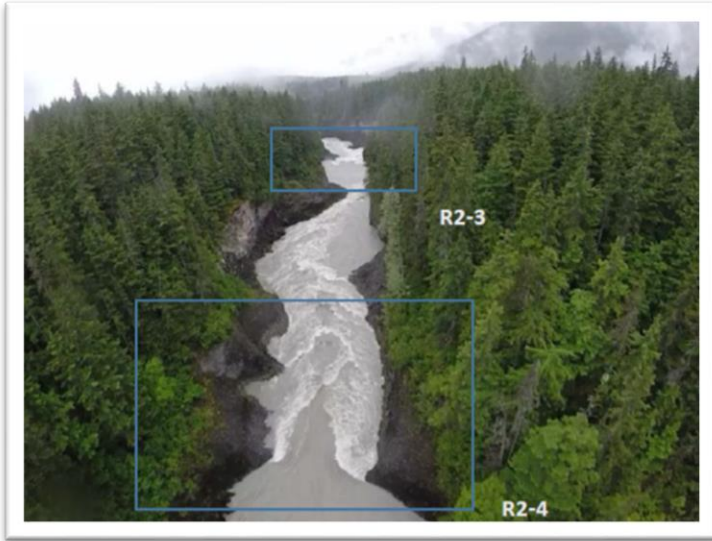


Iskut Watershed Sockeye Salmon Enhancement Feasibility

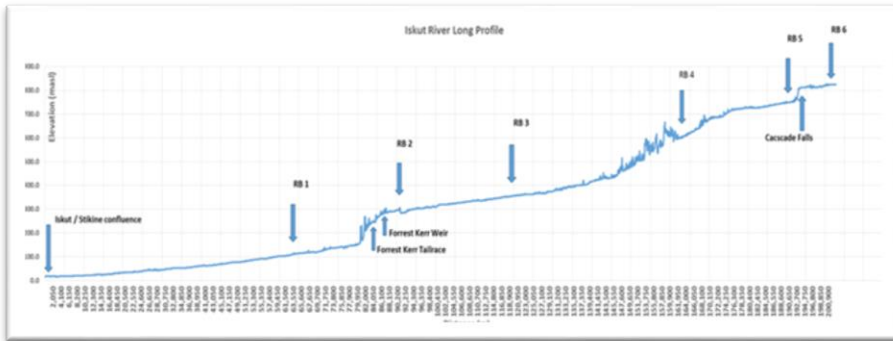


2017 Final Report

Prepared by:
Tahltan Fisheries



and
Fisheries & Oceans Canada



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1.0 INTRODUCTION

1.1 PROJECT SYNOPSIS

Iskut River sockeye are currently known only to spawn in the lower portion of the river. However, in the upper Iskut watershed there are multiple large chain lakes (and additional riverine habitats) that could potentially support substantial salmon production thru enhancement and the provision of migration access.

This was the first year of an initial scoping and reconnaissance exercise to assess the relative feasibility of providing sockeye access to the upper Iskut watershed. The project was jointly implemented by Tahltan Fisheries (TF) and Fisheries & Oceans Canada (DFO), with funding being provided by the Northern Fund (NF) of the Pacific Salmon Commission (PSC). Project activities included: collecting information from literature and mapping; exploratory field surveys; and consultations with involved or affected Parties.

The longer term preliminary concept for this potential enhancement initiative is to: provide for sockeye access (both in and out of the system); initially seed / plant sockeye in the upper watershed; and then monitor subsequent progress. Ideally, a self-sufficient sockeye population could be established, which would limit the need for continued planting or a terminal fishery on the lower river.

1.2 RATIONALE AND OBJECTIVES

Currently there is reliance upon the Tahltan Lake sockeye egg-take / fry planting project as the sole means of achieving the Stikine enhancement production goal (of 100,000 adults). The development of other enhancement opportunities would provide more diversity and greater flexibility to the overall Stikine enhancement program. The intent of diversifying or expanding the existing Stikine enhancement program was reflected in the 2009 Transboundary PST arrangements. It states that: *For the duration of this Chapter, the Parties will pursue a diverse program to enhance sockeye production in the Stikine River...and that...The existing enhancement program may be expanded to include new activities such as barrier removal, habitat improvement and/or other agreed enhancement projects.* (PST Appendix to Annex IV, Chapter 1, section 5.)

This project is also consistent with several goals of the NF which encourages projects such as:

- Integrated planning exercises that will assist in directing restoration and enhancement efforts for stocks of interest (Goal 1: g);
- Provide new habitat for salmon spawning and rearing (Goal 2: b).

The general objectives for the 2017 project were as follows:

1. To collect information regarding the feasibility of providing sockeye access and/or fry out-plants to the upper Iskut watershed;
2. Opportunistically collect information on the habitat or production potential of the upper chain lakes and potential donor stocks;
3. To work with the TBR Enhancement Sub-Committee regarding planning details;

4. To consult with government agencies, local First Nations; and relevant industry regarding issues or opportunities for such an enhancement project;
5. Prepare a final report and present the results for further consideration.

1.3 WATERSHED OVERVIEW

Watershed characteristics for the Iskut River above the Forrest Kerr weir are included in Table 1 below.

Table 1: Iskut River above Forrest Kerr Watershed Characteristics	
Watershed Area	6973 km²
Mean Annual Discharge	256.49 m³/s
Snow/glacier coverage	13.6%
Water surface area	71 km²
Elevation range (min, mean, max)	253m, 1304m, 2264m
Coniferous forest cover	35.6% (2479 km²)
Wetland coverage	0.6% (41 km²)

The total watershed area of the Iskut watershed above the Forrest Kerr / Iskut confluence is approximately 7000 km² with an average annual discharge of 256 m³/second. The Iskut River is a left bank tributary of the Stikine with a confluence located approximately 11 km northeast of the Canada / US border. Iskut River sockeye spawn in a large and diverse network of river channels and secondary groundwater influenced waterbodies in the braided lower 60km of the Iskut River. A detailed breakdown of the fish passage challenges assessed by the 2017 reconnaissance is included in Section 3.4 of this report.

2.0 METHODS

2.1 APPROACH

The scoping and reconnaissance field work was undertaken from August 16th to 21st, 2017 by a joint assessment team from TF and the DFO. Focused field activities included an overflight of the potential migration corridor (PMC) to assess migration obstacles, Lake Limnology sampling, and a foot traverse to Cascade Falls to assess passage enhancement potential.

2.2 AERIAL SURVEY

A helicopter overflight of the PMC was conducted on August 17th, 2017 starting at 11:15am. The general flight path started at the headwaters of the Iskut watershed near the village of Iskut (UTM: 9V441537mE, 6412270mN, 934m asl) and then down to the confluence of the Iskut and Forrest Kerr Creek (9V398852mE, 6289319mN, 248m asl). Survey conditions were fair, with overcast sky and sporadic light rain. Digital video was captured of the entire PMC for obstacle assessment and corridor ichthyo-mechanical analysis. Still photos of features of interest were also taken.

2.3 LAKES – LIMNOLOGY

Boat surveys of Kinaskan, Tatogga and Eddontenajon Lakes were conducted to collect water quality, pelagic invertebrate samples and spot sonar bathymetry data to assess ecological suitability for

enhancement. The methods employed mirrored those used previously at other Stikine lakes, as described below.

General:

There were 1-2 specific limno sampling sites at each of the 3 lakes. Targeted site locations considered an allowance for adequate depth of about 15-20+m during vertical plankton tows. For each site, the GPS location was recorded and the boat was kept on these coordinates for all samples.

Zooplankton:

1. One sample was taken at each site.
2. The plankton net used was 100 micrometers mesh, with a hoop diameter of 50 cm and total length of 1.5 m.
3. Ethanol was used as the preservative at concentrations of roughly 80%.
4. The plankton net on a measured rope line was lowered close to the maximum available depth, without hitting the bottom when deployed. Ensuring the net was straight down from boat, it was then pulled up quickly.
5. Water was splashed on outside of lower part of net (to rinse all plankton into collector).
6. The collector was unscrewed and poured into a 500ml bottle. It was then rinsed out several times with ethanol to get all plankton out.
7. The bottle was labelled with Lake / Site # / Date / SCOR net and "Z" (for zooplankton) on top of the cap.
8. Zooplankton samples were stored in a cool place and then shipped to Zotec Services in Nanaimo, BC for analysis.

Total Phosphorus:

1. One sample was taken at each site using glass test tubes with screw on caps.
2. Lake surface water was filtered thru a funnel that has fine screen on top into the test tube, which was rinsed 3 times and then filled up.
3. A label was attached showing: Lake / Site # / Date.
4. Phosphorus samples were stored in a cool place and then shipped to the DFO – Cultus Lake Lab for analysis.

Chlorophyll A:

1. One sample was taken at each site using 1L plastic bottles (with duct tape on outside) numbered.
2. Lake surface water was filtered thru a funnel that has fine screen on top into the bottle, which was rinsed 3 times and then filled up.

Shore Treatment:

3. 500ml of the water sample was filtered thru a volumetric flask using an attached hand air pump. (The correct filters to use for chlorophyll are: Millipore, MF Membrane Filters, 0.45um HA catalogue number: HAWP04700.)
4. The filter was removed (using rubber gloves and tweezers), folded in half and then wrapped in a piece of tin foil.

5. A label was attached showing: Lake / Site # / Date.
6. Chlorophyll samples were stored in a freezer and then shipped to the DFO – Cultus Lake Lab for analysis.

Additional limno sampling at lake sites:

1. Secchi depths at each site.
2. Water temperature depth profiles for Tatogga and Eddontenajon Lakes at every 1.5m.
3. Temperature, conductivity, dissolved oxygen and pH were taken for each lake at 1.0m depth using a Hanna model HI 98194 multi-meter.

2.4 OTHER ACTIVITIES

- Desk-top data assessment of the historic fisheries resources and biophysical (limnology and bathymetry) data in the study area.
- A foot traverse to Cascade Falls was undertaken to initially assess the fish passage mitigation potential. (Cascade Falls is approximately 7 km below the outlet of Kinaskan Lake and can be hiked to from the trail head on highway 37.
- Groundwater prospecting was conducted using a temperature probe or towed data logger in some of the chain lakes.
- Some minnow trapping was conducted in several tributaries.

3.0 RESULTS

3.1 BACKGROUND INFORMATION**Species Distribution**

The Iskut River system is known to have twenty fish species which include both anadromous and freshwater resident life histories. A full list of species with the potential to occur in the Iskut River and current conservation status is summarized in Table 2. The Iskut River contains two species of conservation concern. Both cutthroat trout and bull trout are blue-listed by the BC Conservation Data Centre (CDC) as species of concern. Bull trout are also identified as a species of special concern by the Committee on the Status of Endangered Wildlife in Canada (B.C. Conservation Data Centre, 2017). The Iskut River contains all five species of Pacific salmon as well as steelhead trout which utilize habitats in the lower 80 km section of the Iskut River for both spawning and rearing. A table summarizing the approximate distribution of fish species based on available information can be found in Appendix A1.

Table 2. Fish species reported to occur within the Iskut River watershed.

Scientific Name	Common Name	*Life History	Provincial	BC CDC	**COSEWIC	Global	*** CF Priority
<i>Lampetra tridentata</i>	Pacific Lamprey	A	S5 (2010)	Yellow		G4 (2012)	6
<i>Oncorhynchus gorbuscha</i>	Pink Salmon	A	S5	Yellow		G5 (1996)	6
<i>Oncorhynchus keta</i>	Chum Salmon	A	S5	Yellow		G5 (1996)	6
<i>Oncorhynchus kisutch</i>	Coho Salmon	A	S4 (2000)	Yellow		G4 (2001)	2
<i>Oncorhynchus mykiss</i>	Steelhead trout	A	S5 (2004)	Yellow		G5 (2008)	6
<i>Oncorhynchus nerka</i>	Sockeye Salmon	A	S4 (2000)	Yellow		G5 (2003)	2
<i>Oncorhynchus tshawytscha</i>	Chinook Salmon	A	S4	Yellow		G5 (1996)	2
<i>Oncorhynchus clarkii clarkii</i>	Cutthroat Trout, clarkii subspecies	A/FR	S3S4 (2004)	Blue		G4T4 (1997)	2
<i>Salvelinus malma</i>	Dolly Varden Char	A/FR	S4 (2011)	Yellow		G5 (2000)	2
<i>Catostomus catostomus</i>	Longnose Sucker	FR	S5 (2010)	Yellow		G5 (2015)	6
<i>Cottus aleuticus</i>	Coast Range Sculpin	FR	S5 (2010)	Yellow		G5 (2015)	5
<i>Cottus asper</i>	Prickly Sculpin	FR	S5 (2010)	Yellow		G5 (2015)	5
<i>Cottus cognatus</i>	Slimy Sculpin	FR	S5 (2010)	Yellow		G5 (2015)	6
<i>Couesius plumbeus</i>	Lake Chub	FR	S5 (2010)	Yellow	DD	G5 (2015)	6
<i>Gasterosteus aculeatus</i>	Threespine Stickleback	FR	S5 (2010)	Yellow		G5 (2012)	6
<i>Lota Lota</i>	Burbot	FR	S4 (2004)	Yellow		G5 (2015)	2
<i>Oncorhynchus mykiss</i>	Rainbow Trout	FR	S5 (2004)	Yellow		G5 (2008)	6
<i>Prosopium williamsoni</i>	Mountain Whitefish	FR	S5 (2010)	Yellow		G5 (1996)	6
<i>Salvelinus confluentus</i>	Bull Trout	FR	S3S4 (2011)	Blue	SC(2012)	G4 (2011)	2
<i>Thymallus arcticus</i>	Arctic Grayling	FR	S4 (2004)	Yellow		G5 (2015)	4

* Life History: A = Anadromous FR = Fresh Water Resident

** COSEWIC = Committee on the Status of Endangered Wildlife In Canada

*** CF = Conservation Framework

The distribution of fish species within the Iskut River drainage is restricted by a number of barriers which limit upstream migration. Deeply entrenched and often narrowly confined canyon sections exist on the Iskut River containing chutes and velocity barriers which constitute a barrier or hindrance to the upstream movement of fish. Cascade Falls located immediately below Kinaskan Lake represents a total barrier to upstream fish movement and establishment of fish ascension at this location would require the construction of a fish passage structure and/or modification of the stream channel. A table summarizing known barriers and/or challenges to fish passage on the Iskut River is provided in Appendix A2.

Lower Iskut River

For the purposes of this report, the lower Iskut will be considered the portion of the river commencing at the Iskut/Stikine River confluence and extending upstream to the mouth of Snippacker Creek. This stretch of river is characterized by a wide, braided channel with a gradient between 0.0 - 0.3% (Hawthorn, Grant & Karanka, 1984). The lower braided channel of the Iskut River provides an abundance of fish habitat, with some of the highest quality habitats found in clear water side channels. The lower Iskut River supports a diverse assemblage of freshwater fish species which includes most species that occur within the lower Stikine River.

Some of the major tributaries entering the lower Iskut River include the Johnson River, Inhini River, Hoodoo River, Zippa River, Craig River, Twin River, Bronson Creek, Verrett River and Snippacker Creek. Most tributaries flowing into the lower Iskut River are characterized by steep canyon topography and cold, turbid glacial flows. For this reason, few tributaries entering the lower Iskut main stem contain

abundant high quality fish habitat. The Craig River is one exception, as it has a low gradient stretch of river which contains excellent fish habitat (Hawthorn et al., 1984). A number of low gradient alluvial fans occur where tributary streams enter the Iskut River and these provide fish habitat and important spawning areas for a number of species, including Chinook, pink, chum, coho and sockeye salmon as well as steelhead trout.

Middle Iskut River

For the purposes of this report, the middle Iskut is considered the section of river extending from the Iskut River/Snippacker Creek confluence to approximately 7 km upstream from the mouth of More Creek. The middle reach of the Iskut River is approximately 70 km long and consists of both high gradient erosional canyon sections as well as low gradient depositional braided sections. The Iskut becomes highly entrenched in what is known as the Iskut River Canyon (A.K.A: Forrest Kerr Canyon, Iskut Gorge) which is characterized by a chute cascade complex with water velocities that often exceed 2-3 m/s (Zurkirchen and Bahr, 2005). This canyon section is approximately 20 km long, commencing just below Snippacker creek and continuing upstream to immediately above Volcano Creek. This section of the Iskut River and its tributaries contain minimal quality fish habitat due to the steep canyon topography that dominates this reach. The canyon is considered to be a complete barrier to the upstream movement of fish species and no anadromous species have ever been reported upstream of the Iskut River Canyon (Hawthorn et al., 1984). Approximately 3 km upstream of the Forest Kerr Creek confluence the Iskut channel widens considerably and becomes highly braided with a low gradient and numerous side channels which mirror stream characteristics found in the lower Iskut River. Several sections of good fish habitat exist throughout low gradient sections of the upper Iskut mainstem, primarily in clear water side channels. Some of the larger tributaries entering the middle Iskut River section include Forrest Kerr Creek, Ningunsaw River, Devil Creek, Thomas Creek and More Creek. Most of the tributary streams are fed by glacial melt and as a result are typically turbid. The largest tributaries located within this river reach, including Forest Kerr and More Creek, carry enormous volumes of suspended material resulting from glacial erosion, landslides, and avalanches (Hawthorn et al., 1984). These sediment loads are deposited within low gradient sections of the Iskut River creating a shifting braided river morphology.

Sockeye and coho salmon, as well as steelhead trout, are known to enter the lower Iskut Canyon. In September 2015 sockeye salmon were captured in the McLymont Hydroelectric Facility tail race located below the McLymont River/Iskut River confluence and a single Coho salmon was also observed near McLymont creek in 2005 (Kurtz and Lewi, 2016). Sockeye salmon have been observed near the mouth of Jennifer creek which is located 1.5 km upstream of the McLymont Creek/Iskut River confluence (Kurtz and Lewi, 2016). Jennifer Creek was previously considered to be the upper limit of anadromous fish migration within the Iskut River (Zurkirchen and Bahr. 2005).

Recent observation and research stemming from hydroelectric projects situated within the Iskut River canyon area indicate that anadromous fish species are able to migrate higher within the system than previously thought possible. Steelhead trout have been reported immediately downstream of the Forrest Kerr Hydroelectric generating facility tailrace as well as within the tail race itself (Sherstone and Lewis, 2017). Steelhead trout found within the Forest Kerr Hydroelectric Project tail race represent the furthest observed upstream migration of any anadromous fish species reported on the Iskut River. It is unconfirmed if salmon and steelhead trout spawn successfully within the lower portion of the Iskut

River canyon below the Forrest Kerr facility tailrace. This area includes McLymont and Jennifer Creek and is considered to have limited salmon spawning and rearing habitat (Kurtz and Lewi, 2016). Further investigations are required to determine if these fish are straying from lower reaches of the Iskut River or if they are successfully spawning in the lower canyon.

The uppermost barrier to upstream, seasonal fish migration is considered to be a chute located near km 80 on the Iskut River, about 260 m below Forrest Kerr Creek and immediately below the Forrest Kerr Hydroelectric Project diversion weir (McLean and Lewis 2002; Zurkirchen and Bahr, 2005). The vertical drop at the chute below the intake weir is approximately 3 m at low flow levels, with a length of approximately 5 meters. Another chute/rapids occur upstream of that location consisting of a 2 m drop that would also present a hindrance and potential barrier to upstream fish movements. The water is flowing through both these features at velocities exceeding 3 m/s (Zurkirchen and Bahr, 2005). The effects that the construction of the Forrest Kerr Hydroelectric Project diversion weir may have on these barriers should be further explored. It is possible that construction of the diversion weir and creation of the head pond may have altered the hydrology of these features, possibly making the conditions for fish passage more favorable. The diversion weir associated with the Forrest Kerr Hydroelectric facility creates an impoundment which also limits fish movement (Sigma Engineering Ltd., 2016).

Both bull trout and dolly varden are present in the Iskut River watershed and these species can be difficult to differentiate. Bull trout and dolly varden have been reported within the Iskut River canyon, including the 2 km stream section located immediately downstream of the Forrest Kerr tail race area, the canyon section above the tail race and Forrest Kerr Creek itself (Sherstone & Lewis, 2017). Hybridization is also possible between the two species and dolly varden/bull trout hybrids have been previously documented on the Iskut River (Shell, 1998). The BC Fisheries Information Summary System (FISS) Database and Mapping tool indicates that bull trout and dolly varden range as far upstream on the Iskut as the braided reach located above the mouth of Moore Creek (DFO & MoCCS, 1997). A literature review has revealed that conflicting reports exist regarding the distribution of *Salvelinus* species within the middle Iskut River system (Shell, 1998; McLean & Lewis, 2002; Zurkirchen and Bahr, 2005). A number of sources indicate that dolly varden and bull trout exist in sympatry within the Iskut River and tributaries located above the Iskut River Canyon (Hawthorn et al., 1984; Shell, 1998; DFO & MoCCS, 1997). Shell (1998) reported that DNA samples collected from *Salvelinus* species captured during sampling on the Iskut River indicate that both dolly varden and bull trout occupy the Iskut River above the Iskut River canyon, including Forrest Kerr Creek, Ningunsaw River and More Creek. However, McLean & Lewis (2002) claim that only bull trout are present in Forrest Kerr Creek as well as the Iskut canyon upstream of the Iskut River. McLean & Lewis (2002) based their conclusion on identification conducted by J. D McPhail at UBC in 1997, who confirmed that all specimens recovered above the canyon were bull trout based on their morphology and physical characteristics. Further investigation is required at this time to determine the full extent and species distribution of dolly varden and bull trout within the Iskut River system.

In addition to the species previously mentioned, the middle Iskut also contains mountain whitefish, slimy sculpin, and rainbow trout (Zurkirchen and Bahr, 2005; Shell, 1998; McLean & Lewis, 2002; Hawthorn et al., 1984). There is very little information available describing the fish species distributions upstream of Forest Kerr Creek. There is no evidence that anadromous fish species have ever been reported to exist above the canyon, which supports the premise that it acts as a barrier to upstream movement. It is suspected that mountain whitefish, slimy sculpin, rainbow trout, dolly varden and bull trout have the potential to occur throughout the entire middle Iskut River extending from Snippaker Creek to the braided reach located above More Creek.

Upper Iskut River

For the purposes of this report, the upper Iskut will be described as the portion of the Iskut River commencing approximately 7 km upstream of More creek to the furthest reaches located in the upper headwater tributaries. This river section includes a number of waterbodies including Natadesleen, Kinaskan, Tattoga, Eddontenajon, Kluachon, Todagin, Kluea, and Ealue Lakes. Mowdade Lake is located near the headwater divide of both the Klastline and Iskut River watersheds and it appears that the lake may share some level of connectivity with both systems. DeGisi and Burrows (1996) suggest that Mowdade Lake is part of the Klastline River Drainage. The Habitat Wizard mapping tool located on the FISS Database and Mapping website indicates that Mowdade Lake is part of the Iskut River watershed. An overflight in August of 2017 confirmed that Mowdade Lake appears to be connected to the Little Iskut watershed via a low gradient wetland located on the south end of the lake.

Some of the major tributaries that feed the upper Iskut River include the Little Iskut River, Ball Creek, Durham Creek, Burrage Creek, Eastman Creek, Willow Creek, Todagin Creek, Jackson Creek, Coyote Creek, Mabon Creek, and Kluchon Creek. Cascade falls located approximately 700 m downstream of Natadesleen Lake is considered to be a complete barrier to upstream fish migration. The river splits into two separate channels at the location of the falls. The channel on river right drops approximately 40 m over a distance of 210 m at an average slope of ~ 6 % (Google Earth Pro, 2017). The channel river left drops approximately 45 m over a distance of 400 m with an average slope of 7.4%. (Google Earth Pro, 2017).

There is very limited information regarding species composition and distribution within the upper Iskut River watershed. The species presence/absence from the braided reach located 7 km upstream of More Creek to the base of cascade falls is poorly understood and no documented recordings of any fish species within this section of the upper Iskut River were uncovered (Habitat Wizard, 2017). It is suspected that species found within the Middle Iskut River including bull trout, dolly varden, rainbow trout, slimy sculpin and mountain whitefish may range upstream of More Creek to the base of cascade falls but no reports have been found to confirm this. It is possible that barriers located in the upper canyon reaches, and particularly the barrier located approximately 5.6 km upstream of Barrage Creek, may limit the upstream distribution of these species. Previous reports have indicated that the headwaters of the Iskut River located upstream of Cascade falls and including Natadesleen, Kinaskan, Eddontenajon, Tatogga, and Ealue Lake support a unique monoculture population of rainbow trout (Melymick, 2013, DeGisi and Burrows, 1996). Field observations made during surveys conducted in August 2017 have confirmed the presence of rainbow trout within the chain lakes and tributaries located above cascade falls. The origin this rainbow trout population is unknown, however, McLean and Lewis (2002) suggest that these fish were introduced many years ago and have since established a naturally reproducing population. Further research and investigation is required at this time to confirm the presence of a rainbow trout monoculture within the upper Iskut River watershed.

The headwater lakes including Natadesleen, Kinaskan, Tatogga and Eddontenajon support a renowned rainbow trout fishery that constitutes an important provincial resource. The pristine wilderness setting and the road accessible access make the region a popular angling destination and freshwater fishing is one of the most popular tourism activities along Highway 37 (Melymick, 2013). The tourism industry supports a number of businesses including campgrounds and lodges, transportation services, and sport fishing guides. This rainbow trout fishery also represents an important food source and recreational opportunity for local residents. A creel conducted at Kinaskan Lake provincial campground in 1991

indicated that fishing success was excellent with 8,775 rainbow trout caught between May 15 to September 30th and a catch rate of 1.63 fish/hr (De Leeuw, 1992).

Iskut River Hydroelectric Generating Facilities

Concerns exist regarding current and proposed run-of-river hydroelectric generating facilities on the Iskut River and how these facilities might affect fish populations and habitat. A complete list of Iskut run-of-river hydroelectric projects that are operational or proposed is summarized in Appendix A3. Current Iskut River hydroelectric projects consist of three separate facilities owned and operated by AltaGas Ltd. which include the Forrest Kerr Hydroelectric Project, McLymont Creek Hydroelectric Project and Volcano Creek Hydroelectric Project. Alaska Hydro Corporation's More Creek hydroelectric project is a proposed facility for which an environmental assessment is currently in progress.

The 195 megawatt (MW) Forrest Kerr facility is the largest of the three facilities and located on the Iskut River main stem (McLean & Lewis, 2002). To generate electricity, water flows through turbines in an underground powerhouse located approximately 3.7 km downstream of the Forrest Kerr/Iskut River confluence. The 66 MW McLymont Creek Hydroelectric project is located on McLymont Creek, with the powerhouse and tail race located on the north bank of the Iskut River 1.1 km downstream of the McLymont Creek/Iskut River confluence (Ganshorn, Lewis, & Faulkner, 2016). The Volcano Creek Hydropower Project is an 18 MW run of river hydropower project located on Volcano Creek. A 150 m long penstock conveys flows to a powerhouse located on the left bank of Volcano Creek approximately 2.9 km upstream of the confluence of Volcano Creek and the Iskut River (AltaGas Renewable Energy Inc., 2012). Alaska Hydro Corporation's More Creek Hydroelectric project is a proposed 75 MW project that would be located approximately 2.5 km upstream from More Creek's confluence with the Iskut River. The proposed project will involve the diversion of 80 m³/s from Moore Creek as well as the flooding of 2,104 ha for development of a water storage reservoir for power generation (Sigma Engineering Ltd., 2016).

With run-of-river hydroelectric projects, there exists the potential for fish to become entrained in the intake tunnel. This is of particular concern at the Forrest Kerr facility which is located on the Iskut River mainstem and has the potential to impede or injure fish migrating past the facility. When the Forrest Kerr facility was constructed it was assumed that there would be very few fish in the area at any time of year and no considerations were taken into account for the annual migrations of anadromous fish species (Zurkirchen and Bahr, 2005). There currently exists a risk that fish may enter the Forrest Kerr intake and become entrained. However, efforts have been made to mitigate these risks by reducing intake velocities to <1 m/s and a fishway has been constructed to facilitate upstream fish passage from the sluiceway channel to the headpond. (Zurkirchen and Bahr, 2005). The Forrest Kerr Hydroelectric facility includes a fishway with the intended purpose of allowing upstream migration of fish from the sluiceway channel to the head pond. Past monitoring has indicated that the fishway is not functioning as intended as a result of sediment deposition as well as the entrainment of woody debris. As a result, fish would be unable to pass upstream from the sluiceway channel to the head pond under most conditions (Swain et al., 2017). There are also potential negative effects for downstream migrating fish resulting from passage through the Forrest Kerr sluiceway channel and box culvert. Fish passing through the box culvert may be injured as a result of rapid or extreme pressure changes, strike, turbulence and shear stress. However, injuries resulting from fish passage through the box culvert and sluiceway channel are anticipated to be minimal at proposed flow rates (Lewis, 2012). Both McLymont

Creek and Volcano Creek are considered fishless at the location of the intake and diversion weirs as a result of velocity barriers located downstream. Because the upstream reaches containing the intake works are non-fish bearing there is very little chance for fish to become entrained or injured. The proposed location of the More Creek weir and intake structure is also deemed to be devoid of fish.

Changes to river hydrology and flow rates resulting from hydropower facility operations on the Iskut River have the potential to cause stranding mortality. All three run-of-river hydroelectric facilities currently in place on the Iskut River, as well as the proposed More Creek facility, have the potential to strand fish as a result of reduced stream flow resulting from down ramping. Flow down ramping refers to the diversion of flow from the intake channel and penstock to the sluiceway channel, resulting in a temporary reduction in stream flow below the power generation facility tail race. This reduction in flow persists downstream until the water which has been diverted to the sluiceway channel reaches the tail race and normal flow rates are once again achieved. The reduced flows can persist for several hours and have the potential to dewater downstream fish habitat stranding fish or fish eggs. These ramping events may occur as the result of either planned or emergency shut downs as well as headworks operations to remove debris accumulations (B. Naito personal communication, May 25, 2017). Fish stranding mortality has occurred in the past as a result of down ramping rates at the Forrest Kerr facility and these events are anticipated to continue to occur (Nicholl, Kurtz, Hardwood & Lewis, 2016). The combined reduction in flow rates should down ramping occur at multiple facilities simultaneously is currently unknown, but it is suspected that the negative consequences to fish populations may be substantial.

Run-of-river hydroelectric projects located on the Iskut River and its tributaries all have the potential to affect fish populations through the alteration of hydrology, temperature regimes, sedimentation and ice forming processes. Water diverted to the penstock for power generation purposes results in reduced flow rates between the diversion weir and downstream powerhouse. The Forrest Kerr facility has the greatest potential to affect migrating fish populations as it is located on the mainstem Iskut River. Unlike the proposed More Creek facility, current run-of-river facilities on the Iskut have small head ponds and limited storage capacity. The More Creek hydroelectric project will utilise a 2,104 ha reservoir to store and release water with the intent of optimizing power generation. This will act to moderate flow rates and result in decreased flow rates downstream of the facility during spring freshet and increased flow rates during winter low flow periods. This has the potential to alter hydrology on the Iskut River below More Creek which will, in turn, affect downstream fish and fish habitats.

3.2 RIVER REACH DESCRIPTIONS

The Iskut River can be delineated into 7 macro reaches based on major geomorphic features. These are displayed in Figure 1 and described below.

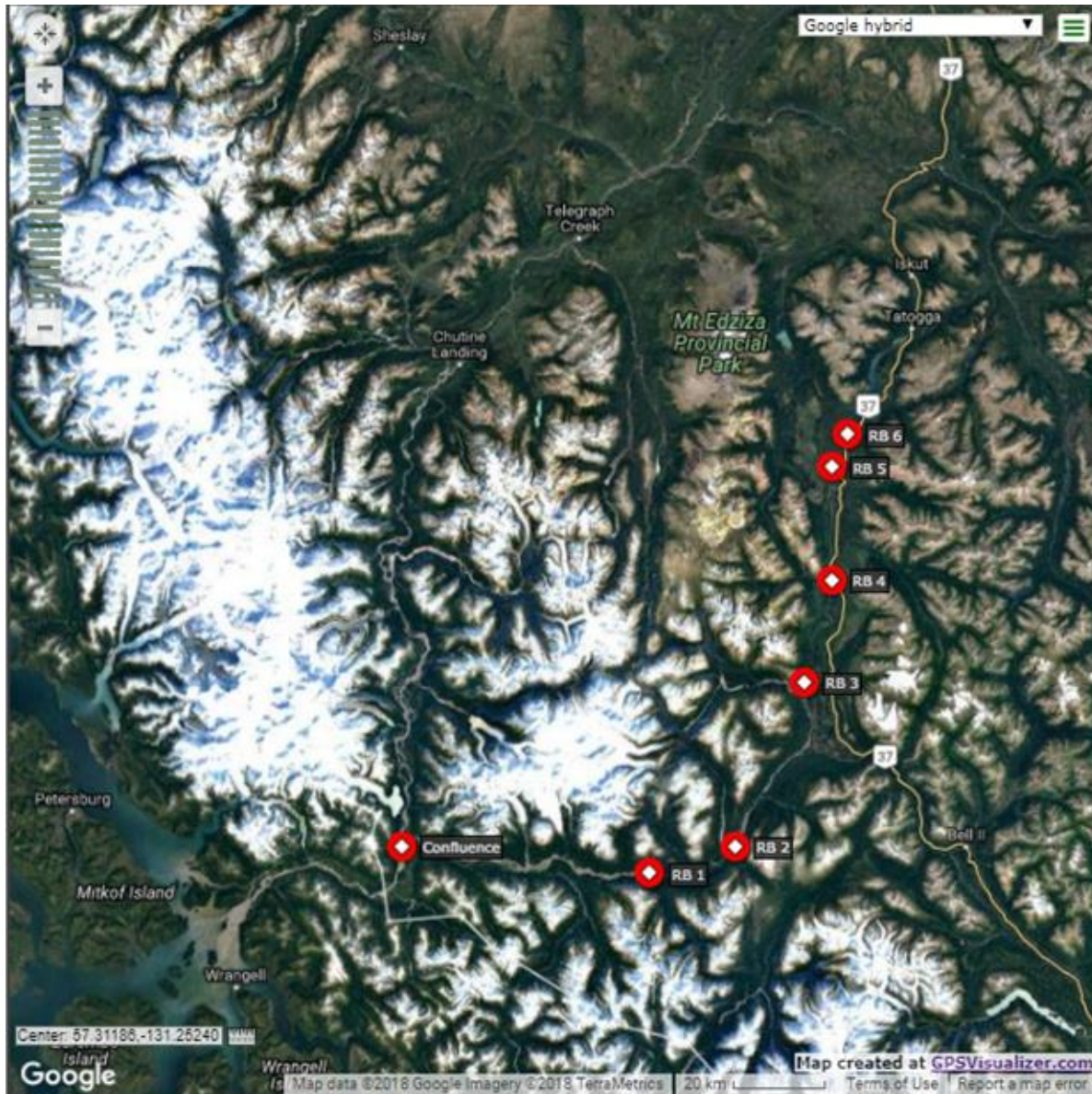


Figure 1: Iskut River delineated reach breaks



Photo 1: Reach 1 of the Iskut River looking upstream from the Stikine confluence.

- **Reach 1:** This is the first 63 km section from the Stikine confluence up to the outlet of the lower Iskut canyon immediately above Verret River. Reach 1 is a wide braided, aggrading channel with complete fish passage. Major fish bearing tributaries in this reach include the Craig, and Verret watersheds;

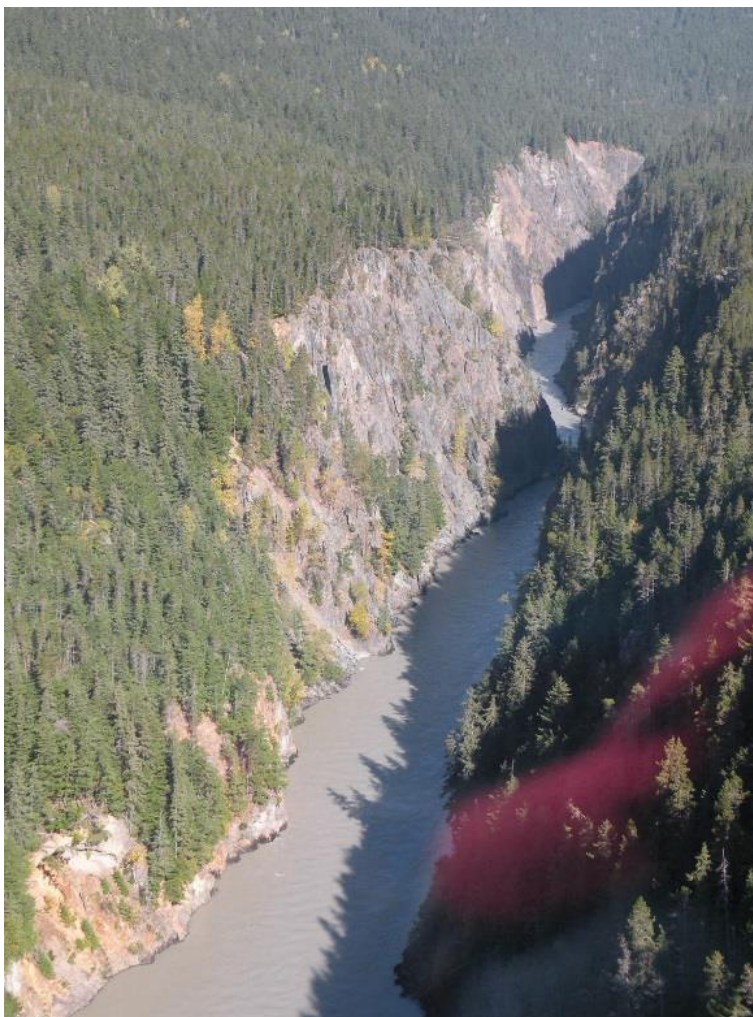


Photo 2: The lower Iskut River Canyon in Reach 2, below the confluence with Forrest Kerr Creek.

- **Reach 2:** This is the first canyon section moving upstream where the river cuts through Quaternary basaltic volcanics from the Hoodoo Mountain volcano to the west. The canyon is largely fish passable for its 27 km length aside from a significant velocity barrier at the top end of the canyon at the intake site for the Forrest Kerr hydro-electric site. The hydro-electric project has a channel spanning Obermeyer weir that imposes a 5 meter vertical step in the channel. Fish passage has recently been confirmed up to the project tailrace approximately 3.5 km downstream of the intake. Major sub-basins reporting to the main stem Iskut include the Snippaker and McClymont watersheds, the latter of which has a run of river hydro-electric project near the Iskut confluence.



Photo 3: Reach 3 above the top end of the lower Iskut canyon.

- **Reach 3:** Upstream of the lower Iskut canyon the valley opens up into a wide mostly braided reach of approximately 30 kms in length. The upper end of the reach alternates between a single thread channel and narrow braided forms as it rises to the upper canyon. There are a number of sub-basins reporting to this reach including the Estshi, Ningunsaw, and Burrage watersheds.



Photo 4: Reach 4 Upper Iskut canyon.

- **Reach 4:** This reach is the 41 km long upper Iskut canyon that follows a discontinuity in the underlying Bowser Sediment bedrock that underlies much of the Iskut watershed. The upper canyon alternates between straight and sinuous alignments as it follows bedrock discontinuities (faults) and has a stepped long profile of flat water, riffles and rapids. Riffles are mostly forced formation type by bedrock outcrop, or more commonly by rubble piles from historic sidewall failures.



Photo 5: Reach 5 at the downstream end.

This end of the reach has several areas of bedrock outcrop forming base level control elements in this mostly alluvial, meandering channel. The upper extent of Reach 5 is Cascade Falls.



Photo 6: *A partially abandoned oxbow upstream of Cascade Falls in reach 6.
Most of reach 6 is clear water alluvial habitat.*

Reach 6: This reach is the 9 km section between Cascade Falls and Kinaskan Lake. The channel in this reach is largely alluvial with isolated bedrock base control. There is a small lake (1.5 km²) midway between Cascade Falls and the outlet of Kinaskan Lake called Natadesleen Lake. This reach is low gradient and has complete fish passage.



Photo 7: Reach 7 includes the chain lake system of the Iskut Plateau.

The picture shows a section of the west shore of Kinaskan Lake near the outlet. Kinaskan is a deep lake (recon sonar indicates 120 meters+ for max depth) with alluvial gravel beaches.

3.3 MIGRATION CORRIDOR ACCESS ASSESSMENT

3.3.1 River Long Profile

Long profiles for the both the Iskut River PMC and the historic Tuya River migration corridor have been plotted using NRCAN DEM data and the BC Watershed Atlas stream network line-work. The long profiles plot a series of water surface elevations against their location coordinates to demonstrate river gradient along the channel centerline between the Stikine-Iskut confluence and Kinaskan Lake. The long profile also shows the major obstacles along the potential migration corridor, primarily the Forrest Kerr Weir and Cascade Falls. The current maximum proven upstream anadromous access point is the Forrest Kerr tailrace, also indicated on the long profile.

Figure 2 (below) shows the two long profiles side by side for comparison. The plot indicates that the Iskut migration corridor is considerably shorter than the Tuya corridor (203km vs. 369km) and has a lower total elevation gain (808m vs. 1,104m). A canyon on the Iskut River has several features that limit salmon passage at approximately 80km above the Stikine River. A second canyon starting at approximately km 140 of the potential migration corridor (reach 4) has some potential sidewall rock slide issues. At km 180 is Cascade Falls which forms an upstream migration barrier at a bedrock outcrop spill point. From that point it is a low gradient 9kms upstream to Kinaskan Lake, a large lake with potential spawning and rearing capacity.

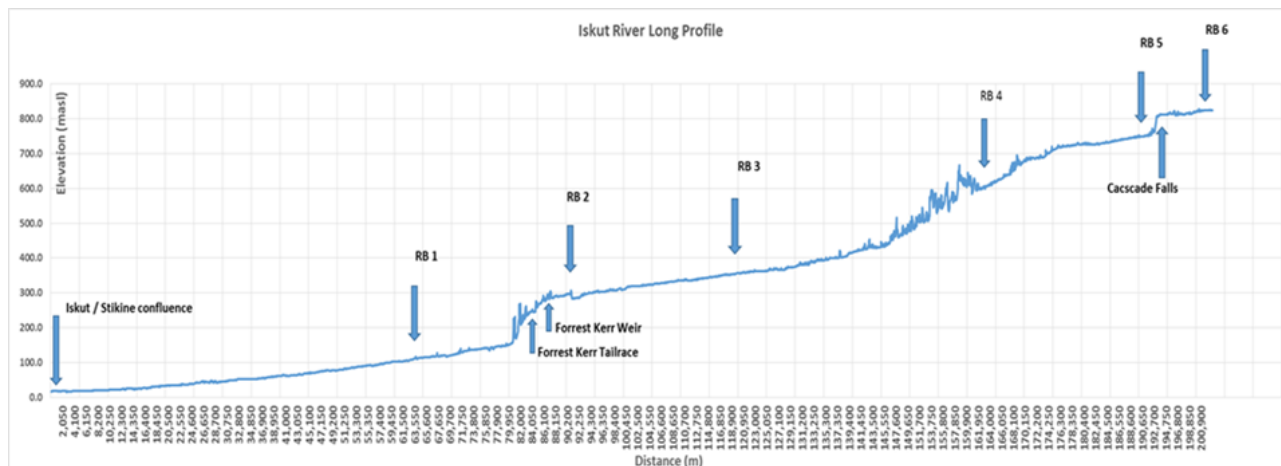


Figure 2: The Iskut River Long Profile.

Source: Data extracted from the 30 m CDED DEM (NRCAN) and the BC Watershed Atlas Stream centerline Network.

The long profile shows a series of elevations along the channel centreline from the Iskut-Stikine confluence up to the outlet of Kinaskan Lake. Elevations are in meters above sea level (masl). Vertical spikes along the profile are an artifact of the data processing where slight mis-alignments of the line work capture points away from the channel centerline. Taller spikes correspond to areas where the channel is entrenched in canyon. Fish passage has been demonstrated upstream to the Forrest Kerr

hydropower tailrace. The first known upstream migration barrier is at the Forrest Kerr Weir in reach 2. A complete upstream barrier is also located at Cascade Falls in reach 5.

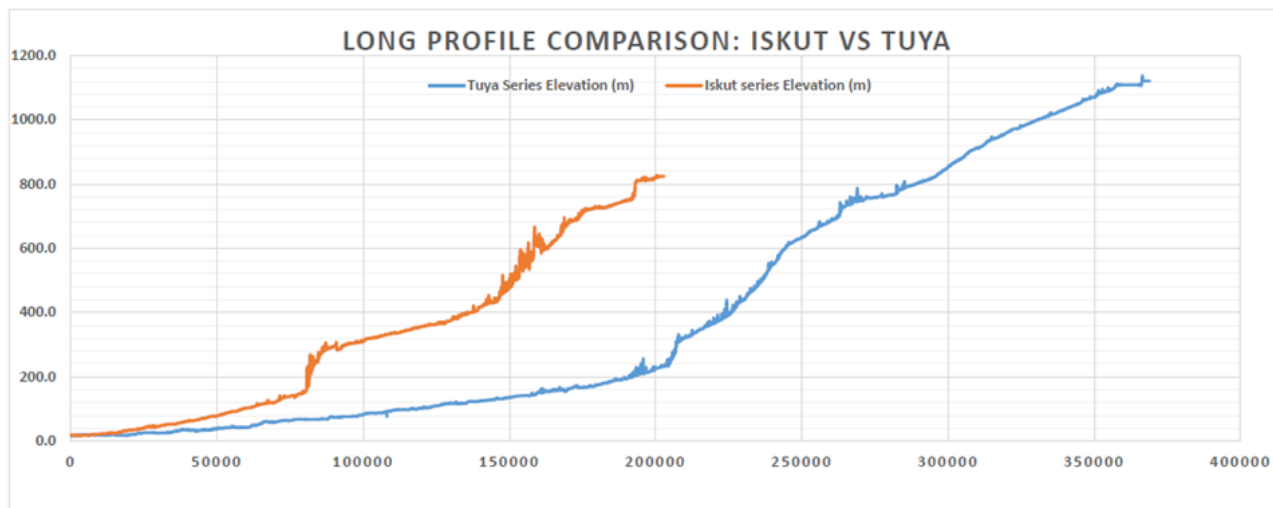


Figure 3: A comparison of the Tuya and Iskut long profiles.

Source: Data extracted from the 30 m CDED DEM (NRCAN) and the BC Watershed Atlas Stream centerline Network.

Figure 3 shows the migration corridors from the Iskut / Stikine confluence up to their respective headwater lakes. As with Figure 2 the line-work includes some sidewall height data that shows where the channel is entrenched in canyon. The plot indicates that the Iskut migration corridor is considerably shorter than the Tuya corridor (203 kms vs 369 kms) and has a lower total elevation gain (808 meters vs 1104 meters)

Larger images of the long profiles in Figures 2 and 3 are located in Appendix B1 and B2.

3.3.2 Preliminary Passage Assessment

One of the main activities in the 2017 reconnaissance was an overflight of the potential migration corridor from Kinaskan Lake to the bottom of Reach 3 at the upper extent of the lower Iskut canyon. The flight was conducted on August 18th with a Tahltan Fisheries representative and two Department of Fisheries and Oceans staff. The purpose of the overflight was to assess the channel for “show-stopper” obstacles that would not likely be feasible to mitigate. Large vertical steps in the long profile that are above the jumping capability of Sockeye and are not amenable to engineered mitigation would fall into the “show-stopper” category. Considerable professional judgement is applied at this early stage of assessment so a digital video record of the overflight was captured to allow for more detailed desktop corridor assessment. The results of the recon assessment are detailed below starting at the top of reach 2 and proceeding up to and inclusive of reach 5. Assessed locations are categorized based on the specific channel and hydraulic conditions as displayed in Table 3 below.

Table 3: Reconnaissance Fish Passage Categories	
Barrier	Classified as a “barrier” if the location is currently not passable at any stage or condition. An engineered structure would be required to establish fish passage.
Obstacle	Classified as an “obstacle” if the location has hydraulic characteristics that may produce passage difficulties at a specific river stage or range of stages. This classification is used for point locations where there is jump height or velocity issues around a spill point, rock cluster or shelf.
Challenge	Classified as a “challenge” if the location has hydraulic conditions that may pose passage difficulties at a specific river stage or range of stages. This classification is used at locations where channel features pose velocity issues along a longitudinal section of channel such as rapids or cascades.

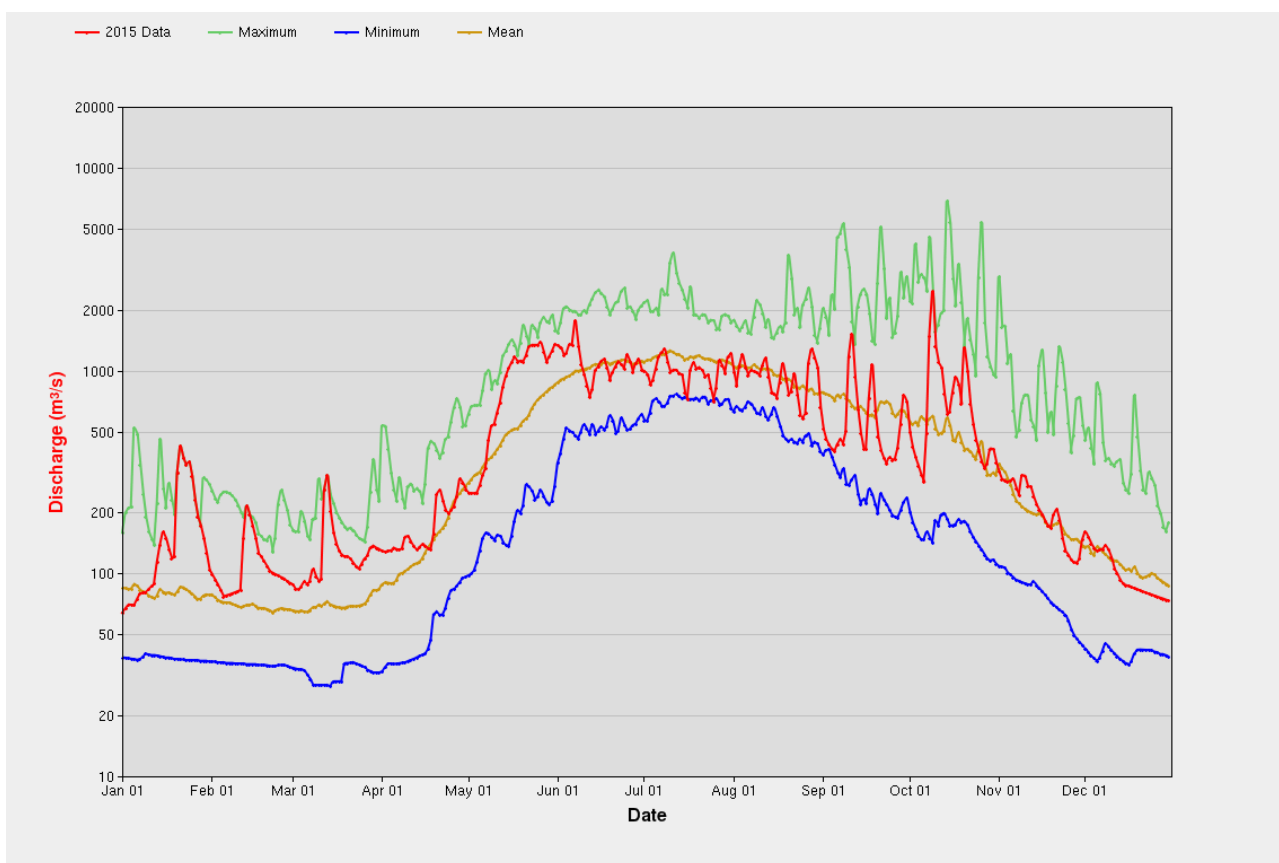


Figure 4: Annual Hydrograph for WSC station 08CG001 Iskut River Below Johnson River in Reach 1 (1959 to 2015).

Fish passage, at a station, is often discharge dependent so it is important to recognize the discharge at the time of overflight assessment for context. In this case the stage (at Iskut River below Johnson River (08CG001) in Reach 1) at the time of the recon was approximately 1550 m³/s (see Figure 4 above) which plots at a point above the long term average for that date, is above the same discharge for that date in 2015 and is well below the maximum discharges for that date (see Figure 5 below). Mid-August plots near the inflection point onto the descending limb of the annual hydrograph.

The discharge on the day of the overflight (1550 m³/s) plots above the average for that day near the inflection point of the descending limb of the annual hydrograph.

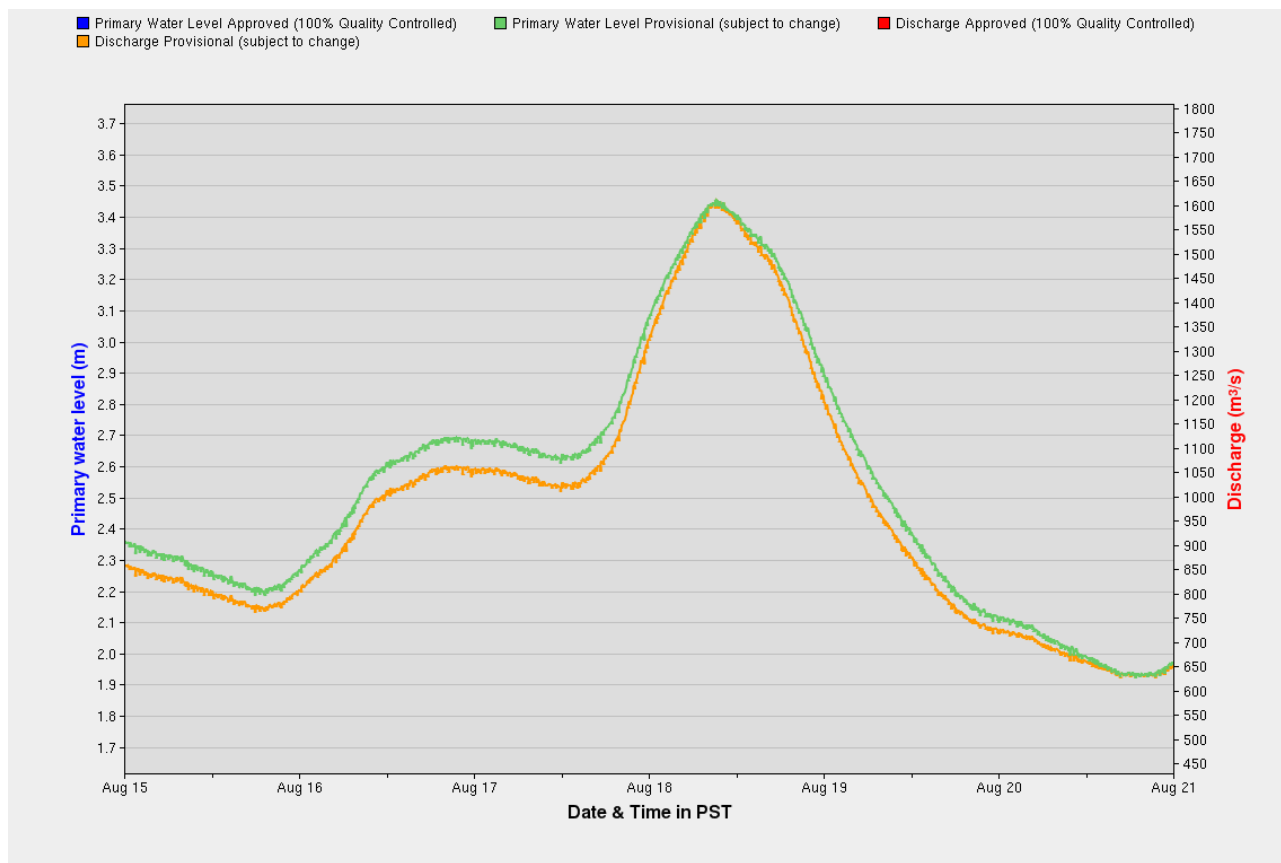


Figure 5: Daily hydrograph for WSC station 08CG001, Iskut River Below Johnson River in Reach 1 for the time period of the overflight passage assessment.

Reach 2 and 3 Migration Corridor Passage Assessment:

The lower Iskut canyon (Reach 2) was not overflowed due to uncertainty around flight rules in the canyon in the vicinity of the Forrest Kerr hydro-power project. The top of Reach 2 and all of Reach 3 were overflowed and video recorded in upstream and downstream directions. It is assumed that the Forrest Kerr hydropower weir is a barrier to upstream migration (barrier R2-1). In addition to that there is a potential challenge and 2 potential obstacles at the top end of reach 2 that warrants further assessment. Challenge R2-2, is pictured below.



Photo 8: Challenge R2-2 is a rapid section just above the Forrest Kerr hydropower project.

This is ranked as a “challenge” based on potential stage dependent velocity issues.

Challenge R2-2 is a rapid section with the potential for velocity issues. This location was backwatered somewhat by the construction of the Forrest Kerr weir and as such passage has improved from historic conditions. There are lower velocity conditions at the sides of the channel that may mitigate velocity issues at most stages and discharges. Obstacles R2-3 and R2-4 (moving upstream) are pictured in the two photos below. These two obstacles may pose velocity issues at higher stages due to the presence of laminar flow at the spill point although there are river right and left passage options with good staging pool hydraulics. Upstream of these sites the channel opens up to Reach 3 which is predominantly a braided channel with no passage issues noted.



Photo 9: Upstream view of obstacles R2-3 and R2-4.

Laminar flow at the spill crest may pose velocity issues for passage at some discharges although there are channel left and right passage options with good staging pool hydraulics.

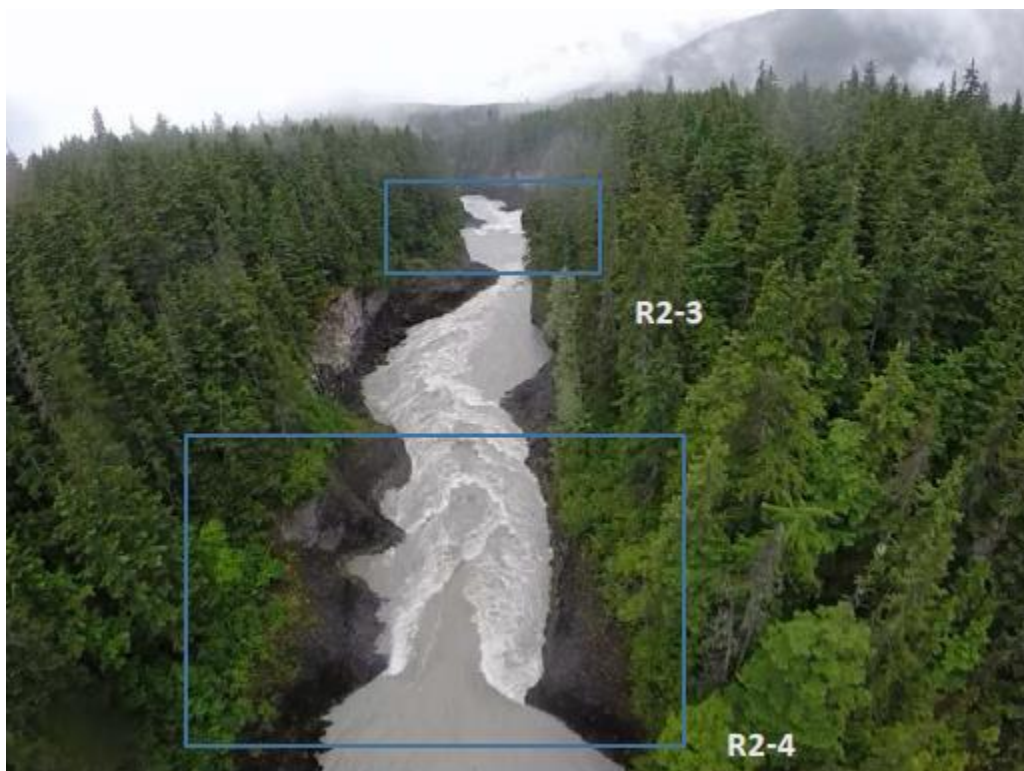


Photo 10: Obstacle R2-4 looking downstream to R2-3.

Laminar flow at the spill crest may pose passage issues although there are passage options with staging pools on both sides of the obstacle.

Reach 4 Migration Corridor Passage Assessment:

Reach 4 is largely confined between sedimentary bedrock sidewalls and as such is highly coupled with sidewall mass wasting processes. Given the high gradient (high shear stress) and the relatively low amount of active floodplain area (minimal area for overbank bedload storage) it is safe to say that the reach is almost entirely in a sediment “transport” mode. As it is coupled with steep, actively eroding sidewalls reach 4 transports the sidewall derived mass wasting load, bedload supplied from reach 5 as well as the tributary load from Ball Creek, Durham and others. From a bedload mass balance perspective it is likely that sidewall and tributary contributions to bedload from reach 4 are the dominant material source to the aggrading, braided channel in reach 3.



Photo 11: Reach 4 at the midpoint.

Most of this reach is well confined by sedimentary sidewalls. There were no obvious barriers, obstacles or challenges noted in reach 4. Riffle-pool-run sequences are common.

No obvious barriers, obstacles or challenges were noted for reach 4 based on the reconnaissance conducted. It is likely that episodic sidewall failures may alter the channel profile. The sidewall rock is quite friable and recent sidewall mass wasting locations were noted to have been cleared by subsequent high flows. Sidewall failure lag deposits were noted in this reach that were associated with riffle development and riffle-pool-run morphology.

Reach 5 Migration Corridor Passage Assessment:

Reach 5 transitions from the fully confined habit of reach 4 to partially confined and unconfined alluvial channel as it approaches the Little Iskut confluence and rises up to the plateau. A barrier and an obstacle were noted in reach 5. Moving upstream from the bottom of reach 5 the area of interest is obstacle R5-1 which is a bedrock outcrop with a transverse spill that may have passage issues at some flows. At the stage observed during the recon the channel river left was not likely passable due to cyclic flow and high turbulence but the river right side may have a “sneaker” channel that would allow for passage at a range of flows (see photo 12 below). Upstream of obstacle R5-1 the gradient reduces and the river habit morphs into an alluvial meandering style up to barrier R5-2. Barrier R5-2 is commonly known as Cascade

Falls where the Iskut falls off a bedrock ledge (see photo 13 below). This is a complete passage barrier that would require an engineered structure to create passage.



Photo 12: Obstacle R5-1 is a bedrock outcrop with a transverse spill that is impassable on river left but may be passable on river right.



Photo 13: Barrier R5-2 (right and left dis-tributaries), also known as Cascade Falls, is a complete barrier to upstream migration.

Cascade Falls (R5-2) is a complete barrier to upstream fish passage due to the large vertical drop of approximately 35 meters. The Iskut forms two channels around a central bedrock island that divides the flow roughly in half. The falls are underlain by a sedimentary bedrock ledge with a stepped, concave long profile. The river right channel appears to be the most mitigatable option of the two dis-tributaries. Cascade Falls is the last passage obstruction of the Iskut River below Kinaskan Lake. The falls is underlain by Bowser Sediment Group rocks that are oriented perpendicular to the main axis of Iskut river flow. This enhances the “stepping” of the long profile producing a step-pool, step cascade morphology that may enhance opportunities for passage mitigation as can be seen in photo 15 below.



Photo 14: The river right side of Cascade Falls (barrier R5-2(R)) is a complete barrier to upstream fish passage.

Obviously, establishing fish passage up Cascade Falls would involve an engineered structure. Mitigating factors include; nearby (1km) industrial road access, the ability to de-water the site for construction by shunting flows to the left dis-tributary and the relatively workable nature of the bedrock.



Photo 15: Looking downstream toward Cascade Falls from the east side access point. The arrow corresponds to the arrow in photo 15.

Reach 6 Migration Corridor Passage Assessment:

Above Cascade Falls is reach 6 which is a meandering alluvial channel of about 9 kilometers up to Kinaskan Lake. There are no passage issues in reach 6 as it is a low gradient, alluvial reach with a small lake about 700 meters upstream of the falls (see photo 18).



Photo 16: Looking upstream from Cascade Falls.
There were no passage issues noted from this point up to Eddontenajon Lake.



Photo 17: Natadesleen Lake, in reach 6, is located about 700 meters upstream of Cascade Falls.

Reach 7 Migration Corridor Passage Assessment:

Reach 7 is the uppermost reach in the recon area of interest and contains the chain lake system of Kinaskan, Tatogga, Edontenajon and Kluachon Lakes. There were no potential passage issues noted during the recon.



Photo 18: Kinaskan Lake looking south towards the outlet.



Photo 19: The north end of Kinaskan Lake showing the short reach of the Iskut River connecting Tatogga Lake to Kinaskan Lake.



Photo 20: Eddontenajon Lake from near the north end looking south.

3.4 FISH PASSAGE ASSESSMENT SUMMARY:

Table 5 is a summary of the issues noted from the migration corridor assessment recon;

Table 5: Iskut River Fish Passage Reconnaissance Summary

Site	Category	Description/Notes
R2-1	Barrier	Forrest Kerr weir. Velocity barrier.
R2-2	Challenge	Approximately 100 meter turbulence / velocity challenge. Stage dependent
R2-3	Obstacle	Bedrock spill with laminar flow, potential velocity issues. Stage dependent.
R2-4	Obstacle	Bedrock spill with laminar flow, potential velocity issues. Stage dependent.
R5-1	Obstacle	Bedrock outcrop, transverse spill, turbulence / velocity

issues. Potential river right passage.

R5-2

Barrier

Cascade Falls, large vertical drop.

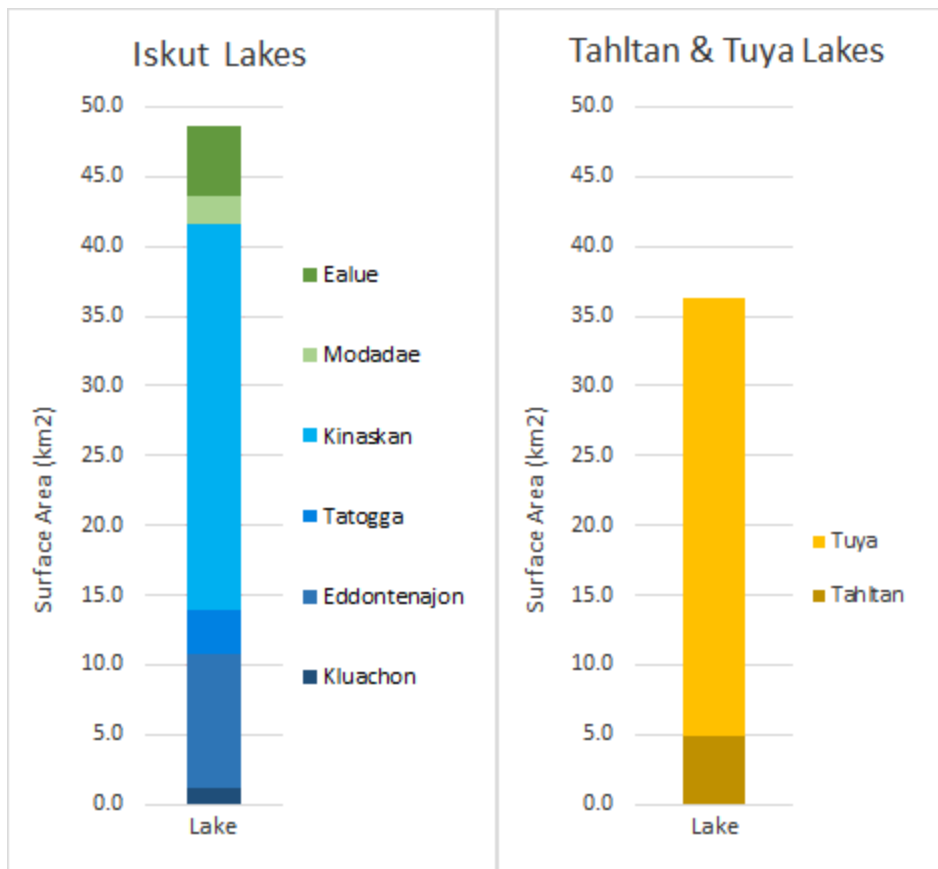
In summary the reconnaissance has identified 2 passage barriers that would require engineering mitigation to develop passage, 3 potential obstacles and 1 potential challenge. It is proposed that in year 2 more detailed assessment will be undertaken along the potential migration corridor to estimate the stage dependence of these potential passage issues and assess their mitigation potential. Year 2 assessment will include aerial photogrammetry, flown at a lower stage, to build a digital elevation model and to assess the stage dependence of the areas of interest identified. This assessment may indicate other stage dependent areas of interest not apparent at the relatively high stage observed in the 2017 recon. Further assessment will focus on lower river stages later in the potential sockeye migration period. The joint assessment team felt that of the non-barrier areas of interest noted none were definitively un-passable at the time and stage they were assessed at. Upstream and downstream digital video of the assessed reaches is available from the authors of this report.

3.4 LAKES HABITAT ASSESSMENT

Studies to date have not identified the sockeye spawning and rearing potential of the Iskut above the canyon, however the chain lakes are known to support healthy rainbow trout populations. Lakes in the Upper Iskut (UI) include Kinaskan, Tatogga, Eddontenajon, Ealue and Kluachon, and in the Middle Iskut (MI) is Modadae Lake. The total surface area for all is 48.6 km², which is larger than Tahltan and Tuya Lakes combined at 36.3km². (See Table 6 and Figures 6 a&b). As well, they all have road access leading north to the community of Iskut. These are “scour chain” lakes formed by large scale paleo flows. Other lakes, formed by similar processes such as Babine, Tahltan and Tuya have produced strong habitat fundamentals in terms of Glacio-fluvial gravel deposits and up associated groundwater upwelling.

Table 6: Surface area of lakes

Lake	km
Ealue	5.0
Kluachon	1.1
Eddontenajon	9.6
Tatogga	3.2
Kinaskan	27.7
Modadae	2.0
Totals	48.6
Tahltan	4.9
Tuya	31.4
Totals	36.3



Figures 6 a&b: Surface area for lakes of interest

Initial results of zooplankton samples collected as vertical hauls in the lakes are presented in Table 7 and Figure 7 below.

Table 7: Zooplankton results

Date sampled	Lake	Site #	Haul depth (m)	Biomass (ug/L)
16-Aug-17	Tatogga	1	15.0	121.815
17-Aug-17	Eddontenagon	1	20.0	892.776
17-Aug-17	Eddontenagon	2	20.0	459.158
18-Aug-17	Kinaskan	1	20.0	503.364

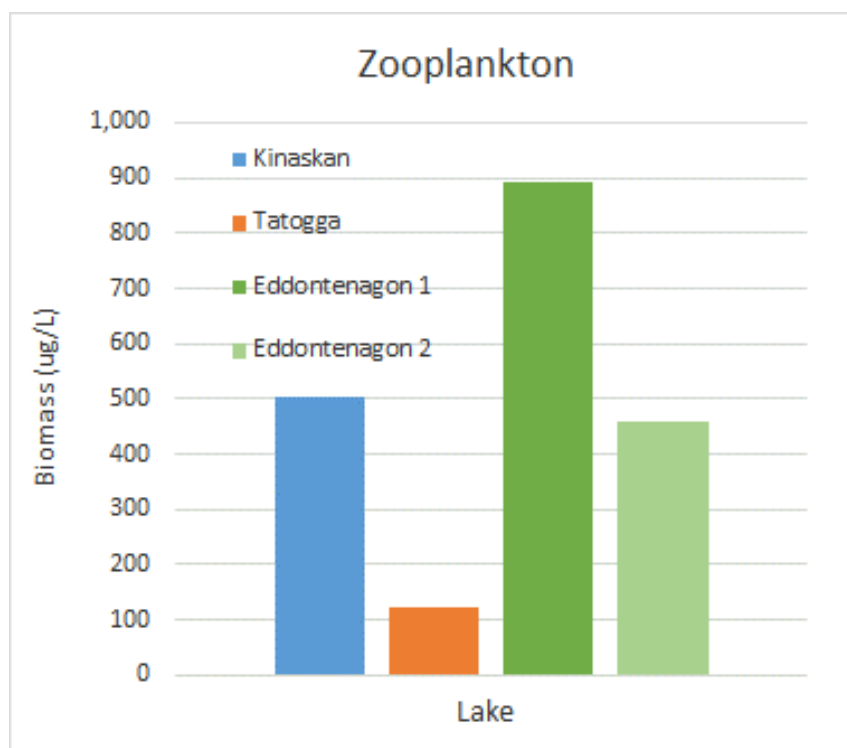


Figure 7: Zooplankton biomass from lake sampling

Initial results of Phosphorus and Chlorophyll A samples collected from the surface water of the lakes are presented in Table 8 and Figure 8 below. To note, the wrong size filters were used for the chlorophyll samples, therefore those results should be considered qualitative.

Table 8: Phosphorus and Chlorophyll A results

Lake	Site #	Date sampled	Time sampled	Phos. (µg/L)	Chl. a 0.45 (µg/L)	Phaeo 0.45 (µg/L)	Corr. Chl.45 (µg/L)
Eddontenajon	1	17-Aug-17	12:00	4.8	0.289	0.122	0.228
Eddontenajon	2	17-Aug-17	12:30	4.4	0.242	0.038	0.223
Tatogga	1	16-Aug-17	15:30	5.5	0.786	0.145	0.714
Kinaskan	1	18-Aug-17	11:00	3.2	0.361	0.071	0.326

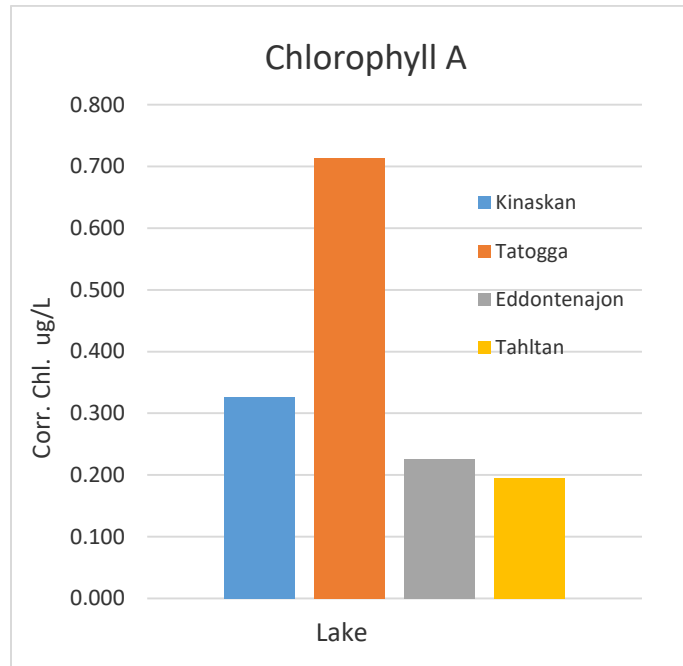


Figure 8: Chlorophyll results from lake sampling

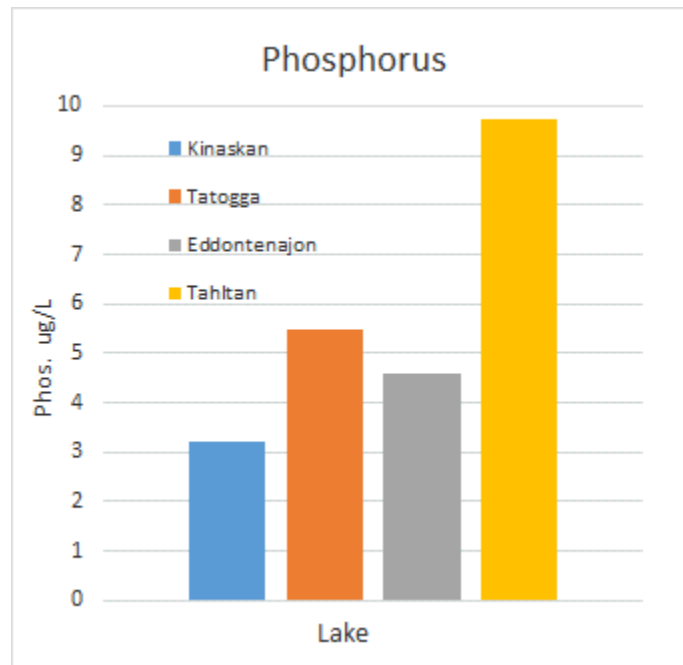


Figure 9: Phosphorus results from lake sampling

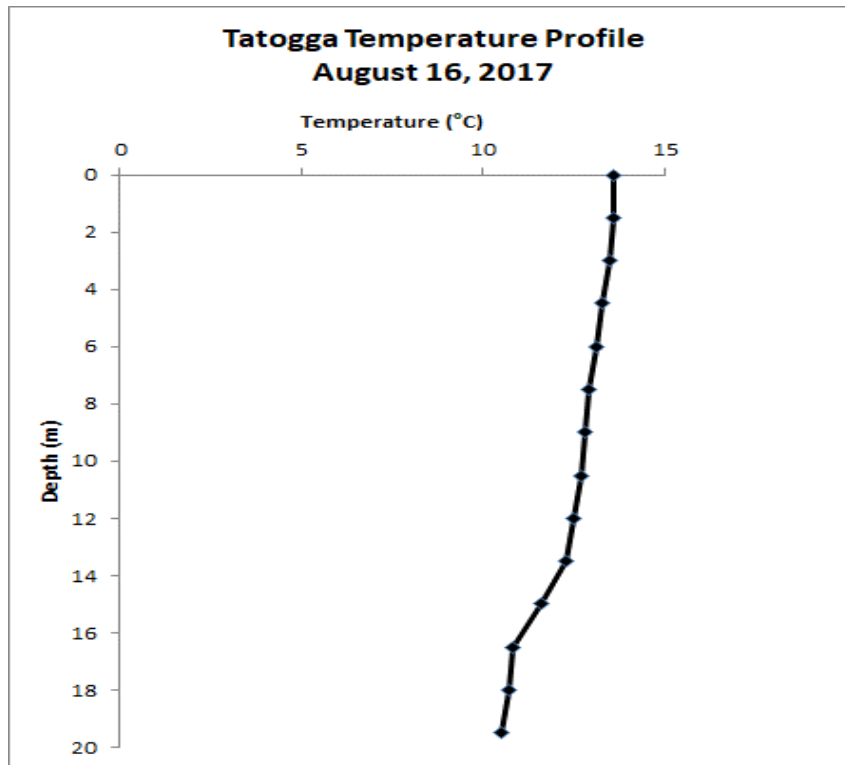


Figure 10: Tatogga Lake vertical temperature profile

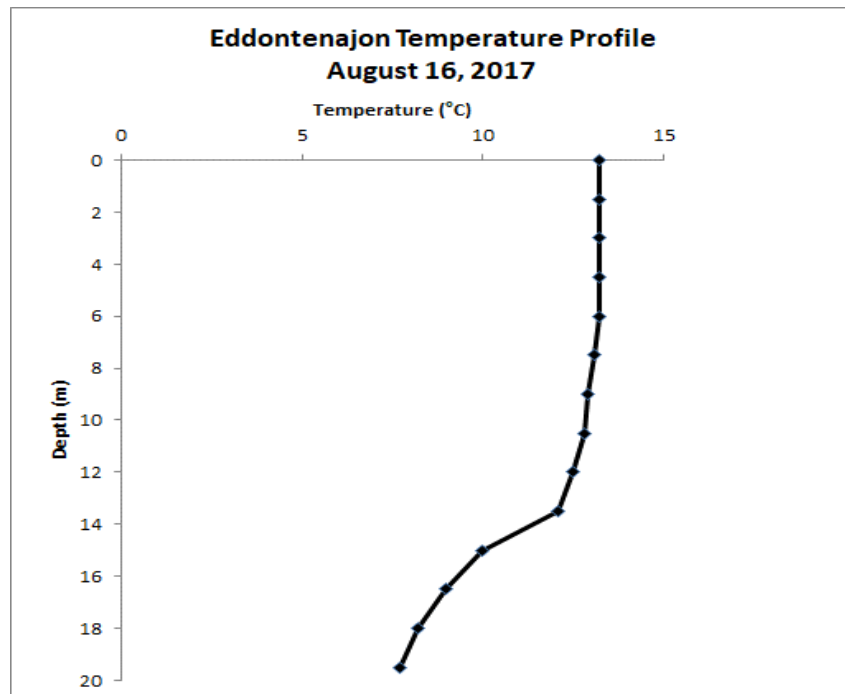


Figure 11: Eddontenajon Lake vertical temperature profile

Vertical water temperature profiles for Tatogga and Eddontenajon Lakes are shown in Figures 10 and 11, above. Site way points for these are N 57.71533, W 130.01047 and N 57.74232, W129.99081, respectively.

Spot water quality measurements and sechi depths are displayed in Table 9 below.

Table 9: Water quality results

Lake	Site #	General Location	GPS point	Date	Time	Depths (m)		WQ meter					Comments
						Total	Sechi	Temp. (° C)	DO (%)	DO (mg/L)	pH	Cond. (µs/cm)	
Tatogga	1	Lake center	025	16-Aug-17	15:30	17.3	1.5	-	-	-	-	-	WQ not taken, meter needed calibration.
Eddontenajon	1	North end	026	17-Aug-17	12:00	33.5	3.5	14.41	53.2	4.89	8.11	242	DO probe not calibrated
Eddontenajon	2	South end	027	17-Aug-17	12:30	27.9	3.0	13.11	61.9	5.81	8.25	242	DO probe not calibrated
Kinaskan	1	South end	031	18-Aug-17		31.1	3.5	10.82	69.3	6.85	8.41	195	DO probe not calibrated
Tatogga	-	Just north of Lodge boat launch, taken from shore	044	21-Aug-17		-	-	12.46	86.4	8.37	8.30	287	DO probe calibrated and membrane changed.

Results of some groundwater prospecting using a temperature probe are shown in Table 10 below. These were all areas deemed to have some potential for spawning. In most cases there were some substantial differences between the surface water temperatures and those within the gravel / substrate. The cooler substrate temperatures provide indication of groundwater influence.

Table 10: Temperature probe results

Lake	General Location	GPS point	Date	Time	Probe temp. (°C)				Substrate type
					Air	Surface	Subst.	Diff.	
Eddontenajon	West side shoreline at south end, approx. 2m out from shoreline, about 0.3m depth	028	16-Aug-17	14:00	10.0	13.2	10.9	2.3	Cobble along shoreline, but below waterline it is predominately silt covered.
Eddontenajon	Shoreline near Red Goat boat launch		16-Aug-17	15:30	10.3	14.3	13.4	0.9	Gravel / cobble - washed and not compacted - extends along shoreline to far north end.
Kinaskan	North end shoreline near inlet fan, about 0.5m depth	032	19-Aug-17		8.4	12.8	11.2	1.6	deep sand
		033			8.4	12.8	11.6	1.2	sand
		034			8.4	12.8	11.6	1.2	some pea gravel
		035			8.4	12.8	10.9	1.9	gravel / sand
		036			8.4	12.8	11.3	1.5	coarser gravel
		037			8.4	12.8	11.7	1.1	gravel / sand
		038			8.4	12.8	11.1	1.7	gravel layer, soft
		039			8.4	12.8	10.8	2.0	gravel layer, soft
		040			8.4	12.8	11.1	1.7	gravel layer, soft
		041			8.4	12.8	11.5	1.3	gravel layer, soft
		inlet			8.4	12.8	10.5	2.3	gravel layer, soft
Tatogga	North end shoreline near Lodge boat launch	045	21-Aug-17		13.2	12.0	5.2	6.8	gravel / cobble over fines
		046			13.2	11.9	7.9	4.0	gravel / fines
		047			13.2	12.0	7.7	4.3	gravel / fines
		048			13.2	8.4	-	-	Jackson Creek outlet
		049			13.2	11.9	4.5	7.4	gravel / cobble over deep sand
		050			13.2	11.9	8.6	3.3	cobble over sand

4.0 DISCUSSION AND RECOMMENDATIONS

With an enhancement area as large as the upper Iskut (7000 km²) a strategic approach is required to plan the assessments and prioritize the scope of work moving forward. The 2017 reconnaissance assessment indicates that there are two locations (R2-1 and R5-2) that would require engineered structures to develop passage to habitats in the watershed above the Forrest Kerr / Iskut River confluence. Strategically this creates two watershed units, one between the R2-1 (Forrest Kerr) and R5-2 (Cascade Falls) and a second unit covering the watershed area upstream of Cascade Falls. For planning purposes we refer to these units as the “Middle Iskut Enhancement area” (the MI: reaches 3, 4 and 5) and the “Upper Iskut Enhancement area” (the UI: reaches 6 and 7) respectively.

The purpose of the 2017 and 2018 assessment programs are to largely to assess the technical feasibility of enhancement as far as the development of sockeye access to the MI and UI. These scopes of work are also designed to characterize the area, extent and fundamental habitat quality of these potential enhancement areas in terms of surface and subsurface hydrology, geomorphology, ecology and water quality. The end goal is to be able to conduct a cost benefit analysis of the capital cost of enhancement (primarily the two access structures) and the potential return in terms of harvestable returns. The general approach being used in the assessment is a modified Overview Watershed Assessment Procedure. Such is defined under the BC Watershed Restoration Program for desktop review with site specific high quality habitat assessments being conducted at locations selected based on published habitat quality criteria and the professional judgement and experience of the assessment team.

The proposed enhancement approach being employed here is based on the following principles:

1. Both enhancement areas (MI and UI) will be assessed for potential to support a staged approach to enhancement starting from the lower habitats to the upper habitats. The staged approach would involve mitigating MI passage issues first, stocking habitats in that unit and once that is deemed successful, moving to mitigate passage to the UI and stocking those habitats.
2. The assessment of potential spawning and rearing enhancement target habitats in the MI and UI will use comparison to “analog” habitats of known sockeye productivity as a template. This allows for the inclusion of sockeye habitat selection preferences in the target enhancement habitats and assists with the identification of potential donor stocks. Ideally, a self-sufficient sockeye population could be established, which would limit the need for continued planting or a terminal fishery on the lower river.

It is proposed that in year 2 more detailed assessments will be undertaken along the potential migration corridor to estimate the stage dependence of these potential passage issues and assess their mitigation feasibility. Year 2 assessment would likely include aerial photogrammetry, flown at a lower river stage than the 2017 overflight, to build a digital elevation model and to assess the stage dependence of the areas of interest identified. A local specialist contractor with extensive experience has been consulted to provide the design and costing for this scope item and is prepared to do the work. This assessment may indicate other stage dependent areas of interest not apparent at the relatively high stage observed in the 2017 recon. Further assessment will focus on lower river stages later in the potential sockeye migration period.

It is anticipated that the 2018 project would involve the following tasks and activities:

(A proposed scope of work for 2018 field activities is shown in Appendix C.)

1. Background Data Review: The first step in the 2018 assessment is to conduct a desktop exercise of existing fisheries reports for the enhancement area to estimate the current extent of fish passage and any existing passage barriers on major tributaries. While there is considerable potential for enhancement of all salmon species we will focus on the potential to enhance sockeye.
2. Migration Corridor Passage Assessment includes the following scope items:
 - a) Drone and helicopter overflight to collect digital photography and digital elevation model data for the migration corridor between Cascade Falls and Verret River. It includes post processing and analysis of the mapped products to support conceptual design of engineered structures. The mapping will also be used to assess all potential migration challenges and to estimate the extent of holding and respite habitats for an assessment of the cumulative effect of migration challenges. A more detailed drone survey will be undertaken at Cascade Falls (immediately below Kinaskan Lake) since this barrier will require an engineered steep pass structure to become passable;
 - b) Geotechnical overview by a Qualified Professional for the Terrain Stability in Reach 4;
3. Additional assessment of spawning and rearing potential, based upon 2017 results:

This scope item includes assessment of lake and riverine habitats in both the UI and MI enhancement areas using a combination of desk based reviews and site specific field assessment of habitats using standard professional methods and protocols. Bathymetric surveys are proposed for Kinaskan and Edontenajon Lakes to assess the available habitat and limnological potential. (Reconnaissance sonar data indicates that portions of Kinaskan Lake exceed 350 feet in depth). Water quality profiles will be collected in both of these lakes to characterize the limnology, stratification and productive capability. Site specific field assessments will be undertaken at key habitats to ensure that sufficient high quality habitats are identified to fulfill the planning needs of the staged enhancement approach. Key habitats identified for the MI enhancement area include Modadae Lake (below Cascade Falls) and Beaverpond Creek (a groundwater fed riverine spawning / rearing candidate in the Upper Ningunsaw watershed) although more site specific assessment sites will be identified as the 2017 report is finalized. For the UI enhancement area key habitats identified for field survey include Snapper Creek (a Kinaskan Lake tributary with good spawning potential), Kinaskan and Edontenajon Lakes, the connector channels between the lakes and other lake tributaries to be determined as the 2017 report is finalized;

4. Consultations with local First Nations, other Government agencies, industry, and stakeholders;
5. Formation of an Enhancement Plan for salmonid enhancement operations, fish passage mitigation, potential implementation timelines, production potential, harvest opportunities, donor stocks and biological risk assessment;
6. A report will be generated that summarizes the project objectives, assessment and consultation results. The report will include a GIS analysis of the migration corridor, habitat potential description of the enhancement target watersheds and lay out a proposed approach for enhancement (the Enhancement Plan) moving forward with stakeholder input. Information and opportunities collected from this project will be presented to the PSC Transboundary Panel, Technical Committee and/or Enhancement Sub-Committee at annual 2018-2019 meetings for consideration, discussion and input.

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APPENDIX A2. DOCUMENTED OR OBSERVED POTENTIAL CHALLENGES TO THE UPSTREAM MIGRATION OF FISH SPECIES ON THE ISKUT RIVER.

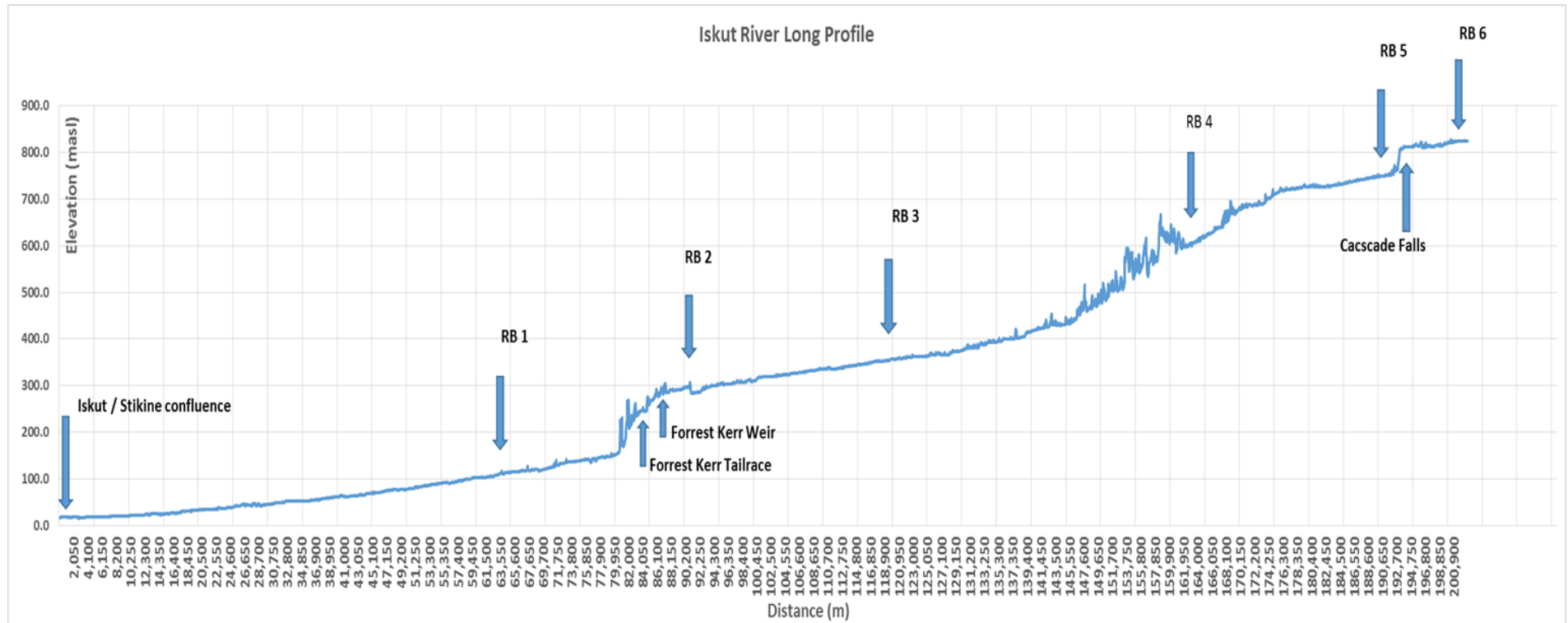
Feature	Description	River Kilometer	Zone	UTM Northing	UTM Easting
Unknown	Unconfirmed challenge, barrier or hazard upstream of Snippaker Creek and approximately ~ 2.7 km downstream of McLymont Creek, details unknown, verification required.	65	9	388,225	6,283,949
Unknown	Unconfirmed challenge, barrier, or hazard ~ 1.7 km d/s of Forrest Kerr/Iskut River confluence. Details unknown, verification required.	75	9	397,478	6,287,982
Unknown	Unconfirmed challenge, barrier or hazard barrier ~ 1.4 km d/s of Forrest Kerr/Iskut River confluence. Details unknown, verification required.	75.3	9	397,589	6,288,003
Unknown	Unconfirmed challenge, barrier or hazard barrier ~ 1.2 km d/s of Forrest Kerr/Iskut River confluence. Details unknown, verification required.	75.5	9	397,723	6,288,037
Unknown	Unconfirmed challenge, barrier or hazard ~ 350 m d/s of Forrest Kerr/Iskut River confluence. Details unknown, verification required.	77	9	398,736	6,288,841
Chute/Rapids	Well documented chute ~ 250 m bellow Forrest Kerr Creek and immediately bellow Forrest Kerr intake site. Feature consists of ~ 3 m drop with a velocity > 3m/s	77.1	9	398,777	6,288,943
Man Impoundment	Made Location of Forrest Kerr Hydroelectric Facility diversion weir, a fish ladder has been constructed to facilitate passage but as a result of issues with fish ladder function and design the weir may still represent a barrier/challenge to fish passage.	77.3	9	398,852	6,289,130
Chute/Rapids	Confirmed and well documented potential barrier located ~ 700 m upstream of the Forrest Kerr/Iskut Confluence. This barrier/challenge would represent at minimum a hindrance to upstream movement at low flows. The feature consist as a 2 m drop with a velocity > 3m/s	78	9	399,396	6,288,897
Chute/Rapids	Observed potential barrier/challenge located approximately 5.6 km upstream of Barrage Creek/Iskut confluence. Further investigation required. Would represent at minimum a hindrance to upstream fish migration.	157.2	9	423,483	6,351,494
Cascade Falls	Observed and well documented barrier located approximately 700 m downstream of Natadesleen Lake. The river splits into two separate channels: River right cascade drops approximately 40 m over a distance of 210 m at an average slope of ~ 6 %; River Left cascade drops approximately 45 m over a distance of 400 m with an average slope of 7.4%.	180	9	424,240	6,370,787

APPENDIX A3. PROPOSED AND CURRENTLY OPERATIONAL RUN OF RIVER HYDROELECTRIC PROJECTS ON THE ISKUT RIVER

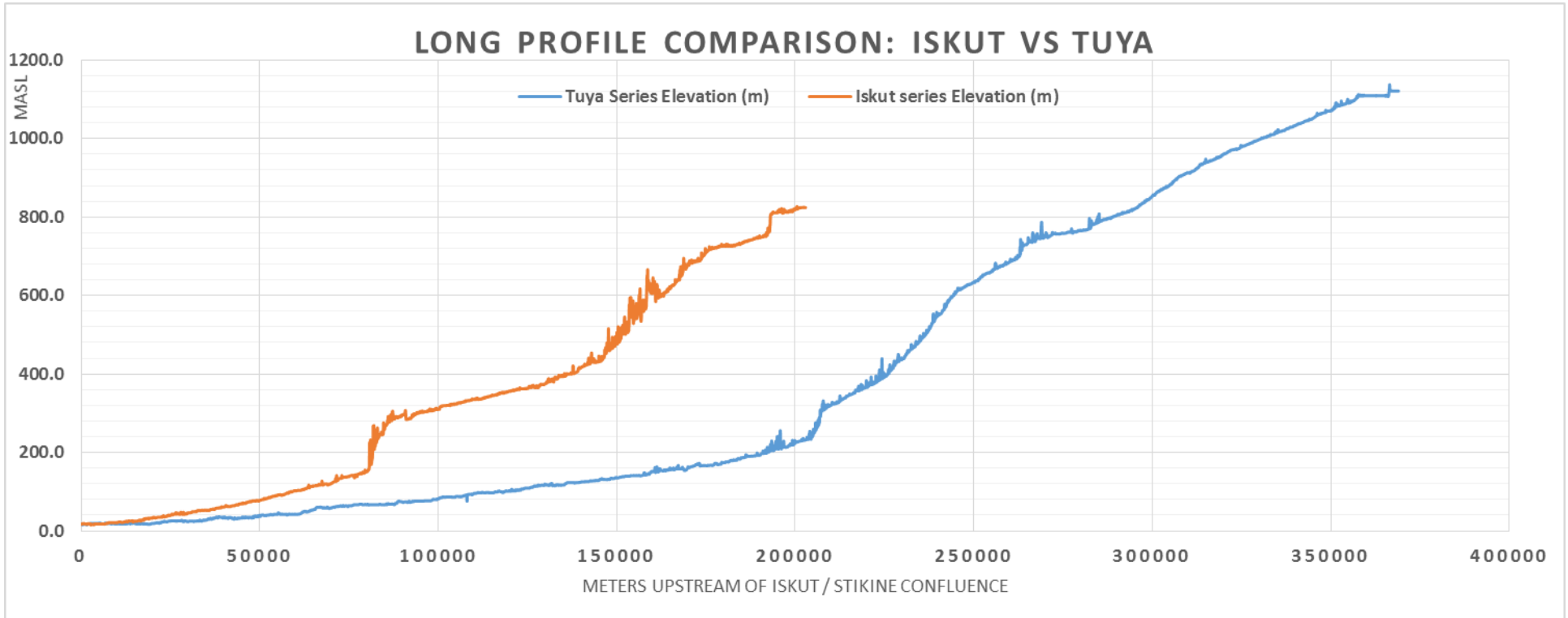
Name of Project	Licensee	Purpose	Mean Annual Discharge m ³ /s	Minimum Base flow m ³ /s	Maximum Diversion m ³ /s	Capacity (MW)	Head Pond (ha)	Penstock Length (km)	Gross Head (m)	Type of Turbine
Volcano Creek Hydropower Project	Altagas Renewable Energy Inc.	Power-General	3.84	0.20	9.90	18.00	1.10	2.80	222.00	2 - MW Vertical Axis Pelton Wheel Turbines
McLymont Hydropower Project	Altagas Renewable Energy Inc.	Power-General	15.90	0.50	30.70	66.00	2.00	2.80	269.00	1 - Pelton Wheel. 3 - Francis Turbines
Forrest Kerr Hydropower Project	Altagas Renewable Energy Inc.	Power General	275.00	16.60	252.00	195.00	8.25	3.18	112.00	9 - Horizontal Axis Francis Turbines
*More Creek Hydropower Project	Alaska Hydro Corporation	Storage-Power			80.00	75.00	2104.00	150.00	118.00	3 - Vertical Axis Francis Type Turbines

* Proposed project - operational capacities yet to be finalised

APPENDIX B1&2: LONG PROFILES



Appendix B1: The Iskut River Long Profile. The long profile shows a series of elevations along the channel centreline from the Iskut-Stikine confluence up to the outlet of Kinaskan Lake. Elevations are in meters above sea level (masl). Vertical spikes along the profile are an artifact of the data processing where slight mis-alignments of the line work capture points away from the channel centerline. Taller spikes correspond to areas where the channel is entrenched in canyon. Fish passage has been demonstrated upstream to the Forrest Kerr hydropower tailrace. The first known upstream migration barrier is at the Forrest Kerr Weir in reach 2. A complete upstream barrier is also located at Cascade Falls in reach 5.



APPENDIX C: PROPOSED 2018 SCOPE OF FIELD WORK

Activity	Tasks	Crew days
Lower Sub-unit Field Program		
Access Recon.	Ground checks for Bob Quin area access (fish and boat launch). Aerial check for sites without roads. Confirm list of accessible lakes for lake survey. Aerial survey for access to upper canyon tribs.	3
Lake Sampling	Conduct lake sampling.	3
Shore spawner Recon. and Bathymetry	Photodocument shore , lake outlet, tributary and outlet spawning sites. Groundwater recon, sediment texture, etc. Bathymetry depends on existing mapping and fisheries recon.	
Recon River sites	Ground and aerial checks of Ningunsaw, Little Iskut and Verret Area. Finalize list of sites for ground survey.	2
Ground survey River Sites	Ground survey at selected sites. Road access only.	3
Upper Sub-unit Field Program		
Lake Profiling CTD	The focus is on Kinaskan and Eddontenajon, Use the results to determine the number of invert tows and water samples.	4
Bathymetry	Bathymetric data collection, with the sounder on the big lakes and spot soundings on the smaller lakes.	5
Invertebrate tows	Tows at lake sites. May be able to use Red Chris data for Ealue, Kluea Lakes.	5
Shore Spawning Recon	May be more detailed on Kinaskan and Eddontenajon. Groundwater prospects, sediment texture, photos, etc	3
River Sites Recon	Snapper, main stem below Kinaskan..	2
Ground / boat survey lake connectors	Ground survey: groundwater prospects, habitat photos, sediment texture, field WQ.	2
RBT genetics	Opportunistic and look at existing samples.	
Access surveys	drone for Cascade then attach equipment to heli...additional ground work left	6