BEAVERLODGE RIVER WEIR MONITORING PROGRAM - 2019 SUMMARY REPORT

BEAVERLODGE RIVER
SE ½ 34-071-10 W6M

Prepared for:
MIGHTY PEACE WATERSHED ALLIANCE

Prepared by:
MATRIX SOLUTIONS INC.

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December 13, 2019

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1 INTRODUCTION

The Mighty Peace Watershed Alliance (MPWA) conducted works to improve fish passage at the Beaverlodge River weir, located southwest of the Town of Beaverlodge, Alberta (Figure 1-1). Natural riffle river features and channel enhancements were built at the weir and immediately downstream; the purpose of the fish passage structure was to create conditions suitable for fish to migrate/pass the weir situated on the Beaverlodge River, with the design species being Arctic Grayling. In order to assess the ongoing performance of the fish passage structures, including structural integrity of the riffles and flow suitability for fish passage through these structures, the MPWA prepared a monitoring plan which was approved by Fisheries and Oceans Canada (DFO).

The fish passage improvement project (the Project) was supported by Alberta Transportation to meet offset conditions in their *Fisheries Act* Authorization to twin the Peace River Bridge, near Peace River, Alberta. A monitoring plan was initially submitted to Alberta Environment and Parks (AEP) to meet monitoring conditions under Alberta *Water Act* Approval No. 00372572-00-00. In addition to the parameters detailed in the monitoring plan submitted to AEP, DFO requested monitoring of fish movement through the fish passage structure over a 3 year period, beginning the first year post-construction (i.e., 2019). Habitat use monitoring will be completed for the next 5 years. Results of the 2019 monitoring program are presented herein.

1.1 Background

The Beaverlodge River weir is situated approximately 12 km upstream from the confluence of the Beaverlodge and the Wapiti rivers (Figure 1-1). The weir was constructed in the early-1980s to provide a drinking water source for the town of Beaverlodge. Fish movement past the weir has been extremely limited to periods of higher discharge such as during spring freshet. Due to the shape of the weir, summer flows have been insufficient to maintain fish passage over the weir in either direction. Consequently, fish populations are low, and some historically abundant populations, such as Arctic Grayling, are now absent and considered functionally extirpated (CharettePellPoscente Environmental Corp. 2012). A fish ladder has been present at the Beaverlodge River weir since 1981; however, the weir has been in disrepair and was unlikely to be providing upstream or downstream fish passage.

As part of the MPWA's larger plans for watershed restoration and water quality improvement in the Beaverlodge River, fish passage improvement structures, comprising of two rock riffles, were installed at the weir, and immediately downstream, in the fall of 2018. The intent of the Project was to create the conditions needed to facilitate fish access to the upstream spawning and rearing habitat in the spring and just as importantly, to downstream habitat later in the summer and fall (i.e., overwintering in the Wapiti River). Historical activities in the watershed, including agriculture and logging, the installation of the weir for water supply, and wetland modifications, among other elements, have altered streamflow, water quality, and fish habitat. The MPWA is still working with stakeholders in the watershed to restore watershed conditions facilitating a return of natural environmental processes.

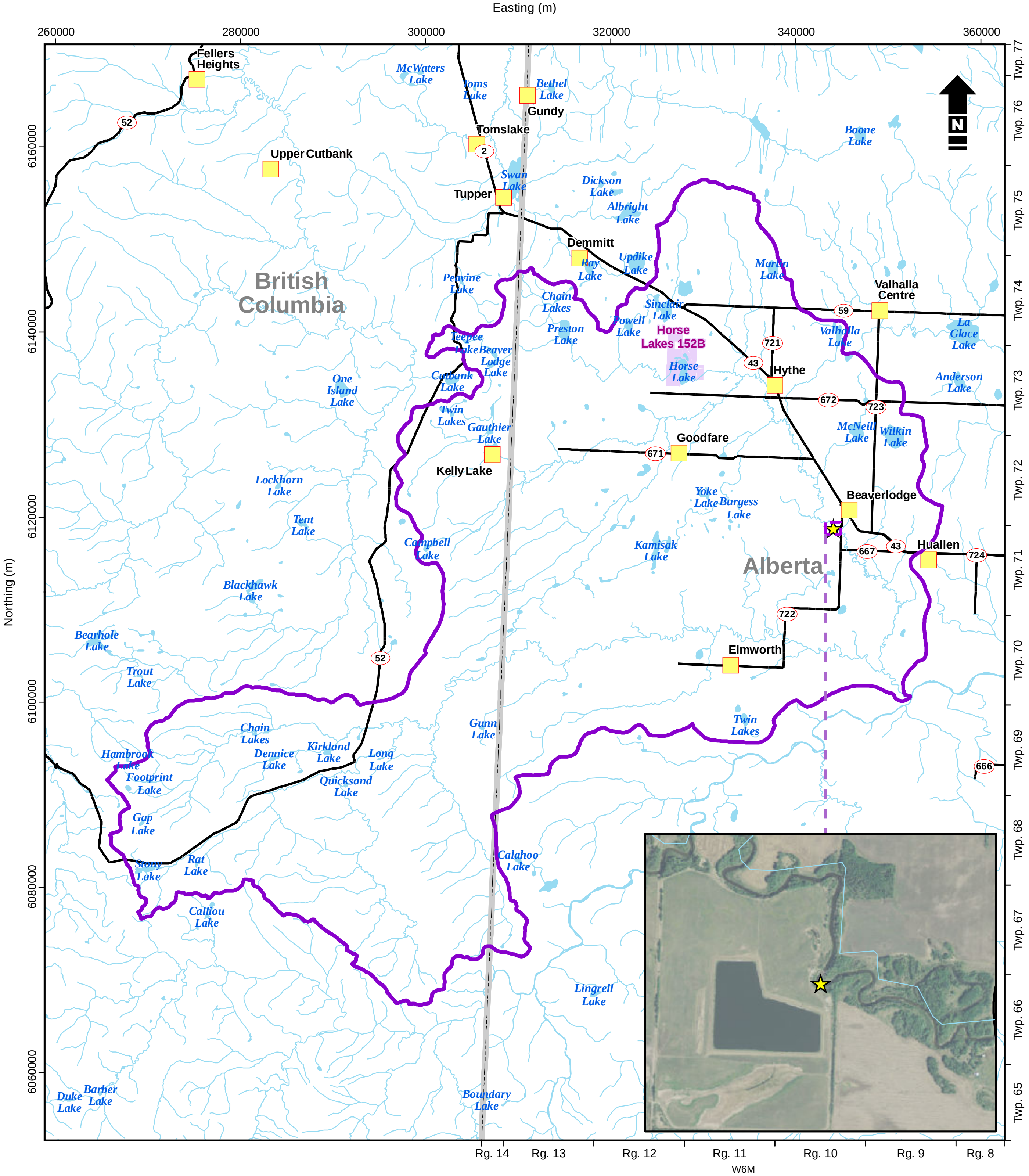
The specific objective of the Project was to create conditions suitable for fish to migrate/pass the weir situated on the Beaverlodge River in a manner that complements the need to keep the existing weir. The objective considered the following:

- maintaining weir (water level) for water supply for the town of Beaverlodge
- passage of Arctic Grayling (*Thylamus arcticus*), among other resident large-bodied fish, including Northern Pike, Bull Trout (*Salvelinus confluentus*), Burbot (*Lota lota)*, Longnose Sucker (*Catostomus catostomus),* White Sucker (*Catostomus commersonii*), and small-bodied fish during spring freshet, but also as importantly, during summer as the hydrograph declines
- minimizing maintenance (e.g., the movement of woody debris, sediment accumulation, and bank erosion) to maximize its capacity to function without attention

The fish passage design considered the extent of different flows to facilitate the passage of fish upstream and downstream past the weir, particularly during the decreasing portion of the hydrograph. The design maximizes available discharge by concentrating river flow into the centre of the structure to permit swimming during low flow periods, but not so much that fish cannot swim and pass.

Arctic Grayling (*Thymallus arcticus*) were an important design consideration; however, the design also considered other resident fish including Northern Pike (*Esox lucius*), Longnose Sucker (*Catostomus Catostomus*), and Burbot (*Lota lota*). The fish passage design considered maximum flow velocities that resident fish can negotiate (i.e., fish burst speed or maximum speed for 10 seconds). This would account for short sections between resting locations within the fish passage structure (i.e., <1 m step between pools). Flow velocities to accommodate burst speeds for various sized fish are outlined below (Katapodis 1992); these velocities consider both anguilliform and subcarangiform swimming forms:

- 20 cm long fish – burst speed/maximum flow velocity is 1.20 m/s
- 25 cm long fish – burst speed/maximum flow velocity is 1.50 m/s
- 30 cm long fish – burst speed/maximum flow velocity is 1.85 m/s
- 40 cm long fish – burst speed/maximum flow velocity is 2.45 m/s



- Redwillow Watershed Boundary
- Community
- Indian Reserve
- Water Body
- Watercourse
- Provincial Boundary
- Highway
- Existing Weir Location

1:600,000 metres

5,900 0 5,900 11,800

NAD 1983 UTM Zone 11N

Reference: Data obtained from AltaLIS © Government of Alberta, GeoBase® and GeoGratis © Department of Natural Resources Canada (all rights reserved) used under license. GDM transportation infrastructure data provided by IHS © 2015 used under license.

I:\MightyPeaceWatershedAlliance\2199\FiguresAndTables\FPA\2019\Report\Aquatics\Figure-1-Site-Location.mxd - Letter_P - 22-Nov-19, 02:54 PM - ipagado - TID001

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MPWA / Beaverlodge Fish Passage

Site Location

Date:	Project:	Submitter:	Reviewer:
November 2019	2199	K. Lowes	S. Christidis

Figure 1-1

1.2 Monitoring Program Parameters

The monitoring program is structured to assess conditions necessary for fish passage during the early and late portions of the hydrograph (i.e., seasonal streamflow measurements including velocity and depth at important points on the structure). However, fish use of the structure is dependent on the success of the MPWA and partner to achieve recovery in watershed conditions that lead to improved hydrology and water quality in the Beaverlodge River to support and restore fisheries populations. Monitoring parameters were developed based on available information on hydrology and potential fish species use and were approved by DFO. Parameters include:

- Visual inspection of the fish passage structure by a qualified engineer to assess erosion and redistribution of sediments (i.e., degradation and aggradation) caused by altered hydraulic dynamics and assess the ongoing structural integrity of the structure.
    - Rationale: ensure that the structures are stable and work with a fisheries biologist to provide recommendations for improvement, if needed.
- Assessment of the passage structure channel shape – channel depth and width, stream discharge, and water depth.
    - Rationale: the channel has been constructed with an inverted parabolic shape concentrating stream flows through the middle of the fish passage structure and these parameters will be used to determine if the channel shape changes over time.
- Monitoring of water depth and velocity over each of the passage structure steps, and water depth in each associated downstream pool.
    - Rationale: the fish passage structure was designed with the intent that flow velocities over each step will be less than burst speeds for anguilliform and subcarangiform fish 20 cm or larger, which is 1.2 m/s (Katapodis 1992).
- Monitoring of water temperature and dissolved oxygen (DO) above and immediately below the fish passage structure.
    - Rationale: concentrating the flows through the central portion of the fish passage structure will decrease the width of the flow, increase depth, and allow water to move through this section of the river more quickly. Thus, water temperatures and DO levels should be maintained.
- Visual inspection by a fish biologist to identify potential conditions that may prevent fish using the fish passage structure.
    - Rationale: changes to site conditions from variable stream flows and hydraulic forces may result in subtle changes to the structure and adjacent habitat that discourage fish from passing.

- Visual inspection of installed wood structures (e.g., root balls) by a fish biologist to assess the nature and value of enhanced habitat.
  - Rationale: determine the ongoing quality and nature of fish habitat in and around the fish passage structures.
- Visual inspection of installed wood structures by a qualified engineer to assess erosion and redistribution of sediments (i.e., degradation and aggradation) caused by altered hydraulic dynamics and assess the ongoing structural integrity of each wood structure.
  - Rationale: ensure that the wood structures are stable and provide recommendations to stabilize, if needed.
- Visual inspection of the bank protection measures along the outside bend of the river immediately downstream of the structure.
  - Rationale: ensure that vegetation is establishing and that measures are effective, and provide recommendations as needed.
- Sonar videography of the channel immediately upstream of the fish passage structure to determine if resident fish are moving through the fish passage structure.
  - Rationale: sonar videography images of fish moving immediately upstream of the fish passage structure is considered evidence of fish successfully swimming through the structure.

2 METHODS

The following subsections describe the methods used to assess the parameters identified in Section 1.2. The upstream (weir) and downstream riffle structures are herein referred to as Riffle 1 and Riffle 2, respectively.

2.1 Spatial Monitoring Extent

Site inspections, hydrology, and fish use monitoring were focussed on a 400 m reach of the Beaverlodge River: 100 m upstream of Riffle 1, within the large scour pool downstream of the Riffle 1, and 100 m downstream of Riffle 2 (Table 2-1; Figure 2-1):

- Six monitoring locations were established for annual site inspections, photographic documentation and water quality monitoring; site included four locations upstream and downstream of Riffle 1 and Riffle 2, and two locations within the scour pool between Riffle 1 and Riffle 2.

- Three fish sampling reaches were established; upstream of Riffle 1 (Reach 1), between Riffle 1 and Riffle 2 (Reach 2), and downstream of Riffle 2 (Reach 3).

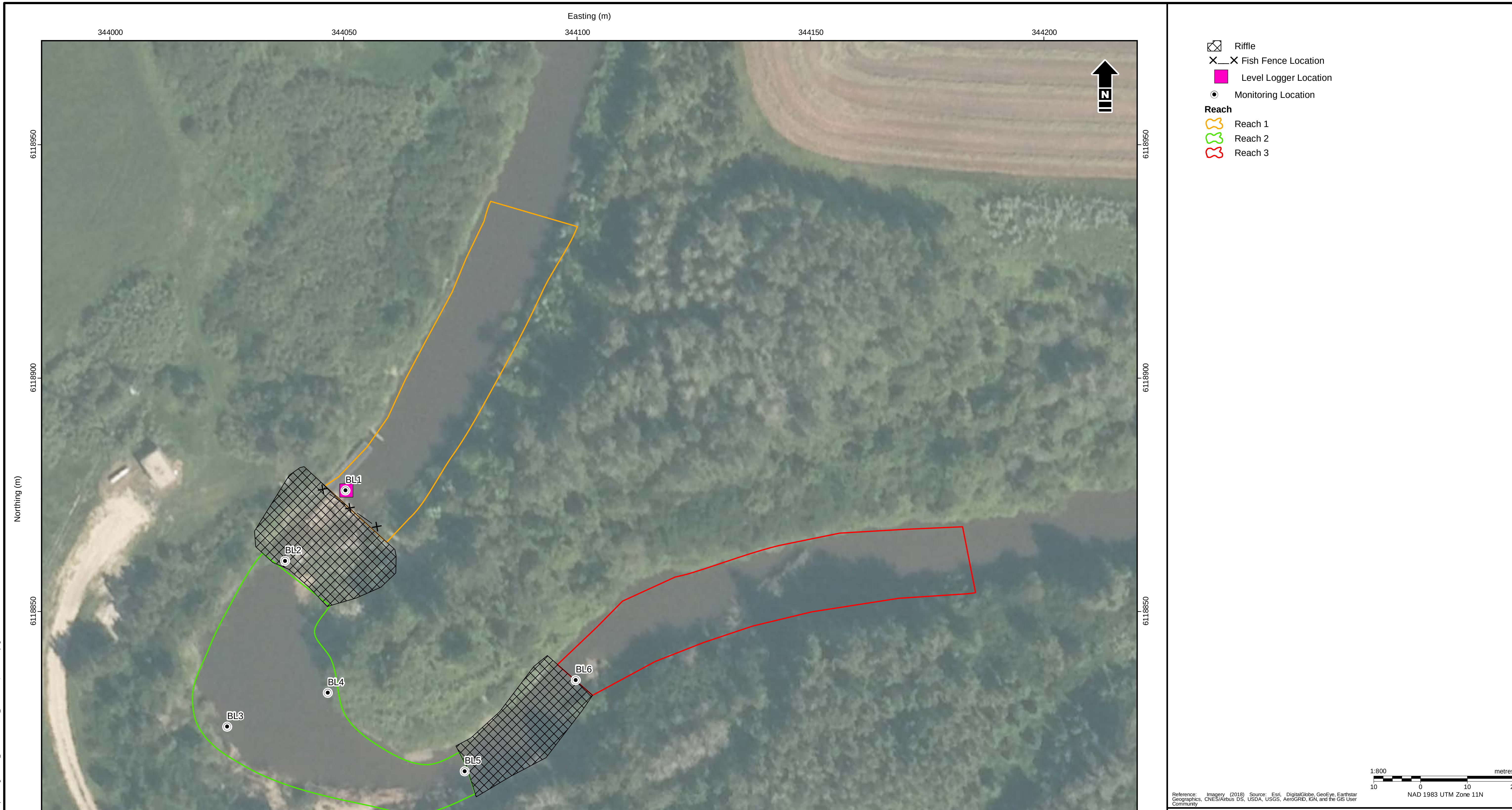
- eDNA sampling was conducted over a larger extent over the Beaverlodge River (see Section 2.1.4); eDNA sampling occurred at six locations, including two locations upstream of the weir, immediately around the weir and riffle structures, and downstream sites between the weir and the confluence of the Red Willow River; the larger monitoring extent was to account for potentially low densities of Arctic Grayling in the river, and therefore low detectability of eDNA; grayling may be present in specific reaches of the Beaverlodge River.

- A pressure transducer was installed and stream discharge measurements taken immediately upstream of Riffle 1.

TABLE 2-1 Site Location

Site ID	Location (UTM Location NAD 83 11 U)	
	Easting	Northing
Riffle Structures		
Riffle 1 (weir, upstream)	344044	6118864
Riffle 2 (downstream)	344093	6118823
Monitoring Locations		
BL1	344049	6118870
BL2	344039	6118857
BL3	344019	6118815
BL4	344038	6118833
BL5	344086	6118811
BL6	344105	6118827
eDNA Sample Locations		
BLeDNA1	341953	6120032
BLeDNA2	344064	6118883
BLeDNA3	344086	6118822
BLeDNA4	344168	6118856
BLeDNA6	349456	6113145
BLeDNA7	345496	6116482
Hydrology		
Manual Flow Measurement Location	344056	6118871
Pressure Transducer Location	344050	6118876

Notes:
UTM = Universal Transverse Mercator Coordinate system
NAD = North American Datum
U = UTM Zone



Reference: Imagery (2018) Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Beaverlodge River

Site Plan

Date:	Project:	Submitter:	Reviewer:
December 2019	2199	K. Lowes	S. Christidis

Figure
2-2

2.2 Habitat Site Inspections

Habitat structure inspections were completed during each site visit to determine if conditions deviated from the engineered design or have changed since the construction completion (based on as-built drawings) in a manner that degrades fish habitat and/or prevents fish using the passage structure. Sites included BL1 to BL6 (Table 2-1; Figure 2-1).

Velocity and water depth measurements were completed to ensure potential fish passage through the structure. In addition, in-situ water quality (water temperature, DO, pH, specific conductance, and turbidity) were measured upstream and downstream of the fish passage structures to determine if these parameters are affected by the structure. In situ water quality was collected using a calibrated YSI 550 or Pro Plus model.

2.3 Hydrology

Streamflow was monitored 1.5 km upstream of the Water Survey of Canada hydrometric gauge 07GFD001 from May 31 to October 1 to estimate the percentage of time that sufficient flow is present within the Beaverlodge River at the Weir location to allow fish passage (Q-fish$_{min}$).

A self-vented Ott Ecolog 500 pressure transducer (0 to 4 m range; 0.05% FS accuracy) was installed upstream of Riffle 1 to record water levels at 15-minute intervals. The transducer was encased inside a stilling well (10 cm diameter PVC pipe) and weighted to the bottom of the stream bed. Four flow measurements and corresponding water level surveys were completed to develop a stage-discharge rating which was used to convert stage to continuous streamflow. Flow measurements were completed using a Sontek Flowtracker Acoustic Doppler Velocimeter.

All hydrometric data was entered into the Matrix AQUARIUS™ database. The software was used throughout the hydrometric data production process including corrections, stage-discharge rating curve development, and streamflow calculations. The British Columbia Resources Information Standards Committee Hydrometric Standards (BC RISC Hydrometric Standards) were followed throughout the processing of hydrometric data (B.C. MoE 2009), moving forward version 2 (2018) standards will be applied. British Columbia RISC Hydrometric Standard Version 1 to 2 revisions primarily include updated data grading criteria to account for improvements in technologies for collecting, calculating and storing hydrometric data. The instrumentation, field methodology and processing of hydrometric data applied in this project meet the British Columbia RISC Hydrometric Standards Version 2.

2.4 Fish Use Monitoring

The objective of the long-term monitoring program is to confirm habitat use by resident fish populations and determine if fish are staging and passing upstream of the fish passage structure. Fish sampling, water sampling for eDNA analysis, sonar videography, a fish fence and trap (fyke net) system, and a mark recapture tagging program were completed to support this objective. All fish sampling, tagging and the installation of the fish fence were conducted under Fish Research Licence (FRL) RL19-1009.

2.4.1 Fish Movement

To observe and document fish movement through the upstream riffle and weir, sonar videography, facilitated with fish fence installation and fishing sampling effort, was conducted from July 2 to 5, 2019.

2.4.1.1 Fish Fence and Trap

A fish fence was installed directly upstream of the weir riffle (Riffle 1). The purpose and orientation of the fish fence was to funnel fish through a single opening mid-channel and in to a trap net, while also allowing the sonar camera to focus on a smaller area and observe fish movement through Riffle 1.

The fish fence construction was based on a design by Anderson and McDonald (1978), and Kristofferson *et al* (1986). Conduit pieces (3 m in length, 18 mm diameter) were placed within holes drilled into two aluminum channel brackets, creating a 16 mm space between each piece of conduit. The spacing allowed for small body fish to move freely through the fence, decreased the potential for a hydraulic head to form, and limited the amount of debris collection and pressure on the fence. Each section of the aluminum channels was held together using U-bolts around 76.2 mm diameter aluminum pipes, 3 m in length held up using 50.8 × 101.6 mm wooden A-frames. The fence and trap were installed for 3 full days, with assembly and deconstruction taking 1 day each. A fyke net was installed upstream of the opening of the fish fence during the early-July field program to act as a fish trap. Fyke net dimensions were 1.2 × 1.2 × 4.5 m, with 4 m wings (reduced to 2 m). The fyke net wing walls were attached to the fish fence; any fish funneled upstream by the fish fence would be captured within the fyke net. The fyke net was in place over the same 3-day period in conjunction with the sonar camera work, and was checked and cleared of fish three times per day.

The fence and trap net were cleared of debris daily.

2.4.1.2 Sonar Videography

Sonar videography was conducted using an ARIS Explorer 1800 rented from Ocean Marine in Washington, United States of America. The ARIS Explorer 1800 has capabilities to detect targets including fish through 35 m of turbid water. The ARIS Explorer 1800 was set up in July in conjunction with the fish fence, and operated on July 3, 4 and 5, 2019. Videography occurred for 3, 2-hour sessions per day on each of the three days, for a total of 18 hours of video. Videos was downloaded from the unit at the end of each day and reviewed at a later time.

2.4.1.3 Tag Recapture Sampling

A tag and recapture sampling study was conducted in conjunction with the sonar camera and fish fence work; this study was conducted to help verify the sonar camera results and is considered a more robust method of observing fish movement. This mark recapture study was added to the program after discussions with AEP fish biologists.

An individually numbered floy tag was attached to all sport and large-bodied fish captured measuring over 200 mm fork length. Tags were attached at the base of the dorsal fin. Each fish tagged was identified to species, weighed and measured, and its location in relation to each riffle structure recorded. Fish were released in the same location as they were captured.

2.4.2 Fish Sampling

Fish sampling was conducted to support the fish movement (tagging, movement through the riffles) and habitat use monitoring parameters. Fish sampling efforts were scheduled to be completed in spring (May/June) and summer (July/August) of the 2019 open water season, with supplementary angling effort occurring in October. However, spring fish sampling efforts were delayed until July due to high water levels within the Beaverlodge River. No fish sampling effort was completed within the riffle structures, due to unsafe high flow conditions. Electrofishing was conducted on July 7 and August 7, 2019, while Angling was conducted on July 7 and 8, August 8, and October 1, 2019.

Each sample reach was approximately 100 m in length and ranged from 1 to 4 m in depth. These reaches were established to determine fish presence and species type below and above each riffle structure.

Electrofishing was completed during the July field program using a SmithRoot Generator Powered Pulse (GPP) 2.5 portable electrofishing unit mounted on an inflatable zodiac boat. Sampling occurred in Reaches 1, 2 and 3 in July, and Reach 1 in August; field crews were unable to complete electrofishing downstream within Reaches 2 and 3 during the August field program due to heavy rain creating unsafe electrofishing conditions. Electrofishing effort was conducted within each sampling reach (Table 2-1; Figure 2-2) over a 2-day period. Temperature and electrical conductivity were measured prior to each electrofishing event to calculate appropriate unit settings.

Electrofishing was typically conducted along the shoreline areas, with limited effort directly over the deeper pool sections where visibility was lower; this was done to avoid the continual shocking of fish without being able to capture them and thereby reducing the risk of mortalities. Pulse bursts of 5 to 15 seconds were conducted while moving the boat slowly against the flow. Captured fish were placed in an aerated container and held for up to 15 minutes before being processed.

Angling effort was completed during the July, August, and October by two crew members with the use of spoon lures, either casting from the shore or boat. Angling effort was targeted toward Arctic Grayling and Northern Pike, with some effort targeting Bull Trout during the fall.

All fish captured through the 2019 sampling events were identified to species, enumerated, measured and weighed.

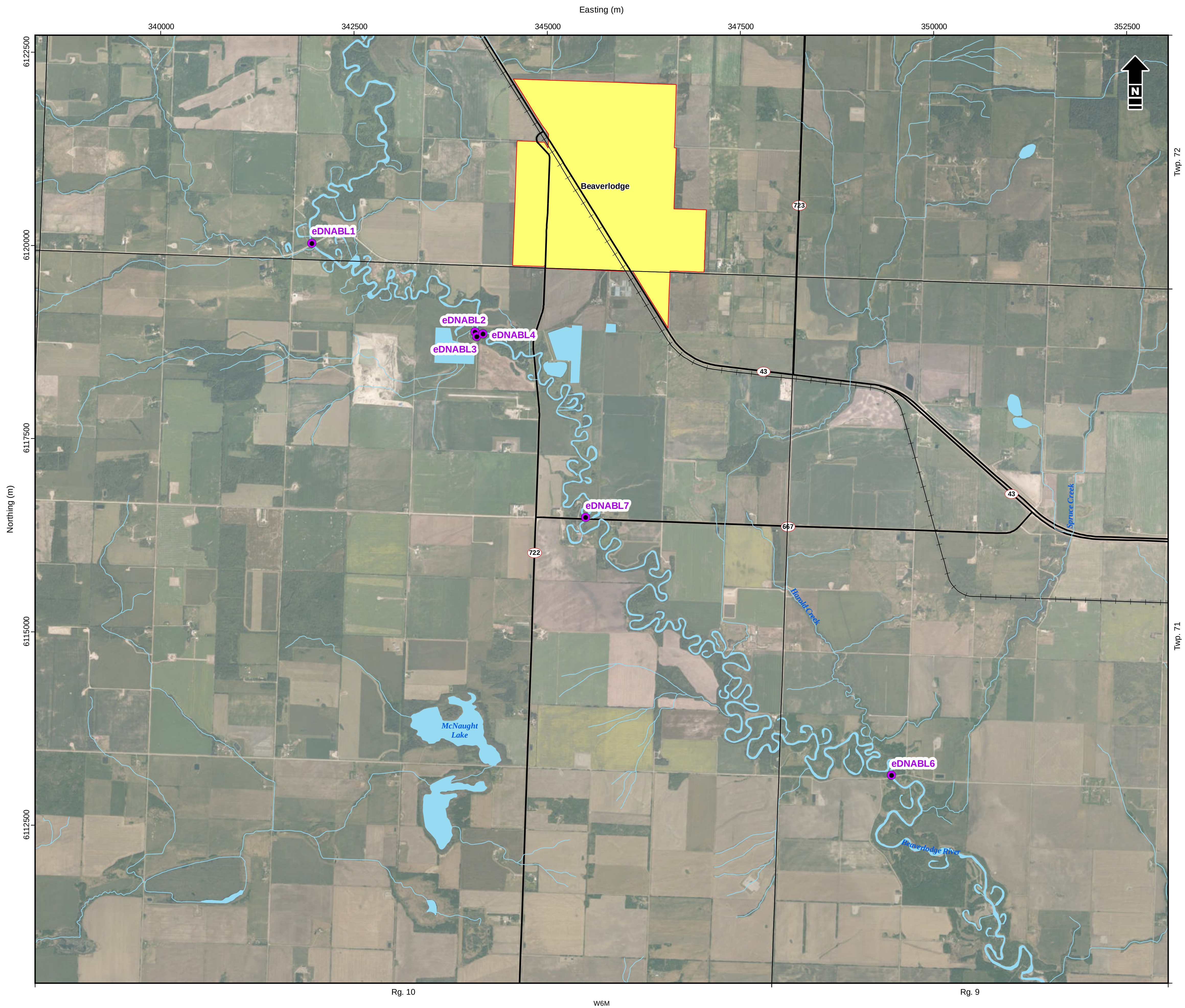
2.4.3 Data Analysis

Measurement end points of fish sampling data included the following:

- relative abundance expressed as the number of fish captured and catch per unit effort (CPUE)
- percent composition
- length frequency (large-bodied fish only)

2.4.4 eDNA Sampling and Analysis

The eDNA monitoring was completed on May 8, 2019 to assess the presence of Arctic Grayling in the Beaverlodge River, and to see if they are able to pass above the weir during the spring migration period. Six sites were selected for eDNA sampling (BLeDNA1 to BLeDNA6; Table 2-1; Figure 2-2). BLeDNA 5 was not sampled due to access constraints. Sampling and data analysis were conducted according to the methods provided by the British Columbia Ministry of Environment's *Environmental DNA Protocol for Freshwater Aquatic Ecosystems* (Hobbs and Goldberg 2017) and are summarized in the following subsections.



Community
Water Body
Watercourse
Highway
Railway
eDNA Sampling Location

1:50,000 metres
510 0 510 1,020
NAD 1983 UTM Zone 11N

Reference: Data obtained from AltaLIS © Government of Alberta used under license. GDM transportation infrastructure data provided by IHS © 2019 used under license.Imagery (2018) Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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eDNA Sampling Location

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Figure 2-2

2.4.4.1 Primer Validation Assay

Single species eDNA detection requires validation of the species-specific DNA primer. To ensure primer validation is accurate, DNA samples from individuals in the target population were required to be tested with the laboratory primer specific to Arctic Grayling. Ideally, tissue samples should be obtained from individuals present in the target population to reduce false negatives due to differences in genetic variability between regional populations. Given that Arctic Grayling are considered functionally extirpated from the Beaverlodge River, tissue samples from the Wapiti River Arctic Grayling population were used. AEP biologists provided tissue samples in the form of scales of Wapiti River Arctic Graying for primer validation purposes. Scales were sent to the Helbing Laboratory at the Department of Biochemistry & Microbiology located in British Columbia for analysis. DNA was extracted and analyzed from the scale samples and were able to be amplified with laboratory Arctic Grayling primer meaning that Arctic Grayling from the Beaverlodge River and Wapiti River populations should be detected with strong efficiency, if DNA was present.

2.4.4.2 Field Sampling and Filtration

Water samples were collected at each site and filtered at a dedicated, sterile filtration location. Methods include:

- To avoid the potential for cross-contention and false positive results, equipment was cleaned and sterilized using bleach solutions and rinsed with DO water between sampling events and during the filtration process.
- Three, 1 L water samples (three replicates per site) were collected per site, using sterile (bleached), non-reactive containers. Water samples were stored on ice within a cooler until filtration.
- Filtration occurred at a dedicated filtration station located at the Matrix Grande Prairie office.
- Each individual 1 L sample was filtered through Thermo-Scientific Nalgene T Analytical Test Filter Funnels, with a 47 mm diameter membrane, 0.45 µm pore size and 250 mL capacity. A minimum of 250 mL of water over a period of at least 30 minutes was filtered for each sample.
- Filters were stored in Ziploc™ bags, labelled according to sample location and replicate number, and preserved using silica desiccant.

2.4.4.3 Laboratory Analysis

Samples were shipped to the Helbing Laboratory for analysis. Samples were tested against the Arctic Grayling DNA primer using quantitative polymerase chain reaction (qPCR) methods. Methods for DNA isolation, eDNA assay set up and data analysis are described in Hobbs *et al*. (2019).

Quality assurance/quality control (QC/QA) on samples was conducted prior to analyzing each sample for the target DNA. This included running an “IntegritE-DNA” viability control to ensure the quality of DNA extracted was suitable for qPCR analysis and that there were no inhibitors present. The IntegritE-DNA used four technical replicates of the ePlant5 qPCR assay; inhibition to the qPCR application process is not occurring if amplifiable DNA is present in the sample (2019).

3 RESULTS

3.1 Habitat Structure Habitat Structure Site Inspections

3.1.1 Riffle Structures

Both riffle structures appeared to be performing as intended. Flow was being directed through the centre of each riffle and a high level of flow variability was observed; numerous step pools, back water eddies, cascades and chutes, were present. Wetted depths in the riffles structures ranged from less than 0.1 m up to 0.4 m. Flow was observed to be moving over the riffles, with no subterranean flow observed; smaller material consisting of fines and gravel had settled within the interstices of the larger cobble and boulder material.

Riffle structures appeared stable, with no erosion observed at the downstream or upstream ends or along the river edges. Some movement of cobble and boulder material may have occurred; however, any movement was likely insignificant. The large pool at the downstream end of Riffle 1 (weir Riffle) was still present, and wetted depths at the time of assessment were up to 3 m (similar depths to what was recorded pre-construction). Wetted depths downstream of Riffle 2 ranged from 0.4 to 2.0 m. Wetted depths upstream of Riffle 1, within 100 m, were up to 2.0 m.

Installation of root balls was abandoned during construction due to bank stability concerns from the contractor and onsite engineer (Matrix 2019). Attempts at the root ball installation did not achieve the desired results; excavation of the already unstable, high banks presented a safety risk to construction crews; attempts to push the root balls into the banks was attempted but the root balls were destroyed in the process. Alternative installation methods such as by excavation were discussed but were deemed too invasive.

Although the additional cover intended by the root balls was not achieved, woody debris from the eroding banks and from upstream have accumulated along the banks (Appendix A, Photographs 3, 6, 12, 16. Additional scrub material has also accumulated along the banks (Appendix A, Photographs 7,18,19). The naturally occurring woody debris and scrub material has provided suitable cover and provided some bank protection.

The MPWA conducted willow planting in the summer of 2019. Plantings occurred along the south bank from Riffle 2 for a distance of 30 m upstream; planting could not be conducted further upstream as the high, unstable bank presented overhead safety concerns (Appendix A, Photographs 1, 16, 19).

3.2 Hydrology

3.2.1 Precipitation

Precipitation from the Environment Canada Climate Data Archive (CDA) for the Beaverlodge Climate Station (Climate ID: 3070560) for 2019, including a comparison to the 1981-2010 normal precipitation (30-year mean precipitation) is provided in Table 3-1. The monthly variation in precipitation for 2019 from the 1981-2010 normal precipitation are shown as percent differences indicating the dominant wet or dry runoff conditions over the course of the year (Table 3-1; Figure 3-1).

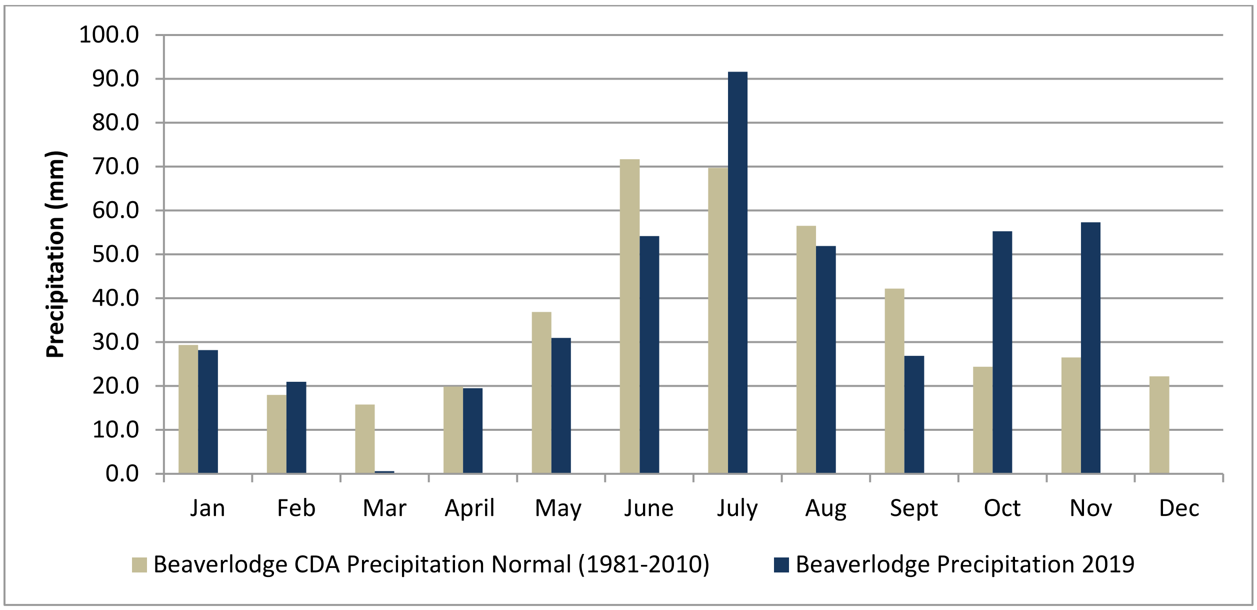

FIGURE 3-1 Beaverlodge Precipitation for 2019 Compared to 30-year Normal Precipitation

Annual precipitation to the end of November was 6% above normal but varied throughout the year. Winter precipitation was near normal in January, February, April and May, while precipitation in March was nearly 100% below normal. Summer precipitation was variable with slightly below normal precipitation in June, August, and September. Greater than normal precipitation was recorded for the months of July, October, and November, contributing to greater low flows in the late-summer and fall.

TABLE 3-1 Beaverlodge Precipitation for 2019 and departures from the 1981-2010 Normal

Year	Site	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual	EOR [1]
1980 - 2010	Beaverlodge CDA 1981-2010 Normal (mm)	29.4	18.0	15.8	19.9	36.9	71.7	69.7	56.5	42.2	24.4	26.5	22.2	433.1	411
2019	Beaverlodge Precipitation (mm)	28.2	21	0.6	19.5	31	54.2	91.6	51.9	26.9	55.3	57.3	-	437.5	437.5
	Departure from Normal	**-4%**	**17%**	**-96%**	**-2%**	**-16%**	**-24%**	**31%**	**-8%**	**-36%**	**127%**	**116 %**	**-**	**1%**	**6%**

1 End of available record.

3.2.2 Water Survey of Canada Gauge 07GD001

Over the period of available record (1968 to 2018), discharge on the Beaverlodge River at the WSC gauge 07GD001 is dominated by snowmelt runoff with maximum annual flows occurring toward the end of April. Streamflow for the remainder of the year is highly dependent on the magnitude and frequency of rainfall runoff events. Base flows decrease throughout the open season with minimum flows frequently approaching zero from August to March (Table 3-2).

TABLE 3-2 Minimum, Mean, and Maximum Average Monthly Discharge (m^3/s) in the Beaverlodge River at 07GD001 (1968 to 2018)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Minimum	0	0	0	0.251	0.011	0.031	0.006	0	0	0	0	0
Mean	0.06	0.13	1.34	10.48	7.29	3.72	2.49	1.11	0.56	0.50	0.15	0.22
Maximum	0.196	0.217	11.50	38.60	39.60	26.100	27.00	15.20	10.20	3.70	0.57	1.22

3.2.3 Beaverlodge River at the Weir

Streamflow measurements completed in 2019 ranged from 1.743 to 3.681 m^3/s and are limited to the lower third of the stage-discharge rating curve. Additional flow measurements are expected to further define the low and high ranges and stability of the stage-discharge rating curve (Appendix B).

Snowmelt runoff occurred before the installation of the hydrometric gauge and distinct rainfall-induced peak flows were recorded in mid-June, late-July, and late-September. A maximum instantaneous flow of 17.358 m^3/s occurred on July 25, corresponding to greater than normal precipitation in July. A minimum instantaneous flow of 0.245m^3/s occurred on June 25. Mean streamflow in September, typically the beginning of the low flow season was elevated at 1.945 m^3/s.

Monthly streamflow statistics for the Beaverlodge River at the Weir for the monitored season (June to October are summarized in Table 3-3 while the streamflow hydrograph and mean daily streamflow summary for 2019 is included in Appendix B. Compared to the 1968 to 2018 average at the WSC gauge 07GD001, minimum monthly flows at the weir were above average from June to September and with the exception of June, mean monthly flows were greater. Maximum monthly flows measured at the weir were less from June to September compared to the WSC gauge 07GD001.

TABLE 3-3 Minimum, Mean, and Maximum Average Monthly Discharge (m^3/s) for the Beaverlodge River at the Weir - 2019

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Minimum						0.245	0.732	2.479	1.027			
Mean						2.045	3.617	5.220	1.945			
Maximum						6.913	17.358	10.460	3.901			

3.2.4 Point Velocity Monitoring

Point velocity measurements were collected randomly throughout each riffle feature. Flow through the riffles was highly variable. Measures were taken within a variety of flow conditions within the channel, including against the channel banks, within step pools, and back water eddies where velocities were lower, and with the centre channel thalweg, cascades, and chutes where velocities were higher.

Point velocities ranged from 0.10 m/s along the banks (0 m/s in pools and back water eddies) to 8.19 m/s within the thalweg mid-channel (recorded during high flow events). Velocities were typically lower against the channel banks when compared to the thalweg at centre channel.

3.3 Water Quality

Water temperatures ranged from 15.9 to 17.7°C in July and August, dropping to below 6°C in October (Table 3-4). DO concentrations were consistently above 7 mg/L at all sampling locations during the summer and increased above 11 mg/L in October. pH was slightly alkaline and stayed relatively constant at all sampling locations and during each sampling event. The EC ranged from 345 to 433 µS/cm in July and decreased between 194.2 to 246.2 µS/cm in August and October.

TABLE 3-4 Water Quality Summary

Date	Water Quality Parameter	BL1	BL2	BL5	BL6
03-Jul-19	pH	8.0	8.0	8.1	8.9
	Temperature (°C)	17.6	17.3	17.7	17.7
	EC (µS/cm)	369.0	363.0	359.0	433.0
	DO (mg/L)	7.9	7.3	8.2	7.9
	Turbidity (NTU)	18.6	17.0	13.3	16.9
04-Jul-19	pH	8.4	8.0	8.1	8.2
	Temperature (°C)	17.7	17.3	17.7	17.7
	EC (µS/cm)	345.0	363.0	359.0	433.0
	DO (mg/L)	7.1	7.3	8.2	7.9
	Turbidity (NTU)	n/a	17.0	13.3	17.0

Date	Water Quality Parameter	BL1	BL2	BL5	BL6
08-Aug-19	pH	7.9	7.5	7.7	7.9
	Temperature (°C)	16.4	15.9	16.9	15.9
	EC (µS/cm)	209.3	263.7	227.7	229.2
	DO (mg/L)	8.7	8.8	8.1	8.15
	Turbidity (NTU)	17.0	21.6	19.1	19.0
01-Oct-19	pH	7.6	7.9	8.1	8.1
	Temperature (°C)	5.0	4.7	5.2	5.2
	EC (µS/cm)	243.8	194.2	245.6	246.2
	DO (mg/L)	11.4	11.0	12.2	11.4
	Turbidity (NTU)	11.0	17.6	9.8	12.3

3.4 Fish Sampling Effort Results

3.4.1 Species Composition and Abundance

Forty-eight fish were captured during fishing effort in July and ten fish captured August; Northern Pike, Longnose Sucke*,* White Sucker, Redside Shiner (*Richardsonius balteatus*) and Lake Chub (*Couesius plumbeus*) were captured in July, while only White Sucker and Redside Shiner were captured in August (Figure 3-2). This was likely due to a reduced fishing effort in August due to safety concerns; see Section 2.4.2). Reach 1 was the only reach sampled in August with nine White Sucker and one Reside Shiner captured (Figure 3-4). No fish were captured during October angling efforts.

White Sucker was the most abundant species during both sampling events, with 33 individuals captured in July, and 9 individuals captured in August (Figure 3-2). Northern Pike was the only sport fish species captured; 6 individuals were captured during the July fish sampling efforts; no pike were captured during August fishing efforts (Figure 3-2).

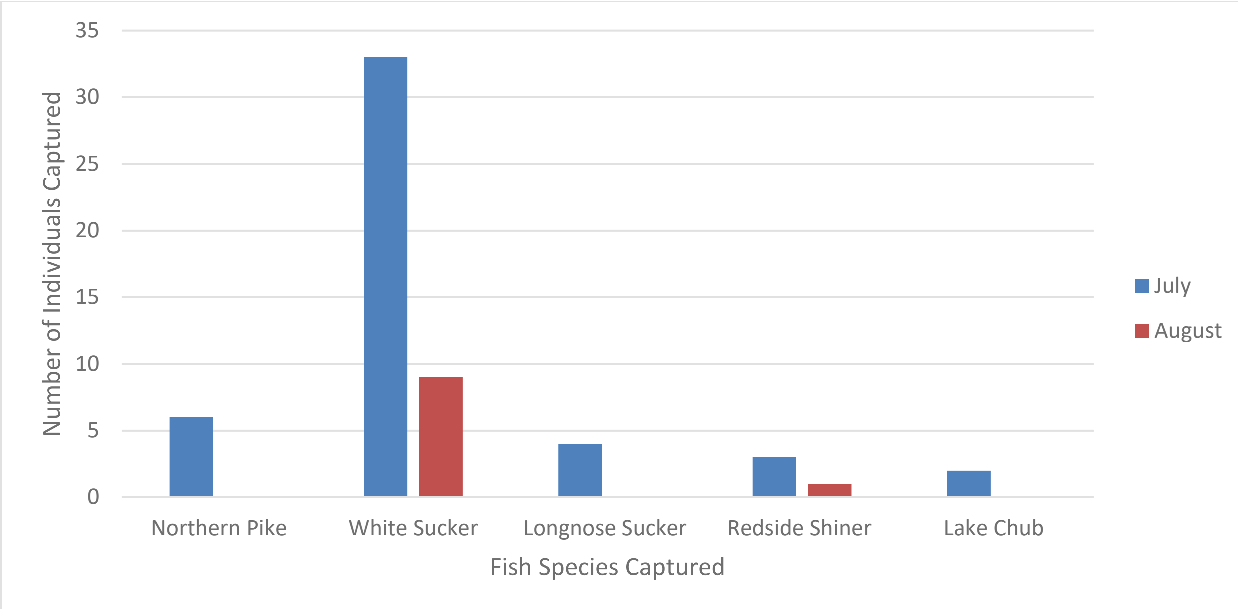

FIGURE 3-2 Species Abundance- Total

Species distribution between the three sampling areas (Figure 3-3) was noted; Northern Pike were captured in both Reach 1 and Reach 2 (Figure 3-3). Longnose Sucker and White Sucker were captured in each sampling reach, Redside Shiner was captured in Reaches 1 and 2, and Lake Chub were only captured in Reach 2 (Figures 3-3 and 3-4).

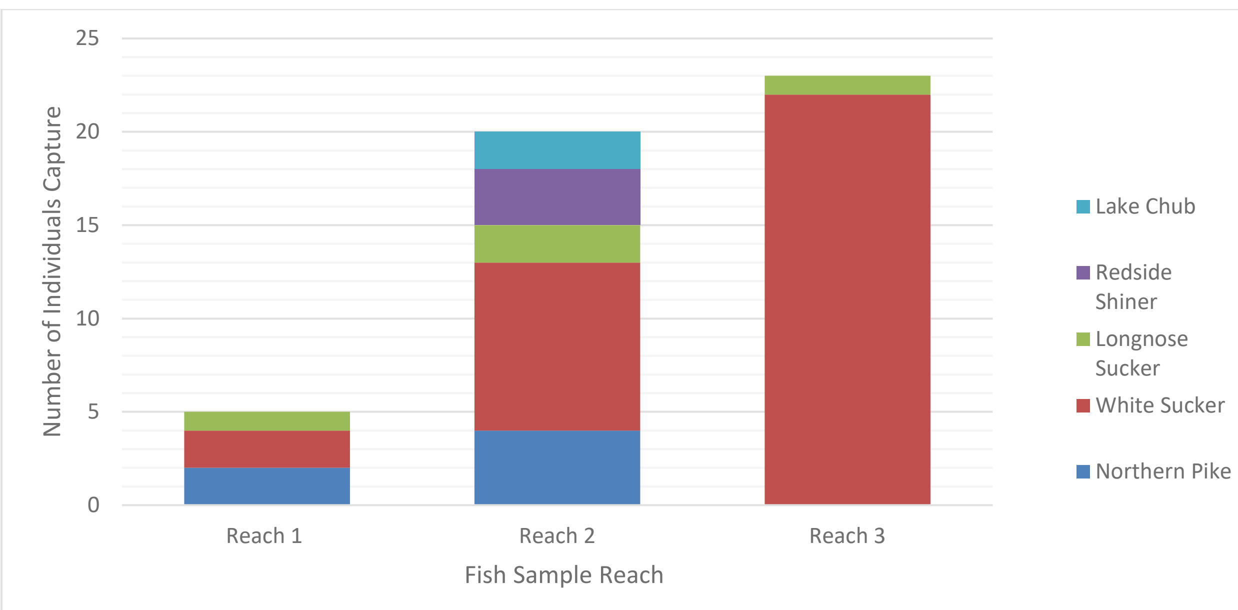

FIGURE 3-3 July Species Abundance- By Sampling Reach

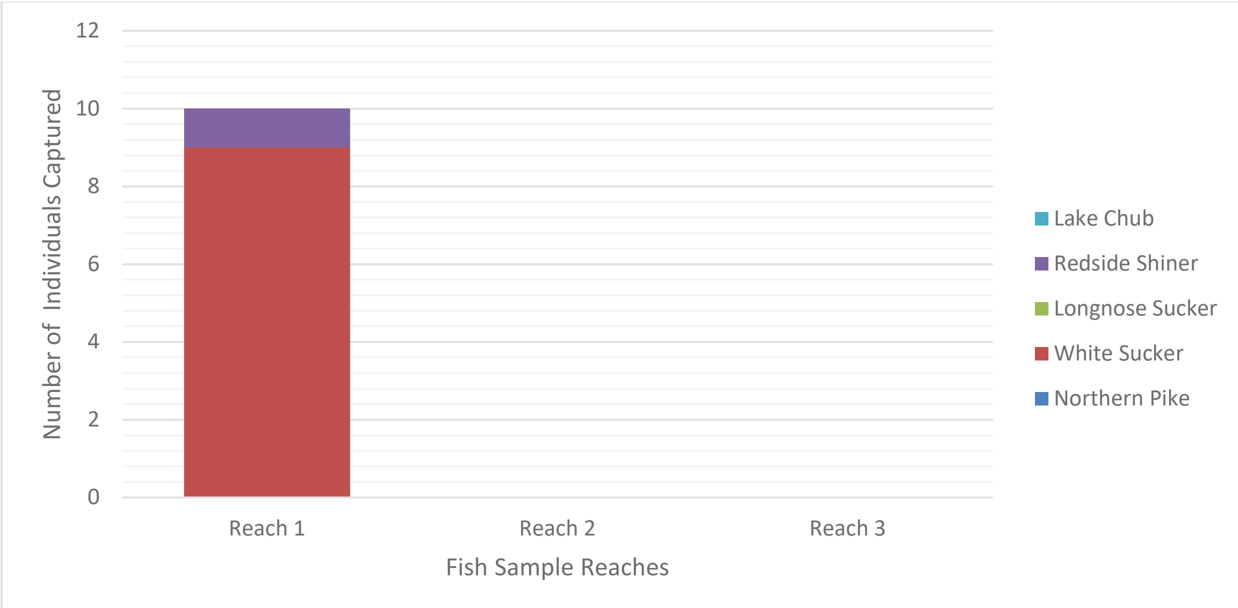

FIGURE 3-4 August Species Abundance- by Sampling Reach (Reach 2 and 3 Were Not Sampled in 2019)

Fish sampling effort in July resulted in the highest fish species diversity (Figure 3-5). White Sucker accounted for the highest portion of fish species captured, representing 70 % of the species composition in July and 90% of the fish species composition in August (Figure 3-5). Lake Chub represented 4% of the total capture in July. In August, Reside Shiner was the only other fish species captured, consisting of 10 % of the species composition in August (Figure 3-5).

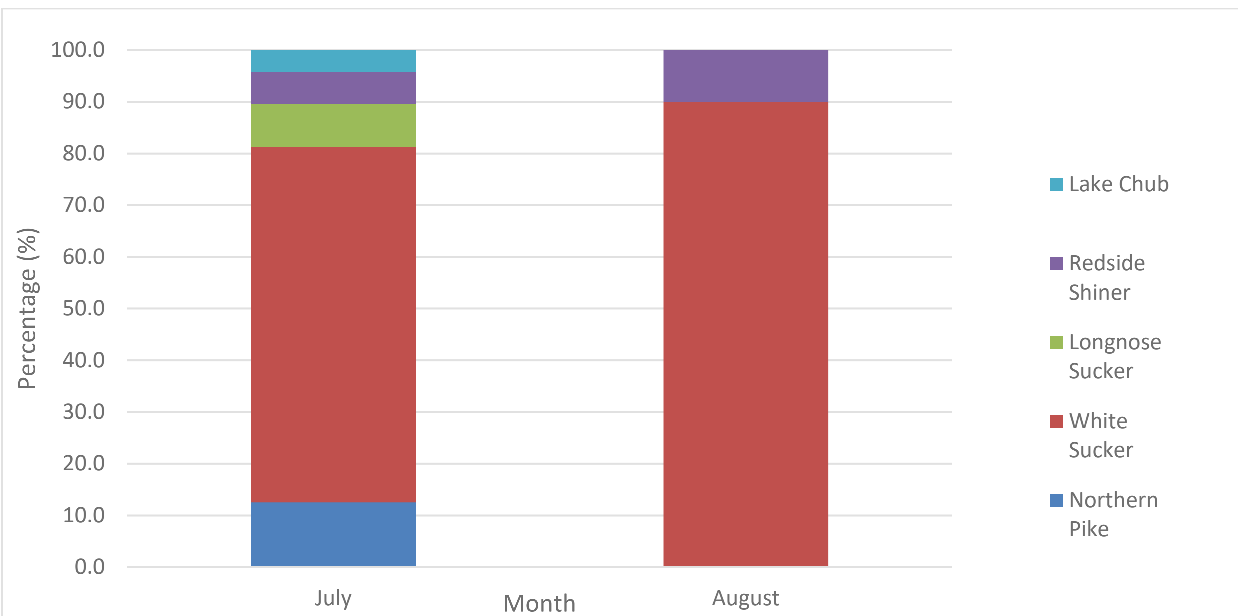

FIGURE 3-5 Species Composition - Total

The July species composition for each reach is presented in Figure 3-6. White Sucker accounted for 67% of the species composition within Reach 1, with Longnose Sucker representing 33%, and Northern Pike accounting for the remaining of the species composition. Species Composition within Reach 2 consisted of White Sucker (45%), Northern Pike (20%), Redside Shiner (115%), Longnose Sucker (10%), and Lake Chub (10%). Reach 3 consisted of 96 % White Sucker, and 4% Longnose Sucker respectfully.

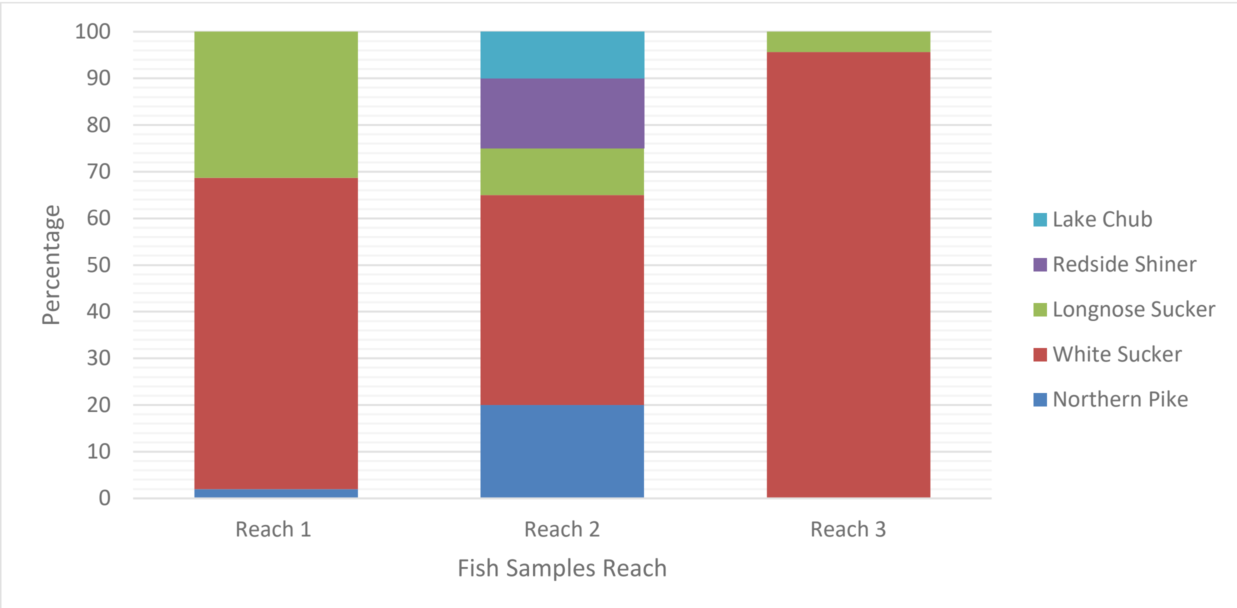

FIGURE 3-6 July Species Composition- by Sampling Reach

Reach 1 was the only location sampled within the study area during the month of August. Fishing efforts resulted in 90% White Sucker of the species composition, with Reside Shiner representing the remaining 10% of the species composition within reach 1 (Figure 3-7).

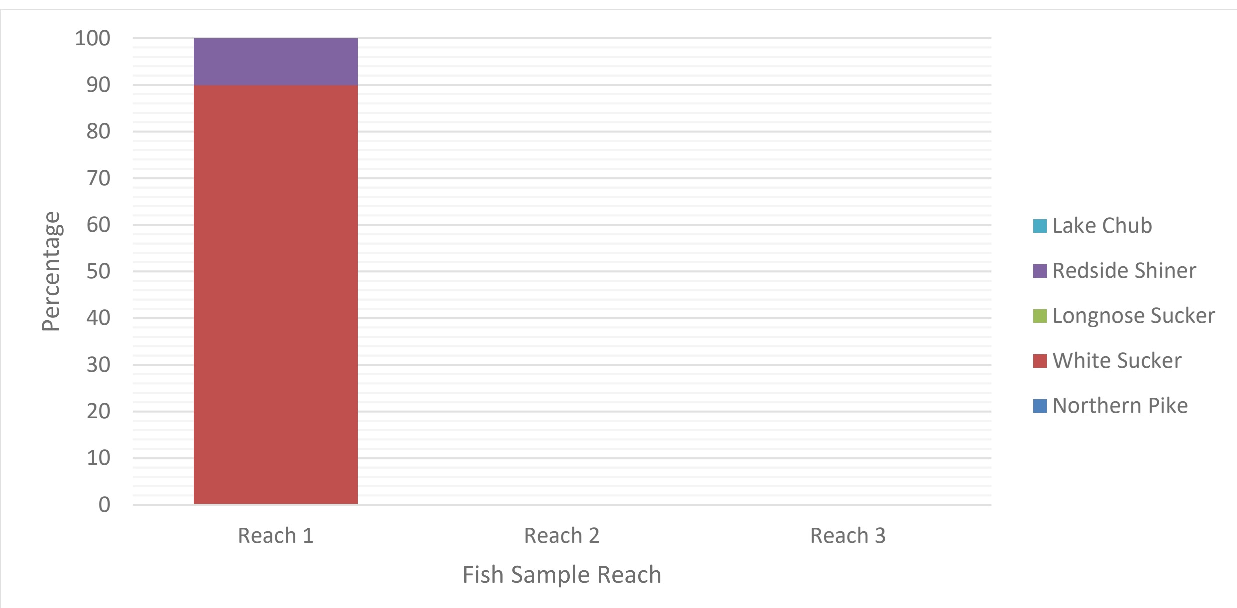

FIGURE 3-7 August Species Composition- by Sampling Reach (Reach 2 and 3 Were Not Sampled)

The CPUE data is displayed in Table 3-5 (electrofishing), Table 3-6 (Angling), and Table 3-7 (Fyke Net). A total effort of 1,948 seconds of electrofishing effort was achieved in July, and 1,132 seconds in August (Table 3-5).

In July, the catch per unit effort was highest for White Sucker (1.6 CPUE), and lowest for Northern Pike (0.1 CPUE) and Lake Chub (0.1 CPUE). Electrofishing effort for Redside Shiner and Longnose Sucker species resulted in a CPUE of 0.2 during the July fish sampling effort. Redside Shiner and White Sucker were the only fish captured during the August fish sampling effort, which results in a CPUE of 0.1 and 0.7, respectfully (Table 3-1).

TABLE 3-5 Catch Per Unit Effort - Electrofishing

Sampling Period	July			August		
Species	Number Captured	Effort (seconds)	CPUE (Fish Captured/100 secs)	Number Captured	Effort (seconds)	CPUE (Fish Captured/100 secs)
Lake Chub	2	1948	0.1	0	1132	0
Longnose Sucker	3	1948	0.2	0	1132	0
Northern Pike	2	1948	0.1	0	0	0
Redside Shiner	3	1948	0.2	1	1132	0.1
White Sucker	31	1948	1.6	8	1132	0.7
TOTAL	**41**	**1948**	**2.1**	**9**	**1132**	**0.8**

Angling effort completed in July resulted in a CPUE of 1.6 (Table 3-6). No fish were captured during the August and October angling effort.

TABLE 3-6 Catch Per Unit Effort - Angling

Sampling Period	July			August			October		
Species	Number Captured	Effort (seconds)	CPUE (Fish Captured/hr)	Number Captured	Effort (seconds)	CPUE (Fish Captured/hr)	Number Captured	Effort (seconds)	CPUE (Fish Captured/hr)
Northern Pike	4	2.5	1.6	N/A	0	0	0	0	0
TOTAL	**4**	**2.5**	**1.6**	**0**	**0**	**0**	**0**	**0**	**0**

In July, fyke net fish sampling effort resulted in a CPUE of 0.0146 for Longnose Sucker and 0.0292 for White Sucker (Table 3-7). Fyke netting completed in August achieved a CPUE of 0.1 for White Sucker; no other species were captured with a fyke net during the August fish sampling effort.

TABLE 3-7 Catch Per Unit Effort - Fyke Net

Sampling Period	July			August		
Species	Number Captured	Effort (seconds)	CPUE (Fish Captured/hr)	Number Captured	Effort (seconds)	CPUE (Fish Captured/hr)
Longnose Sucker	1	68.5	0.01	0	17.8	0
White Sucker	2	68.5	0.03	1	17.8	0.1
TOTAL	**3**	**68.5**	**0.04**	**1**	**17.8**	**0.1**

3.4.2 Size Class

Longnose sucker fork length distribution included 0-50, 51-100 and 151-200 mm (Figure 3-8). In the case of White Sucker, the majority of individuals captured displayed fork length ranges of 151-300 mm (Figure 3-9).

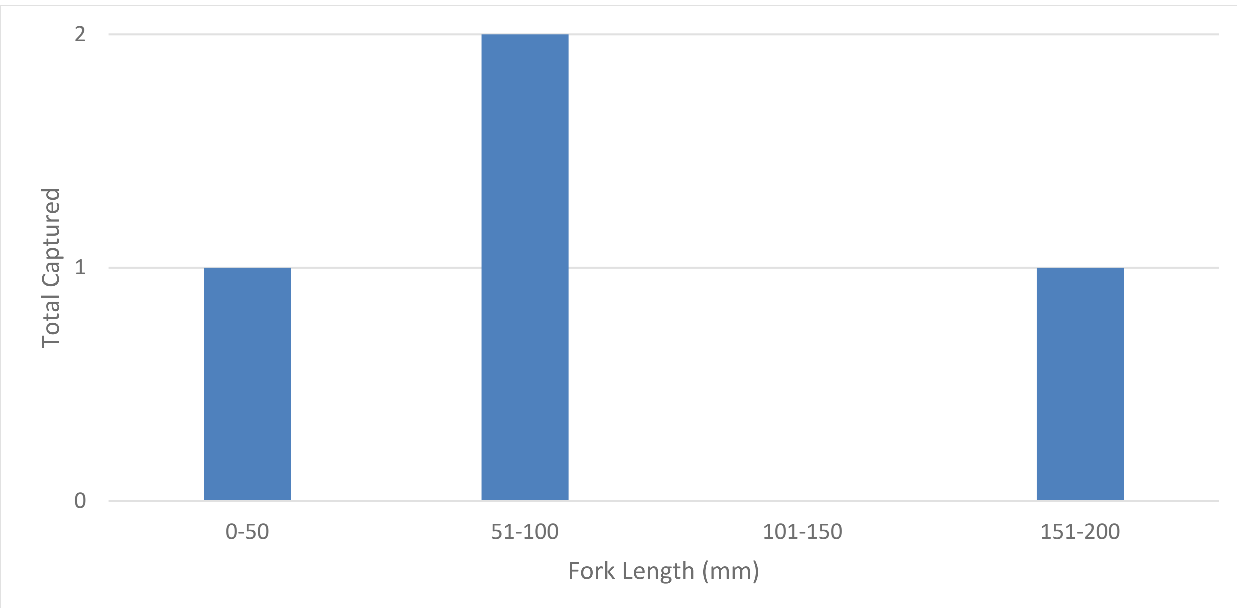

FIGURE 3-8 Longnose Sucker Fork Length Distribution

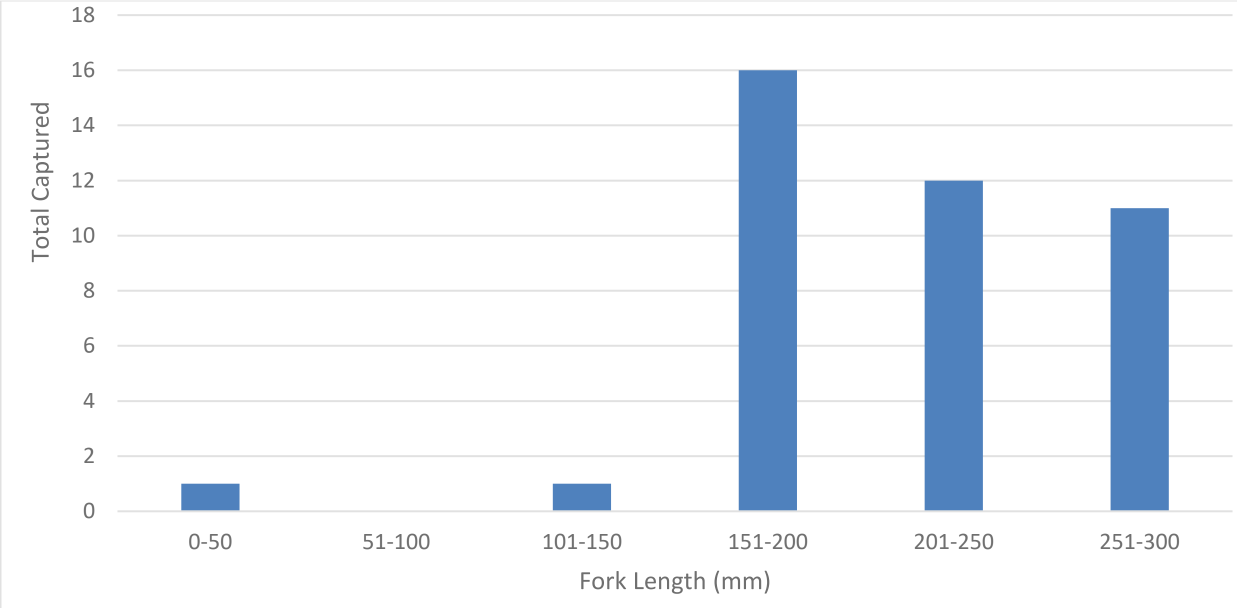

FIGURE 3-9 White Sucker Fork Length Distribution

Fork length for Northern Pike were among the last four fork length ranges, which included 351 to 400 mm, 401 to 450 mm, 451 to 500 mm, 501 to 550 mm (Figure 3-11).

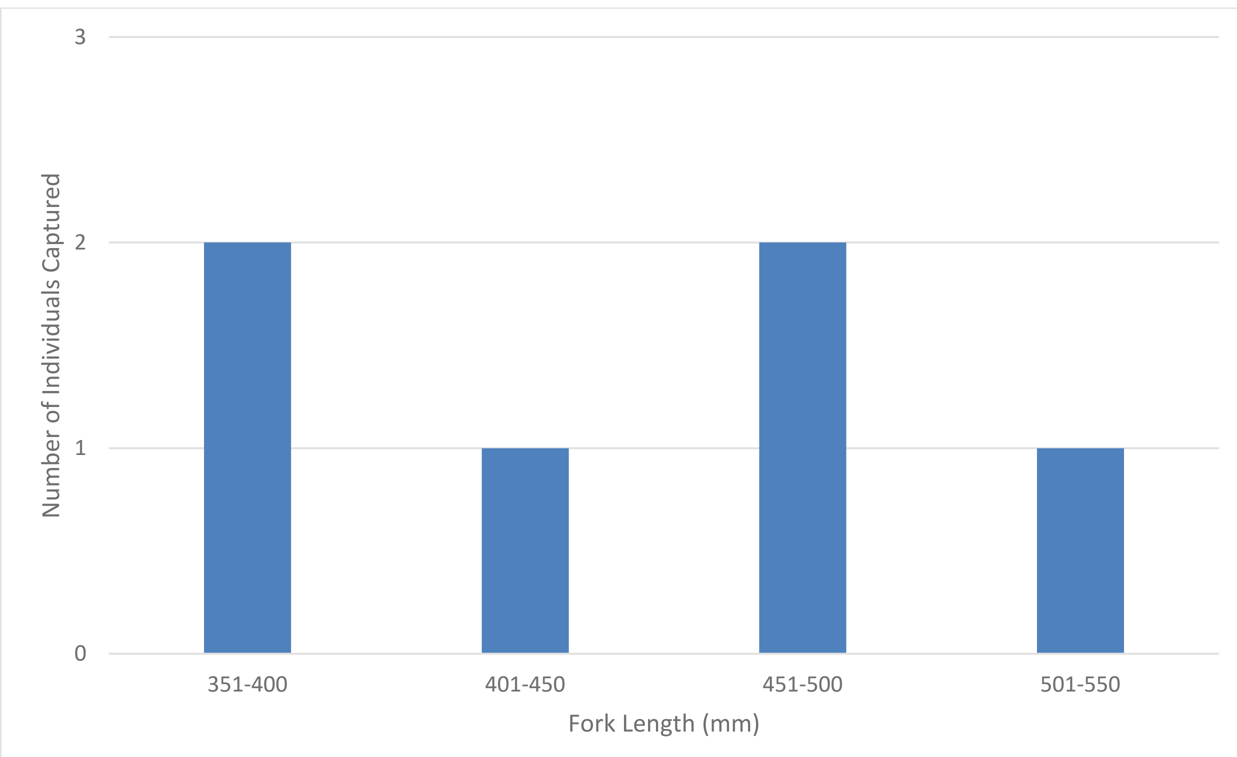

FIGURE 3-10 Northern Pike Fork Length Distribution

3.5 Fish Movement

3.5.1 Floy Tagging

Forty-three fish were tagged during fish sampling effort including 5 Northern Pike, 35 White Sucker, and 3 Longnose Sucker (Table 3-8; Appendix D). No fish were recaptured during consequent fishing efforts.

TABLE 3-8 Floy Tagging Summary

Species	Reach 1	Reach 2	Reach 3	Total
Northern Pike	2	2	0	**4**
White Sucker	11	6	19	**36**
Longnose Sucker	1	1	1	**3**
TOTAL	**14**	**9**	**20**	**43**

3.5.2 Fish Fence/Trap

Two Longnose Sucker and one White Sucker were captured in the fish fence and fyke net trap located upstream of Riffle 1 (weir riffle). None of these fish had floy tags attached. It was unclear whether these fish had moved upstream through the riffle or were resident in this area before the fish fence was installed

3.5.3 eDNA Sampling

Arctic Grayling DNA was not detected in any of the samples analyzed by Hebling Laboratory. Laboratory QA/QC performed using chloroplast DNA amplification was conducted and all samples performed well when tested for chloroplast DNA with the IntegritE-DNA test, meaning that there was ample intact DNA present in the samples, and inhibitory chemicals did not significantly interfere with the qPCR amplifications. Detailed results are presented in Appendix C.

3.5.4 Sonar Videography

A total of 18 hours of sonar camera videography was reviewed for presence of fish and fish movement. Results from the camera work was inconclusive; bed substrates and occasional debris were visible in the video; however, images on the sonar were not clearly presented. Fish presence or movement was not observed.

4 DISCUSSION

Overall, the fish passage improvement area appeared stable and functional. Movement of the riffle materials (cobble and boulders) and erosion and scouring were not observed. Finer materials that settled out within the interstices of the cobble and boulders; flow is remaining on the surface of the riffles; however, all observations of flow over the riffles were observed in high water conditions, so it was not clear if was flowing over the riffles was a function of the fines settling out or the high water conditions.

Fine materials should continue to settle out, and ensure that water flow remains on the surface of the structures, particularly during low flow periods. Water was observed to be flowing over each riffle during all sampling events, and was concentrated through the centre of the channel, achieving one of the design objectives.

Erosion of the steep, unstable south bank has continued to occur. High flows were observed more continuously in 2019 compared to previous years; the pool formed between the two riffle structures is partially intended to slow water velocities and reduce the erosion potential; however, with the longer duration of high flows and already unstable banks, erosion potential was increased in 2019. Woody debris and shrubs have deposited in this area and may provide some erosion protection; however, these materials may continue to shift. The willow plantings that occurred further downstream on the south bank may provide some erosion protection if they are able to establish before further erosion occurs.

In situ water quality data indicated no variation of water quality throughout the sample sites. Monitoring stations downstream are comparable to monitoring stations upstream. In addition, water quality results indicate suitable habitat conditions for sport, sucker, and forage fish species during all sampling events; DO concentrations did not significantly decrease in the summer and fall (flows were higher in October compared to August), and were within Alberta surface water guidelines for the protection of aquatic life. Again, higher water velocities and increase water volumes contributed to improved water quality in the Beaverlodge River throughout the open water season.

July, August, and September 2019 mean monthly flows were above the historical mean. August and September mean monthly flows for 2019 were more than triple the historical mean (Section 3.2). Monitoring during this portion of the hydrograph was of particular interest to determine the success of the design objective of being able to pass fish during flow periods. As flows were higher than average throughout the late summer and fall, downstream migration and movement through the rock riffles was unimpeded. 2019 flow conditions did not allow for observations of fish passage potential during low flows.

Upstream migration potential was assessed based on habitat structure within each riffle and measurement of point velocities. Point velocities within both riffle structures were within flow velocity requirements to accommodate the burst speeds for various sized anguilliform and subcarangiform swimming forms (Section 1.2); although higher velocities were observed in the centre of each riffle, velocities decreased from centre to the edge of the wetted channel. Additionally, the structure of habitat within each riffle was providing suitable holding and resting areas for fish to move upstream. Back water eddies and small pools were present throughout the riffles.

Instream and overhead cover elements were present throughout the assessment reach. Deep water within the runs and pools, along with turbid water, provided the majority of cover. However, woody debris were abundant, particularly along the right downstream bank (south bank), where debris has accumulated and slumping banks have contributed shrub material instream; the majority of fish were captured within these areas. The riffles themselves were providing suitable cover that may be utilized by a range of species, particularly Longnose Sucker and Burbot (Burbot were captured during the 2018 construction fish rescue).

Methods to observe actual fish movement through the riffle structures were inconclusive. Sonar camera videography did not show fish presence within the zone of videography. This does not indicate that fish were not present or moving through the riffle, however it does indicate that the videography may not have been able to capture any fish within the videography zone, or else the movement of fish occurred during a time period when the camera was not recording (recording was limited to 6 hours per day). Fish tagged in the mark recapture program were not recaptured in subsequent fishing effort throughout the season in any of the sampling reaches. Tagged fish may have had their tags come loose, may have moved out of the area of fish sampling effort, or else may have been present in the sampling area and were simply not captured.

The Longnose Sucker and White Sucker captured within the fish fence trap (fyke net) may have passed through Riffle 1; however, given the low numbers captured, these fish may have been present upstream of the riffle and not cleared during fishing effort in this area after the fence was installed, as the fish were not marked in any manner.

Several Northern Pike were captured upstream of the fish fence; again, it is unclear whether these fish are from remnant, resident populations upstream of the weir or if they are from downstream populations that have moved up. The pool downstream of the weir was completely cleared of fish during the construction in 2018, from 30 m upstream of the weir, to 10 m downstream of Riffle 2. Sport, large-bodied and forage fish were present in the cleared area in 2019, indicating that upstream and/or downstream movement has occurred in to this area. Given that no recent fish capture data is available upstream of the riffle to provide an indication of fish presence, community composition and abundance data, it cannot be concluded whether upstream or downstream migration has occurred through the riffles.

5 RECOMMENDATIONS

Monitoring activities will continue to follow the Beaverlodge River monitoring plan (Matrix 2017) with the following recommended changes and additions:

- Sonar camera videography work will be discontinued.
    - Rationale:
        - The sonar camera videography work is temporally limited; the camera is only operating for one quarter of the day, and cannot provide nocturnal fish movement data due to a lack of power source (the run time is limited to the time on site with a generator, and leaving a generator onsite is not practically feasible due to the public access at the site and risk of theft).

    - The camera does not provide additional benefits beyond what a standard fish trap attached to the fish fence would provide; the fish trap is installed for a full 3-day period and is expected to be able to capture fish moving up through riffle. The installation of a fyke net will achieve the same result at a lower cost and with increased fishing effort.

    - Funding/budget to rent the camera and process the data can be put toward more robust methods of assessment, such as an additional tagging program as discussed below.

- Conduct a study using Passive Integrated Transporter (PIT) tags with telemetry location.

  - Rationale: fish can be tagged during the three fish sampling events already undertaken as part of the monitoring program. A stationary telemetry tracking system can be installed directly upstream of Riffle 1, and will be able to monitor fish movement over most of the open water period; a second tracking system may be added to Riffle 2. Adding this study to the monitoring program will not increase the overall yearly monitoring budget. The PIT tag systems are considered a robust method to monitor fish movement and will allow the monitoring of fish movement over a longer duration (e.g., May or June through to October), compared to the 3-day sonar camera program.

- Consider a positive control site for the eDNA sampling program. A site with known Arctic Grayling presence should be sampled to ensure that eDNA is able to be detected. This may coincide with the Red Willow River Arctic Grayling spawning run.

- Backpack electrofishing effort within the riffles, if water velocities and depths are safe for wading.

  - Rationale: observe fish use and species composition within the riffle structures.

- In an effort to increase fishing effort, utilize fyke nets or hoop nets in deeper water.

- Increased monitoring of the erosion along the high, unstable south bank, downstream of Riffle 1.

  - Rationale: more detailed erosional monitoring of this bank should be conducted, as further erosion may pose integrity issues of Riffle 2. This could be achieved through a combination of survey stakes and aerial imagery using an Unmanned Aerial Vehicle.

- Monitor water temperatures at the confluence of the Beaverlodge and Redwillow Rivers to better understand when peak Arctic Grayling movement will occur. Arctic Grayling study on the Redwillow River showed that peak movement coincided with water temperatures of 10°C (Hvenegaard 2001).

Changes to the monitoring program as described above should be approved by DFO before being executed in 2020.

6 REFERENCES

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APPENDIX A
Site Photographs

1. BL1, viewing downstream (May 2019)

2. BL5, viewing downstream (May 2019)

3. BL6, viewing upstream (May 2019)

4. BL1, viewing downstream (July 2019)

5. BL2, viewing upstream (July 2019)

6. BL3, viewing downstream (July 2019)

7. BL4, viewing upstream (July 2019)

8. BL5, viewing downstream (July 2019)

9. BL6, viewing upstream (July 2019)

10. BL1, viewing downstream (August 2019)

11. BL2, viewing upstream (August 2019)

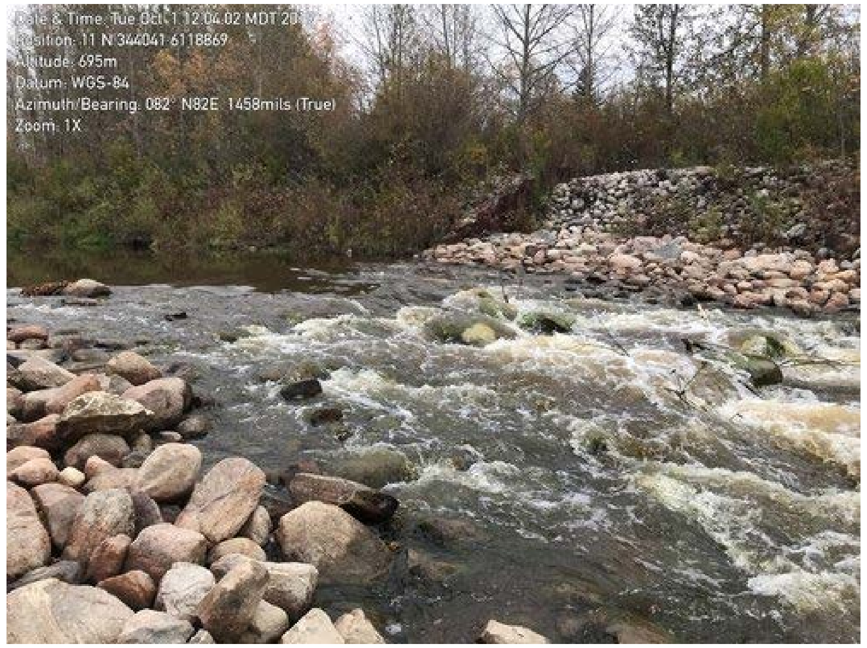
12. BL3, viewing downstream (August 2019)

13. BL4, viewing upstream (August 2019)

14. BL5, viewing downstream (August 2019)

15. BL6, viewing upstream (August 2019)

16. BL1, viewing downstream (October 2019)



17. BL2, viewing upstream (October 2019)

18. BL4, viewing upstream (October 2019)

19. BL3, viewing downstream (October 2019)

20. BL5, viewing downstream (October 2019)

21. BL6, viewing upstream (October 2019)

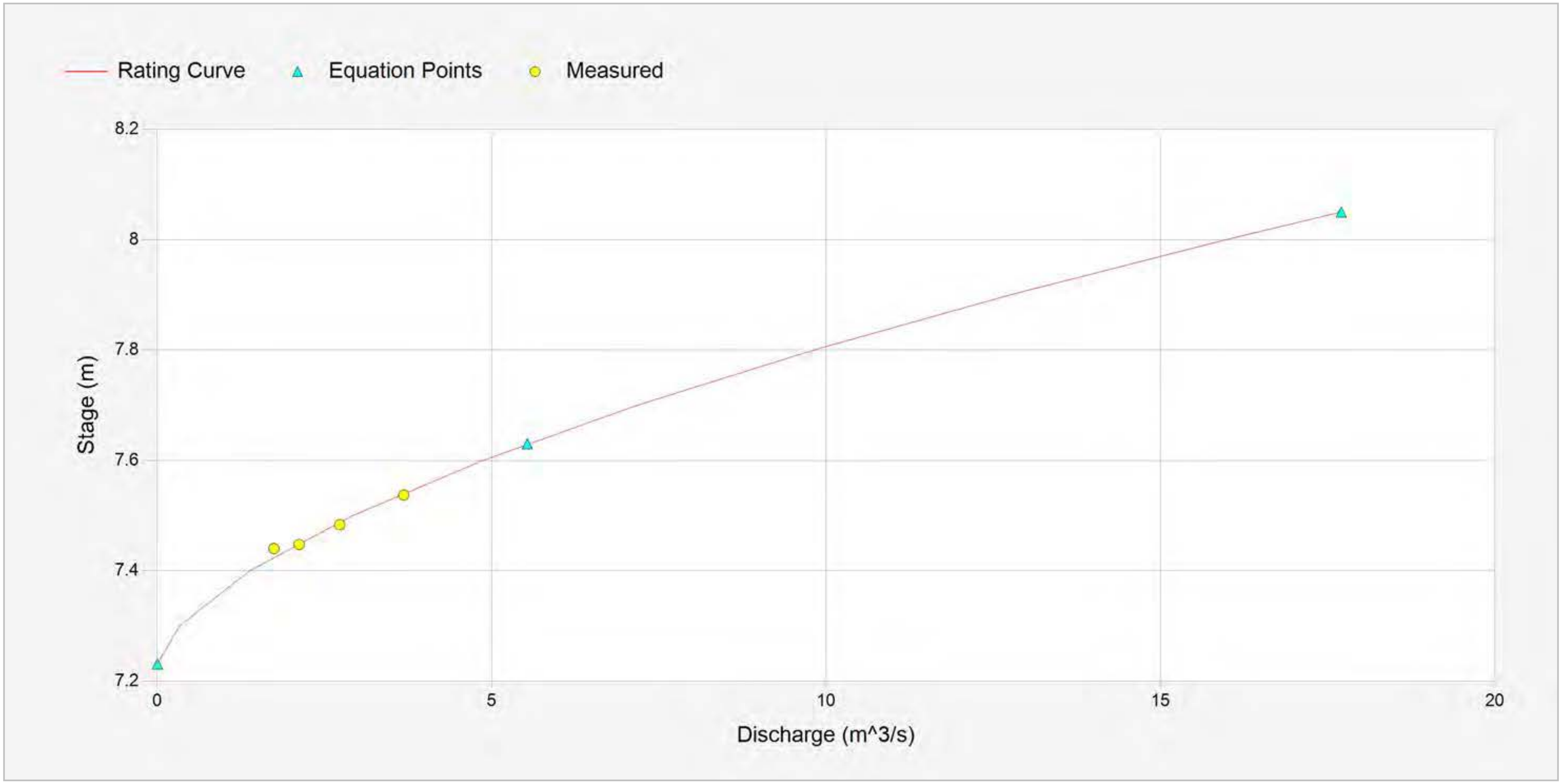
APPENDIX B
Hydrology

Rating Curve

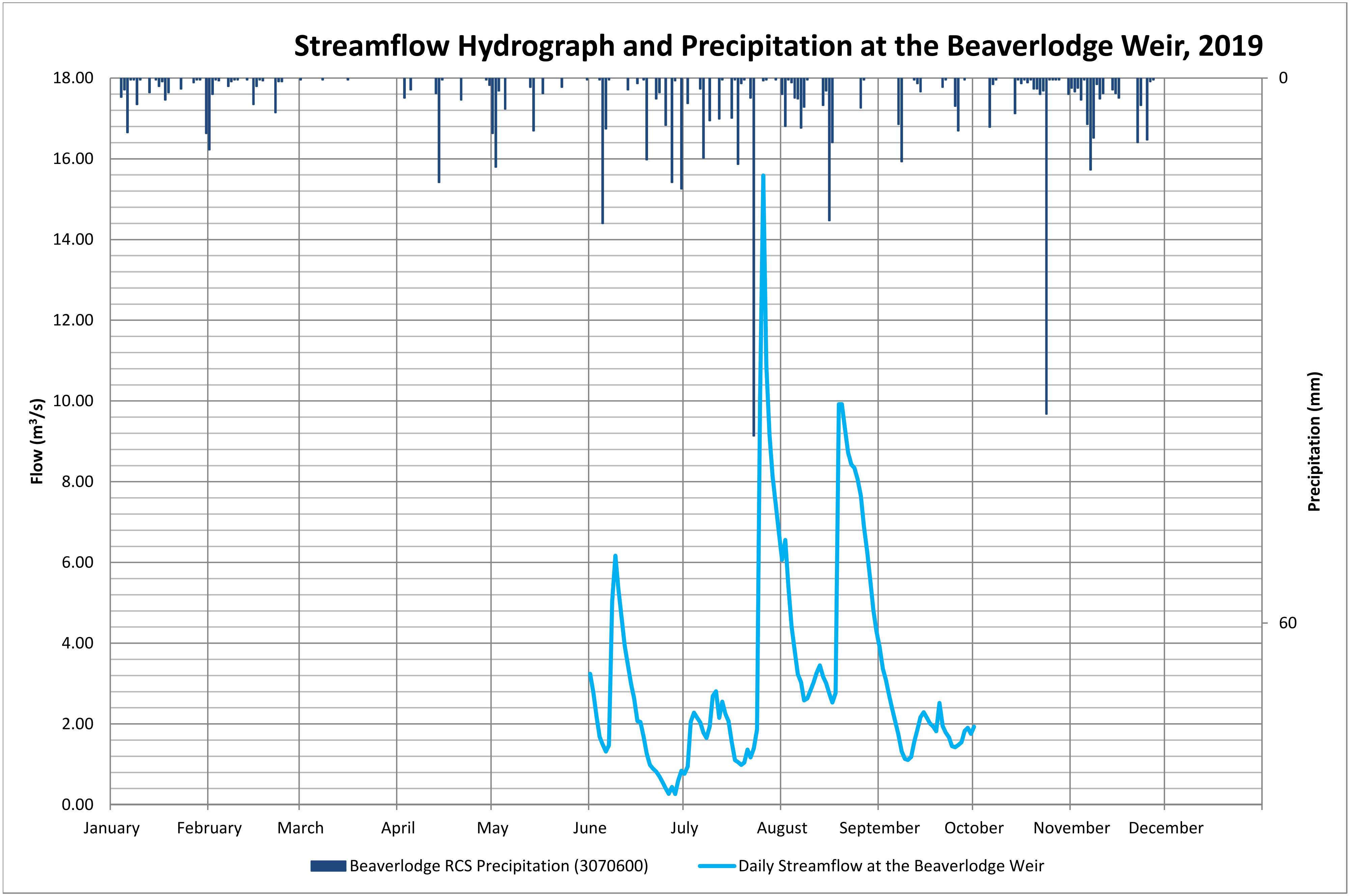
[Untitled Report]

Label: Rating Curve
Description: Site ID-2199-01

Curve on: November 29, 2019 Curve Start Date: May 30, 2019 Location: Beaverlodge River



Date Processed: November 29, 2019 15:27



Streamflow Hydrograph and Precipitation at the Beaverlodge Weir, 2019
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Flow (m³/s)
0
60
Precipitation (mm)
January
February
March
April
May
June
July
August
September
October
November
December
Beaverlodge RCS Precipitation (3070600)
Daily Streamflow at the Beaverlodge Weir

Identifier:	Discharge@2199-01
Location:	Beaverlodge River
Units:	m^3/s

Mean Daily Stream Flow

Year: 2019

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1						3.051 B	0.947 B	6.342 E	3.656 B			
2						2.477 B	1.67 B	6.025 E	3.274 B			
3						1.953 B	2.319 B	4.913 B	2.922 B			
4						1.587 B	2.383 B	4.06 B	2.6 B			
5						1.471 B	2.057 B	3.544 B	2.215 B			
6						1.389 B	1.953 B	3.301 B	2.088 B			
7						3.052 B	1.677 B	2.768 B	1.527 B			
8						6.363 E	1.653 B	2.604 B	1.205 B			
9						5.738 E	2.608 B	2.739 B	1.138 B			
10						5.048 B	2.565 B	2.903 B	1.109 B			
11						4.245 B	2.433 B	3.192 B	1.381 B			
12						3.694 B	2.234 B	3.424 B	1.691 B			
13						3.217 B	2.322 B	3.5 B	2.098 B			
14						2.655 B	2.176 B	3.085 B	2.29 B			
15						2.45 B	1.761 B	2.873 B	2.214 B			
16						2.056 B	1.297 B	2.721 B	2.093 B			
17						1.876 B	1.011 B	2.579 B	2.004 B			
18						1.529 B	1.023 B	5.913 E	1.898 B			
19						1.135 B	0.89 B	10.256 E	1.994 B			
20						0.957 B	0.922 B	9.512 E	2.192 B			
21						0.835 B	1.303 B	8.975 E	1.851 B			
22						0.746 B	1.171 B	8.539 E	1.736 B			
23						0.636 B	1.642 B	8.343 E	1.525 B			
24						0.451 B	3.641 B	8.204 E	1.406 B			
25						0.305 B	15.75 E	7.812 E	1.463 B			
26						0.402 B	12.823 E	7.27 E	1.5 B			
27						0.317 B	9.937 E	6.615 E	1.749 B			
28						0.543 B	8.662 E	5.928 E	1.833 B			
29						0.658 B	7.777 E	5.195 B	1.868 B			
30						0.771 B	7.074 E	4.554 B	1.818 B			
31							6.446 E	4.119 B				
Mean						2.054	3.617	5.22	1.945			
Min						0.245	0.732	2.479	1.027			
Max						6.913	17.358	10.46	3.901			
Total						5323	9688	13980	5040			

Note: Calculated flows are provisional and graded B until the rating is verified further with flow measurements across the full range of high and low flow conditions. For quality grades, see Hydrometric Grading Criteria.

Instantaneous Minimum Flow: 0.245 m3/s on June 25, 2019 at 19:45

Instantaneous Maximum Flow: 17.358 m3/s on July 25, 2019 at 13:30

APPENDIX C
Environmental DNA Results

Helbing Laboratory eDNA Technical Bulletin

All eDNA tools are validated through a rigorous multi-step evaluation protocol that includes tests of DNA target specificity and amplification sensitivity.

General eDNA Assay Information

Target Species	:	Arctic Grayling *(Thymallus arcticus)*
Species Abbreviation	:	THAR
eDNA qPCR Tool	:	eTHAR1
eDNA qPCR Format	:	TaqMan

eDNA Assay Specificity Tests

Multiple qPCR reactions (n=25) performed per target DNA. Detection within the standardized eDNA qPCR assay = Yes

ONTS	ONKI	ONNE	ONGO	ONKE	ONMY	ONCL	THAR	LICA	HOSA	NTC
No	No	No	No	No	No	No	Yes	No	No	No

eDNA Assay Sensitivity Test

DNA (µg/L)	Detection Frequency (n=25)	Binomial Standard error (n=8)
5	96%	7%
1	92%	10%
0.2	88%	11%
0.04	44%	18%
0.008	16%	13%
0	0%	0%

Appendix: Abbreviations

Chinook Salmon(*Oncorhynchus tschawytscha*)	ONTS
Coho Salmon (*Oncorhynchus kisutch)*	ONKI
Sockeye Salmon *(Oncorhynchus nerka)*	ONNE
Pink Salmon *(Oncorhynchus gorbuscha)*	ONGO
Chum Salmon *(Oncorhynchus keta)*	ONKE
Rainbow Trout *(Oncorhynchus mykiss)*	ONMY
Cuttthroat Trout *(Oncorhynchus clarkii)*	ONCL
Arctic Grayling *(Thymallus arcticus)*	THAR
American Bullfrog *(Lithobates(Rana) catesbeiana)*	LICA
Human (*Homo sapiens*)	HOSA
qPCR no template control	NTC
quantitative real-time polymerase chain reaction	qPCR
environmental DNA	eDNA

Master Sort	Sample Number	Location name	Site ID	Sample replicate	Lab Code	Collection date	Day	Month	Year	Collected by	Collection Time	Zone	Easting	Northing	Test for Sps 1	Known Sps 1	DPN	Clean Up Required	IntegritE-DNA Frequency	IntegritE-DNA Call	eTHAR1 Frequency	THAR Lab Call	Biol Call
1	2199190508001	Beaverlodge River	BL1	A	BL1-A	May 8, 2019	08	5	2019	SC	09:42:00	11U	341953	6120032	THAR	No	6	N	4/4	Y	0/8	N	PI
2	2199190508002	Beaverlodge River	BL1	B	BL1-B	May 8, 2019	08	5	2019	SC	09:42:00	11U	341953	6120032	THAR	No	15	N	4/4	Y	0/8	N	PI
3	2199190508003	Beaverlodge River	BL1	C	BL1-C	May 8, 2019	08	5	2019	SC	09:42:00	11U	341953	6120032	THAR	No	13	N	4/4	Y	0/8	N	PI
4	2199190508004	Beaverlodge River	BL2	A	BL2-A	May 8, 2019	08	5	2019	SC	10:18:00	11U	344064	6118883	THAR	No	3	N	4/4	Y	0/8	N	PI
5	2199190508005	Beaverlodge River	BL2	B	BL2-B	May 8, 2019	08	5	2019	SC	10:18:00	11U	344064	6118883	THAR	No	7	N	4/4	Y	0/8	N	PI
6	2199190508006	Beaverlodge River	BL2	C	BL2-C	May 8, 2019	08	5	2019	SC	10:18:00	11U	344064	6118883	THAR	No	2	N	4/4	Y	0/8	N	PI
7	2199190508007	Beaverlodge River	BL3	A	BL3-A	May 8, 2019	08	5	2019	SC	11:40:00	11U	344086	6118822	THAR	No	19	N	4/4	Y	0/8	N	PI
8	2199190508008	Beaverlodge River	BL3	B	BL3-B	May 8, 2019	08	5	2019	SC	11:40:00	11U	344086	6118822	THAR	No	1	N	4/4	Y	0/8	N	PI
9	2199190508009	Beaverlodge River	BL3	C	BL3-C	May 8, 2019	08	5	2019	SC	11:40:00	11U	344086	6118822	THAR	No	18	N	4/4	Y	0/8	N	PI
10	2199190508010	Beaverlodge River	BL4	A	BL4-A	May 8, 2019	08	5	2019	SC	11:00:00	11U	344168	6118856	THAR	No	14	N	4/4	Y	0/8	N	PI
11	2199190508011	Beaverlodge River	BL4	B	BL4-B	May 8, 2019	08	5	2019	SC	11:00:00	11U	344168	6118856	THAR	No	4	N	4/4	Y	0/8	N	PI
12	2199190508012	Beaverlodge River	BL4	C	BL4-C	May 8, 2019	08	5	2019	SC	11:00:00	11U	344168	6118856	THAR	No	10	N	4/4	Y	0/8	N	PI
13	2199190508016	Beaverlodge River	BL6	A	BL6-A	May 8, 2019	08	5	2019	SC	12:24:00	11U	349456	6113145	THAR	No	9	N	4/4	Y	0/8	N	PI
14	2199190508017	Beaverlodge River	BL6	B	BL6-B	May 8, 2019	08	5	2019	SC	12:24:00	11U	349456	6113145	THAR	No	11	N	4/4	Y	0/8	N	PI
15	2199190508018	Beaverlodge River	BL6	C	BL6-C	May 8, 2019	08	5	2019	SC	12:24:00	11U	349456	6113145	THAR	No	17	N	4/4	Y	0/8	N	PI
16	2199190508013	Beaverlodge River	BL7	A	BL7-A	May 8, 2019	08	5	2019	SC	11:50:00	11U	345496	6116482	THAR	No	16	N	4/4	Y	0/8	N	PI
17	2199190508014	Beaverlodge River	BL7	B	BL7-B	May 8, 2019	08	5	2019	SC	11:50:00	11U	345496	6116482	THAR	No	12	N	4/4	Y	0/8	N	PI
18	2199190508015	Beaverlodge River	BL7	C	BL7-C	May 8, 2019	08	5	2019	SC	11:50:00	11U	345496	6116482	THAR	No	5	N	4/4	Y	0/8	N	PI
19	2199190508022	Deionized control	Blank	A	Bnk-A										THAR	No	8	N	4/4	Y	0/8	N	PI

Master Sort	Filter Date	Filter start time	Filter end time	Filtering time (calc)	Sample Volume (ml)	Sample Contents	Preservation Method	Filtered by	Test Priority	Comments	Project Number	Company Name
1	8-May-19	15:46	16:30	0:44	350	Site Water	Silica	SC	1	250- 300 mL of water filte	2199	Matrix Solutions
2	8-May-19	15:47	16:34	0:47	325	Site Water	Silica	SC	1		2199	Matrix Solutions
3	8-May-19	16:33	17:20	0:47	300	Site Water	Silica	SC	1		2199	Matrix Solutions
4	8-May-19	16:45	17:30	0:45	290	Site Water	Silica	SC	1		2199	Matrix Solutions
5	8-May-19	17:15	17:55	0:40	310	Site Water	Silica	SC	1		2199	Matrix Solutions
6	8-May-19	17:38	18:25	0:47	300	Site Water	Silica	SC	1		2199	Matrix Solutions
7	9-May-19	11:25	11:55	0:30	325	Site Water	Silica	SC	1		2199	Matrix Solutions
8	9-May-19	11:25	11:56	0:31	315	Site Water	Silica	SC	1		2199	Matrix Solutions
9	9-May-19	11:56	12:26	0:30	310	Site Water	Silica	SC	1		2199	Matrix Solutions
10	9-May-19	11:57	12:27	0:30	315	Site Water	Silica	SC	1	Sample labelled BL6a - no	2199	Matrix Solutions
11	9-May-19	12:28	13:00	0:32	325	Site Water	Silica	SC	1	Sample labelled BL6b - no	2199	Matrix Solutions
12	9-May-19	12:29	13:02	0:33	315	Site Water	Silica	SC	1	Sample labelled BL6c - no	2199	Matrix Solutions
13	9-May-19	13:05	13:42	0:37	275	Site Water	Silica	SC	1		2199	Matrix Solutions
14	9-May-19	13:04	13:40	0:36	290	Site Water	Silica	SC	1		2199	Matrix Solutions
15	9-May-19	13:43	14:08	0:25	290	Site Water	Silica	SC	1		2199	Matrix Solutions
16	9-May-19	13:44	14:10	0:26	300	Site Water	Silica	SC	1		2199	Matrix Solutions
17	9-May-19	14:12	14:38	0:26	310	Site Water	Silica	SC	1		2199	Matrix Solutions
18	9-May-19	14:12	14:40	0:28	300	Site Water	Silica	SC	1		2199	Matrix Solutions
19		15:45	15:48	0:03			2199	Matrix Solutions				

Laboratory Report of qPCR run controls performed for the eDNA assay

- ☑ qPCR Positive Controls for correct assembly of assay reactions were successful for all technical plate runs
- ☑ qPCR Negative Controls for detection of assay contamination were successful for all technical plate runs

Biologist Status Assignation-RULES:

-Site = **Yes (Y)** if lab call is Yes (2/8 or higher) for at least 1 replicate;
-Site = **Suspected (S)** if lab call is 1/8 for at least 1 replicate;
It is important to note that generally the error rate is highest for 1/8 and 2/8 calls.
-Site = **No (N)** if result is 0/8 for all replicates.

Master Sort	Sample Number	Location name	Site ID	Sample replicate	Collection date	Day	Month	Year	Collection Time	Zone	Easting	Northing	Test for Sps 1	Known Sps 1
1	2199190508001	Beaverlodge River	BLeDNA1	A	May 8, 2019	08	5	2019	09:42:00	11U	341953	6120032	THAR	No
2	2199190508002	Beaverlodge River	BLeDNA1	B	May 8, 2019	08	5	2019	09:42:00	11U	341953	6120032	THAR	No
3	2199190508003	Beaverlodge River	BLeDNA1	C	May 8, 2019	08	5	2019	09:42:00	11U	341953	6120032	THAR	No
4	2199190508004	Beaverlodge River	BLeDNA2	A	May 8, 2019	08	5	2019	10:18:00	11U	344064	6118883	THAR	No
5	2199190508005	Beaverlodge River	BLeDNA2	B	May 8, 2019	08	5	2019	10:18:00	11U	344064	6118883	THAR	No
6	2199190508006	Beaverlodge River	BLeDNA2	C	May 8, 2019	08	5	2019	10:18:00	11U	344064	6118883	THAR	No
7	2199190508007	Beaverlodge River	BLeDNA3	A	May 8, 2019	08	5	2019	11:40:00	11U	344086	6118822	THAR	No
8	2199190508008	Beaverlodge River	BLeDNA3	B	May 8, 2019	08	5	2019	11:40:00	11U	344086	6118822	THAR	No
9	2199190508009	Beaverlodge River	BLeDNA3	C	May 8, 2019	08	5	2019	11:40:00	11U	344086	6118822	THAR	No
10	2199190508010	Beaverlodge River	BLeDNA4	A	May 8, 2019	08	5	2019	11:00:00	11U	344168	6118856	THAR	No
11	2199190508011	Beaverlodge River	BLeDNA4	B	May 8, 2019	08	5	2019	11:00:00	11U	344168	6118856	THAR	No
12	2199190508012	Beaverlodge River	BLeDNA4	C	May 8, 2019	08	5	2019	11:00:00	11U	344168	6118856	THAR	No
13	2199190508016	Beaverlodge River	BLeDNA6	A	May 8, 2019	08	5	2019	12:24:00	11U	349456	6113145	THAR	No
14	2199190508017	Beaverlodge River	BLeDNA6	B	May 8, 2019	08	5	2019	12:24:00	11U	349456	6113145	THAR	No
15	2199190508018	Beaverlodge River	BLeDNA6	C	May 8, 2019	08	5	2019	12:24:00	11U	349456	6113145	THAR	No
16	2199190508013	Beaverlodge River	BLeDNA7	A	May 8, 2019	08	5	2019	11:50:00	11U	345496	6116482	THAR	No
17	2199190508014	Beaverlodge River	BLeDNA7	B	May 8, 2019	08	5	2019	11:50:00	11U	345496	6116482	THAR	No
18	2199190508015	Beaverlodge River	BLeDNA7	C	May 8, 2019	08	5	2019	11:50:00	11U	345496	6116482	THAR	No
19	2199190508022	Deionized control	Blank	A									THAR	No

Master Sort	DPN	Clean Up Required	IntegritE-DNA Frequency	IntegritE-DNA Call	eTHAR1 Frequency	THAR Lab Call	Biol Call	Filter Date	Filtering time (calc)	Sample Volume (ml)	Sample Contents	Preservation Method	Test Priority
1	6	N	4/4	Y	0/8	N	PI	8-May-19	0:44	350	Site Water	Silica	1
2	15	N	4/4	Y	0/8	N	PI	8-May-19	0:47	325	Site Water	Silica	1
3	13	N	4/4	Y	0/8	N	PI	8-May-19	0:47	300	Site Water	Silica	1
4	3	N	4/4	Y	0/8	N	PI	8-May-19	0:45	290	Site Water	Silica	1
5	7	N	4/4	Y	0/8	N	PI	8-May-19	0:40	310	Site Water	Silica	1
6	2	N	4/4	Y	0/8	N	PI	8-May-19	0:47	300	Site Water	Silica	1
7	19	N	4/4	Y	0/8	N	PI	9-May-19	0:30	325	Site Water	Silica	1
8	1	N	4/4	Y	0/8	N	PI	9-May-19	0:31	315	Site Water	Silica	1
9	18	N	4/4	Y	0/8	N	PI	9-May-19	0:30	310	Site Water	Silica	1
10	14	N	4/4	Y	0/8	N	PI	9-May-19	0:30	315	Site Water	Silica	1
11	4	N	4/4	Y	0/8	N	PI	9-May-19	0:32	325	Site Water	Silica	1
12	10	N	4/4	Y	0/8	N	PI	9-May-19	0:33	315	Site Water	Silica	1
13	9	N	4/4	Y	0/8	N	PI	9-May-19	0:37	275	Site Water	Silica	1
14	11	N	4/4	Y	0/8	N	PI	9-May-19	0:36	290	Site Water	Silica	1
15	17	N	4/4	Y	0/8	N	PI	9-May-19	0:25	290	Site Water	Silica	1
16	16	N	4/4	Y	0/8	N	PI	9-May-19	0:26	300	Site Water	Silica	1
17	12	N	4/4	Y	0/8	N	PI	9-May-19	0:26	310	Site Water	Silica	1
18	5	N	4/4	Y	0/8	N	PI	9-May-19	0:28	300	Site Water	Silica	1
19	8	N	4/4	Y	0/8	N	PI		0:03			2199	

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It is important to note that generally the error rate is highest for 1/8 and 2/8 calls.
-Site = **No (N)** if result is 0/8 for all replicates.

APPENDIX D
Tag Data

TABLE A

FloyTagg Data 2019

Beaverlodge River Weir Monitoring Program - SE ½ 34-071-10 W6M

Reach	Season	Species	Number Captured	Length	Tag ID
1	Spring	WHITE SUCKER -WHSC	1	260	17
1	Spring	LONGNOSE SUCKER -LNSC	1	281	18
2	Spring	NORTHERN PIKE -NRPK	1	357	43
2	Spring	WHITE SUCKER -WHSC	1	199	48
2	Spring	WHITE SUCKER -WHSC	1	247	47
2	Spring	WHITE SUCKER -WHSC	1	242	39
2	Spring	WHITE SUCKER -WHSC	1	244	41
2	Spring	LONGNOSE SUCKER -LNSC	1	168	40
2	Spring	NORTHERN PIKE -NRPK	1	519	38
2	Spring	WHITE SUCKER -WHSC	1	265	37
2	Spring	WHITE SUCKER -WHSC	1	215	35
2	Spring	NORTHERN PIKE -NRPK	1	498	13
2	Spring	NORTHERN PIKE -NRPK	1	440	14
2	Spring	NORTHERN PIKE -NRPK	1	491	15
2	Spring	NORTHERN PIKE -NRPK	1	364	16
3	Spring	WHITE SUCKER -WHSC	1	260	34
3	Spring	WHITE SUCKER -WHSC	1	314	33
3	Spring	WHITE SUCKER -WHSC	1	322	32
3	Spring	WHITE SUCKER -WHSC	1	339	31
3	Spring	WHITE SUCKER -WHSC	1	330	30
3	Spring	WHITE SUCKER -WHSC	1	255	29
3	Spring	WHITE SUCKER -WHSC	1	240	28
3	Spring	WHITE SUCKER -WHSC	1	250	27
3	Spring	WHITE SUCKER -WHSC	1	208	26
3	Spring	WHITE SUCKER -WHSC	1	339	1
3	Spring	WHITE SUCKER -WHSC	1	275	2
3	Spring	WHITE SUCKER -WHSC	1	271	3
3	Spring	WHITE SUCKER -WHSC	1	254	4
3	Spring	WHITE SUCKER -WHSC	1	253	5
3	Spring	WHITE SUCKER -WHSC	1	219	7
3	Spring	WHITE SUCKER -WHSC	1	226	8
3	Spring	WHITE SUCKER -WHSC	1	219	9
3	Spring	WHITE SUCKER -WHSC	1	216	10
3	Spring	WHITE SUCKER -WHSC	1	203	11
3	Spring	LONGNOSE SUCKER -LNSC	1	189	12
1	Summer	WHITE SUCKER -WHSC	1	320	19
1	Summer	WHITE SUCKER -WHSC	1	330	21
1	Summer	WHITE SUCKER -WHSC	1	295	22
1	Summer	WHITE SUCKER -WHSC	1	235	23
1	Summer	WHITE SUCKER -WHSC	1	341	24
1	Summer	WHITE SUCKER -WHSC	1	300	25
1	Summer	WHITE SUCKER -WHSC	1	301	51
1	Summer	WHITE SUCKER -WHSC	1	270	52
1	Summer	WHITE SUCKER -WHSC	1	250	53