AR-02	0.005	0.487	0.202
AR-03	ND	ND	ND
AR-07	0.018	0.164	0.077
PP-01	ND	ND	ND
US-01	0.018	0.234	0.101
US-02	0.028	0.333	0.163
US-03	0.002	0.248	0.097
US-04	0.043	0.352	0.178

Note:
ND = No data collected

3.2.1 Downstream of AR-02 to Koojesse Inlet

Downstream of AR-02 to the mouth of the Apex River at the Koojesse Inlet, habitat transitions from a riffle to a steeper series of cascades and rapids; however, these features are unlikely to limit fish passage. At the mouth of the Apex there is a 2 m waterfall which is a barrier for fish migrating up the Apex River from Koojesse Inlet. There are no deep pools along the assessed reach between AR-02 and the mouth of the Apex River to provide overwintering habitat. Spawning and rearing habitat is limited or absent.

3.2.2 Reach AR-02

Channel width and wetted width varied from 12.0 m to 33.6 m with the greatest width at the downstream end of the reach and narrowest 25 m downstream from the start of the reach. Maximum depths ranged from 0.49 m at the upstream end of the reach to 2.5 m at the middle of the reach and then decreased to over 1 m in the downstream portion of the reach. Stream gradient ranged from one to four percent with the highest gradient 25 m downstream of the beginning of the reach and then leveling off to one percent for the downstream segment of the reach. The upstream segment of the reach is a mixture of glide and riffle habitat with pools present in the downstream segment of the reach and extend into Swimming Lake. Cobble was the dominant substrate for upstream half of the reach and transitioned to an increased percentage of boulders in the lower half of the reach, with boulder being the dominant substrate at the downstream end of the reach. The remaining substrate was a mixture of sand and large gravel. The banks throughout the reach were stable. Grass was the dominant riparian vegetation and provided little to no overhead cover. Instream cover was provided by boulder and cobble substrate.

Fish habitat was rated in the field as poor for spawning due to a lack of gravel but moderate for rearing due to the presence of boulders and cobble. There is overwintering potential at the lower end of the reach due to the presence of a pool. Fish passage was rated as good as no obstructions to migration were observed.

Habitat ratings using the HSI from Section 3.1 is presented in Table 3.7.

Table 3.7 HSI Ratings for AR-02

Physical Habitat Parameter	Spawning/Egg Incubation	Juvenile Rearing	Adult Foraging	Overwintering
Dominant substrate	0.25	0.75	1.0	1.0
Substrate size	ND	ND	ND	ND
Depth range	0	0	0.75	1.0
Instream cover	-	0.25	1.0	1.0
Gradient	-	0.75	-	-
Water velocity (m/s)	0.25	0.5	0.5	-
Stream morphology	0.5	0.75	1.0	1.0
HSI Ranking	0.25 (below average)	0.50 (average)	0.85 (above average)	1.0 (excellent)

Notes:
ND = No field data for Apex River
= Not used in HSI calculation

3.2.3 Between Reach AR-02 and Reach AR-03

The habitat between reaches AR-02 and AR-03 varies between a series of runs and pools. There is potential for overwintering in a pool (X m deep) immediately downstream of AR-03 that has good instream cover afforded by boulders. There are no barriers to migration and sufficient depth to provide good fish passage. Some small patches of large gravels could provide potential spawning areas for Arctic char.

3.2.4 Reach AR-03

Channel width varied from 21.1 m to 44.6 m with the widest section was in the upper portions of the reach and then tapering to the lowest width at the end of the reach. Wetted width ranged from 37.6 m to 21.1 m. Maximum depth ranged from 0.37 m to 0.75 m with the shallowest water depth in the upper section of the reach and deepest at the lower end. Stream gradient ranged from one to 5 percent with the lowest gradient in the upper section of the reach and steepest gradient at the lower end of the reach. The reach was a mixture of riffle and glide habitat. Cobble was the dominant substrate at the upper end of the reach followed by boulders. At 25 m downstream large gravel was the dominant substrate followed by sand but then changing again at 50 m downstream where cobble and boulders were again the dominant substrate. The banks throughout the reach were stable. The dominant riparian vegetation was grass although there were areas on the downstream section which were devoid of vegetation. Marginal overhead cover was provided by undercut banks. Instream cover was provided boulders.

Fish habitat was rated in the field as poor for most of the each but at the 25 m transect with the increased amounts of gravel spawning was rated as moderate. Overwintering potential was rated as low. Rearing habitat was rated as moderate while fish passage was rated as good.

Habitat ratings using the HSI from Section 3.1 is presented in Table 3.8.

Table 3.8 HSI Ratings for AR-03

Physical Habitat Parameter	Spawning/Egg Incubation	Juvenile Rearing	Adult Foraging	Overwintering
Dominant substrate	0.25	0.75	1.0	1.0
Substrate size	ND	ND	ND	ND
Depth range	0	0	1.0	0.5
Instream cover	-	0.25	0.75	1.0
Gradient	-	0.75	-	-
Water velocity (m/s)	ND	ND	ND	-
Stream morphology	0.75	0.75	0.75	0.25
HSI Ranking	0.33 (below average)	0.5 (average)	0.88 (above average)	0.69 (average)

Notes:
ND = No field data for Apex River
= Not used in HSI calculation

3.2.5 Between Reach AR-03 and A-02

There is good overwintering habitat between reaches AR-03 and A-02 which includes Swimming Lake with deep pools and cover provided from boulders. Shallow stretches between pools provide potential spawning habitat. There are no barriers to fish passage in this area. Upstream of Swimming Lake habitat is mostly riffle with a cobble/boulder substrate.

3.2.6 Reach A-02

Channel width varied from 18.4 m to 38.0 m with the narrowest section on the upstream portion of the reach and the widest at the center of the reach. Wetted width varied from 14.3 m to 27.7 m at the center of the reach. Maximum water depth varied from 0.38 m to 1.1 m at the center of the reach. Stream gradient was 4% at the upper section of the reach and then 3% for the remainder of the reach. Cobble was the dominant substrate throughout the reach followed by boulders, with smaller amounts of sand, large gravel and bedrock. Riffles was the dominant habitat type throughout the reach except for the center of the reach was primarily glide. Riverbanks were mainly stable for most of the reach except for the lower quarter of the reach where the banks were mostly unstable. Riparian vegetation was dominated by grasses except for the lower section which had no riparian vegetation. Instream cover was limited and provided predominantly by boulders.

Fish habitat for was rated in the field as poor for spawning and overwintering but moderate to good for rearing and fish passage.

Habitat ratings using the HSI from Section 3.1 is presented in Table 3.9.

Table 3.9 HSI Ratings for A-02

Physical Habitat Parameter	Spawning/Egg Incubation	Juvenile Rearing	Adult Foraging	Overwintering
Dominant substrate	0.25	0.75	1	1.0
Substrate size	ND	ND	ND	ND
Depth range	0	0	1	0.5
Instream cover	-	0.75	0.75	1
Gradient	-	0.75	-	-
Water velocity (m/s)	0.5	0.75	0.5	-
Stream morphology	0.5	0.75	1	0.25
HSI Ranking	0.31 (below average)	0.63 (average)	0.85 (above average)	0.69 (average)

Notes:
ND = No field data for Apex River
= Not used in HSI calculation

3.2.7 Between Reach A-02 and A-01

Immediately upstream of reach A-02 stream habitat alternates between riffle and run. Multiple large pools, some with depths over 2m provide potential over wintering habitat for fish. Sections with cascades and chutes could pose as barriers to fish during different flow periods. Shallow riffle sections could potentially become a passage barrier during low flows. No gravel beds were identified for potential spawning areas.

3.2.8 Reach A-01

Channel width varied from 35.0 m to 6.10 m with the narrowest section of the reach being 25 m downstream of the beginning of the reach and the widest being 75 m downstream of the start of the reach. Wetted width varied from 4.8 m to 29.0 m. Maximum water depth ranged from 0.25 m to an estimated 4.0 m in a pool located at the lower end of the reach. Stream gradient varied from 2% to 5 % throughout the reach. Substrate was dominated by cobble with lesser amounts of boulders, large and small gravel and sand. Dominant habitat is riffles followed by pools and glide. Stream banks were stable throughout the reach. Riparian vegetation was a mixture of grasses or no vegetation, providing no overhead cover. Instream cover available was estimated at 17% provided mainly by boulders.

Fish habitat was rated as poor for spawning, moderate for overwintering due to some small pools, moderate to good for rearing and good for fish passage.

Habitat ratings using the HSI from Section 3.1 is presented in Table 3.10.

Table 3.10 HSI Ratings for A-01

Physical Habitat Parameter	Spawning/Egg Incubation	Juvenile Rearing	Adult Foraging	Overwintering
Dominant substrate	0.25	0.75	1	1
Substrate size	ND	ND	ND	ND
Depth range	0	0	0.5	0.5
Instream cover	-	0.25	1.0	1
Gradient	-	0.75	-	-
Water velocity (m/s)	1	0.5	0.5	-
Stream morphology	1	0.75	1	1
HSI Ranking	0.56 (average)	0.50 (average)	0.80 (above average)	0.88 (above average)

Notes:
ND = No field data for Apex River
= Not used in HSI calculation

3.2.9 Between Reach A-01 and AR-07

There are no barriers to fish passage between reaches A-01 and AR-07. About 170m downstream of AR-07 there is a pool with depths over 1m which can provide overwintering habitat. Most of the section of the stream is composed of riffles and runs. There are some small patches of gravel providing potential spawning sites. Substrate is predominantly cobble and boulder between the two reaches. The section of stream immediately upstream of A-01 has good cover provided from large boulders.

3.2.10 Reach AR-07

Channel width varied from 47.0 m to 61.8 m with the widest section being at the upstream start of the reach. Wetted width varied from 55.1 m to 47.0 m. maximum water depth along the length of the reach was fairly consistent, ranging from 0.61 m to 0.79 m. Stream gradient ranged from 1% at the upper section of the reach increasing to 3% 25 m downstream and then 4% the remainder of the reach. The reach consisted entirely of riffle habitat. Substrate through the reach consisted of boulder and cobble with cobble being the most dominant substrate at the upper end of the reach and boulders being the most dominant for the remainder of the reach. The stream banks were all stable except the left bank at the downstream end of the reach which was moderately stable. Riparian vegetation consisted of grass and provided no overhead cover. Instream cover was limited and provided by the boulder substrate.

Fish habitat for spawning and overwintering was rated as none. Rearing habitat was rated as moderate for both rearing and fish passage.

Habitat ratings using the HSI from Section 3.1 is presented in Table 3.11.

Table 3.11 HSI Ratings for AR-07

Physical Habitat Parameter	Spawning/Egg Incubation	Juvenile Rearing	Adult Foraging	Overwintering
Dominant substrate	0.25	0.75	1	1
Substrate size	ND	ND	ND	ND
Depth range	0.5	0.75	1	0.5
Instream cover	-	0.25	0.75	1
Gradient	-	0.75	-	-
Water velocity (m/s)	1	0.75	0.75	-
Stream morphology	0.75	0.75	0.75	0.25
HSI Ranking	0.63 (average)	0.67 (average)	0.85 (above average)	0.69 (average)

Notes:
ND = No field data for Apex River
= Not used in HSI calculation

3.2.11 Between Reach AR-07 and PP-01

The 80m section between reaches AR-07 and PP-01 is a large pool with depths over 2 m. Overwintering habitat is very good with boulders providing good cover in the area. The bottom of the pool is mostly sand substrate with some cobble, large gravel, and boulders. There are no barriers to fish passage. There are no potential spawning areas in this area.

3.2.12 Reach PP-01

Channel width varied from 35.0 m, at 25 m downstream of the upper start of the reach to 52.0 m at the downstream end of the reach. Wetted width varied from 34.0 m to 50.0 m. Maximum depth ranged from 0.74 m to 1.78 m. Stream gradient was 3% at the upper end of the reach with the gradient being 1% for the remainder of the reach. Riffles is the dominant habitat type at the upstream end of the reach with the dominant habitat type being pool habitat from 25 m downstream and continuing throughout the rest of the reach. Substrate varied considerably from the upstream end of the reach to the downstream end with substrate at the upper end of the reach dominated by boulders (80%). At 25 m downstream large gravel was the dominant substrate type at 60% with a mixture of organics, small gravel, and boulders. At 50 m downstream substrate consisted mainly of cobble and boulders at 40% each, followed by sand and large gravel. At 75 m and 100 m downstream sand becomes the dominant substrate followed by large gravel, cobble and boulders. Stream banks throughout the reach were stable. Instream cover is provided primarily by depth of water and boulders where present. Riparian vegetation consisted of grasses and provided no overhead cover.

Fish habitat for spawning was rated as poor but good for overwintering, rearing and fish passage.

Habitat ratings using the HSI from Section 3.1 is presented in Table 3.12.

Table 3.12 HSI Ratings for PP-01

Physical Habitat Parameter	Spawning/Egg Incubation	Juvenile Rearing	Adult Foraging	Overwintering
Dominant substrate	0.5	0.25	1	1
Substrate size	ND	ND	ND	ND
Depth range	0	0	0.5	0.5
Instream cover	-	0.25	1	1
Gradient	-	0.75	-	-
Water velocity (m/s)	ND	ND	ND	-
Stream morphology	0.5	0.5	1	0.75
HSI Ranking	0.33 (below average)	0.35 (below average)	0.88 (above average)	0.81 (above average)

Notes:
ND = No field data for Apex River
= Not used in HSI calculation

3.2.13 Between Reach PP-01 and US-04

The habitat between reaches PP-01 and US-04 is composed mostly of a riffle with boulder substrate. There are some small glide sections with large and small gravels that provide spawning potential. There are no barriers to fish passage and no deeper pools to provide overwintering habitat.

3.2.14 Reach US-04

Channel width and wetted width varied from 10 m to 25.8 m with the narrowest section of the reach at the downstream end of the reach and the widest section 25 m downstream of the beginning of the reach. Maximum depth ranged from 0.44 m to 0.73 m. Stream gradient ranged from 1% to 2%. Habitat type was predominantly riffle with an area of flat water 25m downstream of the beginning of the reach. Cobble was the dominant substrate throughout the reach with varying amounts of sand large gravel and boulders. Stream banks were stable throughout the reach. Instream cover was limited and mainly provided by boulders and water depth. Riparian vegetation consisted of grasses and there was no overhead cover,

Fish habitat was rated as poor for spawning and overwintering, poor to moderate for rearing and good for fish passage.

3.2.15 Between Reach US-04 and US-03

Between reaches US-04 and US-03 there are several cascades and falls creating potential multiple barriers to fish passage. At the bottom of some of these sections there are deeper pools that provide potential overwintering habitat if fish can access them. No areas with potential spawning gravels were identified.

3.2.16 Reach US-03

Channel width and wetted width varied from 58.0 m at the start of the reach to 7.6 m at the end of the reach. Maximum depth varied from 1.3 m at the beginning of the reach and quicky becoming shallower with the minimum of depth 0.08 m 25 m downstream from the beginning of the reach and then gradually increasing in depth to 0.29 m at the end of the reach. Stream gradient was 1% on the upper sections of the reach and increases to 4% at the end of the reach. A pool was present at the beginning of the reach becoming glide habitat followed by riffles for the remainder of the reach. Boulders followed by sand was the dominant habitat at the beginning of the reach while cobble was dominant or co-dominant throughout the remainder of the reach. Smaller amounts of sand, large gravel and boulders were present throughout the reach. Stream banks were stable throughout the reach. Instream cover was provided by depth at the pool location and boulders throughout the reach. Riparian vegetation consisted of grasses and there was no overhead cover.

Fish habitat was rated as poor to moderate for spawning, overwintering, and rearing and good for fish passage.

3.2.17 Between Reach US-03 and US-02

Habitat immediately upstream of US-03 is a large pool with depths greater than 2m providing good overwintering habitat. Upstream of those pools the stream becomes a very braided section of riffles with cobble and boulder substrate. Upstream of the riffles is a series of cascades and waterfalls that are likely barriers to fish passage. Just downstream of US-02 is a large pool with depths over 1m providing potential overwintering habitat. The pool tail out has some sections of large and small gravels suitable for spawning.

3.2.18 Reach US-02

Channel width and wetted width varied from 9.10 m to 18.2 m with the narrowest sections of the reach being at the end and beginning of the reach and the widest section at the center of the reach. Maximum depth ranged from 0.30 m to 0.75 m with the deepest depth at the beginning of the reach and shallowest depth at 75 m downstream of the beginning of the reach. Stream gradient was 3% for most of the reach except at the end of the reach where is was 5%. The dominant habitat was riffles with varying sections of run, glide and pool habitat. Cobble was the dominant substrate throughout most of the reach except at 25 m downstream of the beginning of the reach where the dominant substrate was sand likely due to a pool at this location. The remaining substrate was a mixture of large gravel and boulders. Stream banks were stable throughout the reach. Instream cover was limited and provided by boulders in this reach. Riparian vegetation consisted of grasses and there was no overhead cover.

Fish habitat for spawning, rearing, and overwintering was rated as poor while fish passage was rated as good.

3.2.19 Between Reach US-02 and US-01

Between reaches US-02 and US-01 there are multiple pools with depths over 2m providing good overwintering habitat. On the pool edges and tail outs there are some gravel patches providing potential spawning areas. There are a series of cascades with step pools that are likely not tall enough to be a barrier to fish passage. Although at the top of this series of cascades and pools is a bedrock chute with water velocities up to 1.9 m/s which may act as a velocity barrier.

3.2.20 Reach US-01

Channel width was the narrowest at the upstream start of the reach and increased a maximum of 32.5 m at the downstream end of the reach. Wetted width varied similarly ranging from 5.8 m to 23.6 m. Maximum depth ranged from 0.96 m at the upstream start of the reach to 0.26 m at the downstream end of the reach. Stream gradient ranged from 3% to 5% with the dominant habitat throughout the reach being riffles. Boulders was the dominant substrate throughout the reach ranging from 60% to 80% of the substrate. Cobble was the next dominant substrate type ranging from 15% to 20% throughout the reach. Large gravel and sand were also present within the reach. The stream banks were stable throughout the reach. Instream cover was provided through the boulder substrate. Riparian vegetation was grass. There was minimal overhead cover (approximately 5%) provided by some undercut banks.

Fish habitat for spawning was rated as poor. Overwintering and rearing habitat were both rated as poor to moderate while fish passage was rated as good.

3.2.21 Comparison of HSI Ratings and Field Ratings by Biologist

A comparison of HSI ratings and field ratings by a qualified aquatic biologist is presented in Table 3.13 for the temporary pumping location (PP-01) and downstream reaches only as these reaches may be used for future monitoring purposes during periods of water diversion. Care must be used in interpreting results from the HSI model as it relies heavily on habitat features of Dolly Varden char and bull trout with only limited information for Arctic char. The model also may also not reflect preferred habitat features of smaller resident Arctic char as compared to larger anadromous Arctic char and Dolly Varden char or the larger bull trout. Much of the reported data used in the model also was for rivers in more southerly locations and may not be fully applicable to rivers in an Arctic tundra environment like the Apex River. Examples of these differences include the reference of root wads and woody debris in the rating criteria for instream cover in the HSI model while there are no root wads or woody debris in the Apex River due to the absence of trees and shrubs along the length of the river. Also, water depths used in the HSI model were lower (< 1.0m) to achieve a higher rating for overwintering than what was used in the field assessed ratings (> 1.0 m). In addition, there are gaps in the HSI model where data is not available thus making it difficult to determine the appropriate rating for those habitat features.

Differences in habitat ratings between the HSI model and field assessed ratings by the aquatic biologist mainly occur for the life history parameters of spawning and egg incubation, and overwintering although these differences were not large. Ratings of both approaches for rearing mainly similar for all reaches.

Table 3.13 Comparison of HSI Ratings and Field Ratings by a Qualified Aquatic Biologist

Reach	Spawning and Egg Incubation		Rearing		Adult Foraging		Fish Passage		Overwintering	
	HSI	Field	HSI	Field	HSI	Field	HSI	Field	HSI	Field
AR-02	Below Average to average	Poor	Average	Moderate	Above Average	NR	NR	Good	Excellent	Good
AR-03	Below average	Poor-moderate	Average	Moderate	Above average	NR	NR	Good	average	Poor
A-02	Below Average	Poor	Average	Moderate - good	Above average	NR	NR	Moderate-good	average	Poor
A-01	Average	Poor	Average	Moderate-good	Excellent	NR	NR	Good	Excellent	Moderate
AR-07	Below average	None	Average	Moderate	Above average	NR	NR	Moderate	Above average	None
PP-01	Average	Poor	Average	Good	Above average	NR	NR	Good	Average	Good

Note:
NR = Not rated

3.3 eDNA

Two of the five samples collected at US-01 detected eDNA from Arctic char which was 100% identical to the global reference database. No other species were detected. Metabarcoding was not successful for the remaining three eDNA samples. No eDNA was detected in the negative control filter. The detection of Arctic char DNA upstream of the pumping location indicated that Arctic char are present upstream of this location at the time of the assessment.

4 Summary

The Apex River is approximately eight km in length beginning at an unnamed lake to the north of the City of Iqaluit and flowing into Koojesse Inlet (Figure 1.1). The Apex River has a resident population of Arctic char based on a previous study (Nunami Stantec 2017). No other fish species are known to occur in the river. A waterfall at the mouth of the Apex River prevents fish from moving into the river from Koojesse Inlet.

A fish habitat assessment study was conducted in support of a monitoring program if supplementary water withdrawal for the Lake Geraldine Reservoir exceeds the allowable 10% instantaneous flow. A field survey was conducted between August 16 to August 20, 2022. Ten 100 m reaches were assessed four upstream of the temporary pumping location (PP-01), and five downstream of the temporary pumping location.

A HSI model was developed for Arctic char adapted from a HSI model for Dolly Varden char, developed by AMEX (2012). The HSI model for Arctic char relies heavily on data preferences for Dolly Varden char and bull trout due to the limited detailed habitat preferences of Arctic char available in the literature. There are limitations to the validity of the model as it is not specific to the Apex River, utilizes other species habitat preferences and the use of information from other geographic regions. Although there was a general agreement on rankings HSI model rankings were compared with field assessment rankings by an aquatic biologist, there were also some larger discrepancies especially in the ratings of overwintering habitat where the HSI model used lower favourable water depth for overwintering of fish based on requirements in more southerly geographic locations, which do not necessarily reflect requirements at the Apex River.

Water samples were collected at one site upstream of the temporary pumping location for the collection of eDNA to determine the potential for Arctic char upstream of the temporary pumping location. Analysis of the water samples indicated the potential presence of Arctic char at or above the sampling site. No other fish species were identified through the eDNA analysis.

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Appendix A NatureMetrics Report

FISH METABARCODING **RESULTS**

Order number:	NA-SO00135
Report number:	NM-YRX780
Company:	Stantec Consulting Ltd
Contact:	Doug Chiperzak
Project:	I144903261/502.100-CAO2-FishBsIn Study
Sample type:	Smith-Root filter
Date of report:	22-Nov-2022
Number of samples:	6

Thank you for sending your samples for analysis by NatureMetrics. Your samples have been metabarcoded following our eDNA survey - Fish pipeline. **A taxon-by-sample table of your samples is attached to this report (NM-YRX780.NA-SO00135.Fish.xlsx)**. Each row in the table represents one taxon (OTU), shown with the lowest possible taxonomic assignment based on currently available reference data. Each column represents a sample, showing the proportion of sequence reads per detected OTU. Care should be taken in interpreting the numbers in terms of relative species abundance, but a high sequence proportion can be interpreted as lending greater confidence to a detection. This report contains biodiversity information that may be sensitive, particularly with respect to endangered or protected species. It is the responsibility of the client to ensure that due consideration is given to the data and that the information is shared in a responsible way.

Here we present an overview of the key results, followed by a more detailed report that starts with the taxonomic composition of the samples followed by a more detailed look at the steps taken to extract, amplify, sequence, and analyse your DNA. A glossary for terms in bold is provided at the end of the report to define key terms used within the report.

OVERVIEW OF YOUR RESULTS

- A total of 1 taxon was detected.
- Most abundant sequences: Arctic char (*Salvelinus alpinus*).
- Fish sequence data were obtained from 2 of 6 eDNA samples.

FULL REPORT

Sample composition

A total of 1 taxon was detected (**Table 1**). The taxon was 100% identical to a species in the global reference databases, and a species name is suggested.

The relative proportion of the sequences found in each of the samples is shown in **Figure 1** and **Table 1** and the diversity is summarised in **Table 2** and **Table 3**.

Arctic char (*Salvelinus alpinus*), which accounted for 100% of the total sequence reads, was the most abundant in terms of sequences.

High-quality vertebrate sequence data were obtained for 2 of the 6 eDNA samples. eDNA metabarcoding of fish was not successful for the remaining 4 samples, which failed to amplify despite troubleshooting. All negative controls behaved as expected.

Table 1 (attached separately). Taxon-by-sample table.

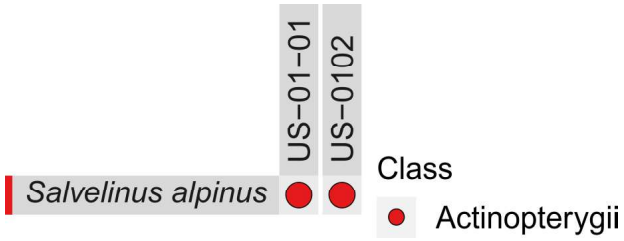


Figure 1. The proportion of the sequencing output allocated to the different species (rows) within each sample (columns). Each bubble per sample represents the proportion of DNA for each species for that sample. The size of the bubble is relative to the number of sequences from all species detected in that sample.

Table 2. Taxon richness among the samples.

Sample ID	Class	Order	Family	Genus	Taxa (Species)
US-01-01	1	1	1	1	1 (1)
US-0102	1	1	1	1	1 (1)

Table 3. The frequency of occurrence of all detected families. Numbers correspond to the number of taxa belonging to those families in those samples.

Class	Order	Family	US-01-01	US-0102	# samples
Actinopterygii	Salmoniformes	Salmonidae	1	1	2

METHODS

DNA from each filter was extracted using a commercial DNA extraction kit with a protocol modified to increase DNA yields. An extraction blank was also processed for the extraction batch. DNA was purified to remove PCR inhibitors using a commercial purification kit.

Comment: DNA yields were as expected.

Purified DNAs were amplified with PCR for a hypervariable region of the 12S rRNA gene to target fish as part of the eDNA survey - Fish pipeline. Our standard analysis includes 12 replicate PCRs per sample.

All PCRs were performed in the presence of both a negative control sample. Amplification success was determined by gel electrophoresis.

Comment: PCR reactions were successful for 2 of 6 samples. Electrophoresis bands were strong and of the expected size. Samples 'NC-01', 'US-01-03', 'US-01-04' and 'US-01-05' failed to amplify despite troubleshooting steps. Overall, 4-8 successful PCRs replicates were obtained for each of the 2 samples submitted for sequencing. No bands were observed on electrophoresis gels for the extraction blank or negative controls.

PCR replicates were pooled and purified, and sequencing adapters were added. Success was determined by gel electrophoresis.

Comment: All samples were successfully indexed, electrophoresis bands were strong and of the expected size. No repeat reactions were necessary.

Amplicons were purified and checked by gel electrophoresis, these were then quantified using a Qubit high sensitivity kit according to the manufacturer's protocol.

Comment: All amplicons were successfully purified.

All purified index PCRs were pooled into a final library with equal concentrations. The final library was sequenced using an Illumina MiSeq V3 kit at 10.5 pM with a 20% PhiX spike in.

Sequence data were processed using a custom bioinformatics pipeline for quality filtering, OTU clustering, and taxonomic assignment.

Comment: Negative controls were as expected. Very few sequences were discarded prior to dereplication, which is indicative of high-quality data with minimal PCR and sequencing errors. A total of 130,422 high-quality sequences, including 130,422 target sequences, were included in the final dataset.

Consensus taxonomic assignments were made for each OTU using sequence similarity searches against the NCBI nt (GenBank) reference database. Assignments were made to the lowest possible taxonomic level where there was consistency in the matches. Conflicts were flagged and resolved manually. Minimum similarity thresholds of 99%, 97%, and 95% were used for species-, genus- and higher-level assignments respectively. In cases where there were equally good matches to multiple species, public records from GBIF were used to assess which were most likely to be present in Canada.

Higher-level taxonomic identifications or multiple potential identifications were reported in cases that could not be resolved in this way.

The OTU table was then filtered to remove low abundance OTUs from each sample (<0.03% or <10 reads, whichever is the greater threshold for the sample). Unidentified, non-target, and common contaminant sequences were then removed.

Note that unidentified or misidentified taxa can result from incomplete or incorrect reference databases, and taxa may be missed due to low quality DNA, environmental contaminants, or the dominance of other species in the sample.

Please note that the abundance of taxa cannot be directly inferred from the proportion of total sequence reads. While the proportion of sequence reads is a consequence of abundance, it is also impacted by biomass, activity, surface area, condition, distance from the physical sample, primer bias, and species-specific variation in the genome.

Table 4. Sample information table.

Kit ID	Sample ID	Volume filtered	Date received
NAS-01-04248	NC-01	2000ml	20-Oct-22
NAS-01-04243	US-01-01	2000ml	20-Oct-22
NAS-01-04245	US-01-03	2000ml	20-Oct-22
NAS-01-04246	US-01-04	2000ml	20-Oct-22
NAS-01-04247	US-01-05	2000ml	20-Oct-22
NAS-01-04244	US-0102	2000ml	20-Oct-22

END OF REPORT

Report issued by: Thomas Shannon

Contact: team@naturemetrics.co.uk

GLOSSARY

adapter	short, artificially synthesised nucleotide sequence which attaches to the ends of the target DNA or RNA sequences prior to sequencing. They are typically used to aid in attachment of the target sequence to other functional molecules/sequences.
amplicon	A DNA sequence which is the product of PCR amplification.
bioinformatics	An interface between genetics, computational biology, statistics, and programming in which DNA or other biological data is processed, analysed and integrated into research or communications.
bioinformatics pipeline	Refers to a data processing pipeline that takes the raw sequence data from high-throughput sequencing (often 20 million sequences or more) and transforms it into usable ecological data. Key steps for metabarcoding pipelines include quality filtering, trimming, merging paired ends, removal of sequencing errors such as chimeras, clustering of similar sequences into molecular Operational Taxonomic Units, and matching one sequence from each cluster against a reference database. The output is a OTU-by-sample table showing how many sequences from each sample were assigned to each OTU.
BMWP	Short for biological monitoring working party, an index that can be used to measure water quality by scoring the presence of aquatic invertebrate indicator taxa. The index is reliant on taxa that are less tolerant of polluted water bodies (e.g. Ephemeroptera, Plecoptera, Trichoptera).
BOLD	Barcode Of Life Database; a specialised database of eukaryote COI reference sequences.
contaminant sequences	The sensitivity of high-throughput sequencing of eDNA means that contamination is always a concern that needs to be minimised. The sources of contamination are threefold: Natural - Examples of natural contaminants include: frequent visitors to site, faecal discharge from predators, livestock, wastewater, and fishing bait. This type of contamination is typically unavoidable and very difficult to quantify. Sequences of this type are typically flagged and conservatively removed from the sequencing output. Typical contaminant species include cow, pig, dog, cat, sheep, etc. Sampling - Human contamination of sampling equipment can reduce the efficiency of the sequencing. This type of

	contamination can be minimised by stringent contamination protocols, such as PPE. Laboratory - Residual DNA can contaminate other samples processed at the same time in other labs. At NatureMetrics this is mitigated by a designated eDNA laboratory, strict decontamination procedures, negative controls, and good laboratory practices.
dereplication	The identification of unique sequences so that only one copy of each sequence is reported.
eBioAtlas	A global partnership between IUCN and NatureMetrics to map the world's biodiversity using DNA from water samples as a foundation for the Global Biodiversity Framework and to enable IUCN Red List Assessments.
eDNA	Short for 'environmental DNA'. Refers to DNA deposited in the environment through excretion, shedding, mucous secretions, saliva etc. This can be collected in environmental samples (e.g. water, sediment) and used to identify the organisms that it originated from. eDNA in water is broken down by environmental processes over a period of days to weeks. It can travel some distance from the point at which it was released from the organism, particularly in running water. eDNA is sampled in low concentrations and can be degraded (i.e. broken into short fragments), which limits the analysis options.
extraction blank	A DNA extraction with no sample added to assess potential contamination during the DNA extraction process.
gel electrophoresis	The process in which DNA is separated according to size and electrical charge via an electric current, while in a gel. The process is used to confirm the successful amplification of a specifically sized fragment of DNA.
high-throughput sequencing	Technology developed in the 2000s that produces millions of sequences in parallel. Enables thousands of different organisms from a mixture of species to be sequenced at once, so community DNA can be sequenced. Various different technologies exist to do this, but the most commonly used platform is Illumina's MiSeq. Also known as Next-Generation Sequencing (NGS) or parallel sequencing.
inhibitors/inhibition	Naturally-occurring chemicals/compounds that cause DNA amplification to fail, potentially resulting in false negative results. Common inhibitors include tannins, humic acids and other organic compounds. Inhibitors can be overcome by either diluting the DNA (and the inhibitors) or by additional cleaning of the DNA, but

dilution carries the risk of reducing the DNA concentration below the limits of detection. At NatureMetrics, inhibition is removed using a commercial purification kit.

invasive

Invasive species are defined using GRIIS (Global Register of Introduced and Invasive Species) which is a checklist of Introduced and Invasive species for each country. The IUCN describes an Introduced species as a species outside of its natural range and dispersal potential, and an Invasive species as an introduced species which becomes established in a habitat, is an agent of change or threatens native biological diversity.

IUCN Red List

The IUCN (International Union for the Conservation of Nature) is a global union of government and civil organisations that disseminates information to assist conservation. The IUCN Red List of Threatened Species is an inventory of the conservation status of over 100,000 species worldwide. The Red List evaluates data such as population trends, geographic range and the number of mature individuals in order to categorise species based on their extinction risk:

Extinct (EX) - No individual of this species remains alive.

Extinct in the Wild (EW) - Surviving individuals are only found in captivity.

Critically Endangered (CE) - species faces an extremely high risk of extinction in the wild. e.g. Population size estimated at fewer than 50 mature individuals.

Endangered (EN) - species faces a very high risk of extinction in the wild. e.g. Population size estimated at fewer than 250 mature individuals.

Vulnerable (VU) - species faces a high risk of extinction in the wild. e.g. Population size estimated at fewer than 10,000 mature individuals and declining.

Near Threatened (NT) - species is below the threshold for any of the threatened categories (CE, E, V) but is close to this threshold or is expected to pass it in the near future.

Least Concern (LC) - species is not currently close to qualifying for any of the other categories. This includes widespread and abundant species.

Data Deficient (DD) - There is currently insufficient data available to make an assessment of extinction risk. This is not a threat category - when more data becomes available the species may be recategorised as threatened.

Jaccard similarity index

This index is a calculation that compares two samples to see which taxa are shared and which are distinct. The higher the percentage,

	the more similar two samples are in their community composition.
metabarcoding	Refers to identification of species assemblages from community DNA using barcode genes. PCR is carried out with non-specific primers, followed by high-throughput sequencing and bioinformatics processing. Can identify hundreds of species in each sample, and 100+ different samples can be processed in parallel to reduce sequencing cost.
NCBI nt	National Centre for Biotechnology Information nucleotide database; a general reference database.
negative control	Used to determine whether PCR reactions are contaminated.
NMDS	Non-metric multidimensional scaling (NMDS) is a method that allows visualisation of the similarity of each sample to one another. The dissimilarity between each sample is calculated, taking into account shared taxa (Jaccard similarity index), and then configured into a 2D ordinal space that allows the similarity-based relationship between each sample to be plotted. Samples which are closer together are more similar to one another in terms of community composition, while samples which are further apart are less similar. This type of clustering analysis allows you to see if certain types of samples, for example, those from a particular habitat type, are more clustered together and therefore more similar to one another compared to other groups.
nucleotide	An individual unit of genetic material which, when strung together constitutes a DNA (or RNA) strand/sequence.
OTU	Operational Taxonomic Unit; similar sequences are clustered into OTUs at a defined similarity threshold. OTUs are approximately equivalent to species and are treated as such in our analyses. Species-level taxonomic assignments may or may not be possible, depending on the availability of reference sequences and the similarity between closely related species in the amplified marker. It may be possible to refine the taxonomic assignment for an OTU later as more sequences are added to reference databases.
PCR	Polymerase Chain Reaction; a process by which millions of copies of a particular DNA segment are produced through a series of heating and cooling steps. Known as an 'amplification' process. One of the most common processes in molecular biology and a precursor to most sequencing-based analyses.

positive control	Used to determine whether the PCR is working correctly.
primers	Short sections of synthesised DNA that bind to either end of the DNA segment to be amplified by PCR. Can be designed to be totally specific to a particular species (so that only that species' DNA will be amplified from a community DNA sample), or to be very general so that a wide range of species' DNA will be amplified. Good design of primers is one of the critical factors in DNA-based monitoring.
rarefaction curve	A plot showing the number of taxa as a function of the sequencing depth (number of reads). Rarefaction curves grow rapidly at first as common species are found then reach a plateau as only the rarest species remain to be detected. Rarefaction curves can provide an indication as to whether the species being studied have been comprehensively sampled.
rarefy	A normalisation technique which transforms the data to remove biases associated with uneven sampling depth (number of reads) across samples. The sampling depth of each sample is standardised to a specified number of reads (usually that of the sample with the lowest depth) by random resampling.
reference databases	Over time, the DNA sequences of many species have been compiled into publicly accessible databases by scientists from around the world. These databases serve as a reference against which unknown sequences can be queried to obtain a species identification. The most commonly accessed database is NCBI, which is maintained by the US National Institute of Health. Anyone can search for DNA sequences at https://www.ncbi.nlm.nih.gov.
richness	The total number of taxa within a sample.
rRNA	Ribosomal RNA.
SAC species	Typically the presence of these species potentially elevates the conservation status of a site to a Special Area of Conservation (SAC). Special Areas of Conservation (SACs) are strictly protected sites designated under the EC Habitats Directive.
sequence(s)	A DNA sequence is made up of four nucleotide bases represented by the letters A, T, C & G. The precise order of these letters is used to compare genetic similarity among individuals or species and to identify species using reference databases. In high-throughput sequencing analyses (e.g. metabarcoding), many identical copies of the same sequence are obtained for each species in the sample. The number of copies obtained per species is known as the number of sequence reads, and this is often -

	although not always - related to the relative abundance of the species.
SILVA	SILVA is a database of small (16S/18S, SSU) and large subunit (23S/28S, LSU) ribosomal RNA sequences for all three domains of life (Bacteria, Archaea and Eukarya).
taxon (s.) / taxa (pl.)	Strictly, a taxonomic group. Here we use the term to describe groups of DNA sequences (OTUs) that are equivalent to species. We do not use the term species because we are unable to assign complete identifications to all of the groups at this time due to gaps in the available reference databases.
taxonomy	The branch of science concerned with classification of organisms.
	species (s./pl.) - A group of genetically similar organisms that show a high degree of overall similarity in many independent characteristics. Related species are grouped together into progressively larger taxonomic units, from genus to kingdom. Homo sapiens (human) is an example of a species.
	genus (s.) / genera (pl.) - A group of closely related species. Each genus can include one or more species. Homo is an example of a genus.
	family (s.) / families (pl.) - A group of closely related genera. Homo sapiens is in the Family Hominidae (great apes).
	order (s.) / orders (pl.) - A group of closely related families. Homo sapiens is in the Order Primates.
	class (s.) / classes (pl.) - A group of closely related orders. Homo sapiens is in the Class Mammalia.
	phylum (s.) / phyla (pl.) - A group of closely related classes. Homo sapiens is in the Phylum Chordata.
UKBAP species	UK Biodiversity Action Plan species have been identified as being the most threatened and requiring conservation action under the UK Biodiversity Action Plan.
UNITE	A ribosomal RNA database for identification of fungi.

Appendix B Site Summary Cards

Nunami Stantec Limited - Apex River Study 2022

Site AR-02: Apex River

UTM Location: 19V 526625 7068410 **Survey Date:** August 17, 2022

Legal Location: **Watercourse Class:**

Crew Initials: AB, CM **Restricted Activity Period:**

Physical Channel Transect Data

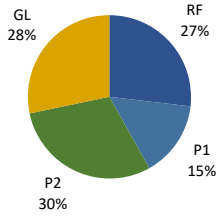
Transect # (Location)	0	25	50	75	100
Channel Width (m)	17.6	12.0	27	18.6	33.6
Wetted Width (m)	16.3	12.0	26.9	18.6	33.6
Depth at LDB + 25% (m)	0.24	0.05	2.10	0.49	0.55
Depth at LDB + 50% (m)	0.12	0.14	0.65	0.86	0.05
Depth at LDB + 75% (m)	0.07	0.15	0.35	0.53	0.15
Max. Depth (m)	0.49	0.87	2.5	1.14	1.08
Gradient (%)	2	4	1	1	1
Dominant Habitat Unit	GL	RF	GL	P1	P2
Stream Bed					
Substrate (% of Transect Area) – Organics	0	0	0	0	0
Sand	20	10	15	10	5
Small Gravel	0	0	0	0	0
Large Gravel	10	5	10	10	5
Cobble	60	80	65	40	20
Boulder	10	5	10	40	70
Bedrock	0	0	0	0	0
Embeddedness	L	L	L	L	L

Bank Measurements	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Bank Height (m)	0.23	0.25	0.37	0.20	0.19	0.43	0.28	0.25	0.53	0.25
Bank Slope (°)	80	80	70	80	60	70	80	80	80	80
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F
Subdom. Bank Material	O	O	O	O	O	O	O	O	O	BL
Dom. Riparian Veg.	G	G	G	G	N	G	G	G	G	G
Subdom. Riparian Veg.					G					N

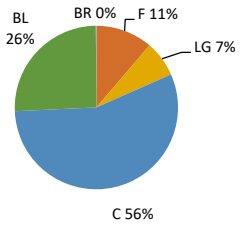
Habitat Inventory / Reach Data

Instream Cover (%):	6	Overhead Cover (%):	0
Dom. Instream Cover:	DC	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	BL	Subdom. Overhead Cover:	
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	07:26
Water Temperature (°C):	8.6
Dissolved Oxygen (mg/L):	10.38
Sp. Conductivity (µs/cm):	68.0
pH:	7.64
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	SI
Islands:	N
Bars:	SP
Coupling:	PC
Confinement:	FC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	Coarse Fish	Sport Fish
Spawning:	None	None	Poor
Overwintering:	None	None	Good
Rearing:	None	None	Moderate
Passage:	None	None	Good

P

Fish Sampling Data

Method	Effort

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

Species	Efish Catch (n)	Trap Catch (n)	Efish CPUE (#fish/100s)	Trap CPUE (#fish/hr)	Rel. Abundance (% of total)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site AR-03: Apex River

UTM Location: 19V 526559 7068632 **Survey Date:** August 17, 2022

Legal Location: **Watercourse Class:**

Crew Initials: AB, CM **Restricted Activity Period:**

Physical Channel Transect Data

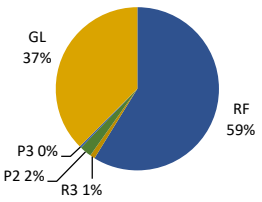
Transect # (Location)	0	25	50	75	100
Channel Width (m)	37.6	44.6	32	27.1	21.1
Wetted Width (m)	37.6	37.5	24.3	21.4	21.1
Depth at LDB + 25% (m)	0.21	0.10	0.37	0.30	0.27
Depth at LDB + 50% (m)	0.19	0.35	0.43	0.21	0.10
Depth at LDB + 75% (m)	0.16	0.08	0.38	0.16	0.11
Max. Depth (m)	0.37	0.63	0.63	0.58	0.75
Gradient (%)	1	2	2	3	5
Dominant Habitat Unit	RF	GL	GL	RF	RF
Stream Bed					
Substrate (% of Transect Area) – Organics	0	0	0	0	0
Sand	10	20	5	5	5
Small Gravel	0	10	0	0	0
Large Gravel	10	60	5	5	10
Cobble	60	10	75	45	65
Boulder	20	0	15	45	20
Bedrock	0	0	0	0	0
Embeddedness	L	L	L	L	L

Bank Measurements	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Bank Height (m)	0.16	0.16	0.28	0.10	0.20	0.19	0.37	0.37	0.21	0.48
Bank Slope (°)	80	70	80	30	90	90	70	90	80	90
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	BL	F	BD	F
Subdom. Bank Material	O	O	O	O	O	O	F	O	BL	O
Dom. Riparian Veg.	G	G	G	G	G	N	G	G	N	G
Subdom. Riparian Veg.							N	N	G	

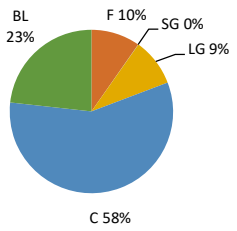
Habitat Inventory / Reach Data

Instream Cover (%):	11	Overhead Cover (%):	0
Dom. Instream Cover:	BL	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	-	Subdom. Overhead Cover:	-
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	12:07
Water Temperature (°C):	8.7
Dissolved Oxygen (mg/L):	10.46
Sp. Conductivity (µs/cm):	68.0
pH:	7.32
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	IR
Islands:	N
Bars:	SP
Coupling:	PC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	Coarse Fish	Sport Fish
Spawning:	None	None	Poor-moderate
Overwintering:	None	None	Poor
Rearing:	None	None	Moderate
Passage:	None	None	Good

P

Fish Sampling Data

Method	Effort

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

Species	Efish Catch (n)	Trap Catch (n)	Efish CPUE (#fish/100s)	Trap CPUE (#fish/hr)	Rel. Abundance (% of total)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site A-02: Apex River

UTM Location: 19 V 526260 7069180 **Survey Date:** August 16, 2022

Legal Location: **Watercourse Class:**

Crew Initials: AB, CM **Restricted Activity Period:**

Physical Channel Transect Data

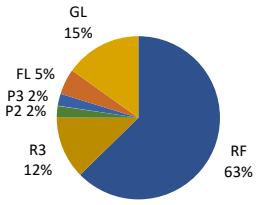
Transect # (Location)	0	25	50	75	100
Channel Width (m)	18.4	32.0	38	26.0	30.0
Wetted Width (m)	14.3	21.0	27.7	20.0	21.0
Depth at LDB + 25% (m)	0.24	0.36	0.79	0.31	0.33
Depth at LDB + 50% (m)	0.37	0.21	0.32	0.00	0.00
Depth at LDB + 75% (m)	0.40	0.18	0.11	0.19	0.37
Max. Depth (m)	0.71	0.38	1.1	0.69	0.77
Gradient (%)	4	3	3	3	3
Dominant Habitat Unit	RF	RF	GL	RF	RF
Stream Bed					
Substrate (% of Transect Area) – Organics	0	0	0	0	0
Sand	5	5	20	10	5
Small Gravel	0	0	0	0	0
Large Gravel	10	5	15	10	5
Cobble	60	40	30	60	40
Boulder	25	30	20	20	40
Bedrock	0	5	5	0	10
Embeddedness	L	L	L	L	L

Bank Measurements	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Bank Height (m)	0.31	0.10	0.32	0.30	0.34	0.17	0.38	0.30	0.40	0.35
Bank Slope (°)	70	30	80	70	90	60	90	70	45	30
Bank Stability	S	S	S	S	MS	S	US	S	US	US
Dom. Bank Material	F	BL	F	BL	F	F	F	F	F	F
Subdom. Bank Material	O	F	O	F	O	BD	O	BD	C	BD
Dom. Riparian Veg.	G	G	G	G	G	G	G	G	N	N
Subdom. Riparian Veg.	N	N	N	N	N	N	N	N	G	G

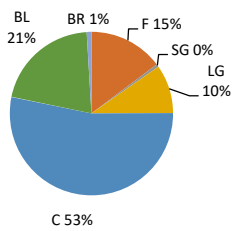
Habitat Inventory / Reach Data

Instream Cover (%):	2	Overhead Cover (%):	1
Dom. Instream Cover:	BL	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	-	Subdom. Overhead Cover:	-
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	08:03
Water Temperature (°C):	7.5
Dissolved Oxygen (mg/L):	10.66
Sp. Conductivity (µs/cm):	67.8
pH:	7.78
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	ST
Islands:	O
Bars:	SP
Coupling:	PC
Confinement:	FC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	Coarse Fish	Sport Fish
Spawning:	None	None	Poor
Overwintering:	None	None	Poor
Rearing:	None	None	Moderate-Good
Passage:	None	None	Moderate-Good

P

Fish Sampling Data

Method	Effort

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

Species	Efish Catch (n)	Trap Catch (n)	Efish CPUE (#fish/100s)	Trap CPUE (#fish/hr)	Rel. Abundance (% of total)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site A-01: Apex River

UTM Location: 19V 526548 7069946 **Survey Date:** August 16, 2022

Legal Location: **Watercourse Class:**

Crew Initials: AB, CM **Restricted Activity Period:**

Physical Channel Transect Data

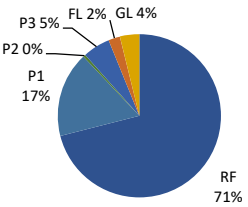
Transect # (Location)	0	25	50	75	100
Channel Width (m)	26.0	6.10	22	35.0	20.0
Wetted Width (m)	20.5	4.80	17.0	29.0	20.0
Depth at LDB + 25% (m)	0.60	0.42	0.60	0.14	0.48
Depth at LDB + 50% (m)	0.58	0.43	1.01	0.43	0.38
Depth at LDB + 75% (m)	0.32	0.25	1.46	0.37	0.43
Max. Depth (m)	0.98	1.15	1.6	0.66	4.00
Gradient (%)	2	5	3	3	4
Dominant Habitat Unit	P3	RF	P1	RF	RF
Stream Bed					
Substrate (% of Transect Area) Organics	0	0	0	0	0
Sand	30	0	30	20	10
Small Gravel	10	0	0	5	0
Large Gravel	10	5	0	30	5
Cobble	20	90	50	20	5
Boulder	30	5	20	25	80
Bedrock	0	0	0	0	0
Embeddedness	L	N	L	L	L

Bank Measurements	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Bank Height (m)	0.38	0.09	0.72	0.72	0.14	0.18	0.13	0.23	0.32	0.41
Bank Slope (°)	80	15	90	45	20	45	20	70	70	70
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	BL	C	C	F	F	F	F	F
Subdom. Bank Material	BL	BL	C	BL	F	O	SG	BL	BL	BL
Dom. Riparian Veg.	G	N	N	N	N	G	N	G	G	G
Subdom. Riparian Veg.		G			G		G			N

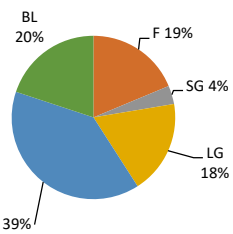
Habitat Inventory / Reach Data

Instream Cover (%):	17	Overhead Cover (%):	-
Dom. Instream Cover:	BL	Dom. Overhead Cover:	-
Subdom. Instream Cover:	DC	Subdom. Overhead Cover:	-
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	12:17
Water Temperature (°C):	9.6
Dissolved Oxygen (mg/L):	10.71
Sp. Conductivity (µs/cm):	66.6
pH:	7.79
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	IR
Islands:	I
Bars:	SP
Coupling:	DC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	Coarse Fish	Sport Fish
Spawning:	None	None	Poor
Overwintering:	None	None	Moderate
Rearing:	None	None	Moderate-Good
Passage:	None	None	Good

P

Fish Sampling Data

Method	Effort	Species	Efish Catch (n)	Trap Catch (n)	Efish CPUE (#fish/100s)	Trap CPUE (#fish/hr)	Rel. Abundance (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site AR-07: Apex River

UTM Location: 19V 525871 7070396 **Survey Date:** August 18, 2022

Legal Location: 00-00-000-00W4M **Watercourse Class:**

Crew Initials: AB, CM **Restricted Activity Period:**

Physical Channel Transect Data

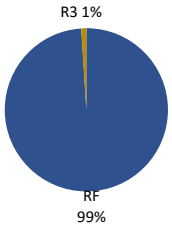
Transect # (Location)	0	25	50	75	100
Channel Width (m)	61.8	53.0	58	47.0	50.5
Wetted Width (m)	55.1	48.7	53.0	43.7	47.5
Depth at LDB + 25% (m)	0.34	0.25	0.16	0.36	0.21
Depth at LDB + 50% (m)	0.24	0.30	0.47	0.30	0.33
Depth at LDB + 75% (m)	0.27	0.52	0.30	0.27	0.22
Max. Depth (m)	0.62	0.79	0.74	0.61	0.72
Gradient (%)	1	3	4	4	4
Dominant Habitat Unit	RF	RF	RF	RF	RF
Stream Bed					
Substrate (% of Transect Area): Organics	0	0	0	0	0
Sand	0	0	0	0	0
Small Gravel	0	0	0	0	0
Large Gravel	0	0	5	0	0
Cobble	60	30	15	10	20
Boulder	40	70	80	90	80
Bedrock	0	0	0	0	0
Embeddedness	N	N	N	N	L

Bank Measurements	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Bank Height (m)	0.18	0.28	0.27	0.18	0.27	0.10	0.25	0.21	0.22	0.17
Bank Slope (°)	60	45	50	70	70	60	90	45	60	80
Bank Stability	S	S	S	S	S	S	S	S	MS	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F
Subdom. Bank Material	O	BL	O	BL	O	O	O	O	O	O
Dom. Riparian Veg.	G	G	G	G	G	G	G	G	G	G
Subdom. Riparian Veg.		N		N				N	N	

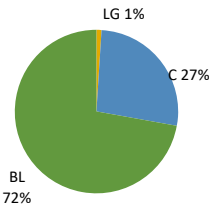
Habitat Inventory / Reach Data

Instream Cover (%):	6	Overhead Cover (%):	-
Dom. Instream Cover:	BL	Dom. Overhead Cover:	-
Subdom. Instream Cover:	-	Subdom. Overhead Cover:	-
Maximum Depth (m)		Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	07:19
Water Temperature (°C):	7.0
Dissolved Oxygen (mg/L):	10.61
Sp. Conductivity (µs/cm):	66.7
pH:	7.22
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	ST
Islands:	N
Bars:	SP
Coupling:	PC
Confinement:	FC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	Coarse Fish	Sport Fish
Spawning:	None	None	None
Overwintering:	None	None	None
Rearing:	None	None	Moderate
Passage:	None	None	Moderate

P

Fish Sampling Data

Method	Effort

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

Species	Efish Catch (n)	Trap Catch (n)	Efish CPUE (#fish/100s)	Trap CPUE (#fish/hr)	Rel. Abundance (% of total)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site PP-01: Apex River

UTM Location: 19V 525736 7070513 **Survey Date:** August 18, 2022

Legal Location: 00-00-000-00W4M **Watercourse Class:**

Crew Initials: AB, CM **Restricted Activity Period:**

Physical Channel Transect Data

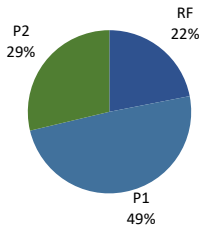
Transect # (Location)	0	25	50	75	100
Channel Width (m)	50.5	35.0	40	51.0	52.0
Wetted Width (m)	47.5	34.0	39.0	50.0	50.0
Depth at LDB + 25% (m)	0.43	0.43	0.78	1.00	1.20
Depth at LDB + 50% (m)	0.47	0.57	1.10	-	-
Depth at LDB + 75% (m)	0.39	0.70	1.33	1.55	1.17
Max. Depth (m)	1.43	0.74	1.6	1.78	1.38
Gradient (%)	3	1	1	1	1
Dominant Habitat Unit	RF	P2	P1	P1	P1
Stream Bed					
Substrate (% of Transect Area): Organics	0	10	0	0	0
Sand	0	0	20	70	55
Small Gravel	0	10	0	0	0
Large Gravel	0	60	10	10	10
Cobble	20	20	40	10	20
Boulder	80	0	30	10	15
Bedrock	0	0	0	0	0
Embeddedness	N	L	L	M	M

Bank Measurements	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Bank Height (m)	0.22	0.96	0.14	0.17	0.18	0.25	0.23	0.2	0.18	0.14
Bank Slope (°)	45	60	30	45	70	-	45	45	45	45
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F
Subdom. Bank Material	O	BL	O	BL	BL	BL	BL	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

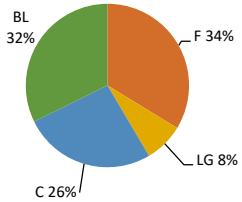
Habitat Inventory / Reach Data

Instream Cover (%):	61	Overhead Cover (%):	0
Dom. Instream Cover:	DC	Dom. Overhead Cover:	-
Subdom. Instream Cover:	BL	Subdom. Overhead Cover:	-
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	07:52
Water Temperature (°C):	7.0
Dissolved Oxygen (mg/L):	10.59
Sp. Conductivity (µs/cm):	67.3
pH:	7.12
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	SI
Islands:	N
Bars:	SP
Coupling:	DC
Confinement:	FC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	Coarse Fish	Sport Fish
Spawning:	None	None	poor
Overwintering:	None	None	good
Rearing:	None	None	good
Passage:	None	None	good

P

Fish Sampling Data

Method	Effort	Species	Efish Catch (n)	Trap Catch (n)	Efish CPUE (#fish/100s)	Trap CPUE (#fish/hr)	Rel. Abundance (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site US-04: Apex River

UTM Location: 19V 525371 7070950 **Survey Date:** August 20, 2022

Legal Location: **Watercourse Class:**

Crew Initials: AB, CM **Restricted Activity Period:**

Physical Channel Transect Data

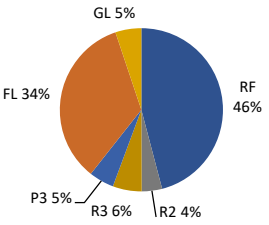
Transect # (Location)	0	25	50	75	100
Channel Width (m)	18.1	25.8	13	14.4	10.0
Wetted Width (m)	18.1	25.8	12.3	13.6	10.0
Depth at LDB + 25% (m)	0.55	0.10	0.27	0.12	0.32
Depth at LDB + 50% (m)	0.14	0.13	0.26	0.35	0.14
Depth at LDB + 75% (m)	0.15	0.25	0.17	0.10	0.20
Max. Depth (m)	0.71	0.53	0.44	0.73	0.71
Gradient (%)	2	1	2	2	2
Dominant Habitat Unit	RF	FL	RF	RF	RF
Stream Bed					
Substrate (% of Transect Area) – Organics	0	0	0	0	0
Sand	20	20	10	10	10
Small Gravel	0	10	0	0	0
Large Gravel	10	25	10	10	10
Cobble	65	40	60	65	65
Boulder	5	5	20	15	15
Bedrock	0	0	0	0	0
Embeddedness	M	M	L	L	L

Bank Measurements	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Bank Height (m)	0.16	0.15	0.03	0.28	0.16	0.09	0.17	0.38	0.26	0.23
Bank Slope (°)	90	80	90	90	90	60	90	70	90	90
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F
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.										

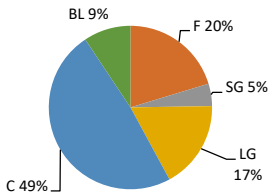
Habitat Inventory / Reach Data

Instream Cover (%):	2	Overhead Cover (%):	0
Dom. Instream Cover:	BL	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	DC	Subdom. Overhead Cover:	-
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	11:54
Water Temperature (°C):	9.4
Dissolved Oxygen (mg/L):	10.35
Sp. Conductivity (µs/cm):	65.7
pH:	7.16
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	IR
Islands:	O
Bars:	MD
Coupling:	DC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	Coarse Fish	Sport Fish
Spawning:	None	None	Poor
Overwintering:	None	None	Poor
Rearing:	None	None	Poor-moderate
Passage:	None	None	Good

P

Fish Sampling Data

Method	Effort

Species	Efish Catch (n)	Trap Catch (n)	Efish CPUE (#fish/100s)	Trap CPUE (#fish/hr)	Rel. Abundance (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site US-03: Apex River

UTM Location: 19V 525419 7071445 **Survey Date:** August 20, 2022

Legal Location: 00-00-000-00W4M **Watercourse Class:**

Crew Initials: AB, CM **Restricted Activity Period:**

Physical Channel Transect Data

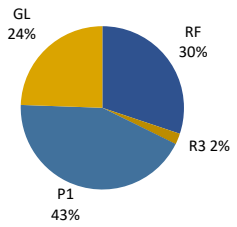
Transect # (Location)		0	25	50	75	100
Channel Width (m)		58.0	54.5	27	24.2	7.60
Wetted Width (m)		58.0	54.5	27.4	21.3	7.60
Depth at LDB + 25% (m)		1.3	0.08	0.17	0.16	0.29
Depth at LDB + 50% (m)		-	0.22	0.14	0.11	0.28
Depth at LDB + 75% (m)		1.1	0.27	0.13	0.20	0.30
Max. Depth (m)		1.59	0.58	0.34	0.43	0.92
Gradient (%)		1	1	2	2	4
Dominant Habitat Unit		P1	GL	RF	RF	RF
Stream Bed						
Substrate (% of Transect Area)	Organics	0	0	0	0	0
	Sand	30	20	10	20	10
	Small Gravel	0	0	0	0	0
	Large Gravel	10	10	10	20	10
	Cobble	10	40	40	40	40
	Boulder	50	30	40	20	40
	Bedrock	0	0	0	0	0
Embeddedness		M	L	L		L

Bank Measurements	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Bank Height (m)	0.29	0.06	0.31	0.13	0.17	0.08	0.23	0.11	0.62	0.51
Bank Slope (°)	80	45	80	80	90	45	90	20	80	60
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F
Subdom. Bank Material	O	O	O	O	O	O	O	O	BL	BL
Dom. Riparian Veg.	G	G	G	G	G	N	G	G	G	G
Subdom. Riparian Veg.		N		N					N	N

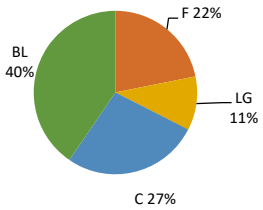
Habitat Inventory / Reach Data

Instream Cover (%):	42	Overhead Cover (%):	-
Dom. Instream Cover:	DC	Dom. Overhead Cover:	-
Subdom. Instream Cover:	BL	Subdom. Overhead Cover:	-
Maximum Depth (m)		Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	08:56
Water Temperature (°C):	8.5
Dissolved Oxygen (mg/L):	10.45
Sp. Conductivity (µs/cm):	66.1
pH:	7.11
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	IR
Islands:	N
Bars:	SD
Coupling:	DC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	Coarse Fish	Sport Fish
Spawning:	None	None	poor-moderate
Overwintering:	None	None	Poor-Moderate
Rearing:	None	None	Poor-moderate
Passage:	None	None	Good

P

Fish Sampling Data

Method	Effort

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

Species	Efish Catch (n)	Trap Catch (n)	Efish CPUE (#fish/100s)	Trap CPUE (#fish/hr)	Rel. Abundance (% of total)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited - Apex River Study 2022

Site US-02: Apex River

UTM Location: 19V 525666 7072105 **Survey Date:** August 19, 2022

Legal Location: 00-00-000-00W4M **Watercourse Class:**

Crew Initials: AB, CM **Restricted Activity Period:**

Physical Channel Transect Data

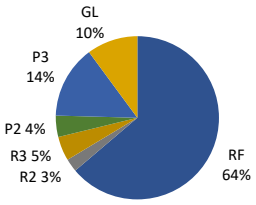
Transect # (Location)	0	25	50	75	100
Channel Width (m)	9.60	13.9	18	14.5	9.10
Wetted Width (m)	9.60	13.9	18.2	14.3	9.10
Depth at LDB + 25% (m)	0.40	0.39	0.13	0.16	0.14
Depth at LDB + 50% (m)	0.22	0.29	0.17	0.30	0.33
Depth at LDB + 75% (m)	0.16	0.35	0.36	0.25	0.11
Max. Depth (m)	0.75	0.52	0.50	0.30	0.56
Gradient (%)	3	3	3	3	5
Dominant Habitat Unit	R3	P3	GL	RF	RF
Stream Bed					
Substrate (% of Transect Area) Organics	0	0	0	0	0
Sand	10	40	20	10	20
Small Gravel	0	0	0	0	0
Large Gravel	20	20	10	20	10
Cobble	65	30	65	60	75
Boulder	5	10	5	10	5
Bedrock	0	0	0	0	0
Embeddedness	L	M	L	L	L

Bank Measurements	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Bank Height (m)	0.35	0.14	0.13	0.10	0.14	0.10	0.14	0.09	0.23	0.22
Bank Slope (°)	90	80	90	90	90	30	90	60	90	90
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F
Subdom. Bank Material	O	O	O	O	O	O	O	O	O	O
Dom. Riparian Veg.	G	N	G	G	G	N	G	G	G	G
Subdom. Riparian Veg.										

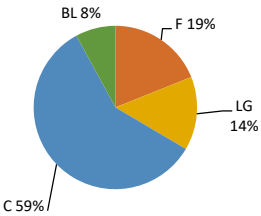
Habitat Inventory / Reach Data

Instream Cover (%):	1	Overhead Cover (%):	0
Dom. Instream Cover:	BL	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	-	Subdom. Overhead Cover:	-
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

Time of Day (HH:MM):	12:56
Water Temperature (°C):	10.9
Dissolved Oxygen (mg/L):	10.25
Sp. Conductivity (µs/cm):	62.4
pH:	7.62
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	ST
Islands:	N
Bars:	SP
Coupling:	DC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	Coarse Fish	Sport Fish
Spawning:	None	None	Poor
Overwintering:	None	None	Poor
Rearing:	None	None	Poor
Passage:	None	None	Good

P

Fish Sampling Data

Method	Effort

Species	Efish Catch (n)	Trap Catch (n)	Efish CPUE (#fish/100s)	Trap CPUE (#fish/hr)	Rel. Abundance (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA

Nunami Stantec Limited -Apex River Study 2022

Site US-01: Apex River

UTM Location: 19V 525685 7072648 **Survey Date:** August 19, 2022

Legal Location: **Watercourse Class:**

Crew Initials: AB, CM **Restricted Activity Period:**

Physical Channel Transect Data

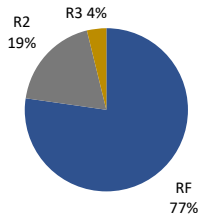
Transect # (Location)	0	25	50	75	100
Channel Width (m)	5.80	10.9	6.9	16.0	32.5
Wetted Width (m)	5.80	10.9	6.80	16.0	23.6
Depth at LDB + 25% (m)	0.42	0.32	0.54	0.34	0.26
Depth at LDB + 50% (m)	0.60	0.25	0.44	0.54	0.25
Depth at LDB + 75% (m)	0.38	0.38	0.37	0.26	0.19
Max. Depth (m)	0.96	0.69	0.87	0.91	0.26
Gradient (%)	3	5	4	2	3
Dominant Habitat Unit	RF	RF	R2	R2	RF
Stream Bed					
Substrate (% of Transect Area) – Organics	0	0	0	0	0
Sand	10	10	10	10	0
Small Gravel	0	0	0	0	0
Large Gravel	0	10	5	0	0
Cobble	15	20	15	20	20
Boulder	75	60	70	70	80
Bedrock	0	0	0	0	0
Embeddedness	L	L	L	L	N

Bank Measurements	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Bank Height (m)	0.30	0.36	0.31	0.18	0.20	0.33	0.38	0.31	0.41	0.20
Bank Slope (°)	90	90	80	90	90	80	80	80	90	45
Bank Stability	S	S	S	S	S	S	S	S	S	S
Dom. Bank Material	F	F	F	F	F	F	F	F	F	F
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.									N	N

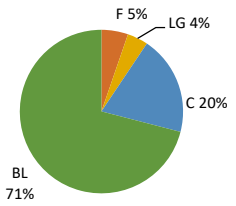
Habitat Inventory / Reach Data

Instream Cover (%):	21	Overhead Cover (%):	5
Dom. Instream Cover:	BL	Dom. Overhead Cover:	UC
Subdom. Instream Cover:	-	Subdom. Overhead Cover:	-
Maximum Depth (m)	-	Dom. Aquatic Veg. Type:	-

Habitat Distribution



Substrate Composition



Water Quality Data

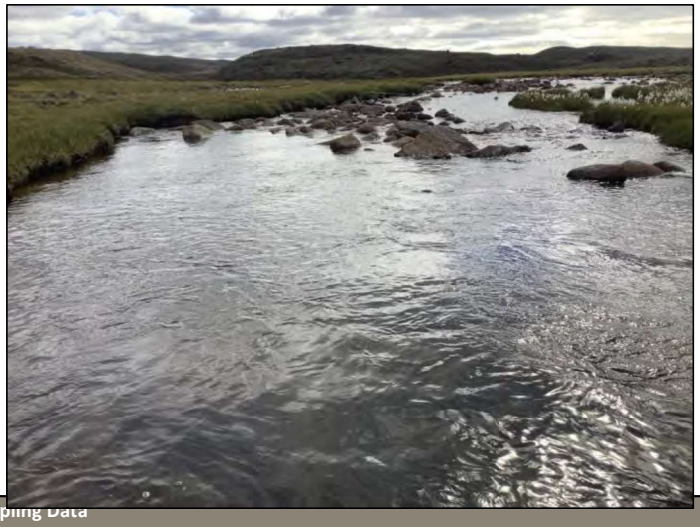
Time of Day (HH:MM):	08:40
Water Temperature (°C):	7.8
Dissolved Oxygen (mg/L):	10.65
Sp. Conductivity (µs/cm):	63.1
pH:	7.07
Turbidity (NTU):	0.00

Channel Characteristics

Pattern:	SI
Islands:	I
Bars:	SP
Coupling:	DC
Confinement:	OC
Flow Stage:	Moderate

Fish Habitat Assessment Ratings

	Forage Fish	Coarse Fish	Sport Fish
Spawning:	None	None	Poor
Overwintering:	None	None	Poor-moderate
Rearing:	None	None	Poor-moderate
Passage:	None	None	Good



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Fish Sampling Data

Method	Effort	Species	Efish Catch (n)	Trap Catch (n)	Efish CPUE (#fish/100s)	Trap CPUE (#fish/hr)	Rel. Abundance (% of total)

Electrofisher Settings

Volts	Freq. (Hz)	Duty Cycle (%)	Dist. (m)

General Comments

Prepared by: CB Reviewed by: LA