SOCIETY FOR ECOSYSTEM RESTORATION IN NORTHERN BRITISH COLUMBIA

Skeena Watershed Fish Passage Restoration Planning 2022

Prepared for
Habitat Conservation Trust Foundation - CAT23-6-288
BC Fish Passage Remediation Program
Ministry of Transportation and Infrastructure

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on behalf of
Society for Ecosytem Restoration in Northern British Columbia

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Research & Consulting

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Acknowledgement

Modern civilization has a long journey ahead to acknowledge and address the historic and ongoing impacts of colonialism that have resulted in harm to the cultures and livelihoods living interconnected with our ecosystems for many thousands of years.

The Society for Ecosytem Restoration in Northern British Columbia recognizes the Habitat Conservation Trust Foundation, BC Fish Passage Remediation Program and Ministry of Transportation and Infrastructure for making a significant financial contributions to supporting Skeena Watershed Fish Passage Restoration Planning. Partnerships are key to conserving BC's wildlife, fish, and their habitats.

1 Introduction

This report is available as both a pdf and as an online interactive report at https://newgraphenvironment.github.io/fish_passage_skeena_2022_reporting/. We recommend viewing online as the web-hosted version contains more features and is more easily navigable. Please reference the website for the latest version number and download the latest pdf from https://github.com/NewGraphEnvironment/fish_passage_skeena_2022_reporting/raw/master/docs/skeena2022.pdf

Since 2020, the Society for Ecosystem Restoration Northern British Columbia (SERNbc) has been undertaking an initiative to plan and conduct fish passage restoration planning activities in the Bulkley River and Morice River watershed groups which are sub-basins of the Skeena River watershed. The study area was expanded in 2022 to include the Zymoetz Watershed Group and the Kispiox River watershed group.

This report builds on reporting from field activities conducted in 2020 (Irvine 2021) and 2021 which can be viewed interactively here and here. Additionally, although part of the same overall intitive, to facilitate timelines, reporting for field activities conducted in the Bulkley River Watershed Group in 2022 have been included under separate cover and can be viewed here.

Please note that at the time of reporting, this document was a living document changing over time. Version numbers are logged for each release with modifications, enhancements and other changes tracked here. Issues and planned enhancements are tracked here.

The health and viability of freshwater fish populations can depend on access to tributary and off channel areas which provide refuge during high flows, opportunities for foraging, overwintering habitat, spawning habitat and summer rearing habitat (Bramblett et al. 2002; Swales and Levings 1989; Diebel et al. 2015). Culverts can present barriers to fish migration due to low water depth, increased water velocity, turbulence, a vertical drop at the culvert outlet and/or maintenance issues (Slaney, Zaldokas, and Watershed Restoration Program (B.C.) 1997; Cote et al. 2005). As road crossing structures are commonly upgraded or removed there are numerous opportunities to restore connectivity by ensuring that fish passage considerations are incorporated into repair, replacement, relocation and deactivation designs.

Although remediation and replacement of stream crossing structures can have benefits to local fish populations, the costs of remedial works can be significant and the impacts of the work often complex to evaluate and quantify. Additionally, allocation of ecosystem restoration funding towards infrastructure upgrades on transportation right of ways are not always considered ethical under all circumstances from all perspectives. When funds are finite and invested groups are engaged in fund raising, cost benefits and the ethics of crossing replacements should be explored collaboratively alongside the cost benefits and ethics of alternative investment activities including transportation corridor relocation/deactivation, land procurement/covenant, cattle exclusion, riparian/floodplain restoration, habitat complexing, water conservation, commercial/recreational fishing management, salt water interventions and research.

2 Background

The study area includes the Bulkley River, Zymoetz River, Kispiox River and Morice River watershed groups (Figure 2.1) and is within the traditional territories of the Gitxsan and Wet'suwet'en.

2.1 Wet'suwet'en

Wet'suwet'en hereditary territory covers an area of 22,000km^2 including the Bulkley River and Morice River watersheds and portions of the Nechako River watershed. The Wet'suwet'en people are a matrilineal society organized into the Gilseyhu (Big Frog), Laksilyu (Small Frog), Tsayu (Beaver clan), Gitdumden (Wolf/Bear) and Laksamshu (Fireweed) clans. Within each of the clans there are are a number of kin-based groups known as Yikhs or House groups. The Yikh is a partnership between the people and the territory. Thirteen Yikhs with Hereditary Chiefs manage a total of 38 distinct territories upon which they have jurisdiction. Within a clan, the head Chief is entrusted with the stewardship of the House territory to ensure the Land is managed in a sustainable manner. Inuk Nu'at'en (Wet'suwet'en law) governing the harvesting of fish within their lands are based on values founded on thousands of years of social, subsistence and environmental dynamics. The Yintahk (Land) is the centre of life as well as culture and it's management is intended to provide security for sustaining salmon, wildlife, and natural foods to ensure the health and well-being of the Wet'suwet'en (Office of the Wet'suwet'en 2013; "Office of the Wet'suwet'en" 2021; FLNRORD 2017).

2.2 Gitxsan

Gitxsan means "People of the River Mist". The Gitxsan Laxyip (traditional territories) covers an area of 33,000km^2 within the Skeena River and Nass River watersheds. The Laxyip is governed by 60 Simgiigyet (Hereditary Chiefs), within the traditional hereditary system made up of Wilps (House groups). Anaat are fisheries tenures found throughout the Laxyip. Traditional governance within a matrilineal society operates under the principles of Ayookw (Gitxsan law) ("Gitxsan Huwilp Government" 2021). Many band members live in Hazelton, Kispiox and Glen Vowell (the Eastern Gitxsan) as well as within Kitwanga, Kitwankool and Kitsegukla (the Western Gitxsan) (Powell, Jensen, and Pedersen 2018).

2.3 Project Location

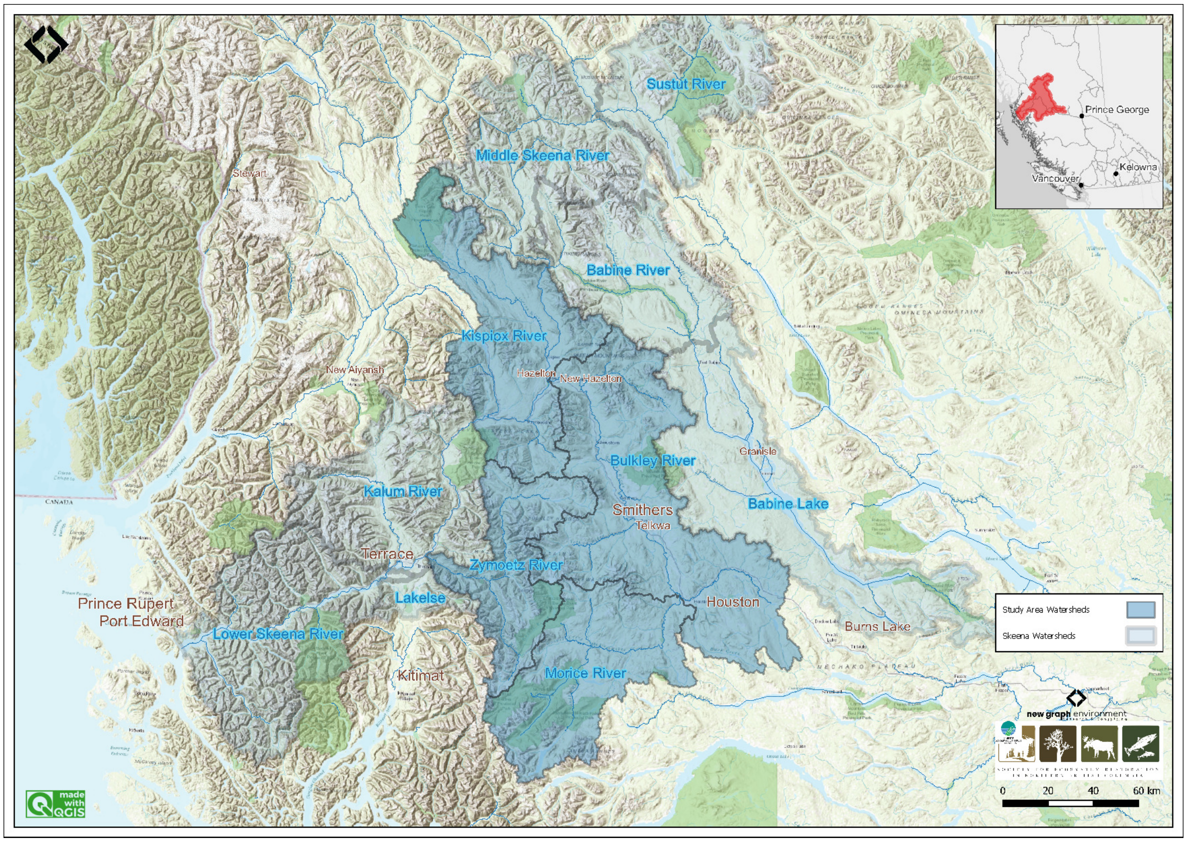


Figure 2.1: Overview map of Study Areas

2.3.1 Bulkley River

The Bukley River is an 8th order stream that drains an area of 7,762 km^2 in a generally northerly direction from Bulkley Lake on the Nechako Plateau to its confluence with the Skeena River at Hazleton. It has a mean annual discharge of 139.2 m^3/s at station 08EE004 located near Quick (~27km south of Telkwa) and 19.4 m^3/s at station 08EE003 located upstream near Houston. Flow patterns at Quick are heavily influenced by inflows from the Morice River (enters just downstream of Houston) resulting in flow patterns typical of high elevation watersheds which receive large amounts of precipitation as snow leading to peak levels of discharge during snowmelt, typically from May to July (Figures 2.2 - 2.3). The hydrograph peaks faster and generally earlier (May - June) for the Bulkley River upstream of Houston where the topography is of lower lower elevation (Figures 2.2 and 2.4).

2.3 Project Location

Changes to the climate systems are causing impacts to natural and human systems on all continents with alterations to hydrological systems caused by changing precipitation or melting snow and ice increasing the frequency and magnitude of extreme events such as floods and droughts (IPCC 2014; ECCC 2016). These changes are resulting in modifications to the quantity and quality of water resources throughout British Columbia and are likely to compound issues related to drought and flooding in the Bulkley River watershed where numerous water licenses are held with a potential over-allocation of flows identified during low flow periods (ILMB 2007).

The valley bottom has seen extensive settlement over the past hundred years with major population centers including the Village of Hazelton, the Town of Smithers, the Village of Telkwa and the District Municipality of Houston. As a major access corridor to northwestern British Columbia, Highway 16 and the Canadian National Railway are major linear developments that run along the Bulkley River within and adjacent to the floodplain with numerous crossing structures impeding fish access into and potentially out from important fish habitats. Additionally, as the valley bottom contains some of the most productive land in the area, there has been extensive conversion of riparian ecosystems to hayfields and pastures leading to alterations in flow regimes, increases in water temperatures, reduced streambank stability, loss of overstream cover and channelization (ILMB 2007; Wilson and Rabnett 2007).

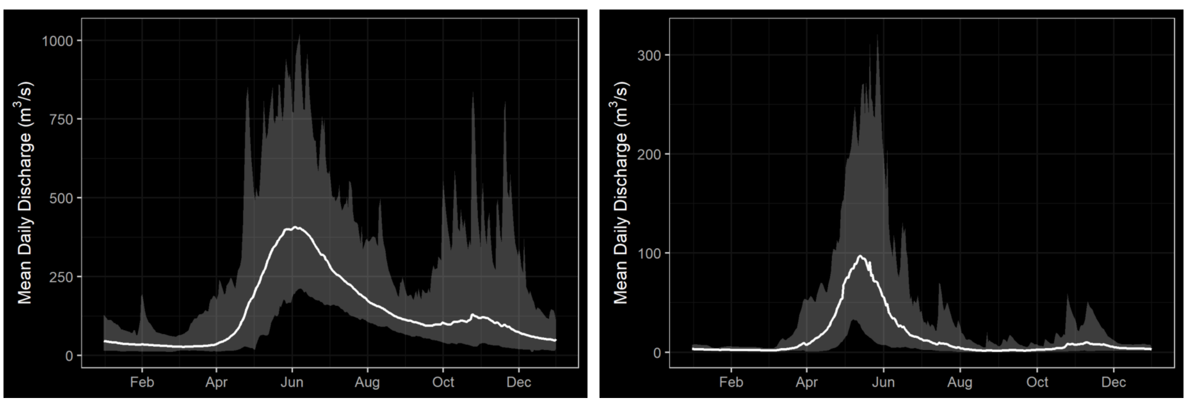


Figure 2.2: Hydrograph for Bulkley River at Quick (Station #08EE004) and near Houston (Station #08EE003).

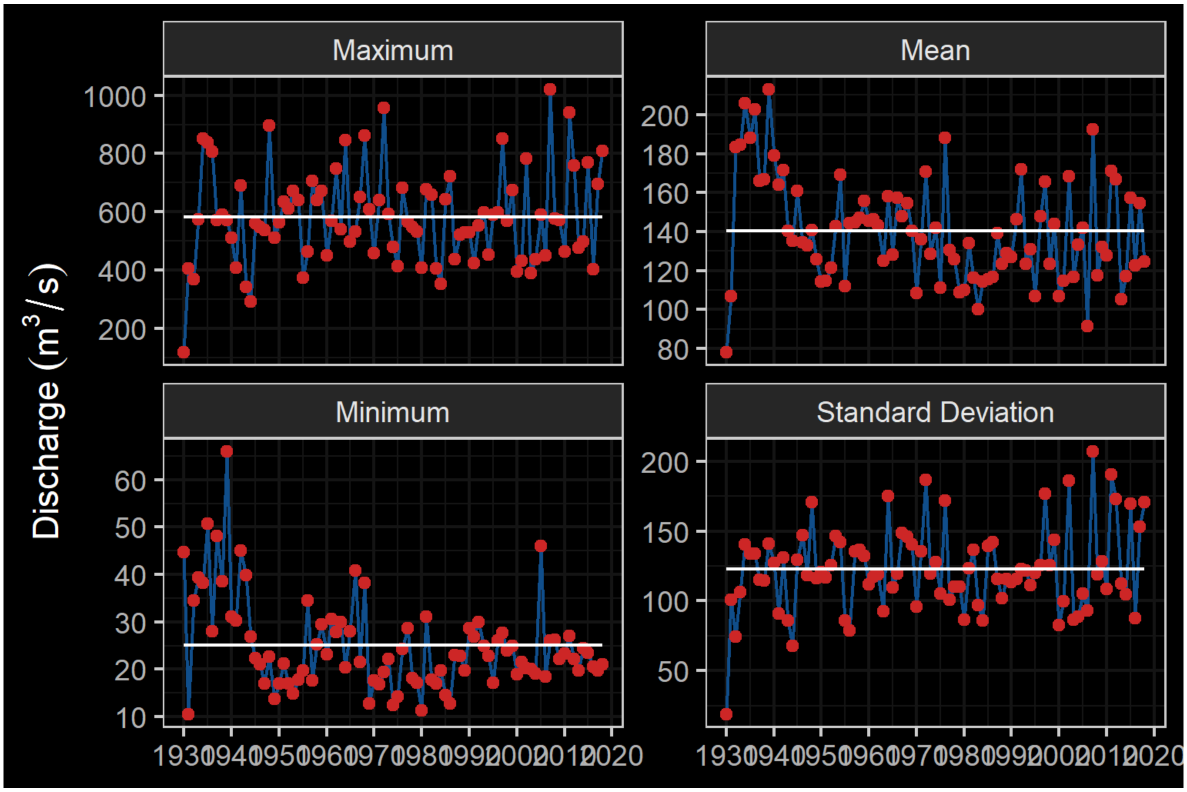


Figure 2.3: Summary of hydrology statistics for Bulkley River at Quick (Station #08EE004 - daily discharge data from 1930 to 2018).

Figure 2.4: Summary of hydrology statistics for Bulkley River near Houston (Station #08EE003 - daily discharge data from 1980 to 2018).

2.3.2 Morice River

The Morice River watershed drains 4,379 km^2 of Coast Mountains and Interior Plateau in a generally south-eastern direction. The Morice River is an 8th order stream that flows approximatley 80km from Morice Lake to the confluence with the upper Bulkley River just north of Houston. Major tributaries include the Nanika River, the Atna River, Gosnell Creek and the Thautil River. There area numerous large lakes situated on the south side of the watershed including Morice Lake, McBride Lake, Stepp Lake, Nanika Lake, Kid Price Lake, Owen Lake and others. There is one active hydrometric station on the mainstem of the Morice River near the outlet of Morice Lake and one historic station that was located at the mouth of the river near Houston that gathered data in 1971 only (Environment and limate Change Canada 2021). An estimate of mean annual discharge for the one year of data available for the Morice near it's confluence with the Bulkley River is 113.3 m^3/s. Mean annual discharge is estimated at 75.4 m^3/s at station 08ED002 located near the outlet of Morice Lake. Flow patterns are typical of high elevation watersheds influenced by coastal weather patterns which receive large amounts of winter precipitation as snow in the winter and large precipitation events in the fall. This leads to peak levels of discharge during snowmelt, typically from May to July with isolated high flows related to rain and rain on snow events common in the fall (Figures 2.5 - 2.6).

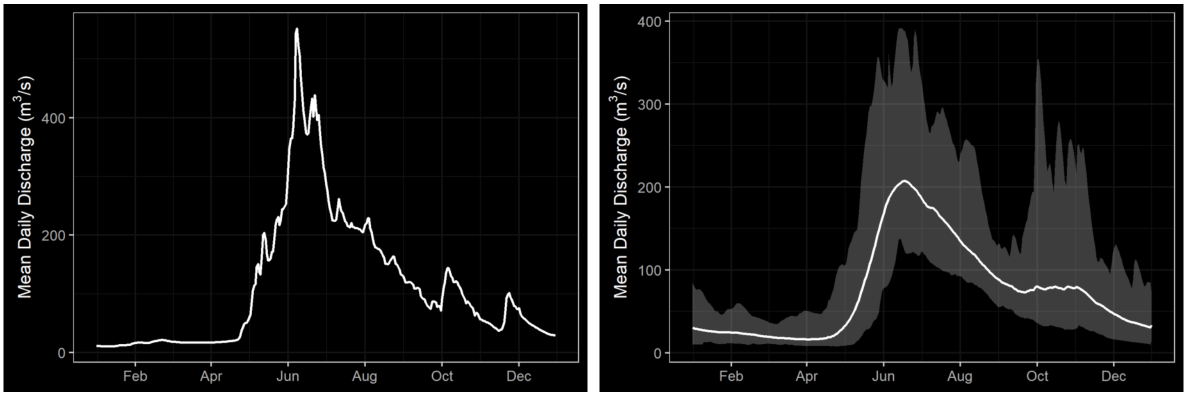


Figure 2.5: Left: Hydrograph for Morice River near Houston (Station #08ED003 - 1971 data only). Right: Hydrograph for Morice River near outlet of Morice Lake (Station #08ED002).

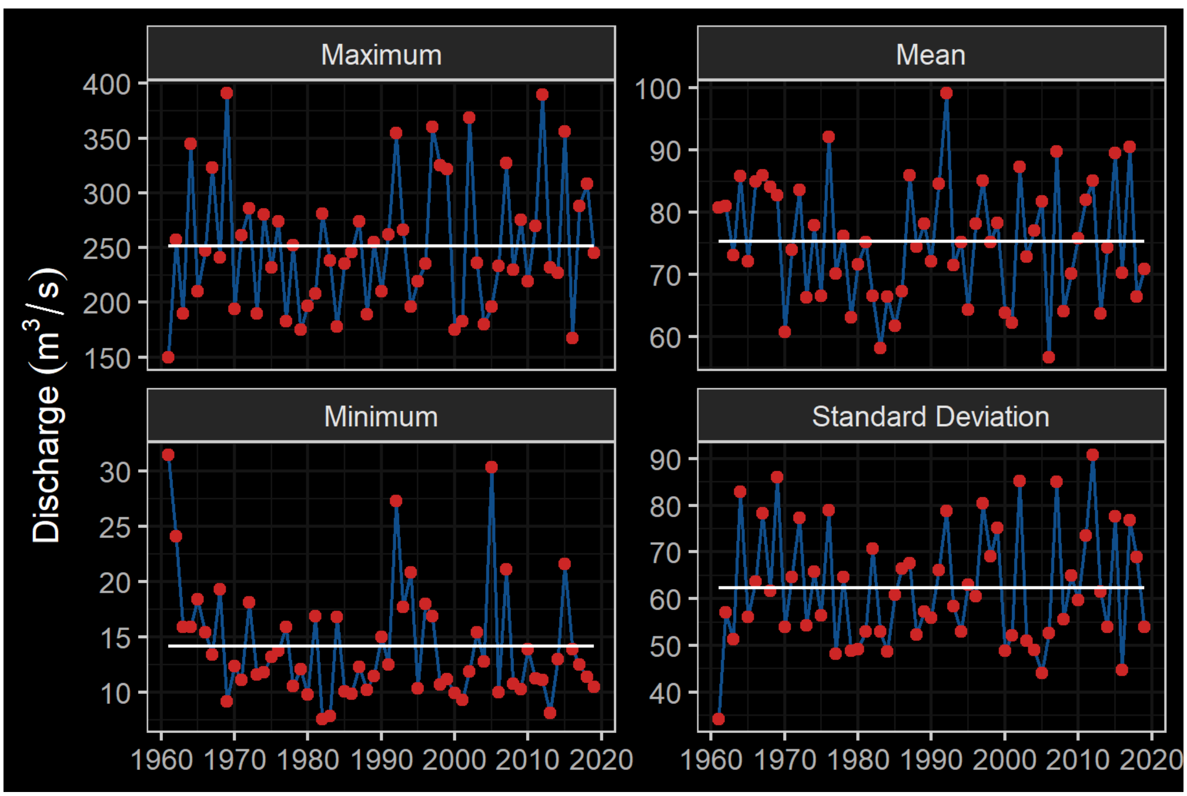


Figure 2.6: Summary of hydrology statistics for Morice River near outlet of Morice Lake (Station #08ED002 - Lat 54.116829 Lon -127.426582). Available daily discharge data from 1961 to 2018.

2.3.3 Zymoetz River

The Zymoetz River (known locally as the Copper River) watershed is an eighth order stream that drains an area of 3,028 km^2 in a generally westerly direction. It is considered a major tributary of the Skeena River, as it contributes approximately 10% of the flow. The headwater lakes are located approximately 20km southwest of Smithers, and they include Aldrich, Dennis and McDonell Lakes. The upper and lower portions of the watershed are accessed via logging roads off of Highway 16 from Smithers and Terrace, respectively. Access to the middle watershed is difficult due to road wash out. The Zymoetz River flows roughly 120km, starting just west of Hudson Bay mountain near Smithers and ending at the confluence of the Skeena River, approximately 8km north-east of Terrace. Elevations in the watershed range from 120m at the confluence, to 2740m in the Howson Range. The lower end of the Zymoetz watershed has seen a significant reduction in riparian habitat due to fires, forest development practices, pipe line and road construction (Allen Gottesfeld, Rabnett, and Hall 2002). Snowmelt plays a big role in controlling the stream hydrology, with a mean annual discharge estimated at 105.3 m^3/s at station 08EF005 located near Smithers. Peak discharge happens in May to early June, which is typical of a high elevation watershed like this (Figures 2.7 - 2.8).

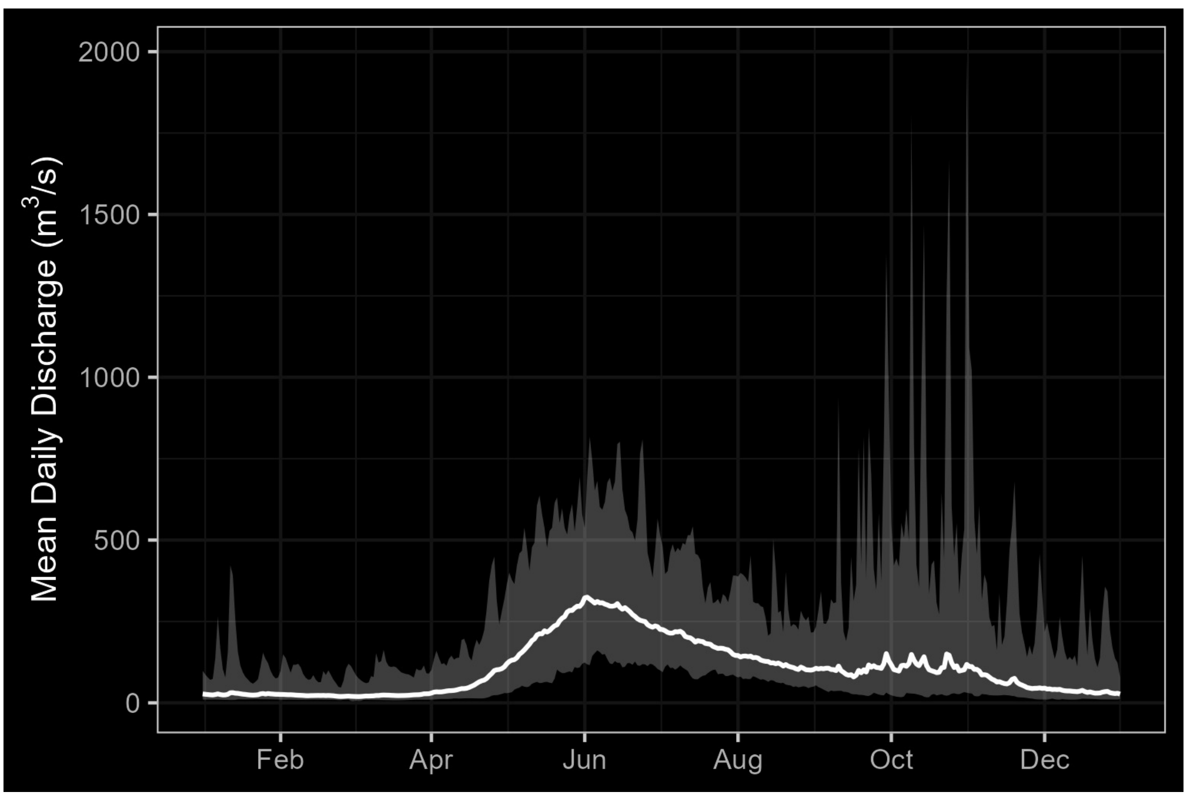


Figure 2.7: Hydrograph for Zymoetz River (Station #08EF005).

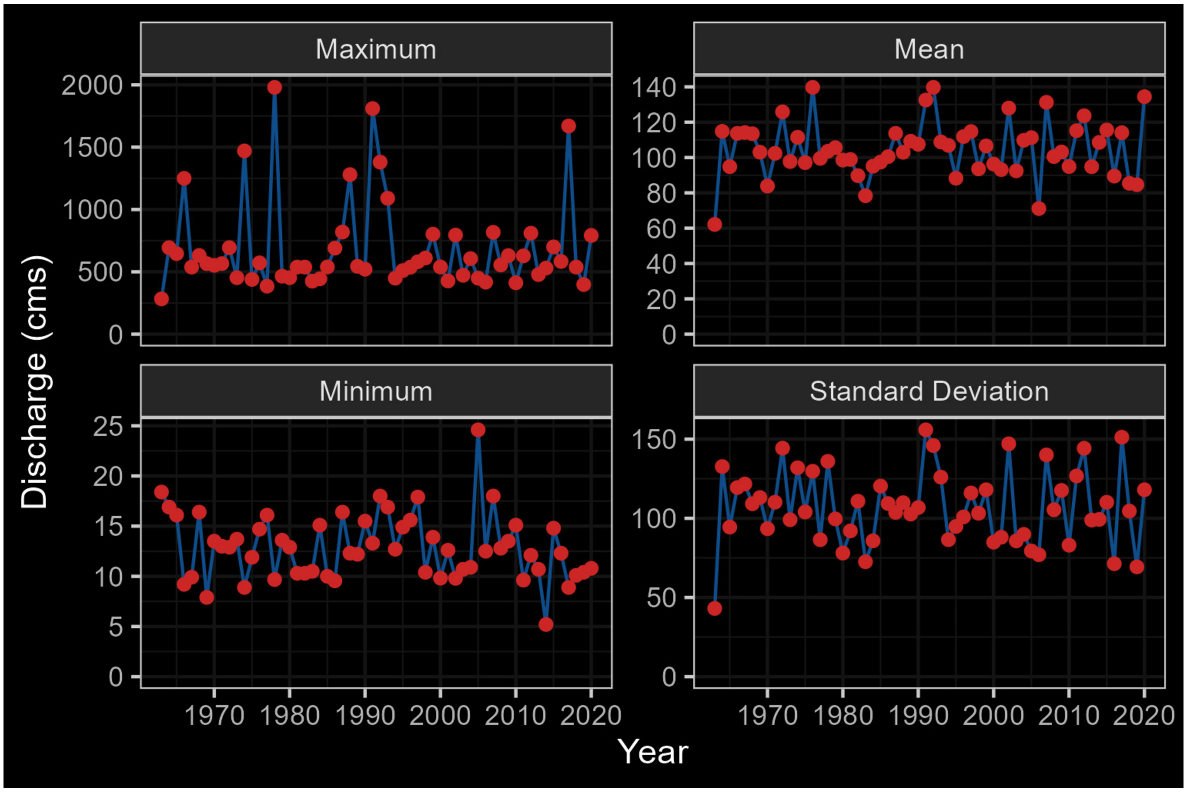


Figure 2.8: Summary of hydrology statistics for Zymoetz River (Station #08EF005 - Lat 54.116829 Lon -127.426582). Available daily discharge data from 1997 to 2021.

2.3.4 Kispiox River

The Kispiox River watershed is a seventh order stream that drains an area of 2,088km^2 in a south east direction. It is a large tributary of the Skeena River, contributing approximately 9% of its flow. It flows 140km to the confluence of the Skeena River, near Kispiox Village. Elevations in the watershed range from 200m at the mouth to as high as 2090m on Kispiox Mountain. The mainstream of the Kispiox is fed mainly by glacier melt and high elevation snow melt. Swan and Stephens Lakes (located in the upper watershed) are important sockeye systems. Swan Lake drains via Club Lake into Stephens Lake which in turn flows via Stephens Creek into the mainstem of the Kispiox River. Some of the biggest threats to aquatic ecosystems in the Kispiox valley are reported as erosion, obstructions, sedimentation, and altered water yield. The upper third of the Kispiox watershed (upstream of the Nangeese River) is well protected from development by the Swan Lake Kispiox River Provincial Park and because it contains few roads with little forestry development (Allen Gottesfeld, Rabnett, and Hall 2002). The Kispiox River has a mean annual discharge estimated at 45 m^3/s at station 08EB004 located near Hazelton. Peak discharge happens in May and June as a result of the spring snowmelt (Figures 2.9 - 2.10).

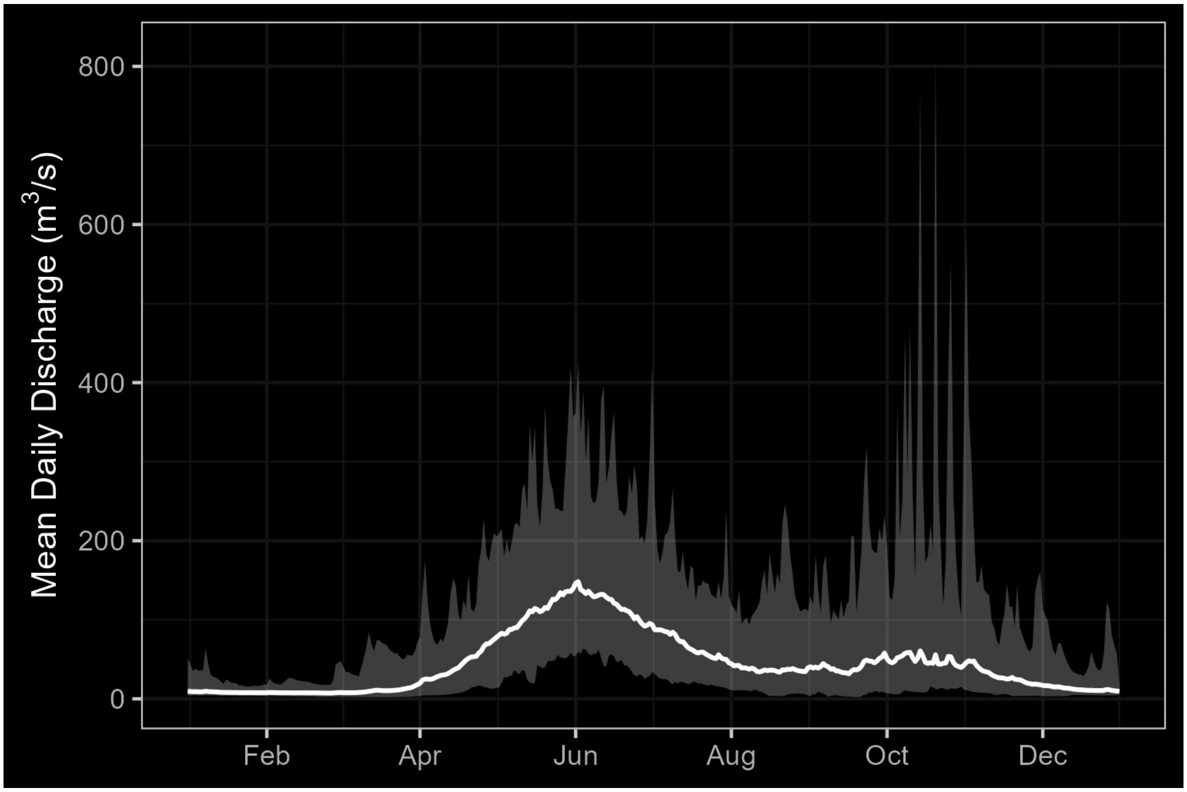


Figure 2.9: Hydrograph for Kispiox River near Hazelton (Station #08EB004).

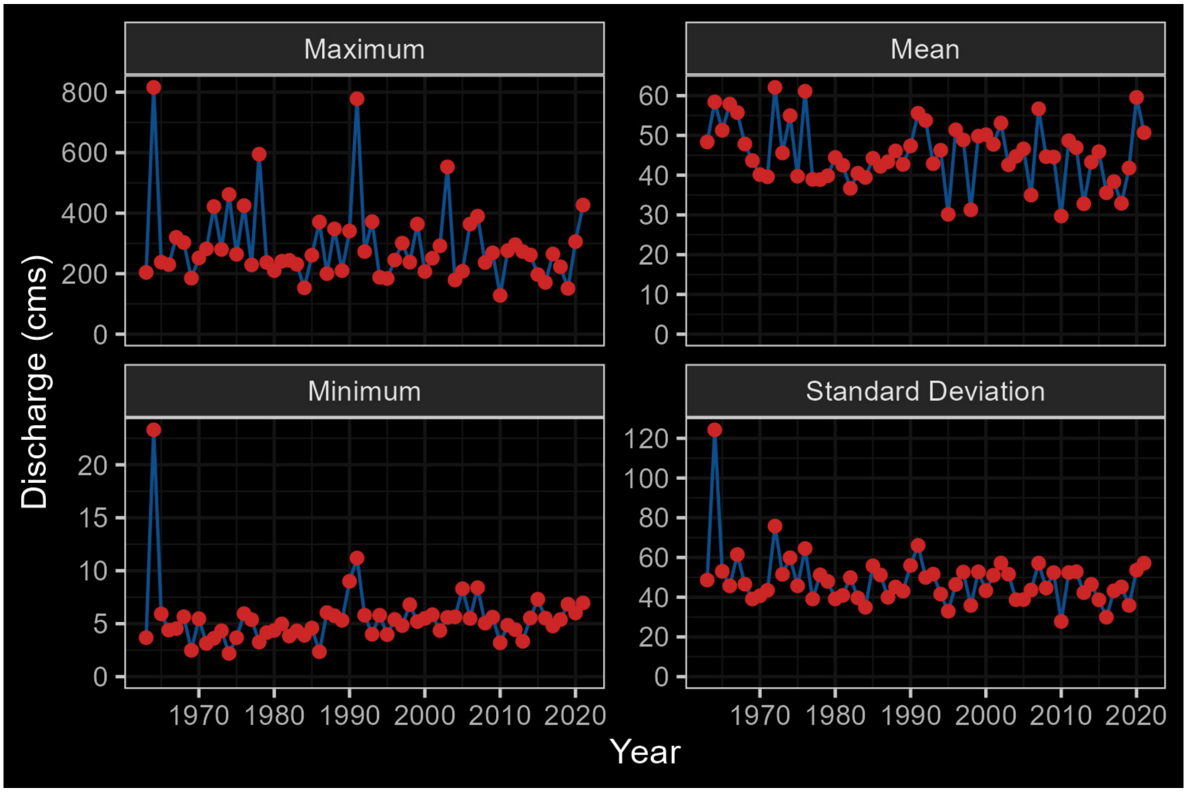


Figure 2.10: Summary of hydrology statistics for Kispiox River near Hazelton (Station #08EB004). Available daily discharge data from 1963 to 2021.

2.4 Fisheries

In 2004, IBM Business Consulting Services (2006) estimated the value of Skeena Fisheries at an annual average of $110 million dollars. The Bulkley-Morice watershed is an integral part of the salmon production in the Skeena drainage and supports an internationally renown steelhead, chinook and coho sport fishery (Tamblyn 2005).

2.4.1 Bulkley River

Traditionally, the salmon stocks passing through and spawning in Bulkley River were the principal food source for the Gitxsan and Wet'suwet'en people living there (Wilson and Rabnett 2007). Wilson and Rabnett (2007) detail numerous fishing areas located within the lower Bulkley drainage (from the confluence of the Skeena to the confluence with the Telkwa River) and the upper Bulkley drainage which includes the mainstem Bulkley River and tributaries upstream of the Telkwa River confluence. Anadromous lamprey passing through and spawning in the upper Bulkley River were traditionally also an important food source for the Wet'suwet'en (Wilson and Rabnett 2007; pers comm. Mike Ridsdale, Environmental Assessment Coordinator, Office of the Wet'suwet'en).

Approximately 11.3 km downstream of the Bulkley Lake outlet and just upstream of Watson Creek, the upper Bulkley falls is an approximately 4m high narrow rock sill that crosses the Bulkley River, producing a steep cascade section. This obstacle to fish passage is recorded as an almost complete barrier to fish passage for salmon during low water flows. Coho have not been observed beyond the falls since 1972 (Wilson and Rabnett 2007).

Renowned as a world class recreational steelhead and coho fishery, the Bulkley River receives some of the heaviest angling pressure in the province. In response to longstanding angler concerns with respect to overcrowding, quality of experience and conflict amongst anglers, an Angling Management Plan was drafted for the river following the initiation of the Skeena Quality Waters Strategy process in 2006 and an extensive multi-year consultation process. The plan introduces a number of regulatory measures with the intent to provide Canadian resident anglers with quality steelhead fishing opportunities. Regulatory measures introduced with the Angling Management Plan include prohibited angling for non-guided non-resident aliens on Saturdays and Sundays, Sept 1 - Oct 31 within the Bulkley River, angling prohibited for non-guided non-resident aliens on Saturdays and Sundays, all year within the Suskwa River and angling prohibited for non-guided non-resident aliens Sept 1 - Oct 31 in the Telkwa River. There is no fishing permitted upstream of the Morice/Bulkley River Confluence (FLNRO 2013a, 2013b; FLNRORD 2019).

2.4.2 Morice River

Detailed reviews of Morice River watershed fisheries can be found in Bustard and Schell (2002), Allen Gottesfeld, Rabnett, and Hall (2002), Schell (2003), A. Gottesfeld and Rabnett (2007), and ILMB (2007) with a comprehensive review of water quality by Oliver (2018). Overall, the Morice watershed contains high fisheries values as a major producer of chinook, pink, sockeye, coho and steelhead.

2.4.3 Zymoetz River

Within the Zymoetz Watershed, there are many areas with high fishery values. Steelhead are the most extensively documented fish species in the Zymoetz River watershed. Adults enter the river from JUly to November and then go on to spawn the following year in late spring to early summer. The Zymoetz River is a relatively steep system. Two canyons are located 6.4 and 19.6 kilometers upstream of the Skeena River confluence. These canyons make access to the Zymoetz difficult for pink and chum salmon (Allen Gottesfeld, Rabnett, and Hall 2002). The Zymoetz River is renowned for its aggressive steelhead that have been known to take flies or lures. There is a 50km stretch upstream of Limonite Creek that’s very remote and offers high quality fishing opportunities for anglers (FLNRORD 2013).

Traditional First Nations use of the upper Zymoetz River watershed by the Gitxsan and Wet’suwet’en people differed between community sites, residences, and fish houses, and was large and diverse. From the upper to lower Zymoetz River and to the Skeena River, a significant ancient grease trail connected, with a branch track forking through Limonite Creek and flowing down the

Telkwa River. The fishery used a weir at the mouth of McDonell Lake and spears at Six Mile Flats, near Dennis Lake. There is no information on native fisheries on the lower Zymoetz River. The Zymoetz is considered to be one of the top ten steelhead rivers in BC (Allen Gottesfeld, Rabnett, and Hall 2002).

2.4.4 Kispiox River

Kispiox River salmon are a important food source and cultural symbol for the Gitxsan people with sockeye and coho historically the two most significant species. Gitangwalk and Lax Didax, two significant villages that were both abandoned in the early 1900s, were situated on the Kispiox in such a way as to block the sockeye and coho salmon's upstream migration to the Upper Kispiox River spawning grounds providing opportunities to gather and preserve a significant amount of high-quality food over relatively short time periods (Allen Gottesfeld, Rabnett, and Hall 2002). The 100 km of mainstem and 300km of tributary streams in the Kispiox River Watershed are considering high value fish habitat supprting migration, spawning and rearing for many fish species. The Kispiox fisheries supports both recreational and commercial fishing while also enhancing the ecology, nutrient regime, and structural diversity of the drainage. Since 1992, sockeye and coho escapements from the Kispiox Watershed have been documented by the Gitxsan Watershed Authorities as they creates strong cultural, economic, and symbolic ties for the local communities (Allen Gottesfeld, Rabnett, and Hall 2002).

2.4.4.1 Fish Species

Fish species recorded in the Bulkley River and Morice River watershed groups are detailed in Table 2.1 (MoE 2020a). Coastal cutthrout trout and bull trout are considered of special concern (blue-listed) provincially. Summaries of some of the Skeena and Bulkley River fish species life history, biology, stock status, and traditional use are documented in Schell (2003), Wilson and Rabnett (2007), Allen Gottesfeld, Rabnett, and Hall (2002) and Office of the Wet'suwet'en (2013). Wilson and Rabnett (2007) discuss chinook, pink, sockeye, coho, steelhead and indigenous freshwater Bulkley River fish stocks within the context of key lower and upper Bulkley River habitats such as the Suskwa River, Station Creek, Harold Price Creek, Telkwa River and Buck Creek. Key areas within the upper Bulkley River watershed with high fishery values, documented in Schell (2003), are the upper Bulkley mainstem, Buck Creek, Dungate Creek, Barren Creek, McQuarrie Creek, Byman Creek, Richfield Creek, Johnny David Creek, Aitken Creek and Emerson Creek.

Some key areas of high fisheries values for chinook, sockeye and coho are noted in Bustard and Schell (2002) as McBride Lake, Nanika Lake, and Morice Lake watersheds. A draft gantt chart for select species in the Morice River and Bulkley River watersheds was derived from reviews of the aforementioned references and is included as Figure 2.11. The data is considered in draft form and will be refined over the spring and summer of 2021 with local fisheries technicians and knowledge holders during the collaboratory assessment planning and fieldwork activities planned.

In the 1990’s the Morice River watershed, A. Gottesfeld and Rabnett (2007) estimated that chinook comprised 30% of the total Skeena system chinook escapements. It is estimated that Morice River coho comprise approximatley 4% of the Skeena escapement with a declining trend noted since the 1950 in A. Gottesfeld and Rabnett (2007). Coho spawn in major tributaries and small streams ideally at locations where downstream dispersal can result in seeding of prime off channel habitats including warm productive sloughs and side channels. Of all the salmon species, coho rely on small tributaries the most (Bustard and Schell 2002). Bustard and Schell (2002) report that much of the distribution of coho into non-natal tributaries occurs during high flow periods of May - early July with road culverts blocking migration into these habitats.

Summaries of historical fish observations in the Bulkley River and Morice River watershed groups (n=4033), graphed by remotely sensed average gradient as well as measured or modelled channel width categories for their associated stream segments where calculated with `bcfishpass` and `bcfishobs` and are provided in Figures 2.12 - 2.13.

Table 2.1: Fish species recorded in the Bulkley River and Morice River watershed groups.

Scientific Name	Species Name	Species Code	BC List	Provincial FRPA	COSEWIC	SARA	Bulkley	Morice
Catostomus catostomus	Longnose Sucker	LSU	Yellow	–	–	–	Yes	Yes
Catostomus commersonii	White Sucker	WSU	Yellow	–	–	–	Yes	Yes
Catostomus macrocheilus	Largescale Sucker	CSU	Yellow	–	–	–	Yes	Yes
Chrosomus eos	Northern Redbelly Dace	RDC	Yellow	–	–	–	Yes	–
Coregonus clupeaformis	Lake Whitefish	LW	Yellow	–	–	–	Yes	Yes
Cottus aleuticus	Coastrange Sculpin (formerly Aleutian Sculpin)	CAL	Yellow	–	–	–	Yes	Yes
Cottus asper	Prickly Sculpin	CAS	Yellow	–	–	–	Yes	Yes
Couesius plumbeus	Lake Chub	LKC	Yellow	–	DD	–	Yes	Yes
Entosphenus tridentatus	Pacific Lamprey	PL	Yellow	–	–	–	Yes	Yes
Hybognathus hankinsoni	Brassy Minnow	BMC	No Status	–	–	–	Yes	–
Lota lota	Burbot	BB	Yellow	–	–	–	Yes	Yes
Mylocheilus caurinus	Peamouth Chub	PCC	Yellow	–	–	–	Yes	Yes
Oncorhynchus clarkii	Cutthroat Trout	CT	No Status	–	–	–	Yes	Yes
Oncorhynchus clarkii	Cutthroat Trout (Anadromous)	ACT	No Status	–	–	–	Yes	–
Oncorhynchus clarkii clarkii	Coastal Cutthroat Trout	CCT	Blue	–	–	–	Yes	Yes
Oncorhynchus gorbuscha	Pink Salmon	PK	Yellow	–	–	–	Yes	Yes

Scientific Name	Species Name	Species Code	BC List	Provincial FRPA	COSEWIC	SARA	Bulkley	Morice
Oncorhynchus keta	Chum Salmon	CM	Yellow	–	–	–	Yes	Yes
Oncorhynchus kisutch	Coho Salmon	CO	Yellow	–	–	–	Yes	Yes
Oncorhynchus mykiss	Rainbow Trout	RB	Yellow	–	–	–	Yes	Yes
Oncorhynchus mykiss	Steelhead	ST	Yellow	–	–	–	Yes	Yes
Oncorhynchus mykiss	Steelhead (Summer-run)	SST	Yellow	–	–	–	Yes	Yes
Oncorhynchus nerka	Kokanee	KO	Yellow	–	–	–	Yes	Yes
Oncorhynchus nerka	Sockeye Salmon	SK	Yellow	–	–	–	Yes	Yes
Oncorhynchus tshawytscha	Chinook Salmon	CH	Yellow	–	–	–	Yes	Yes
Prosopium coulterii	Pygmy Whitefish	PW	Yellow	–	NAR (Nov 2016)	–	Yes	Yes
Prosopium coulterii pop. 3	Giant Pygmy Whitefish	GPW	Yellow	–	–	–	Yes	–
Prosopium williamsoni	Mountain Whitefish	MW	Yellow	–	–	–	Yes	Yes
Ptychocheilus oregonensis	Northern Pikeminnow	NSC	Yellow	–	–	–	Yes	Yes
Pungitius pungitius	Ninespine Stickleback	NSB	Unknown	–	–	–	Yes	–
Rhinichthys cataractae	Longnose Dace	LNC	Yellow	–	–	–	Yes	Yes
Rhinichthys falcatus	Leopard Dace	LDC	Yellow	–	NAR (May 1990)	–	–	Yes
Richardsonius balteatus	Redside Shiner	RSC	Yellow	–	–	–	Yes	Yes
Salvelinus confluentus pop. 26	Bull Trout	BT	Blue	–	–	–	Yes	Yes
Salvelinus fontinalis	Brook Trout	EB	Exotic	–	–	–	Yes	Yes
Salvelinus malma	Dolly Varden	DV	Yellow	–	–	–	Yes	Yes
Salvelinus namaycush	Lake Trout	LT	Yellow	–	–	–	Yes	Yes
–	Arctic Char	AC	–	–	–	–	–	Yes
–	Cutthroat/Rainbow cross	CRS	–	–	–	–	Yes	–
–	Dace (General)	DC	–	–	–	–	–	Yes
–	Lamprey (General)	L	–	–	–	–	Yes	Yes
–	Minnow (General)	C	–	–	–	–	Yes	Yes
–	Salmon (General)	SA	–	–	–	–	Yes	Yes
–	Sculpin (General)	CC	–	–	–	–	Yes	Yes
–	Sucker (General)	SU	–	–	–	–	Yes	Yes
–	Whitefish (General)	WF	–	–	–	–	Yes	Yes

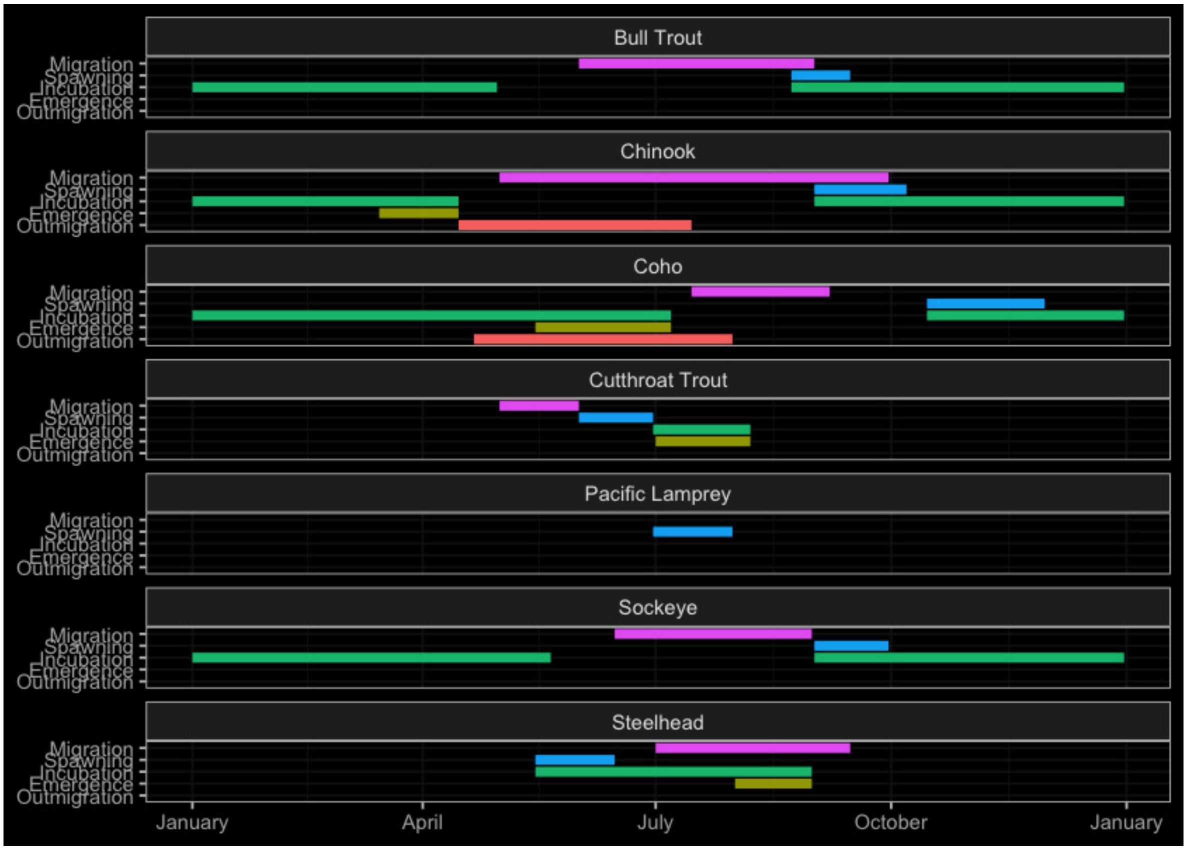


Figure 2.11: Gantt chart for select species in the Morice River and Bulkley River watersheds. To be updated in consultation with local fisheries techicians and knowledge holders.

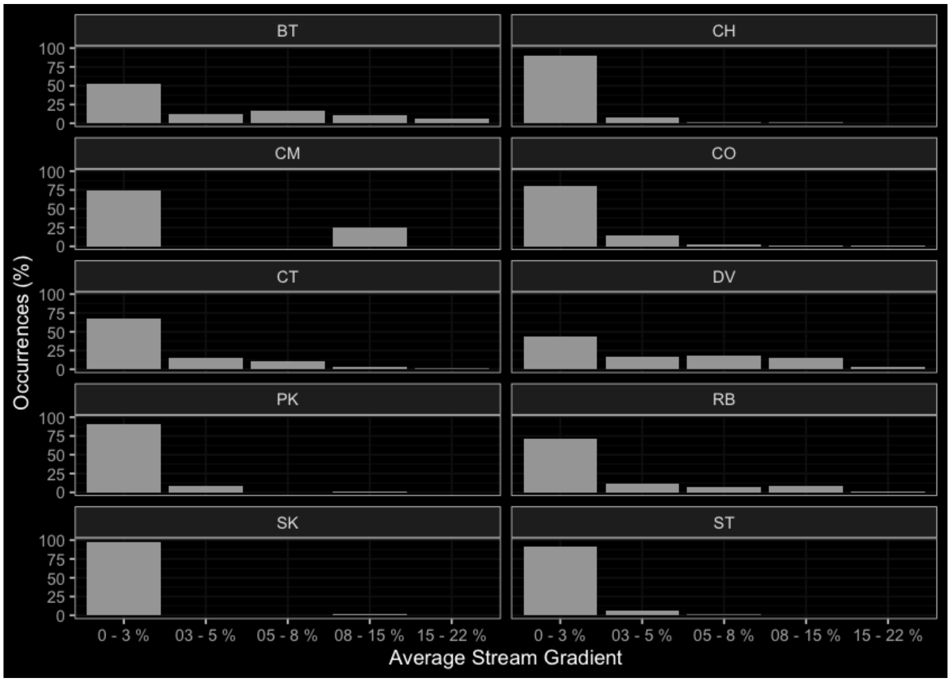


Figure 2.12: Summary of historic salmonid observations vs. stream gradient category for the Bulkley River watershed group.

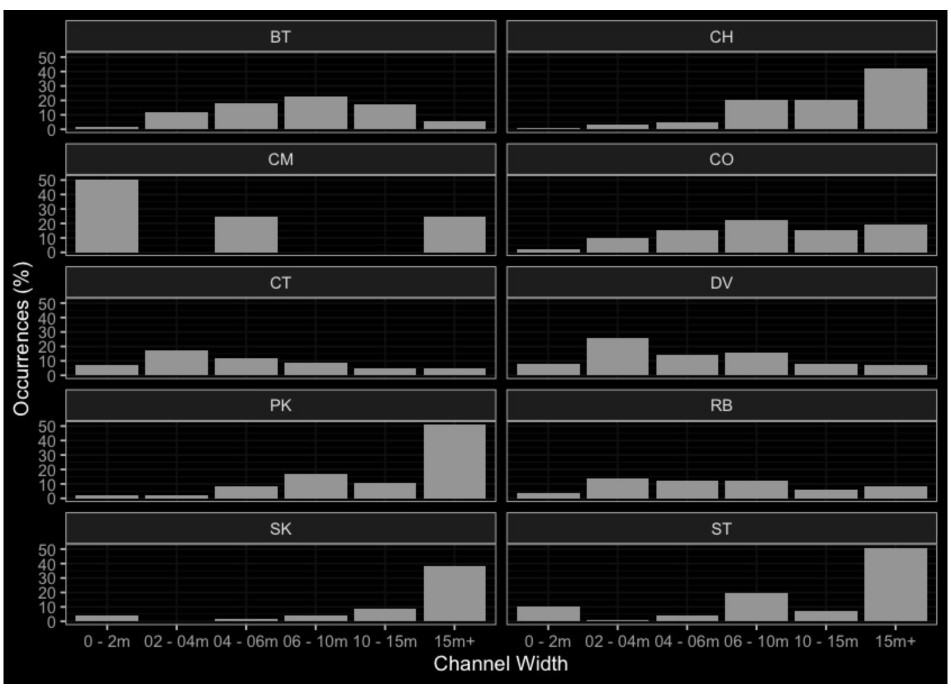


Figure 2.13: Summary of historic salmonid observations vs. channel width category for the Bulkley River watershed group.

2.4 Fisheries

3 Methods

Workflows for the project have been classified into planning, fish passage assessments, habitat confirmation assessments, reporting and mapping. All components leveraged `R`, `SQL` or `Python` programming languages to facilitate workflow tracking, collaboration, transparency and continually improving research. Project workflows utilized local and remote `postgreSQL` databases as well as a "snapshot" of select datasets contained within a local `sqlite` database. A data and script repository to facilitate this reporting is located on Github.

3.1 Planning

To identify priorities for crossing structure rehabilitation, background literature, fisheries information, PSCIS, and `bcfishpass` (Norris 2021d) outputs were reviewed. `bcfishpass` is an updated open-source code repository comprised of tools ported over from the `Fish Habitat Model` (Norris and Mount 2016) developed by the BC Ministry of Environment along with a number of significant upgrades and new features. Scripts within `bcfishpass` also pull and analyze data using other open-source tools such as `bcdata` (Norris 2021b), `bcfishobs` (Norris 2021c), and `fwapg` (Norris 2021a) which serve numerous functions related to open-data access as well as the analysis of the BC Freshwater Atlas, roads, fish and fish habitat in British Columbia.

3.1.1 Habitat Modelling

`bcfishpass` calculates the average gradient of BC Freshwater Atlas stream network lines at minimum 100m long intervals starting from the downstream end of the streamline segment and working upstream. The network lines are broken into max gradient categories with new segments created if and when the average slope of the stream line segment exceeds user provided thresholds. For this project, the user provided gradient thresholds used to delineate "potentially accessible habitat" were based on estimated max gradients that salmon (15% - coho and chinook) and steelhead (20%) are likely to be capable of ascending.

Through this initiative and other SERN/New Graph led initiatives, the Provincial Fish Passage Remediation Program and connectivity restoration planning by the Canadian Wildlife Federation (Mazany-Wright et al. 2021), `bcfishpass` has been designed to prioritize potential fish passage barriers for assessment or remediation. The software is under continual development and has been designed and constructed by Norris (2021d) using sql and python based shell script libraries to generate a simple model of aquatic habitat connectivity. The model identifies natural barriers (ex. steep gradients for extended distances) and hydroelectric dams to classifying the accessibility upstream by fish (Norris 2021d). On potentially accessible streams, scripts identify known barriers (ex. waterfalls >5m high) and additional anthropogenic features which are primarily road/railway stream crossings (i.e. culverts) that are potentially barriers. To prioritize these features for assessment or remediation, scripts report on how much modelled potentially accessible aquatic habitat the barriers may obstruct. The model can be refined with known fish observations upstream of identified barriers and for each crossing location, the area of lake and wetland habitat upstream, species documented upstream/downstream, an estimate of watershed area (on 2nd order and higher streams), mean annual precipitation weighted to upstream watershed area and channel width can be collated using `bcfishpass`, `fwapg` and `bcfishobs`. This, information, can be used to provides an indication of the potential quantity and quality of habitat potentially gained should fish passage be restored by comparing to user defined thresholds for the aforementioned parameters. A discussion of the methodology to derive channel width is below.

Gradient, channel size and stream discharge are key determinants of channel morphology and subsequently fish distribution. High value rearing, overwintering and spawning habitat preferred by numerous species/life stages of fish are often located within channel types that have relatively low gradients and large channel widths (also quantified by the amount of flow in the stream). Following delineation of “potentially accessible habitat”, the average gradient of each stream segment within habitat classified as below the 15% and 20% thresholds was calculated and summed within species and life stage specific gradient categories. Average gradient of stream line segments can be calculated from elevations contained in the provincial freshwater atlas streamline dataset. To obtain estimates of channel width upstream of crossing locations, Where available, `bcfishpass` was utilized to pull average channel gradients from Fisheries Information Summary System (FISS) site assessment data (MoE 2020d) or PSCIS assessment data (MoE 2021) and associate with stream segment lines. When both FISS and PSCIS values were associated with a particular stream segment, FISS channel width was used. When multiple FISS sites were associated with a particular stream segment a mean of the average channel widths was taken. To model channel width for 2nd order and above stream segments without associated FISS or PSCIS sites, first `fwapg` was used to estimate the drainage area upstream of the segment. Then, rasters from ClimateBC (Wang et al. 2012) were sampled for each stream segments and a mean annual precipitation weighted by upstream watershed area was calculated. Mean annual precipitation was then combined with the channel widths and BEC zone information (gathered through a spatial query tied to the bottom of the stream segment) into a dataset (n = 22990) for analysis fo the relationship between these variables. The details of this analysis and resulting formula used to estimate channel width on stream segments in the Skeena Watershed is included as a technical appendix at https://www.poissonconsulting.ca/f/859859031.

`bcfishpass` and associated tools have been designed to be flexible in analysis, accepting user defined gradient, channel width and stream discharge categories (MoE 2020d). Although currently in draft form, and subject to development revisions, gradient and channel width thresholds for habitat with the highest intrinsic value for a number of fish species in the Skeena watershed groups have been specified and applied to model habitat upstream of stream crossing locations with the highest intrinsic value (Table 3.1). Thresholds were derived based on a literature review with references provided in Table 3.2. Output parameters for modelling are presented in Table 3.3.

Table 3.1: Stream gradient and channel width thresholds used to model potentially highest value fish habitat.

Variable	Chinook Salmon	Coho Salmon	Steelhead	Sockeye Salmon
Spawning Gradient Max (%)	4	5	4	2
Spawning Width Min (m)	4	2	4	2
Rearing Gradient Max (%)	5.0	5.0	7.4	–
Rearing Width Min (m)	1.5	1.5	1.5	1.5

Table 3.2: References for stream gradient and channel width thresholds used to model potentially highest value fish habitat. Preliminary and subject to revisions.

Variable	Chinook Salmon	Coho Salmon	Steelhead	Sockeye Salmon
Spawning Gradient Max (%)	0.03 (Kirsch et al. 2004, Busch et al. 2011, Cooney and Holzer 2006)	0.05 (Roberge et al. 2002, Sloat et al. 2017)	0.04 (Scheer and Steel 2006, Cooney and Holzer 2006)	0.02 (Lake 1999, Hoopes 1972)
Spawning Width Min (m)	3.7 (Busch et al. 2011, Cooney and Holzer 2006)	2 (Sloat et. al 2017)	3.8 (Cooney and Holzer 2006)	2 (Woll et al. 2017)
Rearing Gradient Max (%)	0.05 (Woll et al. 2017, Porter et al. 2008)	0.05 (Kirsch et al. 2004, Porter et al. 2008, Rosenfeld et al. 2000)	0.074 (Porter et al. 2008)	–

Table 3.3: bcfishpass outputs and associated definitions

Attribute	Definition
ST Network (km)	Steelhead model, total length of stream network potentially accessible upstream of point
ST Lake Reservoir (ha)	Steelhead model, total area lakes and reservoirs potentially accessible upstream of point
ST Wetland (ha)	Steelhead model, total area wetlands potentially accessible upstream of point
ST Slopeclass03 Waterbodies (km)	Steelhead model, length of stream connectors (in waterbodies) potentially accessible upstream of point with slope 0-3%
ST Slopeclass03 (km)	Steelhead model, length of stream potentially accessible upstream of point with slope 0-3%
ST Slopeclass05 (km)	Steelhead model, length of stream potentially accessible upstream of point with slope 3-5%
ST Slopeclass08 (km)	Steelhead model, length of stream potentially accessible upstream of point with slope 5-8%
ST Spawning (km)	Length of stream upstream of point modelled as potential Steelhead spawning habitat
ST Rearing (km)	Length of stream upstream of point modelled as potential Steelhead rearing habitat
CH Spawning (km)	Length of stream upstream of point modelled as potential Chinook spawning habitat
CH Rearing (km)	Length of stream upstream of point modelled as potential Chinook rearing habitat
CO Spawning (km)	Length of stream upstream of point modelled as potential Coho spawning habitat
CO Rearing (km)	Length of stream upstream of point modelled as potential Coho rearing habitat
CO Rearing (ha)	Area of wetlands upstream of point modelled as potential Coho rearing habitat
SK Spawning (km)	Length of stream upstream of point modelled as potential Sockeye spawning habitat
SK Rearing (km)	Length of stream upstream of point modelled as potential Sockeye rearing habitat
SK Rearing (ha)	Area of lakes upstream of point modelled as potential Sockeye rearing habitat

* Steelhead model uses a gradient threshold of maximum 20% to determine if access if likely possible

3.2 Fish Passage Assessments

In the field, crossings prioritized for follow-up were first assessed for fish passage following the procedures outlined in “Field Assessment for Determining Fish Passage Status of Closed Bottomed

Structures" (MoE 2011a). Crossings surveyed included closed bottom structures (CBS), open bottom structures (OBS) and crossings considered "other" (i.e. fords). Photos were taken at surveyed crossings and when possible included images of the road, crossing inlet, crossing outlet, crossing barrel, channel downstream and channel upstream of the crossing and any other relevant features. The following information was recorded for all surveyed crossings: date of inspection, crossing reference, crew member initials, Universal Transverse Mercator (UTM) coordinates, stream name, road name and kilometer, road tenure information, crossing type, crossing subtype, culvert diameter or span for OBS, culvert length or width for OBS. A more detailed "full assessment" was completed for all closed bottom structures and included the following parameters: presence/absence of continuous culvert embedment (yes/no), average depth of embedment, whether or not the culvert bed resembled the native stream bed, presence of and percentage backwatering, fill depth, outlet drop, outlet pool depth, inlet drop, culvert slope, average downstream channel width, stream slope, presence/absence of beaver activity, presence/absence of fish at time of survey, type of valley fill, and a habitat value rating. Habitat value ratings were based on channel morphology, flow characteristics (perennial, intermittent, ephemeral), fish migration patterns, the presence/absence of deep pools, un-embedded boulders, substrate, woody debris, undercut banks, aquatic vegetation and overhanging riparian vegetation (Table 3.4). For crossings determined to be potential barriers or barriers based on the data (see Barrier Scoring (page 25)), a culvert fix and recommended diameter/span was proposed.

Table 3.4: Habitat value criteria (Fish Passage Technical Working Group, 2011).

Habitat Value	Fish Habitat Criteria
High	The presence of high value spawning or rearing habitat (e.g., locations with abundance of suitably sized gravels, deep pools, undercut banks, or stable debris) which are critical to the fish population.
Medium	Important migration corridor. Presence of suitable spawning habitat. Habitat with moderate rearing potential for the fish species present.
Low	No suitable spawning habitat, and habitat with low rearing potential (e.g., locations without deep pools, undercut banks, or stable debris, and with little or no suitably sized spawning gravels for the fish species present).

3.2.1 Barrier Scoring

Fish passage potential was determined for each stream crossing identified as a closed bottom structure as per MoE (2011a). The combined scores from five criteria: depth and degree to which the structure is embedded, outlet drop, stream width ratio, culvert slope, and culvert length were used to screen whether each culvert was a likely barrier to some fish species and life stages (Table 3.5, Table 3.6. These criteria were developed based on data obtained from various studies and reflect an estimation for the passage of a juvenile salmon or small resident rainbow trout (Clarkin et al. 2005 ; Bell 1991; Thompson 2013).

Table 3.5: Fish Barrier Risk Assessment (MoE 2011).

Risk	LOW	MOD	HIGH
Embedded	>30cm or >20% of diameter and continuous	<30cm or 20% of diameter but continuous	No embedment or discontinuous
Value	0	5	10
Outlet Drop (cm)	<15	15-30	>30
Value	0	5	10
SWR	<1.0	1.0-1.3	>1.3
Value	0	3	6
Slope (%)	<1	1-3	>3
Value	0	5	10
Length (m)	<15	15-30	>30
Value	0	3	6

Table 3.6: Fish Barrier Scoring Results (MoE 2011).

Cumlative Score	Result
0-14	passable
15-19	potential barrier
>20	barrier

3.2.2 Cost Benefit Analysis

A cost benefit analysis was conducted for each crossing determined to be a barrier based on an estimate of cost associated with remediation or replacement of the crossing with a structure that facilitates fish passage and the amount of potential habitat that would be made available by remediating fish passage at the site (habitat gain index).

3.2.2.1 Habitat Gain Index

The habitat gain index is the quantity of modelled habitat upstream of the subject crossing and represents an estimate of habitat gained with remediation of fish passage at the crossing. For this project, a gradient threshold between accessible and non-accessible habitat was set at 20% (for a minimimum length of 100m) intended to represent the maximum gradient of which the strongest swimmers of anadromous species (steelhead) are likely to be able to migrate upstream.

For reporting of Phase 1 - fish passage assessments within the body of this report (Table 3.5), a "total" value of habitat <20% output from `bcfishpass` was used to estimate the amount of habitat upstream of each crossing less than 20% gradient before a falls of height >5m - as recorded in MoE (2020c) or documented in other `bcfishpass` online documentation. For Phase 2 - habitat confirmation sites, conservative estimates of the linear quantity of habitat to be potentially gained by fish passage restoration, steelhead rearing maximum gradient threshold (7.4%) was used. To generate areas of habitat upstream, the estimated linear length was multiplied by half the downstream channel width measured (overall triangular channel shape) as part of the fish passage assessment protocol. Although these estimates are not generally conservative, have low accuracy and do not account for upstream stream crossing structures they allow a rough idea of the best candidates for follow up.

Potential options to remediate fish passage were selected from MoE (2011a) and included:

- Removal (RM) - Complete removal of the structure and deactivation of the road.
- Open Bottom Structure (OBS) - Replacement of the culvert with a bridge or other open bottom structure. Based on consultation with FLNR road crossing engineering experts, for this project we considered bridges as the only viable option for OBS type .
- Streambed Simulation (SS) - Replacement of the structure with a streambed simulation design culvert. Often achieved by embedding the culvert by 40% or more. Based on consultation with FLNR engineering experts, we considered crossings on streams with a channel width of <2m and a stream gradient of <8% as candidates for replacement with streambed simulations.
- Additional Substrate Material (EM) - Add additional substrate to the culvert and/or downstream weir to embed culvert and reduce overall velocity/turbulence. This option was considered only when outlet drop = 0, culvert slope <1.0% and stream width ratio < 1.0.
- Backwater (BW) - Backwatering of the structure to reduce velocity and turbulence. This option was considered only when outlet drop < 0.3m, culvert slope <2.0%, stream width ratio < 1.2 and stream profiling indicates it would be effective..

Cost estimates for structure replacement with bridges and embedded culverts were generated based on the channel width, slope of the culvert, depth of fill, road class and road surface type. Road details were sourced from FLNRORD (2020b) and FLNRORD (2020a) through `bcfishpass`.

Interviews with Phil MacDonald, Engineering Specialist FLNR - Kootenay, Steve Page, Area Engineer - FLNR - Northern Engineering Group and Matt Hawkins - MoTi - Design Supervisor for Highway Design and Survey - Nelson were utilized to helped refine estimates.

Base costs for installation of bridges on forest service roads and permit roads with surfaces specified in provincial GIS road layers as rough and loose was estimated at $25000/linear m and assumed that the road could be closed during construction and a minimum bridge span of 15m. For streams with channel widths <2m, embedded culverts were reported as an effective solution with total installation costs estimated at $50k/crossing (pers. comm. Phil MacDonald, Steve Page) adjusted for inflation. For larger streams (>6m), span width increased proportionally to the size of the stream (ex. for an 8m wide stream a 12m wide span was prescribed). For crossings with large amounts of fill (>3m), the replacement bridge span was increased by an additional 3m for each 1m of fill >3m to account for cutslopes to the stream at a 1.5:1 ratio. To account for road type, a multiplier table was also generated to estimate incremental cost increases with costs estimated for structure replacement on paved surfaces, railways and arterial/highways costing up to 20 times more than forest service roads due to expenses associate with design/engineering requirements, traffic control and paving. The cost multiplier table (Table 3.7) should be considered very approximate with refinement recommended for future projects.

Table 3.7: Cost multiplier table based on road class and surface type.

Class	Surface	Class Multiplier	Surface Multiplier	Bridge $K/10m	Streambed Simulation $K
FSR	Rough	1	1	250	50
FSR	Loose	1	1	250	50
Resource	Loose	1	1	250	50
Permit	Loose	1	1	250	50
Unclassified	Loose	1	1	250	50
Unclassified	Rough	1	1	250	50
Unclassified	Paved	1	2	500	100
Unclassified	Unknown	1	2	500	100
Local	Loose	4	1	1000	200
Local	Paved	4	2	2000	400
Arterial	Paved	15	2	7500	1500
Highway	Paved	15	2	7500	1500
Rail	Rail	15	2	7500	1500

3.3 Climate Change Risk Assessment

In collaboration with the Ministry of Transportation and Infrastructure (MoTi), a new climate change replacement program aims to prioritize vulnerable culverts for replacement (pers. comm Sean Wong, 2022) based on data collected and ranked related to three categories - culvert condition, vulnerability and priority. Within the "condition" risk category - data was collected and crossings were ranked based on erosion, embankment and blockage issues. The "climate" risk category included ranked assessments of the likelihood of both a flood event affecting the culvert as well as the consequence of a flood event affecting the culvert. Within the "priority" category the following factors were ranked - traffic volume, community access, cost, constructability, fish bearing status and environmental impacts (Table 3.8). This project is still in its early stages with methodology changes likely going forward.

Table 3.8: Climate change data collected at MoTi culvert sites

Parameter	Description
erosion_issues	Erosion (scale 1 low - 5 high)
embankment_fill_issues	Embankment fill issues 1 (low) 2 (medium) 3 (high)
blockage_issues	Blockage Issues 1 (0-30%) 2 (>30-75%) 3 (>75%)
condition_rank	Condition Rank = embankment + blockage + erosion
condition_notes	Describe details and rational for condition rankings
likelihood_flood_event_affecting_culvert	Likelihood Flood Event Affecting Culvert (scale 1 low - 5 high)
consequence_flood_event_affecting_culvert	Consequence Flood Event Affecting Culvert (scale 1 low - 5 high)
climate_change_flood_risk	Climate Change Flood Risk (likelihood x consequence) 1-6 (low) 6-12 (medium) 10-25 (high)
vulnerability_rank	Vulnerability Rank = Condition Rank + Climate Rank
climate_notes	Describe details and rational for climate risk rankings
traffic_volume	Traffic Volume 1 (low) 5 (medium) 10 (high)
community_access	Community Access - Scale - 1 (high - multiple road access) 5 (medium - some road access) 10 (low - one road access)
cost	Cost (scale: 1 high - 10 low)
constructability	Constructibility (scale: 1 difficult -10 easy)
fish_bearing	Fish Bearing 10 (Yes) 0 (No) - see maps for fish points
environmental_impacts	Environmental Impacts (scale: 1 high -10 low)
priority_rank	Priority Rank = traffic volume + community access + cost + constructability + fish bearing + environmental impacts
overall_rank	Overall Rank = Vulnerability Rank + Priority Rank
priority_notes	Describe details and rational for priority rankings

3.4 Habitat Confirmation Assessments

Following fish passage assessments, habitat confirmations were completed in accordance with procedures outlined in the document "A Checklist for Fish Habitat Confirmation Prior to the Rehabilitation of a Stream Crossing" (Fish Passage Technical Working Group 2011). The main objective of the field surveys was to document upstream habitat quantity and quality and to determine if any other obstructions exist above or below the crossing. Habitat value was assessed based on channel morphology, flow characteristics (perennial, intermittent, ephemeral), the presence/absence of deep pools, un-embedded boulders, substrate, woody debris, undercut banks, aquatic vegetation and overhanging riparian vegetation. Criteria used to rank habitat value was based on guidelines in Fish Passage Technical Working Group (2011) (Table 3.4).

During habitat confirmations, to standardize data collected and facilitate submission of the data to provincial databases, information was collected on "Site Cards". Habitat characteristics recorded included channel widths, wetted widths, residual pool depths, gradients, bankfull depths, stage, temperature, conductivity, pH, cover by type, substrate and channel morphology (among others). When possible, the crew surveyed downstream of the crossing to the point where fish presence had been previously confirmed and upstream to a minimum distance of 600m. Any potential obstacles to fish passage were inventoried with photos, physical descriptions and locations recorded on site cards. Surveyed routes were recorded with time-signatures on handheld GPS units.

Fish sampling was conducted on a subset of sites when biological data was considered to add significant value to the physical habitat assessment information. When possible, electrofishing was utilized within discrete site units both upstream and downstream of the subject crossing with electrofisher settings, water quality parameters (i.e. conductivity, temperature and ph), start location, length of site and wetted widths (average of a minimum of three) recorded. For each fish captured, fork length and species was recorded, with results included within the fish data submission spreadsheet. Fish information and habitat data will be submitted to the province under scientific fish collection permit CB20-611971.

3.5 Reporting

Reporting was generated with `bookdown` (Xie 2016) from `Rmarkdown` (Allaire et al. 2023) with primarily `R` (R Core Team 2022) and `SQL` scripts. The `R` package `fpr` contains many specialized custom functions related to the work (Irvine [2022] 2022). In addition to numerous spatial layers sourced through the BC Data Catalogue then stored and queried in a local `postgresql` and `sqlite` databases data inputs for this project include:

- Populated Fish Data Submission Spreadsheet Template - V 2.0, January 20, 2020
- Populated pscis_assessment_template_v24.xls
- `bcfishpass` outputs.
- Custom CSV file detailing Phase 2 site:
    - priority level for proceeding to design for replacement
    - length of survey upstream and downstream
    - a conservative estimate of the linear length of mainstem habitat potentially available upstream of the crossing
    - fish species confirmed as present upstream of the crossing
- GPS tracks from field surveys.
- Photos and photo metadata

Version changes are tracked here and issues/planned enhancements tracked here.

3.6 Mapping

Mapping was completed by Hillcrest Geographics. `pdf` maps were generated using `QGIS` with data supplied via a `postgreSQL` database. A QGIS layer file defining and symbolizing all layers required for general fish passage mapping was developed and at the time of reporting was kept under version control within `bcfishpass`.

4 Results and Discussion

4.1 Climate Change Risk Assessment

Preliminary climate change risk assessment data for Ministry of Transportation and Infrastructure sites is presented below. Phase 1 sites are contained in Table 4.1, and Phase 2 sites are in Table 4.2. Raw data is provided here.

Table 4.1: Preliminary climate change risk assessment data for Ministry of Transportation and Infrastructure sites (Phase 1 PSCIS)

Site	198200	198215	198216	198197	198209	198206	198186	198221	198196	198202	198201	198207
External ID	8300012	8300042	8300054	8300105	8300111	8300118	8300162	8300178	8300186	8300188	8300917	2022090501
MoTi ID	1528424	1524776	3321227	3321236	1524149	1525645	1524552	1529688	1524780	1529371	1528426	1524566
Stream	Tea Creek	Dale Creek	Tributary to Skeena River	Tributary to Kispiox River	Tributary to Kispiox River	Tributary to McCully Creek	Tributary to Kispiox River	Tributary to Kitwanga River	Tributary to Kispiox River	Tributary to Kitwanga River	Tributary to Tea Creek	Tributary to Kispiox River
Road	Moore Road	Date Creek FSR	Kispiox Valley Road	Kispiox Valley Road	Kispiox Valley Road	Helen Lake Road	Poplar Park Road	11A Ave	Date Creek FSR	Hwy 37	Moore Road	Poplar Park Rd
Erosion (scale 1 low - 5 high)	1	1	1	2	1	1	1	1	2	1	3	1
Embankment fill issues 1 (low) 2 (medium) 3 (high)	1	1	1	1	1	1	1	1	1	1	2	1
Blockage Issues 1 (0-30%) 2 (>30-75%) 3 (>75%)	1	2	2	1	1	1	2	2	1	1	1	2
Condition Rank = embankment + blockage	3	4	4	4	3	3	4	4	4	3	6	4
Likelihood Flood Event Affecting Culvert (scale 1 low - 5 high)	1	1	1	2	1	1	1	4	1	3	2	1
Consequence Flood Event Affecting Culvert (scale 1 low - 5 high)	1	3	4	2	3	1	1	1	1	5	2	3
Climate Change Flood Risk (likelihood x consequence) 1-6 (low) 6-12 (medium) 10-25 (high)	1	3	4	4	3	1	1	4	1	15	4	3
Vulnerability Rank = Condition Rank + Climate Rank	4	7	8	8	6	4	5	8	5	18	10	7

Site	198200	198215	198216	198197	198209	198206	198186	198221	198196	198202	198201	198207
10 (high)	3	3	8	5	5	1	4	1	7	9	5	1
Community Access - Scale - 1 (high - multiple road access) 5 (medium - some road access) 10 (low - one road access)	8	3	10	7	5	5	8	1	9	8	9	1
Cost (scale: 1 high - 10 low)	8	5	2	4	7	1	7	1	6	2	8	10
Constructibility (scale: 1 difficult -10 easy)	9	5	2	6	7	10	8	9	5	4	8	10
Fish Bearing 10 (Yes) 0 (No) - see maps for fish points	10	10	10	10	0	0	0	10	0	0	10	0
Environmental Impacts (scale: 1 high -10 low)	7	7	9	6	1	10	8	9	6	4	7	10
Priority Rank = traffic volume + community access + cost + constructability + fish bearing + environmental impacts	45	33	41	38	25	27	35	31	33	27	47	32
Overall Rank = Vulnerability Rank + Priority Rank	49	40	49	46	31	31	40	39	38	45	57	39

Table 4.2: Preliminary climate change risk assessment data for Ministry of Transportation and Infrastructure sites (Phase 2 PSCIS)

Site	198215	198216	198220
MoTi ID	1524776	3321227	4092
Stream	Tributary to Kispiox River	Tributary to Skeena River	Tea Creek
Road	Date Creek FSR	Kispiox Valley Road	Highway 37
Erosion (scale 1 low - 5 high)	1	1	3
Embankment fill issues 1 (low) 2 (medium) 3 (high)	1	1	1
Blockage Issues 1 (0-30%) 2 (>30-75%) 3 (>75%)	2	2	1
Condition Rank = embankment + blockage	4	4	5
Likelihood Flood Event Affecting Culvert (scale 1 low - 5 high)	1	1	1
Consequence Flood Event Affecting Culvert (scale 1 low - 5 high)	3	4	5
Climate Change Flood Risk (likelihood x consequence) 1-6 (low) 6-12 (medium) 10-25 (high)	3	4	5
Vulnerability Rank = Condition Rank + Climate Rank	7	8	10
Traffic Volume 1 (low) 5 (medium) 10 (high)	3	8	9
Community Access - Scale - 1 (high - multiple road access) 5 (medium - some road access) 10 (low - one road access)	3	10	1
Cost (scale: 1 high - 10 low)	5	2	1
Constructibility (scale: 1 difficult -10 easy)	5	2	2
Fish Bearing 10 (Yes) 0 (No) - see maps for fish points	10	10	10
Environmental Impacts (scale: 1 high -10 low)	7	9	2
Priority Rank = traffic volume + community access + cost + constructability + fish bearing + environmental impacts	33	41	25
Overall Rank = Vulnerability Rank + Priority Rank	40	49	35

4.2 Phase 1

Field assessments were conducted between September 05 2022 and September 26 2022 by Allan Irvine, R.P.Bio. and Mateo Winterscheidt, B.Sc., Tieasha Pierre, Vern Joseph, Dallas Nikal, Alexandria Nikal, Jesse Olson and Colin Morrison. A total of 61 Phase 1 assessments at sites not yet inventoried into the PSCIS system included 18 crossings considered “passable”, 7 crossings considered “potential” barriers and 32 crossings considered “barriers” according to threshold values based on culvert embedment, outlet drop, slope, diameter (relative to channel size) and length (MoE 2011a). Additionally, although all were considered fully passable, 4 crossings assessed were fords and ranked as “unknown” according to the provincial protocol. A summary of crossings assessed, a cost estimate for remediation and a priority ranking for follow up for Phase 1 sites is presented in Table 4.3. Detailed data with photos are presented in [Attachment 2](https://www.newgraphenvironment.com/fish_passage_skeena_2022_reporting/appendix---phase-1-fish-passage-assessment-data-and-photos.html.

“Barrier” and “Potential Barrier” rankings used in this project followed MoE (2011a) and reflect an assessment of passability for juvenile salmon or small resident rainbow trout at any flows potentially present throughout the year (Clarkin et al. 2005 ; Bell 1991; Thompson 2013). As noted in Bourne et al. (2011), with a detailed review of different criteria in Kemp and O’Hanley (2010), passability of barriers can be quantified in many different ways. Fish physiology (i.e. species, length, swim speeds) can make defining passability complex but with important implications for evaluating connectivity and prioritizing remediation candidates (Bourne et al. 2011; Shaw et al. 2016; Mahlum et al. 2014; Kemp and O’Hanley 2010). Washington Department of Fish & Wildlife (2009) present criteria for assigning passability scores to culverts that have already been assessed as barriers in coarser level assessments. These passability scores provide additional information to feed into decision making processes related to the prioritization of remediation site candidates and have potential for application in British Columbia.

Table 4.3: Upstream habitat estimates and cost benefit analysis for Phase 1 assessments conducted on sites not yet inventoried in PSCIS. Steelhead network model (total length stream network <20% gradient).

PSCIS ID	External ID	Stream	Road	Result	Habitat value	Stream Width (m)	Priority	Fix	Cost Est ($K)
2880	–	Mooluck Creek	Kuldo FSR	Barrier	Medium	3.50	mod	SS-CBS	50
8525	–	Tributary to Coal Creek	McDonell FSR	Barrier	Medium	1.40	mod	SS-CBS	50
8527	–	Tributary to Zymoetz River	McDonell FSR	Barrier	Low	1.50	low	SS-CBS	50
196441	–	Cullon Creek	Kuldo FSR	Potential	High	3.00	mod	OBS	250
198182	8302064	Tributary to Kispiox River	Helen Lake Rd	Barrier	Medium	1.40	mod	SS-CBS	50
198183	8302070	Tributary to Kispiox River	Helen Lake Rd	Barrier	Medium	2.30	mod	OBS	250
198184	8302074	Tributary to Kispiox River	Helen Lake Rd	Barrier	Low	1.10	low	SS-CBS	50
198185	8300115	Trib to McCully Creek	Helen Lake Rd	Barrier	Low	1.30	low	SS-CBS	200
198186	8300162	Tributary to Kispiox River	Poplar Park Rd	Potential	Low	1.20	low	SS-CBS	200
198187	2798180	Tributary to Kispiox River	Poplar Park Rd	Barrier	Low	2.10	low	OBS	–
198188	8300161	Tributary to Kispiox River	Poplar Park Rd	Barrier	Low	2.30	low	OBS	1000
198190	8302683	Sweetie River	Nangeese FSR	Barrier	Low	1.90	low	SS-CBS	50
198191	8302061	Tributary to Kispiox River	Corral Main	Barrier	Medium	1.50	mod	SS-CBS	50
198192	8302062	Tributary to Kispiox River	Corral Main	Barrier	Low	1.90	low	SS-CBS	50
198193	8301747	Tributary to Cullon Creek	Kuldo FSR	Barrier	Low	1.80	low	SS-CBS	50
198194	8301750	Tributary to Cullon Creek	Kuldo FSR	Barrier	Medium	1.90	mod	SS-CBS	50
198195	8301761	Tributary to Cullon Creek	Kuldo FSR	Barrier	Low	1.50	low	SS-CBS	50
198196	8300186	Tributary to Kispiox River	Kispiox Westside Rd	Barrier	Low	2.40	low	OBS	1000
198197	8300105	Tributary to Kispiox River	Kispiox Valley Rd	Barrier	Low	1.80	low	SS-CBS	200
198198	8300104	Tributary to Kispiox River	Kispiox Valley Rd	Potential	Low	1.20	low	SS-CBS	200
198199	8300103	Tributary to Kispiox River	Kispiox Valley Rd	Barrier	Low	1.40	low	SS-CBS	200
198202	8300188	Tributary to Kitwanga River	Hwy 37	Potential	Low	1.80	low	SS-CBS	50
198203	2022090901	Tributary to Kitwanga River	Kitwancool Branch 2 FSR	Potential	Medium	1.70	low	SS-CBS	50
198204	8302421	Tributary to Kispiox River	Helen 9000	Potential	Low	15.00	low	OBS	500
198205	8302065	Tributary to Kispiox River	Helen Lake Rd	Barrier	Low	2.20	low	OBS	250
198206	8300118	Tributary to McCully Creek	Helen Lake Rd	Barrier	Low	2.00	low	OBS	–
198207	2022090501	Tributary to Kispiox River	Poplar Park Rd	Barrier	High	2.20	high	OBS	–

PSCIS ID	External ID	Stream	Road	Result	Habitat value	Stream Width (m)	Priority	Fix	Cost Est ($K)
198208	8300030	Tributary to Sweetin River	Kispiox Valley Rd	Barrier	Low	0.80	low	SS-CBS	200
198209	8300111	Tributary to Kispiox River	Kispiox Valley Rd	Barrier	Low	1.90	low	SS-CBS	200
198210	8302403	Tributary to Kispiox River	Mitten Mainline	Potential	Low	4.30	low	OBS	250
198213	8301749	Tributary to Cullon Creek	Kuldo FSR	Barrier	Low	1.00	low	SS-CBS	50
198214	8301748	Tributary to Cullon Creek	Kuldo FSR	Barrier	Low	1.60	low	SS-CBS	50
198215	8300042	Tributary to Kispiox River	Kispiox Westside Rd	Barrier	High	5.30	high	OBS	1750
198217	8301485	Tributary to Skeena River	Sik e Dakh Water Tower Rd	Barrier	High	5.60	high	OBS	–
198218	2787053	Tributary to Kispiox River	Kispiox Valley Rd	Barrier	Medium	2.00	mod	OBS	–
198219	8300033	Tributary to Kispiox River	Seventeen Mile Rd	Potential	Medium	2.50	low	OBS	1000
198220	8300095	Tributary to Kitwanga River	Hwy 37	Barrier	High	5.00	high	OBS	22875
198221	8300178	Tributary to Kitwanga River	11A Ave	Barrier	Medium	4.00	mod	OBS	–
198222	8302257	Pinenut Creek	Babine Slide FSR	Barrier	High	8.20	high	OBS	325
198224	4601067	Tributary to Zymoetz River	Hankin FSR	Barrier	Medium	1.45	mod	SS-CBS	50
198225	8300128	Sterritt creek	Babine Slide FSR	Barrier	Low	3.70	low	OBS	325
198230	8300108	Trib to Sammon Lake	Kispiox Valley Rd	Barrier	Medium	1.90	mod	SS-CBS	200
198236	8301994	Tributary to Kitwanga River	Kitwancool Branch 2 FSR	Barrier	High	2.30	high	OBS	250

4.3 Phase 2

During 2022 field assessments, habitat confirmation assessments were conducted at 8 sites in the Morice River, Zymoetz River and Kispiox River watersheds. A total of approximately 7km of stream was assessed, fish sampling utilizing electrofishing surveys were conducted at two streams. Georeferenced field maps are presented in Attachment 1.

As collaborative decision making was ongoing at the time of reporting, site prioritization can be considered preliminary. In total, 5 crossings were rated as high priorities for proceeding to design for replacement, 3 crossings were rated as moderate priorities, and 0 crossings were rated as low priorities. Results are summarized in Tables 4.4 - 4.3 with raw habitat and fish sampling data included in digital format here. A summary of preliminary modelling results illustrating the quantity of chinook, coho and steelhead spawning and rearing habitat potentially available upstream of each crossing as estimated by measured/modelled channel width and upstream accessible stream length are presented in Figure 4.1. Detailed information for each site assessed with Phase 2 assessments (including maps) are presented within site specific appendices to this document.

Table 4.4: Overview of habitat confirmation sites. Steelhead rearing model used for habitat estimates (total length of stream segments <7.5% gradient)

PSCIS ID	Stream	Road	UTM (11U)	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
8530	Sandstone Creek	Mcdonell FSR	582704 6073877	–	5.7	Medium	high	Medium value habitat. Abundant cover from woody debris, overhanging veg and undercut banks. Wide channel throughout with graveled areas suitable for spawning. Trace distribution of deep pools suitable for rearing. A couple smaller cascades (<1m in height) thar may block smaller fish. 11:23:33
197379	Tributary to Owen Creek	Morice-Owen FSR	640961 6005930	CO,RB	0.8	High	high	Abundant undercut banks with some pools. Healthy riparian vegetation providing cover and woody debris to habitat. Good flow.
198215	Dale Creek	Kispiox Westside Rd	582154 6135026	–	0.8	High	moderate	Moderate value habitat. Numerous cascades that are approx 1m in height, with deep pools below. Wide stream throughout. A lot of large woody debris over stream. Dam upstream. Average gradient of 7. Trace areas with gravels that could be suitable for spawning. 12:58:40
198216	Tributary to Skeena River	Kispiox Valley Rd	583026 6130402	–	–	High	–	–
198217	Tributary to Skeena River	Sik-e-dakh Water Tower Rd	582851 6130491	–	1.4	High	high	High value habitat. Abundant gravels suitable for CO, ST, RB spawning. Local knowledge of historic CO spawning in system. Multiple large beaver dams in site. Stream flows adjacent to community of Glen Valle and supplies community drinking water. Upstream end of site was u/s of beaver dam complex on southern tributary. 10:10
198220	Tea Creek	Hwy 37	563431 6109637	CO,CRS,CT,DV,RB,ST	19.4	High	high	Moderate value habitat. Only a few areas with fines suitable for spawning. Mostly cobbles in stream. Wide channel throughout with a lot of woody debris. Large amounts of undercut banks that can provide cover. But not many deep pools. Some steep eroding banks found every so often. 15:47:55
198222	Pinenut Creek	Babine Slide FSR	587054 6138716	–	3.9	High	high	DJ is recorded as falls on form. Medium value habitat for ST, DV, CCT and CO. Approximately 500m upstream of crossing. This is a high energy system with numerous areas of multiple channel and islands and elevated bars. High flows are pushing most large woody debris out of the main channel resulting in lower complexity and most cover available as boulders. there are rare pockets of gravel suitable for spawning. 13:44:56
198225	Sterritt creek	Babine Slide FSR	584899 6152502	–	1.3	Low	moderate	Has potential for fish but gradient is steep. Bank full depth is very high and when stream is high it fans out. Lots of lwd are main factor in stream direction and development. Other steams near creek water is higher may be one stream. 12:50:07
198236	Tributary to Kitwanga							

4.3 Phase 2

PSCIS ID	Stream	Road	UTM (11U)	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
River	Kitwancool Branch 2 FSR	550300 6140708	–	0.0	Medium	moderate	SFC site. See their notes. High value habitat, abundant gravels suitable for resident and anadronous spawning. Debris in downstream section potentially an access issue. Frequent pools due to LWD in canyon that was not logged. 14:48	

Table 4.5: Summary of Phase 2 fish passage reassessments.

PSCIS ID	Embedded	Outlet Drop (m)	Diameter (m)	SWR	Slope (%)	Length (m)	Final score	Barrier Result
8530	No	0.30	2.4	1.4	3.0	28	39	Barrier
197379	No	0.47	1.5	4.3	1.5	26	34	Barrier
198215	No	1.10	3.7	1.4	4.0	32	42	Barrier
198216	Yes	0.00	2.0	2.8	0.5	24	14	Passable
198217	No	0.60	2.5	2.2	3.5	10	36	Barrier
198220	No	0.72	4.8	1.0	1.5	75	34	Barrier
198222	No	0.45	3.8	2.2	2.5	30	37	Barrier
198225	No	2.00	2.4	1.5	3.5	30	42	Barrier
198236	No	0.24	1.7	1.4	2.0	10	26	Barrier

Table 4.6: Summary of Phase 2 habitat confirmation details.

PSCIS ID	Length surveyed upstream (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
8530	600	3.8	2.3	0.6	3.2	moderate	high
197379	800	6.4	3.1	0.7	4.8	moderate	high
198215	800	3.8	2.3	0.5	7.0	moderate	medium
198217	300	6.0	3.4	0.4	2.5	moderate	high
198217	100	1.6	1.4	–	10.0	moderate	medium
198217	275	5.0	3.3	0.3	4.7	moderate	high
198220	600	4.2	2.8	0.4	3.9	moderate	medium
198222	650	13.1	5.7	0.4	3.6	trace	medium
198225	500	12.2	5.5	0.4	4.4	abundant	medium
198236	500	3.0	2.6	0.4	5.8	moderate	high

Table 4.7: Summary of watershed area statistics upstream of Phase 2 crossings.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
8530	14.2	814	810	1282	1040	1029	SSW
197379	32.9	672	688	1418	931	909	SSW
198215	8.8	250	359	1173	802	689	E
198216	5.5	237	243	1287	483	401	ESE
198217	5.5	245	243	1287	483	401	ESE
198220	52.2	251	229	1141	587	568	SSW
198222	21.5	277	420	1964	1077	1006	SW
198225	14.4	369	470	2296	1441	1334	SW
198236	4.8	449	528	1760	1001	916	SE

* Elev P60 = Elevation at which 60% of the watershed area is above

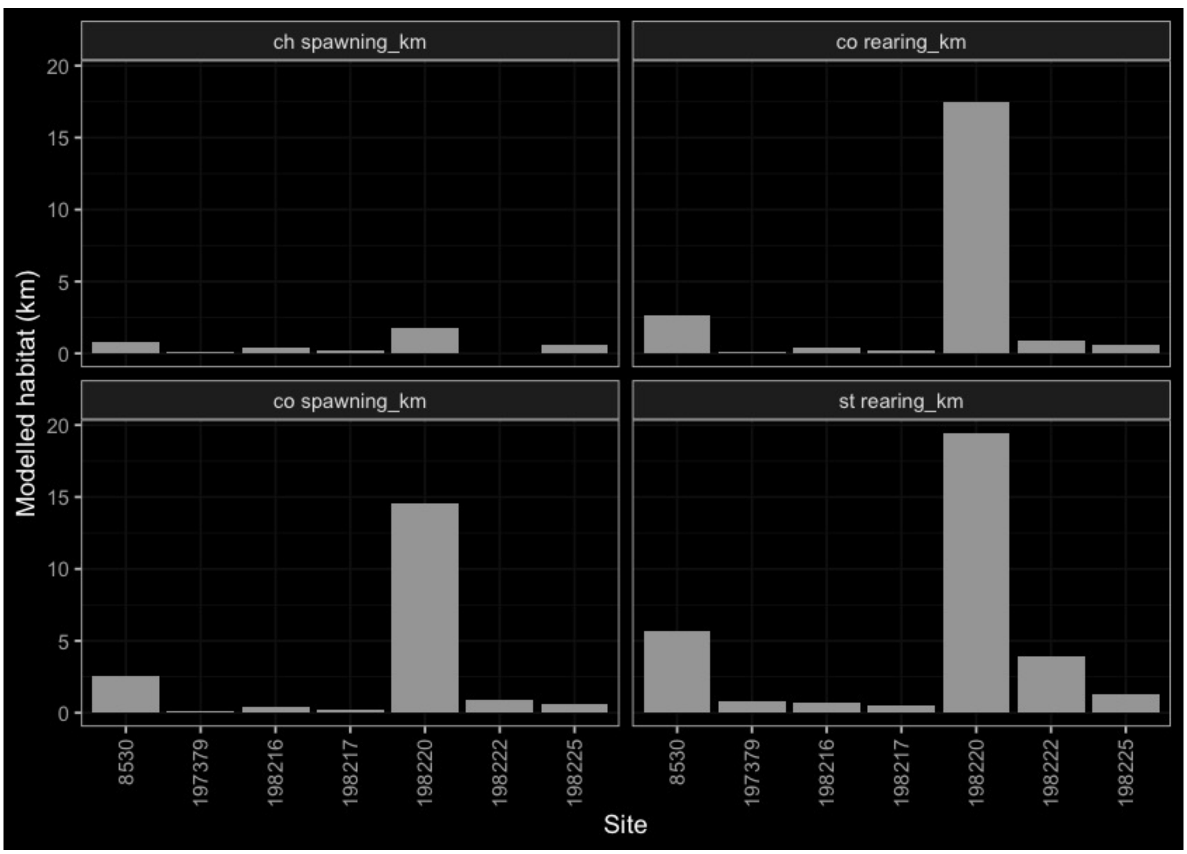


Figure 4.1: Summary of potential habitat upstream of habitat confirmation assessment sites estimated based on modelled channel width and upstream channel length.

4.3.1 Fish Sampling

Fish sampling was conducted at 8 sites with a total of 146 fish captured. Fork length data was used to delineate salmonids based on life stages: fry (0 to 65mm), parr (>65 to 110mm), juvenile (>110mm to 140mm) and adult (>140mm) by visually assessing the histograms presented in Figure 4.2. A summary of sites assessed are included in Table 4.8 and raw data is provided in Attachment 3. A summary of density results for all life stages combined of select species is also presented in Figure 4.3. Results are presented in greater detail within individual habitat confirmation site appendices.

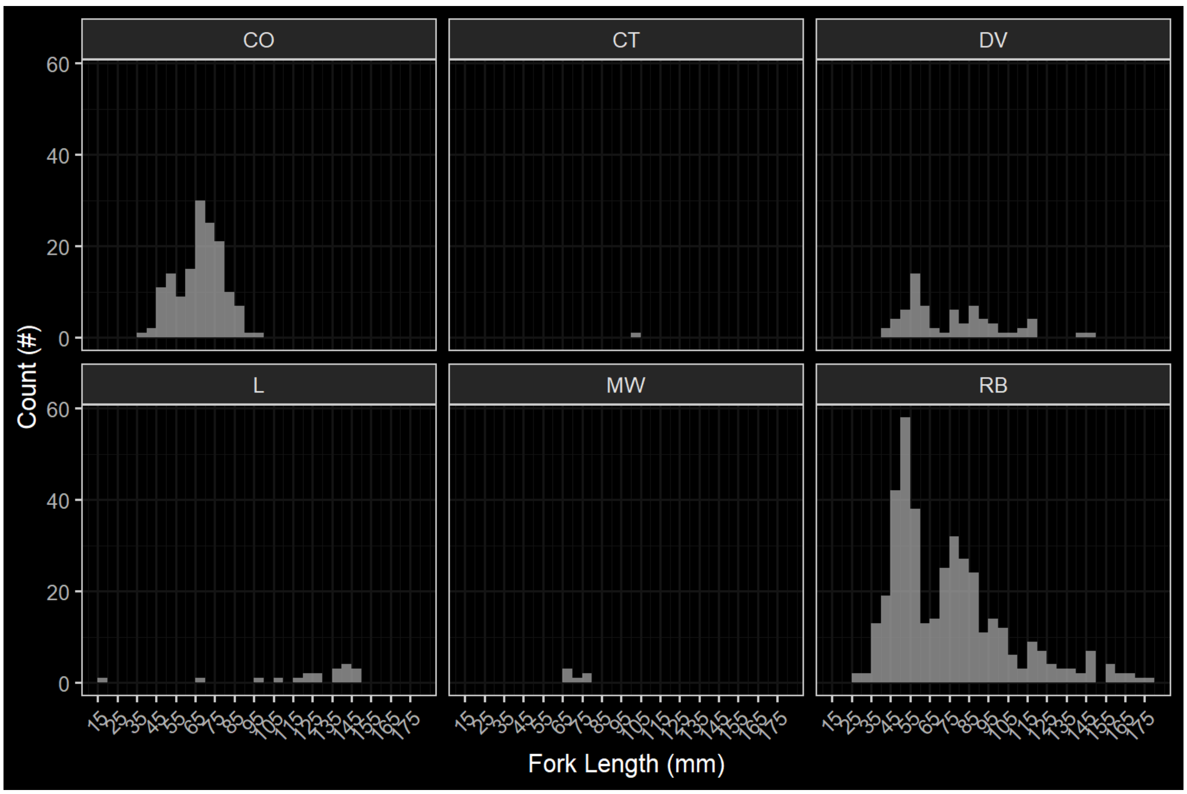


Figure 4.2: Histograms of fish lengths by species. Fish captured by electrofishing during habitat confirmation assessments.

Table 4.8: Summary of electrofishing sites.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
197379_ds_ef1	1	5	5.00	25.0	Open
197379_us_ef1	1	11	1.70	18.7	Open
8530_ds_ef1	1	14	2.40	33.6	Open
8530_ds_ef2	1	15	3.33	50.0	Open
8530_ds_ef3	1	11	4.15	45.7	Open
8530_us_ef1	1	17	2.40	40.8	Open
8530_us_ef2	1	21	2.40	50.4	Open
8530_us_ef3	1	21	2.80	58.8	Open

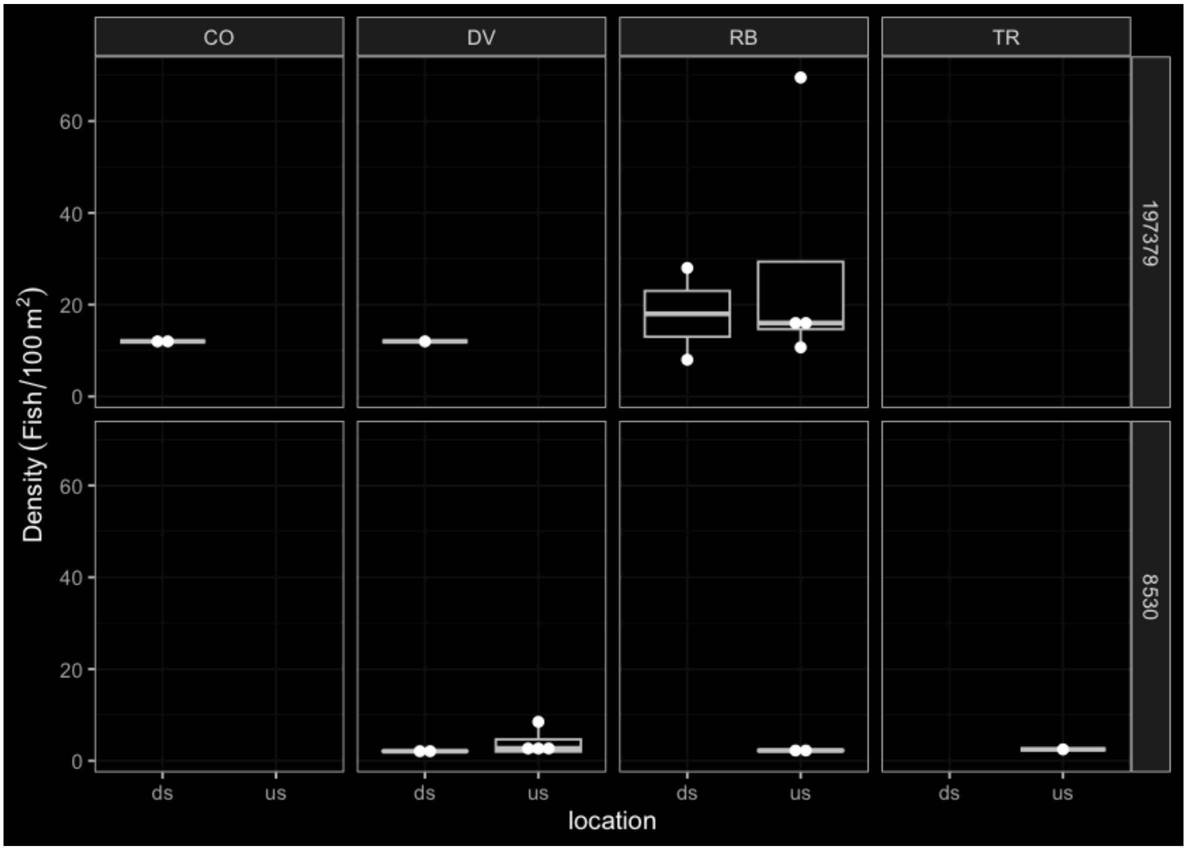


Figure 4.3: Boxplots of densities (fish/100m2) of fish captured by electrofishing during habitat confirmation assessments.

4.4 Phase 3

Engineering designs have been completed for replacement of PSCIS crossing 58159 on McDowell Creek (Irvine 2021) with a clear-span bridge and for removal of the collapsed bridge (PSCIS crossing 197912) on Robert Hatch Creek. Designs for McDowell and Robert Hatch were procured by SERNbc and Canadian Wildlife Federation respectively. At the time of reporting, the Ministry of Transportation and Infrastructure, in collaboration with Canadian Wildlife Federation was in the process of procuring designs for remediation of fish passage at three sites documented in Irvine (2021) including PSCIS 123445 on Tyhee Creek, PSCIS 124500 on Helps Creek and PSCIS 197640 on a tributary to Buck Creek. Additionally, the Ministry of Transportation and Infrastructure were procuring a design for PSCIS crossing 124420 on Station Creek (also know as Mission Creek) near New Hazleton (pers. comm. Sean Wong, Environmental Programs, MoTi).

5 Recommendations

Recommendations for potential incorporation into collaborative watershed connectivity planning include:

- Continue to acquire background information and leverage ongoing research initiatives in the region to collaboratively clarify current conditions and identify limiting factors to inform prioritization and effectiveness monitoring programs.

- Develop strategies to explore cost and fisheries production benefits of stream crossing structure upgrades alongside alternative/additional restoration and enhancement investments such as land conservation/procurement/covenant, cattle exclusion, riparian restoration, habitat complexing, water conservation, commercial/recreational fishing management, water treatment and research. Ideentify and pursue opportunities to collaborate and leverage initiatives together in study area watersheds (ex. fish passage rehabilitation, riparian restoration and cattle exclusion) for maximum likely restoration benefits.

- Refine barrier thresholds for road-stream crossing structures to explore metrics specific to life stage and life history types of species of interest. This will further focus efforts of potential remediation actions based on biological attributes (ex. timing of migration, size/direction of fish migrating, population dynamics, etc.) and could result in the consideration of interim “stop-gap” physical works to alter crossing characteristics that can address key connectivity issues yet be significantly less costly than structure replacements (ex. building up of downstream area with rock riffles to decrease the outlet drop size and/or increasing water depth within pipe with baffles and substrate additions).

- Model fish densities (fish/m^2) vs. habitat/water quality characteristics (i.e. gradient, discharge, alkalinity, elevation, riparian health, distance from high order streams, etc.) using historically gathered electrofishing and remotely sensed geodata to inform crossing prioritization, future data acquisition needs and the monitoring of restoration actions.

- Continue to develop `bcfishpass`,`bcfishobs`, `fwapg`, `bcdata` and `fpr` as well as to share open source data analysis and presentation tools that are scaleable and facilitate continual improvement. Tools should continue to be flexible and well documented to allow the future incorporation of alternative fragmentation indicators, habitat gain/value metrics and watershed sensitivity indicators.

- Continue to collaborate with potential partners to build relationships, explore perspectives and develop “road maps” for aquatic restoration in different situations (MoT roads, rail lines, permit roads of different usages, FSRs, etc.) – documenting the people involved, discussions and processes that are undertaken, funding options, synergies, measures of success, etc.

Tributary to Owen Creek - 197379 - Appendix

Site Location

PSCIS crossing 197379 is located on Tributary to Owen Creek 28km south-west of Houston, BC at approximately km 21 on the Morice-Owen Forest Service Road (FSR), approximately 0.2km upstream from the confluence with the Owen River. A habitat confirmation assessment was conducted at the site in 2021 with the site revisited in the summer of 2022 for fish sampling (electrofishing and tagging). At the time of reporting, the Huckleberry Multi-Use Site was located immediately south of the subject stream at a location of approximately 1.1km upstream of the FSR. A remote workcamp, the site is reported as housing up to 800-1200 workers employed to construct TC Energy's Coastal GasLink (CGL) pipeline project. Water for the camp (150,000 litres/day) is trucked in from the District of Houston with with another 150,000 litres/day of effluent trucked back to Houston from disposal (Burns Lake Lakes District News 2022).

Background

At crossing 197379, Tributary to Owen Creek is a third order stream with a watershed area upstream of the crossing of approximately 32.9km^2. The elevation of the watershed ranges from a maximum of 1418m to 672m at the crossing (Table 5.1). Upstream of crossing 197379, have previously been recorded (Norris 2022). A total of 67ha of lake and 129ha of wetland is modelled upstream of the Forest Service Road (Table 5.2). PSCIS stream crossing 197379 was ranked as a moderate priority for follow up by Irvine (2021) with notes indicating than 1km of potential habitat but a very large channel width recorded in past PSCIS assessment. A map of the watershed is provided in map attachment 093L.103.

Table 5.1: Summary of derived upstream watershed statistics for PSCIS crossing 197379.

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
197379	32.9	672	1418	931	909	SSW

* Elev P60 = Elevation at which 60% of the watershed area is above

Table 5.2: Summary of fish habitat modelling for PSCIS crossing 197379.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0.8	0.8	100
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	0.1	0.1	100
ST Slopeclass05 (km)	0.0	0.0	–
ST Slopeclass08 (km)	0.7	0.7	100
ST Spawning (km)	0.1	0.1	100
ST Rearing (km)	0.8	0.8	100
CH Spawning (km)	0.1	0.1	100
CH Rearing (km)	0.1	0.1	100
CO Spawning (km)	0.1	0.1	100
CO Rearing (km)	0.1	0.1	100
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 197379 had an outlet drop of 0.5m, was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.3). Water temperature was 12°C, pH was 7.9 and conductivity was 249uS/cm.

Table 5.3: Summary of fish passage assessment for PSCIS crossing 197379.

Location and Stream Data	•	Crossing Characteristics	–
Date	2021-09-07	Crossing Sub Type	Round Culvert
PSCIS ID	197379	Diameter (m)	1.5
External ID	–	Length (m)	26
Crew	KP	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	640960.8	Resemble Channel	No
Northing	6005930	Backwatered	No
Stream	Tributary to Owen Creek	Percent Backwatered	–
Road	Morice-Owen FSR	Fill Depth (m)	5

Stream Characteristics at Crossing

Location and Stream Data	•	Crossing Characteristics	–
Road Tenure	FLNR DND 9947	Outlet Drop (m)	0.47
Channel Width (m)	6.4	Outlet Pool Depth (m)	0.9
Stream Slope (%)	4.8	Inlet Drop	No
Beaver Activity	No	Slope (%)	1.5
Habitat Value	High	Valley Fill	Deep Fill
Final score	34	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	19

Location and Stream Data	•	Crossing Characteristics	–
Comments: Two thirds of culvert on upstream side has baffles. Fish sampling and PIT tagging conducted. Design underway by MoF. 13:18			
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 197379 for 190m (Figure 5.2). The average channel width was 4.3m, the average wetted width was 2.6m, and the average gradient was 3.3%.The dominant substrate was cobbles with gravels sub-dominant.Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris and undercut banks. The stream had signs of high flow due to eroded banks. Habitat below the culvert was rated as medium value with likely important rearing areas for coho and steelhead rearing during high flow events in the Owen Creek mainstem.

Stream Characteristics Upstream

The stream was surveyed for 800m in a downstream direction to the culvert from the location of an approximately 8m high waterfall (Figure 5.3). The dominant substrate was cobbles with gravels sub-dominant.The average channel width was 6.4m, the average wetted width was 3.1m, and the average gradient was 4.8%.Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, deep pools, and overhanging vegetation. Near the falls, bedrock dominated the stream substrate and the gradient was noted as 7%. The mixed decidous and coniferous forest riparian was noted as healthy. Pockets of gravel suitable for coho, steelhead and resident rainbow trout/cutthrout trout were observed. Overall, the habitat upstream of the FSR was rated as high value, containing habitat suitable for rearing and spawning of both anadromous as well as resident fish species. Of note, when the site was revisited in 2022 the stream was primarily dewatered with numerous fish concentrated within isolated pools.

Fish Sampling

Electrofishing was conducted in 2022 with results summarised in Tables 5.5 - 5.6 and Figure 5.1. A total of 35 fish were captured upstream and 30 fish were captured downstream (Figure 5.5). Although coho, dolly varden, rainbow trout and cutthrout trout (rainbow and cutthrout were potentially hybrd rainbow/cutthrout) parr (likely 1 year old fish) were captured downstream of the crossing, only rainbow trout and cutthrout trout were captured upstream. As noted, the stream was mostly dry at the time of electrofishing, with fish concentrated in pools. All fish over 60mm that were captured were tagged with Passive Integrated Transponders (PIT tags) with data stored here.

Conclusion

Crossing 197379 on an unnamed tributary to Owen Creek was assessed for habitat characteristics in 2021 and for fish composition in 2022. As electrofishing in 2022 captured coho, dolly varden, rainbow trout and cutthrout trout (rainbow and cutthrout were potentially hybrid rainbow/cutthrout) parr (likely 1 year old fish) downstream of the crossing and only rainbow trout and cutthrout trout upstream, it appears as though the culvert was a barrier to upstream migration of coho and dolly varden spawners in 2021. Although intermittent streams experience periods without streamflow, residual pools within these systems can provide valuable habitat for juvenile salmon encouraging high growth rates and subsequent increased rates of overwinter survival (Ebersole et al. 2006; Wigington Jr et al. 2006). Wigington Jr et al. (2006) measured overwinter survival rates of fish utilizing intermittent tributaries as higher than those in mainstem habitats with survival rates equivalent of those in perennial streams. They noted that fish tagged in mainstems moved into intermittent tributaries when streamflow resumed in the fall and hypothesized that use of residual pools during dry periods and migration into these systems during times of increased flow can result in positive outcomes for these fish due to lower competitive fish densities and higher food resources when compared to coho in perennial tributary habitat. Both Ebersole et al. (2006) and Wigington Jr et al. (2006) measured coho smolts from intermittent streams as considerably larger than those that used perennial habitats leading to greater overwinter survival illustrating the importance of maintaining connectivity in these systems.

There was 0.8km of habitat upstream of the culvert between the Morice-Owen FSR and the 8m high waterfall with habitat rated as high value for coho, steelhead and resident rainbow/cuthrout rearing and spawning. Crossing 197379 was ranked as a high priority for proceeding to design for replacement. Of note, at the time of reporting, due to our prioritization work, a design for a replacement structure to more effectively facilitate upstream migration for all fish life stages and species was being developed by Mark Dewit from the Ministry of Forests.

Table 5.4: Summary of habitat details for PSCIS crossing 197379.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
197379	Downstream	190	4.3	2.6	0.3	3.3	moderate	medium
197379	Upstream	800	6.4	3.1	0.7	4.8	moderate	high

Table 5.5: Fish sampling site summary for 197379.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
197379_ds_ef1	1	5	5.0	25.0	Open
197379_us_ef1	1	11	1.7	18.7	Open

Table 5.6: Fish sampling density results summary for 197379.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
197379_ds_ef1	CO	fry	3	12.0	FALSE
197379_ds_ef1	CO	parr	3	12.0	FALSE
197379_ds_ef1	CT	fry	5	20.0	FALSE
197379_ds_ef1	CT	parr	7	28.0	FALSE
197379_ds_ef1	DV	parr	3	12.0	FALSE
197379_ds_ef1	RB	parr	7	28.0	FALSE
197379_ds_ef1	RB	juvenile	2	8.0	FALSE
197379_us_ef1	CT	fry	3	16.0	FALSE
197379_us_ef1	CT	parr	11	58.8	FALSE
197379_us_ef1	RB	fry	3	16.0	FALSE
197379_us_ef1	RB	parr	13	69.5	FALSE
197379_us_ef1	RB	juvenile	3	16.0	FALSE
197379_us_ef1	RB	adult	2	10.7	FALSE

[*] nfc_pass FALSE means fish were captured in final pass indicating more fish of this species/lifestage may have remained in site. Mark-recaptured required to reduce uncertainties.

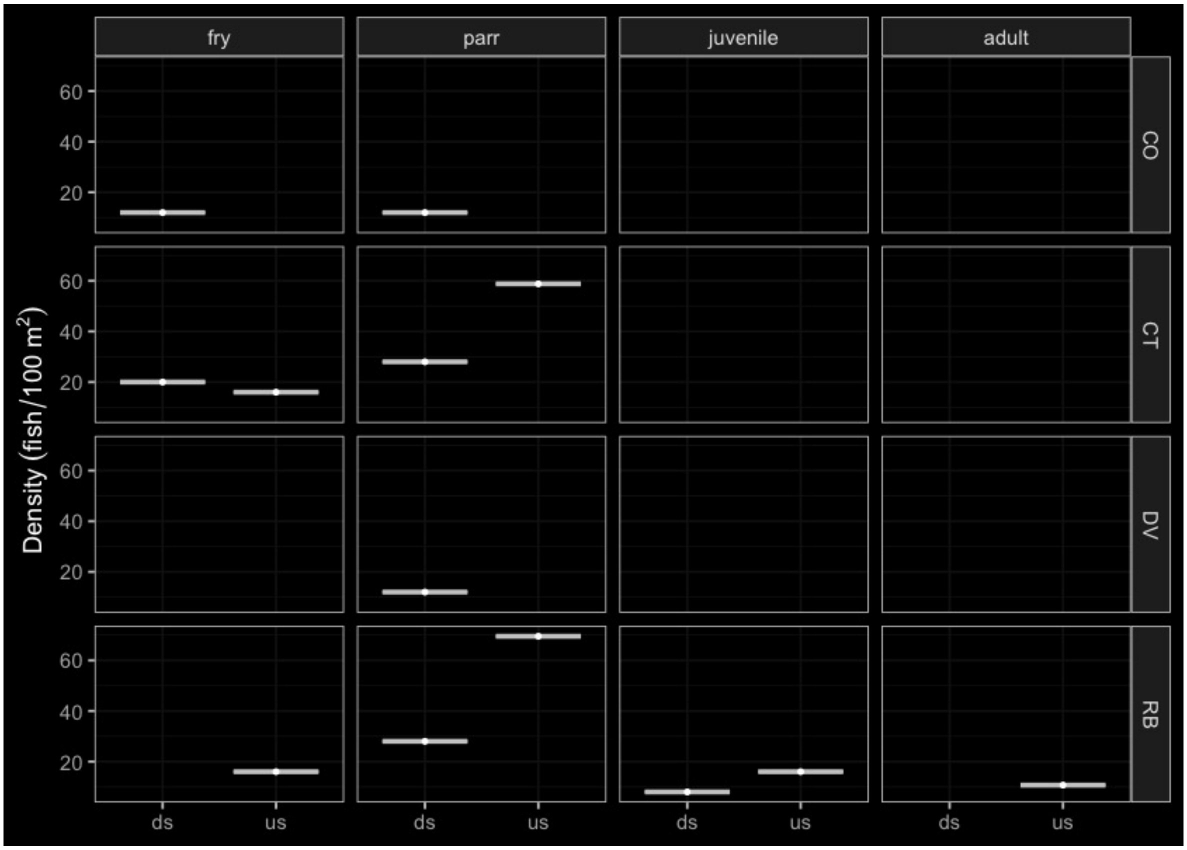


Figure 5.1: Densites of fish (fish/100m2) captured upstream of PSCIS crossing 197379.

Figure 5.2: Left: Typical habitat downstream of PSCIS crossing 197379. Right: Typical habitat downstream of PSCIS crossing 197379.

Figure 5.3: Left: Typical habitat upstream of PSCIS crossing 197379. Right: Large woody debris jam upstream of PSCIS crossing 197379.

Figure 5.4: Left: Typical habitat upstream of PSCIS crossing 197379. Right: Waterfall upstream of PSCIS crossing 197379.

Figure 5.5: Left: Coho trout captured downstream of PSCIS crossing 197379. Right: Cutthroat trout captured upstream of PSCIS crossing 197379.

Dale Creek - 198215 - Appendix

Site Location

PSCIS crossing 198215 is located on Dale Creek. The site is located on Kispiox Westside Rd (also known as Date Creek FSR), just outside the Gitxsan village of Kispiox. Crossing 198215 was located 0.1km upstream from the confluence with the Kispiox River. This crossing is the responsibility of the Ministry of Transportation and Infrastructure. The `chris_culvert_id` of this structure is 1524775.

Background

At crossing 198215, Dale Creek is a third order stream with a watershed area upstream of the crossing of approximately 8.8km^2. The elevation of the watershed ranges from a maximum of 1173m to 359m near the crossing (Table 5.7). At the time of reporting, there was no fisheries information available for the area upstream of crossing 198215(MoE 2020b; Norris 2022).

Table 5.7: Summary of derived upstream watershed statistics for PSCIS crossing 198215.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
198215	8.8	250	359	1173	802	689	E

* Elev P60 = Elevation at which 60% of the watershed area is above

Two dams were listed as present on Dale Creek at the time of survey. This information was gathered from the Canadian Aquatic Barrier Database, as well as `bcfishpass` (Canadian Wildlife Federation 2023). The first dam was located approximately 600m upstream of crossing 198215 (`dam_id`: 166c070f-a324-40fb-addb-886dd23a9fc1), and the second one was located 200m further upstream (`dam_id`: 0de8a19d-eb93-4102-b124-8738f27e9e13). The Dale Creek watershed provides the community of Kispiox with domestic water (Rabnett, Gottesfeld, and Hall 2003). One of the dams is likely the location of drinking water storage and treatment infrastructure.

A summary of habitat modelling outputs is presented in Table 5.8. A map of the watershed is provided in map attachment 093M.106.

Table 5.8: Summary of fish habitat modelling for PSCIS crossing 198215.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0.8	0.6	75
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.0	0.0	–
ST Slopeclass08 (km)	0.6	0.6	100
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	0.0	0.0	–
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	0.0	0.0	–
CO Spawning (km)	0.0	0.0	–
CO Rearing (km)	0.0	0.0	–
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

5.1 Climate Change Risk Assessment

Preliminary climate change risk assessment data for the site is presented in Tables 5.9 - 5.10.

Table 5.9: Summary of climate change risk assessment for PSCIS crossing 198215.

Condition and Climate Risk	Rank	Priority	Rank
Erosion (scale 1 low - 5 high)	1	Traffic Volume 1 (low) 5 (medium) 10 (high)	3
Embankment fill issues 1 (low) 2 (medium) 3 (high)	1	Community Access - Scale - 1 (high - multiple road access) 5 (medium - some road access) 10 (low - one road access)	3
Blockage Issues 1 (0-30%) 2 (>30-75%) 3 (>75%)	2	Cost (scale: 1 high - 10 low)	5
Condition Rank = embankment + blockage + erosion	4	Constructibility (scale: 1 difficult -10 easy)	5
Likelihood Flood Event Affecting Culvert (scale 1 low - 5 high)	1	Environmental Impacts (scale: 1 high -10 low)	7
Consequence Flood Event Affecting Culvert (scale 1 low - 5 high)	3	Fish Bearing 10 (Yes) 0 (No) - see maps for fish points	10
Climate Change Flood Risk (likelihood x consequence) 1-6 (low) 6-12 (medium) 10-25 (high)	3	Priority Rank = traffic volume + community access + cost + constructability + fish bearing + environmental impacts	33
Vulnerability Rank = Condition Rank + Climate Rank	7	Overall Rank = Vulnerability Rank + Priority Rank	40

Table 5.10: Details and rational for climate risk rankings

Category	Comments
Condition	Right pipe completely blocked. Structure appears near the end of life. Although ineffective, historic work done downstream to try to backwater the structure.
Climate	Large tributary so significant flood eventscould wash out the Date Creek FSR.
Priority	Some residences on this road so potentially joint MoTi and MoF management. Deep fill will make replacement difficult, costs high and blow out consequences significant.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 198215 was un-embedded, non-backwatered and ranked as a barrier barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.11). There was two culverts side by side, but one was not functioning and had debris blocking the outlet. There was low flow through the functioning culvert at the time of survey. The outlet drop was significant at 1.1m. Water temperature was 10°C, pH was 8.3 and conductivity was 164uS/cm.

Table 5.11: Summary of fish passage assessment for PSCIS crossing 198215.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-09-09	Crossing Sub Type	Round Culvert
PSCIS ID	198215	Diameter (m)	3.7
External ID	–	Length (m)	32
Crew	AI JO	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	582153.7	Resemble Channel	No
Northing	6135026	Backwatered	No
Stream	Dale Creek	Percent Backwatered	–
Road	Kispiox Westside Rd	Fill Depth (m)	5.5
Road Tenure	MoTi Local	Outlet Drop (m)	1.1
Channel Width (m)	5.3	Outlet Pool Depth (m)	0.85
Stream Slope (%)	5.5	Inlet Drop	No
Beaver Activity	No	Slope (%)	4
Habitat Value	High	Valley Fill	Deep Fill
Final score	42	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	20.5

Stream Characteristics at Crossing

Location and Stream Data	•	Crossing Characteristics	–
Comments: .75-.90 m lock block step located approximately 30 m down stream of culvert. Double pipe however right pipe is not functioning and is 50% blocked at the outlet. Both pipes are of same diameter (1.85m). 9:32			
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 198215 for 60m to the confluence with the Kispiox River (Figure 5.6). The dominant substrate was cobbles with gravels sub-dominant.Total cover amount was rated as trace with boulders dominant. Cover was also present as large woody debris and overhanging vegetation.The average channel width was 5.3m, the average wetted width was 2.1m, and the average gradient was 11%. This stretch of stream was steep with one lock block step approximately 30m downstream of the culvert that was approximately 1m in height that could block upstream migration for non adult fish species. The lock block was likely place in this location to backwater the site, minimize the culvert outlet drop and facilitate upstream fish passage. The habitat was rated as medium value for salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 198215 for 800m (Figure 5.7). Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris, boulders, deep pools, and overhanging vegetation.The dominant substrate was cobbles with boulders sub-dominant.The average channel width was 3.8m, the average wetted width was 2.3m, and the average gradient was 7%. There were numerous cascades that were approximately 1m in height at the time of survey, with deep outlet pools. The stream channel was frequently confined and restricted from lateral migration from the valley walls. Significant amounts of large woody debris were found in and around the stream, adding complexity. There were trace amount of gravels suitable for spawning. After the first 500m of the survey, there were logs placed within the streambed perpendicular to the flow direction at regular intervals. It is presumed these logs were placed to capture substrate and provide complexity and spawning/rearing habitat. The stream was surveyed to the mapped location of a dam. Although the dam was not present there appeared to be some remnants of a historic structure in the form of logs (Figure 5.8). The habitat was rated as medium value as an important migration corridor containing spawning habitat suitable for coho and steelhead and having moderate rearing potential for both species.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 198215 with a bridge (20.5m span) is recommended. The cost of the work is estimated at \$2,050,000 for a cost benefit of 390.2 linear m/\$1000 and 1034.1 m^2/\$1000.

Conclusion

The BC freshwater atlas streamline indicates the stream gradient was greater than 9% below the location of the dams. After surveying the stream, measurements indicate the average gradient was below the 8% cutoff which determines accessible steelhead habitat. Therefore, there was an estimated 0.8km of habitat suitable for steelhead rearing. Areas surveyed were rated as medium value for salmonid rearing and spawning. 198215 was ranked as a moderate priority for proceeding to design for replacement. Electrofishing upstream of the culvert is recommended to provide insight into fish community composition and density.

Table 5.12: Summary of habitat details for PSCIS crossing 198215.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198215	Downstream	60	5.3	2.1	0.8	11	trace	medium
198215	Upstream	800	3.8	2.3	0.5	7	moderate	medium

Figure 5.6: Left: Typical habitat downstream of PSCIS crossing 198215. Right: Lock block step downstream of PSCIS crossing 198215.

Figure 5.7: Left: Typical habitat upstream of PSCIS crossing 198215. Right: Typical habitat upstream of PSCIS crossing 198215.

Figure 5.8: Left: Location of old historic dam, upstream of PSCIS crossing 198215. Right: Typical habitat upstream of PSCIS crossing 198215.

Tributary to Skeena River - 198216 & 198217 - Appendix

Site Location

PSCIS crossing 198216 and 198217 are located on a Tributary to Skeena River, just outside the small community of Sik-E-Dakh (Glen Vowell). Crossing 198216 is located 1.8km upstream from the confluence with the Skeena River on Kispiox Valley Rd and is the responsibility of the Ministry of Transportation and Infrastructure. Crossing 198217 is located on Sik-e-dakh Water Tower Rd 300m upstream from Kispiox Valley Rd and appears to be under the jurisdiction of the Sik-E-Dakh 2 Indian Reserve.

Background

Located on the west side of the Skeena River, between Hazelton and Kispiox, Sik-E-Dakh is a Gitxsan community home to the Glen Vowell Band. “Sik-E-Dakh” means “Bright Lights Behind Mountain” (“Sik-E-Dakh (Glen Vowell Band)” 2023). The subject stream supplies drinking water to the community with drinking water storage and treatment infrastructure located on Sik-e-dakh Water Tower Rd beyond the location of 198217. The underlying territory of this stream is within the Xsu Wii Masxwit/ Antgililibixw Wilp.

Approximately 300m north of crossing 198217 on Kispiox Valley Road, GIS modelling indicates there is a crossing located on Glen Vowell Creek (modelled crossing ID 8300064). This area was canvassed and there was no culvert or structure found. In 2018, (Triton Environmental Consultants Ltd. 2020) electrofished a section of Glen Vowell Creek upstream of modelled crossing 8301266 and captured cutthroat and dolly varden. This stream is mapped as immediately north of the flows east before draining into the Skeena River. Immediately before the confluence, GIS modelling indicates there is a crossing located on Peter Brown Drive (modelled crossing ID 8300001) however, this location was also investigated and there was no crossing found. There are some discrepancies between the mapped stream channel locations in the BC freshwater atlas and the actual on the ground reality. This could be the result of anthroprogenic influences (ie. dredged stream channels or channel redirection due to protection of road and community infrastructure).

At crossing 198216, Tributary to Skeena River is a second order stream with a watershed area upstream of the crossing of approximately 5.5km^2. The elevation of the watershed ranges from a maximum of 1287m to 243m near the crossing (Table 5.13). At the time of reporting, there was no fisheries information available for the area upstream of the highway crossing 198216 (MoE 2020b; Norris 2022). Local knowledge holder (Chief Francis), noted that the local community historically harvested coho from the stream. Gitksan Watershed Authorities and local residents are working together to gather information about the system from elders and other local knowledge holders in the community to help inform watershed restoration planning. There is concern in the community that the stream flows are not as consistent as in the past and there are hopes that restoration activities could help increase fisheries productivity in the system. There is a network of dykes surrounding the Sik-e-Dakh community.

Table 5.13: Summary of derived upstream watershed statistics for PSCIS crossing 198216.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
198216	5.5	237	243	1287	483	401	ESE

* Elev P60 = Elevation at which 60% of the watershed area is above

A summary of habitat modelling outputs is presented in Table 5.14. Note that the BC freshwater atlas does not capture the upstream watershed, therefore the modelling is likely inaccurate. A map of the watershed is provided in map attachment 093M.106. A digital elevation model of the area is presented in Figure 5.9 (BC Government 2022).

Table 5.14: Summary of fish habitat modelling for PSCIS crossing 198217.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	5.7	5.7	100
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	6.6	6.6	100
ST Slopeclass03 Waterbodies (km)	0.6	0.0	0
ST Slopeclass03 (km)	1.2	1.2	100
ST Slopeclass05 (km)	0.0	0.0	–
ST Slopeclass08 (km)	2.0	2.0	100
ST Spawning (km)	0.2	0.2	100
ST Rearing (km)	0.5	0.5	100
CH Spawning (km)	0.2	0.2	100
CH Rearing (km)	0.2	0.2	100
CO Spawning (km)	0.2	0.2	100
CO Rearing (km)	0.2	0.2	100
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

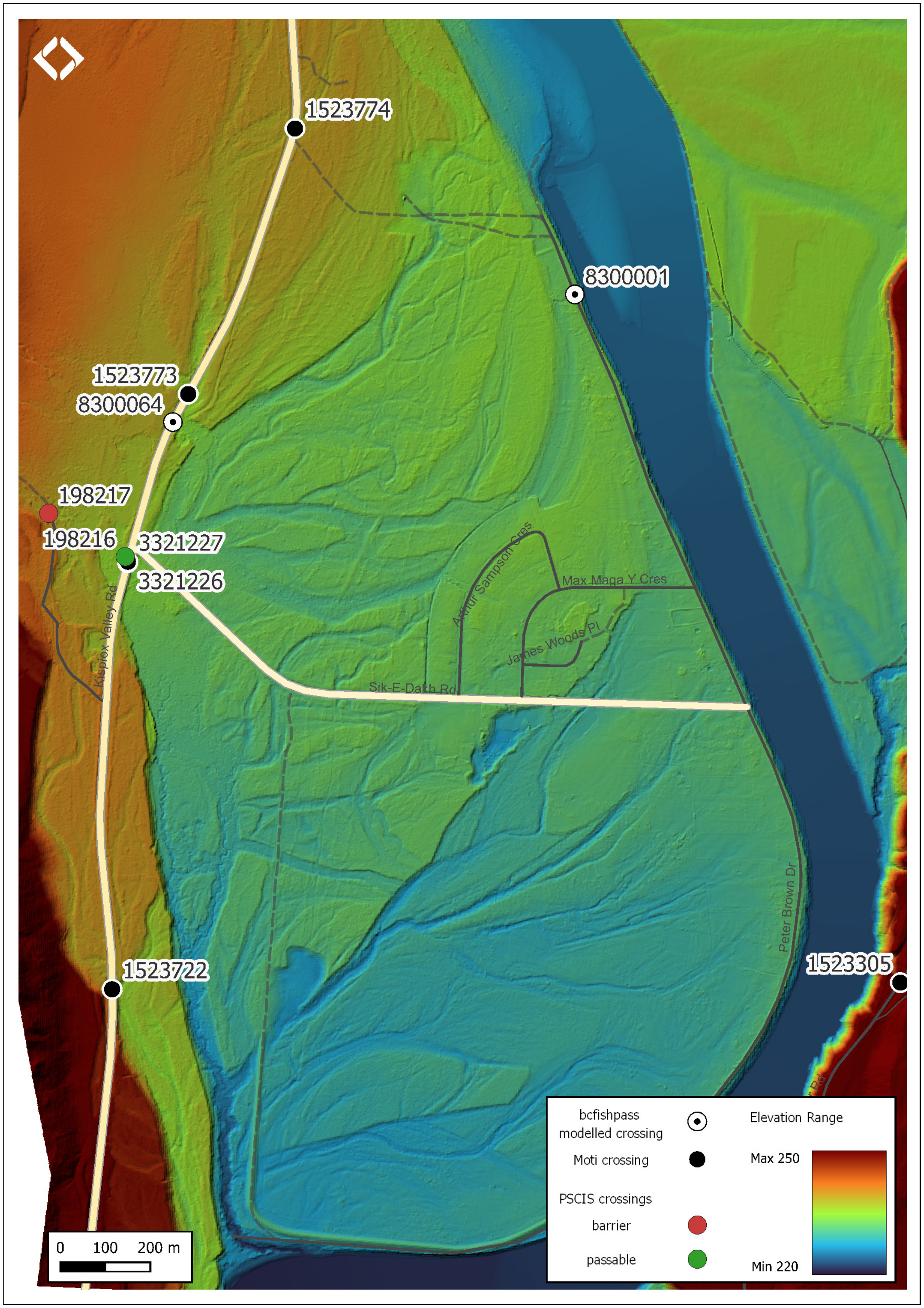

1523774
8300001
1523773
8300064
198217
198216
3321227
3321226
Max Maga Y Cres
Arthur Sampson Cres
James Woods Pl
Kispiox Valley Rd
Sik-E-Dakh Rd
Peter Brown Dr
1523722
1523305
bcfishpass modelled crossing
Moti crossing
PSCIS crossings
barrier
passable
Elevation Range
Max 250
Min 220
0 100 200 m

Figure 5.9: Digital elevation model of the watershed outside the community of Sik-E-Dakh.

5.2 Climate Change Risk Assessment

Preliminary climate change risk assessment data for PSCIS site 198217 on Sik-e-dakh Water Tower Rd is presented in Tables 5.15 - 5.16.

Table 5.15: Summary of climate change risk assessment for PSCIS crossing 198216.

Condition and Climate Risk	Rank	Priority	Rank
Erosion (scale 1 low - 5 high)	1	Traffic Volume 1 (low) 5 (medium) 10 (high)	8
Embankment fill issues 1 (low) 2 (medium) 3 (high)	1	Community Access - Scale - 1 (high - multiple road access) 5 (medium - some road access) 10 (low - one road access)	10
Blockage Issues 1 (0-30%) 2 (>30-75%) 3 (>75%)	2	Cost (scale: 1 high - 10 low)	2
Condition Rank = embankment + blockage + erosion	4	Constructibility (scale: 1 difficult -10 easy)	2
Likelihood Flood Event Affecting Culvert (scale 1 low - 5 high)	1	Environmental Impacts (scale: 1 high -10 low)	9
Consequence Flood Event Affecting Culvert (scale 1 low - 5 high)	4	Fish Bearing 10 (Yes) 0 (No) - see maps for fish points	10
Climate Change Flood Risk (likelihood x consequence) 1-6 (low) 6-12 (medium) 10-25 (high)	4	Priority Rank = traffic volume + community access + cost + constructability + fish bearing + environmental impacts	41
Vulnerability Rank = Condition Rank + Climate Rank	8	Overall Rank = Vulnerability Rank + Priority Rank	49

Table 5.16: Details and rational for climate risk rankings

Category	Comments
Condition	Large amount of flow is going in between the two pipes and not through them. Trash guards on inlets are quite damaged. Beaverdams located immediately down stream. Roadfill material is made of road barriers. Pipes are in bad shape.
Climate	Significant amounts of water moving through here and this highway is a major corridor for people living in the Kispiox community and associated valley upstream.
Priority	–

Stream Characteristics at Crossings

PSCIS crossing 198216 was embedded, backwatered and ranked as passable to upstream fish passage (Table 5.17). There were two culverts side by side, and both of them had trash racks on the inlet side that could be a barrier to adult coho. The trash rack had grid sizes of approximately 13cm by 13cm.

At the time of the survey, PSCIS crossing 198217 was comprised of two pipes. The outlet drops were measured as 0.6m with both pipes un-embedded and non-backwatered. The crossing ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.18). Water temperature was 9.2°C, pH was 7.6 and conductivity was 133uS/cm.

Table 5.17: Summary of fish passage assessment for PSCIS crossing 198216.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-09-09	Crossing Sub Type	Round Culvert
PSCIS ID	198216	Diameter (m)	2
External ID	–	Length (m)	24
Crew	AI	Embedded	Yes
UTM Zone	9	Depth Embedded (m)	0.2
Easting	583025.5	Resemble Channel	Yes
Northing	6130402	Backwatered	Yes
Stream	Tributary to Skeena River	Percent Backwatered	95
Road	Kispiox Valley Rd	Fill Depth (m)	3
Road Tenure	MoTi Arterial	Outlet Drop (m)	0
Channel Width (m)	5.6	Outlet Pool Depth (m)	0.8
Stream Slope (%)	1.5	Inlet Drop	Yes
Beaver Activity	Yes	Slope (%)	0.5
Habitat Value	High	Valley Fill	Deep Fill
Final score	14	Barrier Result	Passable
Fix type	–	Fix Span / Diameter	–

Location and Stream Data	•	Crossing Characteristics	–
Comments: Culvert appears very old and near end of life. Nice gravels upstream. Flow is moving between the two 1 m pipes. Trash rack on inlet could be barrier to adult coho migrating upstream. 10:57			
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Table 5.18: Summary of fish passage assessment for PSCIS crossing 198217.

Location and Stream Data	•	**Crossing Characteristics**	–
Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-09-09	Crossing Sub Type	Round Culvert
PSCIS ID	198217	Diameter (m)	2.5
External ID	–	Length (m)	10
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	582851.3	Resemble Channel	No
Northing	6130491	Backwatered	No
Stream	Tributary to Skeena River	Percent Backwatered	–
Road	Sik-e-dakh Water Tower Rd	Fill Depth (m)	1
Road Tenure	Resource	Outlet Drop (m)	0.6
Channel Width (m)	5.6	Outlet Pool Depth (m)	0.7
Stream Slope (%)	1.5	Inlet Drop	Yes
Beaver Activity	Yes	Slope (%)	3.5
Habitat Value	High	Valley Fill	Deep Fill
Final score	36	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Location and Stream Data	•	Crossing Characteristics	–

Comments: Francis (chief) indicated this is historic coho harvest site for Glen Vowell community and historic coho spawning stream. 2 1.25m culverts side by side. Trash rack has been removed from inlet. Inlet has significant amount of debris. Extensive gravels present suitable for CO spawning upstream and downstream. Good flow and large stream. On road to water treatment plant. 12:20

Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.

Stream Characteristics Downstream of 198216

The area downstream of crossing 198216 consisted of open wetland habitat with shrubs and floodplains. There was a beaver dam approximately 100m downstream of the culvert. Surveys were conducted with a remotely piloted aircraft with resulting images stitched into an orthomosaic presented here and here.

Stream Characteristics Upstream of 198216 and Downstream of 198217

The stream was surveyed downstream from crossing 198217 for 300m to crossing 198216 (Figure 5.11). The average channel width was 5m, the average wetted width was 2.9m, and the average gradient was 1.8%.Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris.The dominant substrate was fines with gravels sub-dominant. The area surveyed was mostly wetland habitat, with three large beaver dams spaced evenly along surveyed length. Multiple channels were present after the first beaver dam, separated by heavily vegetated banks. There was muddy bed material with some fines and gravels but nothing bigger. More gravels were present closer to crossing 198216 that were suitable for spawning. There were abundant deep pools present near wetland that could be suitable for rearing if habitat is opened up. The habitat was rated as medium value as an important migration corridor containing suitable spawning habitat and having moderate rearing potential for resident and anadromous salmonids. The area immediately upstream of 198216 was also surveyed by drone presented here and here.

Stream Characteristics Upstream of 198217

Three sections of stream were surveyed. The first section was surveyed upstream of crossing 198217 for 300m (Figure 5.10). Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, deep pools, and overhanging vegetation.The dominant substrate was gravels with cobbles sub-dominant.The average channel width was 6m, the average wetted width was 3.4m, and the average gradient was 2.5%. Abundant gravels were present suitable for coho, steelhead, and rainbow spawning. Multiple large beaver dams were present within the area surveyed. The upstream end of site was adjacent to a beaver dam complex. The habitat was rated as high value for salmonid rearing and spawning.

The second section was surveyed on an upstream tributary to the main stream for 100m. The average channel width was 1.6m, the average wetted width was 1.4m, and the average gradient was 10%.Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, and overhanging vegetation.The dominant substrate was gravels with cobbles sub-dominant. There was extensive beaver activity in this section. This was a steeper, smaller stream with extensive areas of gravel suitable for resident and anadronous salmonids. Multiple small steps from large and small woody debris with heights ranging from 20-40cm were present at the time of survey. The stream was surrounded by an old growth riparian forest. The habitat was rated as medium value for salmonid rearing and spawning.

The third section was surveyed on a tributary to the mainstem for 275m. The dominant substrate was gravels with cobbles sub-dominant.Total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, large woody debris, boulders, undercut banks, and overhanging vegetation.The average channel width was 5m, the average wetted width was 3.3m, and the average gradient was 4.7%. This is a major contributing tributary to downstream flow. Abundant gravels were present suitable for spawning. There were sporadic pools suitable for juvenile coho and steelhead overwintering. The mature old growth mixed riparian provided a stable channel and large woody debris. Wildlife trails were found throughout the forest. The habitat was rated as high value for salmonid rearing and spawning.

Structure Remediation and Cost Estimate

Although replacement of PSCIS crossing 198217 with a bridge (15m span with a cost estimated at $300,000) is tentatively recommended, conditions within the greater watershed should be assessed more comprehensively first to determine how the channel alignment and wetland configuration/capacity (between Water Tower Road and the Skeena River) have been impacted by the installation of roads and Sik-E-Dakh community infrastructure as alternative options may provide greater restoration actions.

Conclusion and Recommendations

There was more than 1.4km of habitat modelled upstream of crossing 198217 with gradients less than 10%. Areas surveyed rated as high value for coho rearing and spawning. In collaboration with the local Sik-E-Dakh community, a plan to gather local knowledge, provide educational opportunities for local community members and eventually rehabilitate this system is being layed out by the Gitksan Watershed Authorities. Recommendations going forward include:

- If it can be located, conduct an assessment of modelled crossing 8301266, located approximately 375m further up Water Tower Road from crossing 198217. During the assessment, survey upstream and downstream (several hundred meters if possible) to try to determine if (and how much) water flows where this stream segment has been mapped in the freshwater atlas of BC.
- As the extent/duration of seasonal dewatering could decrease and the amount of rearing habitat available increased by encouraging water retention in beaver influenced wetland areas, an inventory of beaver dams, analysis of the watershed with the beaver restoration assessment tool and wetland mapping is recommended. Additionally, we recommend engaging with Ministry of Transportation and Infrastructure representatives and contractors to understand site constraints, road maintenance issues and explore the possibility of

increasing water storage within the wetland areas located upstream and downstream of the highway.

- Electrofishing and PIT tagging upstream and downstream of crossing 198217 (including within the northern tributary that feeds the drinking water intake facility) is recommended to provide insight into fish community composition, density, survival and movement.

- Acquisition of lidar data for areas to the west of current data available on LidarBC (includes area of water intake facilities) to provide information about potential channel and wetland locations. Analysis of this data could provide insight into historic channel dredging/redirections and inform restoration actions.

- Acquisition of temperature data at points likely to contain water all year long (ex. outlet of culverts and upstream of culvert on water tower road). Acquire data for the entire growing season and include areas from main north channel to elevations where coho are expected to populate. The growing season can be defined as per Coleman and Fausch (2007), which delineate the beginning as the first day of the week that average stream temperatures exceed 5°C in the spring and the end as the last day of the week that average stream temperature drops below 4°C.

- Delineation of reaches and acquisition of habitat data incorporating Fish Habitat Assessment Procedures (Johnston and Slaney 1996) within all reaches expected to be populated by coho. An adaptation of assessments (ex. degree of channel incision and percentage of floodplain utilized by the stream) developed to informed low-tech process-based restoration activities (beaver dam analogues and post assisted log structures) could be incorporated into FHAP assessments as per Wheaton et al. (2019).

- Acquire high resolution RGB imagery for the entire area from the confluence to above the water intake infrastructure. Include areas on the west side of the highway where there is the remnant channel on the south of water tower culverts and wetland areas to the north.

- Coho spawner surveys to coincide with known spawning timing in neighbouring systems.

- Snorkel and/or gopro surveys of plunge pool areas below culverts at times of steelhead and coho migrations to scope for adults attempting to ascend the watershed.

- Overall outreach program to gather historic fisheries information for the system and to scope for knowledge regarding alterations to the subject stream tradgectory/floodplain. Through this process of two way education, Kispiox valley residents and restoration practitioners could learn/teach about the role of beavers in local watershed health as well as the history of impacts to aquatic values due to road, community, and ranch development in the area.

- Acquisition of hydrometric information in accordance with the Manual of British Columbia Hydrometric Standards (Resources Information Standards Committee 2018) to build stage discharge curves for the watershed so the relationships between fish life history timings, physical habitat suitability, temperature and flows can be better understood.

Table 5.19: Summary of habitat details for PSCIS crossing 198216 and 198217.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198216	Downstream	–	–	–	–	1.0	none	–
198217	Downstream	300	5.0	2.9	0.4	1.8	moderate	medium
198217	Upstream	300	6.0	3.4	0.4	2.5	moderate	high
198217	Upstream2	100	1.6	1.4	–	10.0	moderate	medium
198217	Upstream3	275	5.0	3.3	0.3	4.7	moderate	high

Figure 5.10: Left: Typical habitat downstream of PSCIS crossing 198217. Right: Typical habitat downstream of PSCIS crossing 198217.

Figure 5.11: Left: Typical habitat upstream of PSCIS crossing 198217. Right: Typical habitat upstream of PSCIS crossing 198217.

Figure 5.12: Left: Typical habitat upstream of PSCIS crossing 198217. Right: Typical habitat upstream of PSCIS crossing 198217.

Tea Creek - 198220 - Appendix

Site Location

PSCIS crossing 198220 (MoTi `chris_hwy_structure_road_id` 4092) is located on Tea Creek, approximately 4.5km north of the village of Kitwanga, on Hwy 37 approximately 0.8km upstream from the confluence with the Kitwanga River. PSCIS crossing 198200 on Moore Road (MoTi `chris_culvert_id` of 1528424) located approximately 200m upstream from the highway was also assessed and PSCIS crossing 198201 (MoTi `chris_culvert_id`s of 1528425 and 1528426) on Moore Road and a tributary to Tea Creek were also assessed. All crossings are the responsibility of the Ministry of Transportation and Infrastructure. Several other road stream crossings are modelled upstream however none are modelled as located on the mainstem of Tea Creek until approximately 4.5km upstream of Moore Road.

Background

At crossing 198220, Tea Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 52.2km^2. The elevation of the watershed ranges from a maximum of 1141m to 251m near the crossing (Table 5.20). Upstream of crossing 198220, have previously been recorded (MoE 2020b; Norris 2022). Steelhead use of the system upstream of the highway was confirmed by a local landowner who reported historic spawning in the tributary to Tea Creek that flows into the stream just below Moore Road and PSCIS crossing 198200.

Table 5.20: Summary of derived upstream watershed statistics for PSCIS crossing 198220.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
198220	52.2	251	229	1141	587	568	SSW

* Elev P60 = Elevation at which 60% of the watershed area is above

In 1997, in partnership with Fisheries and Oceans Canada, the Ministry of Environment, Lands and Parks, Habitat Conservation Trust Fund, and non-governmental organizations (Gitanyow Fisheries Authorities and the Steelhead Society of BC), the Ministry of Transportation conducted fish passage remediation activities on Tea Creek at both Highway 37 as well as on Moore Road. At the highway, backwater weir structures, comprised of notched pre-cast concrete lock block designed to reduce the outlet drop were installed below crossing 198220. At the Moore Road crossing, previously perched culverts were replaced with a bottomless pipe arch (Sweeting, n.d.).

PSCIS stream crossing 198220 was ranked as a high priority for follow up by the Society for Ecosystem Restoration in Northern BC due to the large size of the stream, with many species confirmed upstream. A summary of habitat modelling outputs is presented in Table 5.21. A map of the watershed is provided in map attachment 103P.105.

Table 5.21: Summary of fish habitat modelling for PSCIS crossing 198220.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	100.1	16.4	16
ST Lake Reservoir (ha)	8.8	0.0	0
ST Wetland (ha)	40.8	1.4	3
ST Slopeclass03 Waterbodies (km)	4.9	0.0	0
ST Slopeclass03 (km)	19.4	2.5	13
ST Slopeclass05 (km)	50.3	5.9	12
ST Slopeclass08 (km)	20.7	6.4	31
ST Spawning (km)	1.8	1.5	83
ST Rearing (km)	19.4	11.4	59
CH Spawning (km)	1.8	1.5	83
CH Rearing (km)	10.9	7.2	66
CO Spawning (km)	14.6	7.2	49
CO Rearing (km)	17.5	7.2	41
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

5.3 Climate Change Risk Assessment

Preliminary climate change risk assessment data is presented in Tables 5.22 - 5.23.

Table 5.22: Summary of climate change risk assessment for PSCIS crossing 198220.

Condition and Climate Risk	Rank	Priority	Rank
Erosion (scale 1 low - 5 high)	3	Traffic Volume 1 (low) 5 (medium) 10 (high)	9
Embankment fill issues 1 (low) 2 (medium) 3 (high)	1	Community Access - Scale - 1 (high - multiple road access) 5 (medium - some road access) 10 (low - one road access)	1
Blockage Issues 1 (0-30%) 2 (>30-75%) 3 (>75%)	1	Cost (scale: 1 high - 10 low)	1
Condition Rank = embankment + blockage + erosion	5	Constructibility (scale: 1 difficult -10 easy)	2
Likelihood Flood Event Affecting Culvert (scale 1 low - 5 high)	1	Environmental Impacts (scale: 1 high -10 low)	2
Consequence Flood Event Affecting Culvert (scale 1 low - 5 high)	5	Fish Bearing 10 (Yes) 0 (No) - see maps for fish points	10
Climate Change Flood Risk (likelihood x consequence) 1-6 (low) 6-12 (medium) 10-25 (high)	5	Priority Rank = traffic volume + community access + cost + constructability + fish bearing + environmental impacts	25
Vulnerability Rank = Condition Rank + Climate Rank	10	Overall Rank = Vulnerability Rank + Priority Rank	35

Table 5.23: Details and rational for climate risk rankings

Category	Comments
Condition	Backwatering from previous remediation has failed. There is a big outlet drop.
Climate	Large system with a wide channel. Deep fill so failure would cause extensive damage to highwy and dump large quantities of sediments into Kitwanga River.
Priority	Structure is located on major highway with large amounts of fill. Replacement would be very expensive with large impact on traffic flow.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 198220 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.24). There was low flow through the culvert at the time of survey. Water temperature was 11.6°C, pH was 8.4 and conductivity was 291uS/cm.

PSCIS culvert 198200 culvert located on Moore Road approximately 220m upstream from the highway had a natural streambed and was ranked as passable to all species and life stages at the time of survey (Table 5.25). Although this crossing was incorrectly recorded as a closed bottom structure in 2022, the crossing was more likely an open bottomed pipe arch as noted in Sweeting (n.d.).

PSCIS crossing 198201 located on Moore Road approximately 350m east of crossing 198200 was assessed and ranked as passable at the time of survey (Table 5.26). There were two culverts side by side, with both embedded and non backwatered within a channel noted as 2.1m wide. Fish (up to 20cm in length) were observed within the culverts.

Table 5.24: Summary of fish passage assessment for PSCIS crossing 198220.

Location and Stream Data	•	Crossing Characteristics	–
Date	2022-09-09	Crossing Sub Type	Round Culvert
PSCIS ID	198220	Diameter (m)	4.8
External ID	–	Length (m)	75
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	563431	Resemble Channel	No
Northing	6109637	Backwatered	No
Stream	Tea Creek	Percent Backwatered	–
Road	Hwy 37	Fill Depth (m)	9.9
Road Tenure	MoTi Highway	Outlet Drop (m)	0.72
Channel Width (m)	5	Outlet Pool Depth (m)	0.75
Stream Slope (%)	2	Inlet Drop	No
Beaver Activity	No	Slope (%)	1.5
Habitat Value	High	Valley Fill	Deep Fill
Final score	34	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	30.5

Stream Characteristics at Crossing

Location and Stream Data	•	Crossing Characteristics	–
Comments: Historic backwatering with 6 downstream lock block weirs. Skeena Fisheries Commission has assessed site in past. Very large system, pipe embedded until downstream 10m. Large outlet drop. Abundant algae. 10:46			
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Table 5.25: Summary of fish passage assessment for PSCIS crossing 8300012.

Location and Stream Data	•	**Crossing Characteristics**	–
Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-09-09	Crossing Sub Type	Round Culvert
PSCIS ID	–	Diameter (m)	2.8
External ID	8300012	Length (m)	10
Crew	MW	Embedded	Yes
UTM Zone	9	Depth Embedded (m)	0.22
Easting	563541.6	Resemble Channel	Yes
Northing	6109765	Backwatered	No
Stream	Tributary to Kitwanga River	Percent Backwatered	–
Road	Moore Rd	Fill Depth (m)	1
Road Tenure	MoTi Local	Outlet Drop (m)	0.1
Channel Width (m)	4.3	Outlet Pool Depth (m)	0.1
Stream Slope (%)	2	Inlet Drop	No
Beaver Activity	No	Slope (%)	0
Habitat Value	High	Valley Fill	Deep Fill
Final score	11	Barrier Result	Passable
Fix type	–	Fix Span / Diameter	–

Stream Characteristics at Crossing

Location and Stream Data	•	Crossing Characteristics	–
Comments: Embedded with no outlet drop. Very wide channel with gravels and cobbles. 10:18			
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-09-09	Crossing Sub Type	Round Culvert
PSCIS ID	–	Diameter (m)	1.6
External ID	8300917	Length (m)	8
Crew	MW	Embedded	Yes
UTM Zone	9	Depth Embedded (m)	0.38
Easting	563869.2	Resemble Channel	Yes
Northing	6109781	Backwatered	No
Stream	Tributary to Kitwanga River	Percent Backwatered	–
Road	Moore Rd	Fill Depth (m)	0.7
Road Tenure	MoTi Unclassified	Outlet Drop (m)	0
Channel Width (m)	2.1	Outlet Pool Depth (m)	0.2
Stream Slope (%)	1	Inlet Drop	No
Beaver Activity	No	Slope (%)	1.5
Habitat Value	High	Valley Fill	Deep Fill
Final score	11	Barrier Result	Passable
Fix type	–	Fix Span / Diameter	–

Stream Characteristics at Crossing

Location and Stream Data	•	Crossing Characteristics	–
Comments: Two culverts, both embedded with no drop. Fish spotted in culvert(up to 20 cm in length) and downstream. Erosion near culvert. 10:50			
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 198220 for 400m (Figure 5.13). Total cover amount was rated as moderate with boulders dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation.The average channel width was 5.4m, the average wetted width was 3.2m, and the average gradient was 3%.The dominant substrate was gravels with cobbles sub-dominant. There was boulder cover and gravels throughout the survey but very few pools. The habitat was rated as high value for salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 198220 for 600m (Figure 5.14). The dominant substrate was cobbles with gravels sub-dominant.Total cover amount was rated as moderate with small woody debris dominant. Cover was also present as large woody debris, boulders, undercut banks, and overhanging vegetation.The average channel width was 4.2m, the average wetted width was 2.8m, and the average gradient was 3.9%. Only a few areas contained gravels suitable for spawning. The channel was wide throughout with a lot of woody debris. There were large amounts of undercut banks that provided cover, but very few deep pools. Some steep eroding banks were seen in a few locations on the survey. Juvenile fish were spotted, in the culvert on Moore Road. Overall, the habitat was rated as medium value as an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 198220 with a bridge (30.5m span) is recommended. The cost of the work is estimated at $22,875,000 for a cost benefit of 849 linear m/$1000 and 2122.4 m^2/$1000.

Conclusion

There was 19.4km of habitat modelled upstream of crossing 198220 with areas surveyed rated as medium value for salmonid rearing and spawning. 198220 was ranked as a high priority for proceeding to design for replacement. Electrofishing upstream and downstream of the culvert is recommended to provide insight into fish density and migration patterns.

Table 5.27: Summary of habitat details for PSCIS crossing 198220.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198220	Downstream	400	5.4	3.2	0.3	3.0	moderate	high
198220	Upstream	600	4.2	2.8	0.4	3.9	moderate	medium

Figure 5.13: Left: Typical habitat downstream of PSCIS crossing 198220. Right: Typical habitat downstream of PSCIS crossing 198220.

Figure 5.14: Left: Typical habitat upstream of PSCIS crossing 198220. Right: Typical habitat upstream of PSCIS crossing 198220.

Figure 5.15: Left: Typical habitat upstream of PSCIS crossing 198220. Right: Typical habitat upstream of PSCIS crossing 198220.

Pinenut Creek - 198222 - Appendix

Site Location

PSCIS crossing 198222 is located on Babine Slide FSR, on Pinenut Creek, approximately 15km north east of the small community of Glen Vowell, BC. Crossing 198222 was located on the east side of the Skeena River, approximately 0.6km upstream from the confluence.

Background

At crossing 198222, Pinenut Creek is a third order stream with a watershed area upstream of the crossing of approximately 21.5km^2. The elevation of the watershed ranges from a maximum of 1964m to 420m near the crossing (Table 5.28). At the time of reporting, there was no fisheries information available for the area upstream of crossing 198222(MoE 2020b; Norris 2022).

Table 5.28: Summary of derived upstream watershed statistics for PSCIS crossing 198222.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
198222	21.5	277	420	1964	1077	1006	SW

* Elev P60 = Elevation at which 60% of the watershed area is above

PSCIS stream crossing 198222 was ranked as a high priority for follow up by the Society for Ecosystem Restoration in Northern BC due to significant quantities of habitat upstream modelled by `bcfishpass` as likely suitable for salmon rearing. A summary of habitat modelling outputs is presented in Table 5.29 and a map of the watershed is provided in map attachment 093M.106.

Table 5.29: Summary of fish habitat modelling for PSCIS crossing 198222.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	9.2	8.7	95
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.9	0.9	100
ST Slopeclass08 (km)	3.2	3.2	100
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	3.9	3.9	100
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	0.0	0.0	–

Habitat	Potential	Remediation Gain	Remediation Gain (%)
CO Spawning (km)	0.9	0.9	100
CO Rearing (km)	0.9	0.9	100
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

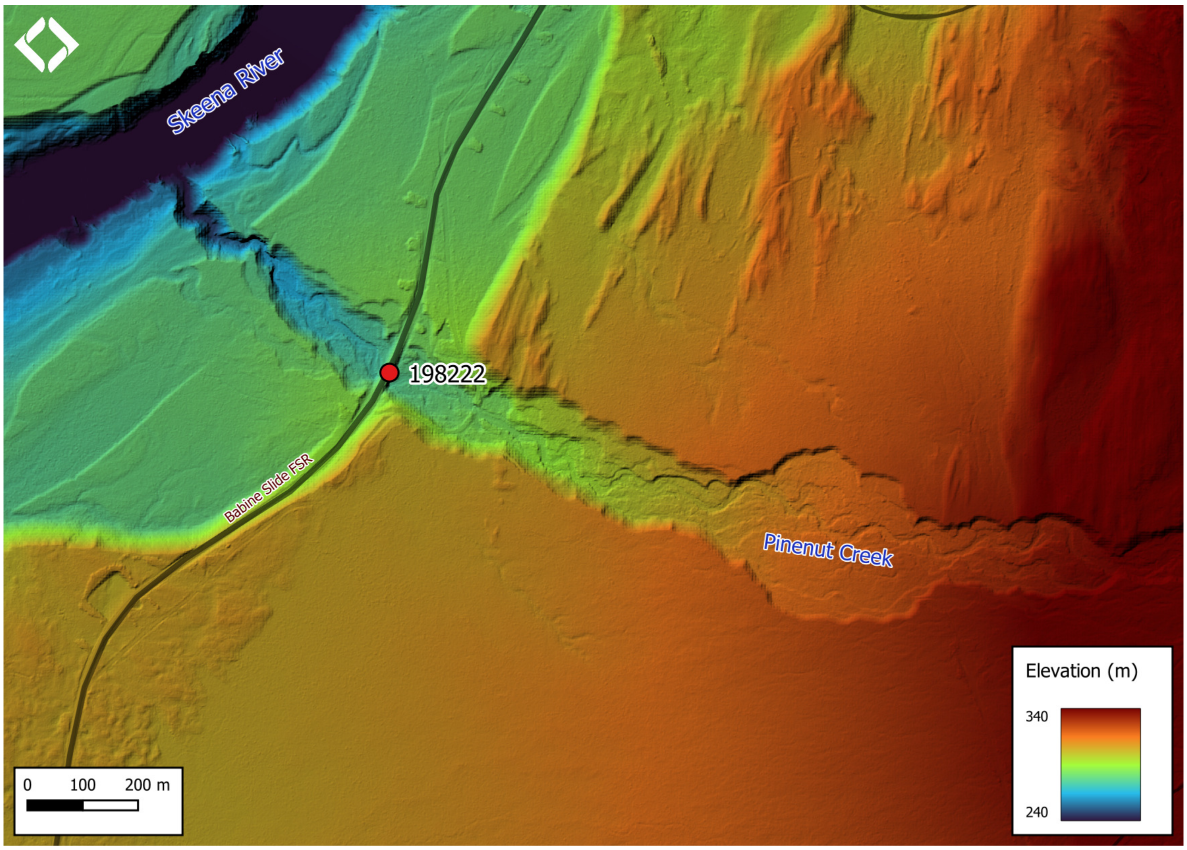


Figure 5.16: Lidar generated digital elevation model of Pinenut Creek at Babine Slide FSR (using elevation data from 2019).

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 198222 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.30). This crossing was replaced in 1985. Water temperature was 9.7°C, pH was 8.2 and conductivity was 75uS/cm.

Table 5.30: Summary of fish passage assessment for PSCIS crossing 198222.

Location and Stream Data	•	Crossing Characteristics	–
Date	2022-09-08	Crossing Sub Type	Round Culvert
PSCIS ID	198222	Diameter (m)	3.8
External ID	–	Length (m)	30
Crew	AI	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	587054	Resemble Channel	No
Northing	6138716	Backwatered	No
Stream	Pinenut Creek	Percent Backwatered	–
Road	Babine Slide FSR	Fill Depth (m)	4
Road Tenure	MoF 4841	Outlet Drop (m)	0.45
Channel Width (m)	8.2	Outlet Pool Depth (m)	0.4
Stream Slope (%)	4	Inlet Drop	No
Beaver Activity	No	Slope (%)	2.5
Habitat Value	High	Valley Fill	Deep Fill
Final score	37	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Location and Stream Data	•	**Crossing Characteristics**	–
Comments: Structure was replaced in 1985. Concrete wing walls on inlet. Structure is in decent shape. 13:39			
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 198222 for 150m (Figure 5.17). The average channel width was 8.1m, the average wetted width was 5.4m, and the average gradient was

4.5%.Total cover amount was rated as trace with boulders dominant. Cover was also present as undercut banks.The dominant substrate was cobbles with gravels sub-dominant. The habitat was rated as medium value for salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 198222 for 650m (Figure 5.18). Total cover amount was rated as trace with boulders dominant. Cover was also present as undercut banks.The dominant substrate was cobbles with boulders sub-dominant.The average channel width was 13.1m, the average wetted width was 5.7m, and the average gradient was 3.6%. There is a collapsed bridge approximately 200m from crossing 198222. Some erosion was present along the sides of the bridge but there was no fish passage issue at the time of survey. This was a high energy system with numerous areas of multiple channels, islands and elevated bars. High flows were pushing most of the large woody debris out of the main channel, resulting in lower complexity. There were rare pockets of gravel suitable for spawning. Overall, the habitat surveyed upstream of the crossing was rated as medium value as an important migration corridor containing habitat suitable for spawning and rearing.

Fish Sampling

To assess potential impacts of the culvert on fisheries values in the stream, minnowtrapping was conducted upstream and downstream of the crossing. Two traps were set downstream of the crossing and two were set upstream; traps were left overnight. 1 dolly varden was captured upstream and 6 dolly varden were captured downstream (Figure 5.20).

Table 5.31: Fish captured in minnowtraps set overnight upstream and downstream of PSCIS crossing 198222.

Location	Species	parr	juvenile
Downstream	DV	3	3
Upstream	DV	0	1

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 198222 with a bridge (15m span) is recommended. The cost of the work is estimated at $375,000 for a cost benefit of 10453.3 linear m/$1000 and 42858.7 m^2/$1000.

Conclusion

Modelling indicates there is 3.9km of habitat upstream of crossing 198222 suitable for steelhead rearing, with areas surveyed rated as medium value for rearing and spawning. Although minnnow trapping is not considered a robust sampling method to definitively determine species composition - results indicated only dolly varden presence immediately adjacent to the crossing. Besides the drop at the outlet, crossing 198222 was in good condition and backwatering of the pipe could be considered if cost of replacement precludes remdiation efforts. Overall the site was ranked as a high priority for proceeding to design for replacement.

Table 5.32: Summary of habitat details for PSCIS crossing 198222.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198222	Downstream	150	8.1	5.4	0.5	4.5	trace	medium
198222	Upstream	650	13.1	5.7	0.4	3.6	trace	medium

Figure 5.17: Left: Typical habitat downstream of PSCIS crossing 198222. Right: Typical habitat downstream of PSCIS crossing 198222.

Figure 5.18: Left: Typical habitat upstream of PSCIS crossing 198222. Right: Collapsed bridge upstream of PSCIS crossing 198222.

Figure 5.19: Left: Typical habitat upstream of PSCIS crossing 198222. Right: Typical habitat upstream of PSCIS crossing 198222.

Figure 5.20: Left: Dolly Varden captured downstream of PSCIS crossing 198222. Right: Dolly Varden captured upstream of PSCIS crossing 198222.

Sterritt creek - 198225 - Appendix

Site Location

PSCIS crossing 198225 is located on Sterritt creek. This site is located on Babine Slide FSR, approximately 1.1km upstream from the confluence with the Skeena River.

Background

At crossing 198225, Sterritt creek is a fourth order stream with a watershed area upstream of the crossing of approximately 14.4km^2. The elevation of the watershed ranges from a maximum of 2296m to 470m near the crossing (Table 5.33). At the time of reporting, there was no fisheries information available for the areas upstream of crossing 198225.

Table 5.33: Summary of derived upstream watershed statistics for PSCIS crossing 198225.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
198225	14.4	369	470	2296	1441	1334	SW

* Elev P60 = Elevation at which 60% of the watershed area is above

A summary of habitat modelling outputs is presented in Table 5.34. A map of the watershed is provided in map attachment 093M.111.

Table 5.34: Summary of fish habitat modelling for PSCIS crossing 198225.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	3.4	0.6	18
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.6	0.6	100
ST Slopeclass08 (km)	0.7	0.0	0
ST Spawning (km)	0.6	0.6	100
ST Rearing (km)	1.3	0.6	46
CH Spawning (km)	0.6	0.6	100
CH Rearing (km)	0.6	0.6	100
CO Spawning (km)	0.6	0.6	100
CO Rearing (km)	0.6	0.6	100
CO Rearing (ha)	0.0	0.0	–

Habitat	Potential	Remediation Gain	Remediation Gain (%)
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

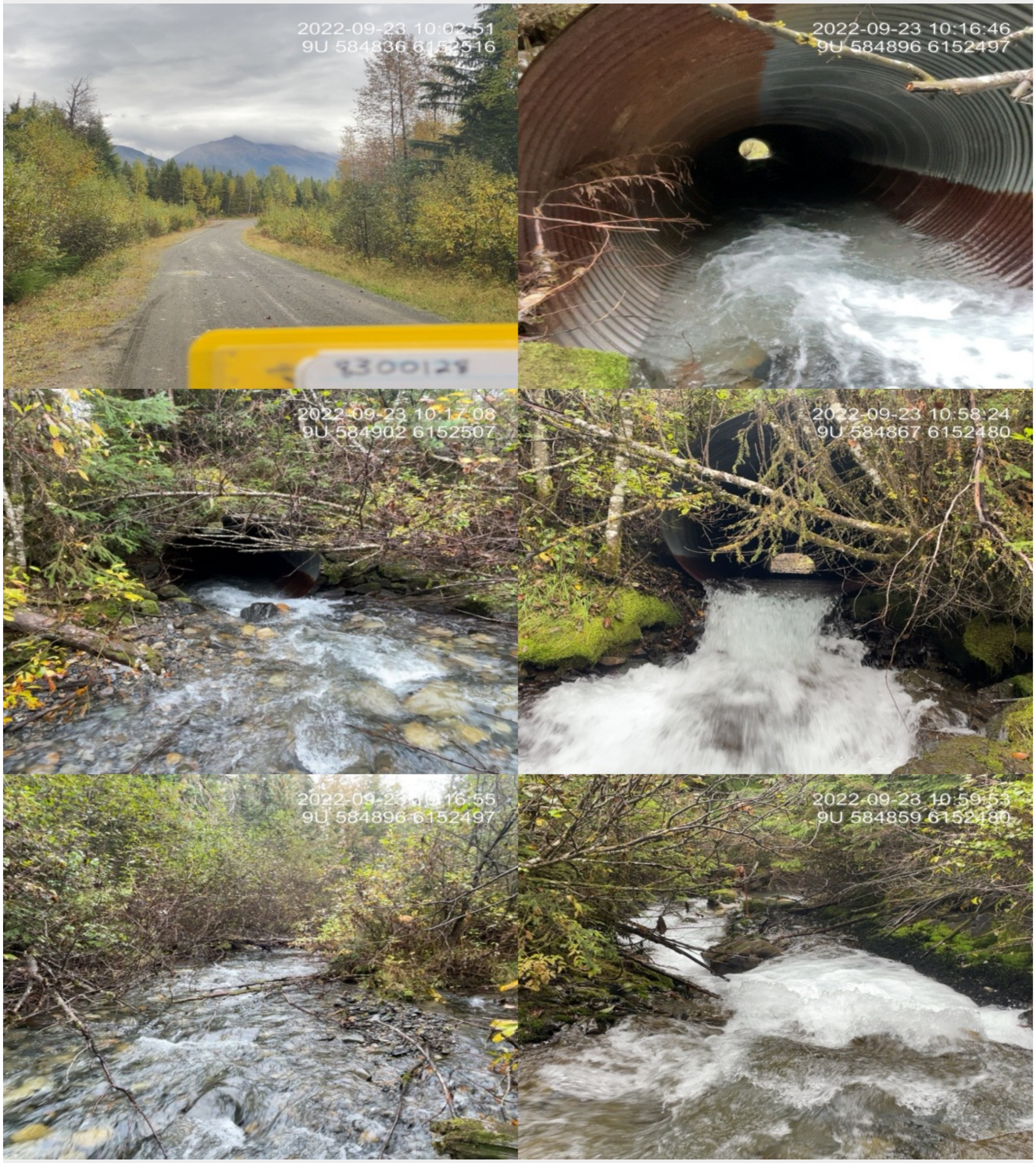
Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 198225 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.35). There was high flow through the culvert at the time of survey. A deep outlet pool (2m) and a large outlet drop (2m) indicate that the culvert may be undersized. Water temperature was 8°C, pH was 7.9 and conductivity was 46uS/cm.

Table 5.35: Summary of fish passage assessment for PSCIS crossing 198225.

Location and Stream Data	•	Crossing Characteristics	–
Date	2022-09-23	Crossing Sub Type	Round Culvert
PSCIS ID	198225	Diameter (m)	2.4
External ID	–	Length (m)	30
Crew	JO	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	584898.7	Resemble Channel	No
Northing	6152502	Backwatered	No
Stream	Sterritt creek	Percent Backwatered	–
Road	Babine Slide FSR	Fill Depth (m)	4
Road Tenure	MoF 4841	Outlet Drop (m)	2
Channel Width (m)	3.7	Outlet Pool Depth (m)	2
Stream Slope (%)	4.5	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	3.5
Habitat Value	Low	Valley Fill	Deep Fill
Final score	42	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Location and Stream Data	•	Crossing Characteristics	–
Comments: Culvert is separating 10 meters in from upstream, top of culvert slumping in. 10:06			
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			



Stream Characteristics Downstream

The stream was surveyed downstream from crossing 198225 for 260m (Figure 5.21). The average channel width was 7.5m, the average wetted width was 5.6m, and the average gradient was

5.6%.The dominant substrate was large rock/bedrock with cobbles sub-dominant.Total cover amount was rated as trace with large woody debris dominant. Cover was also present as small woody debris, boulders, and undercut banks. There was an abundance of large woody debris that created deep pools, diverted water flow, and created natural steps. The habitat was rated as medium value for salmonid rearing.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 198225 for 500m (Figure 5.22). The average channel width was 12.2m, the average wetted width was 5.5m, and the average gradient was 4.4%.The dominant substrate was cobbles with gravels sub-dominant.Total cover amount was rated as abundant with large woody debris dominant. Cover was also present as small woody debris. This stream has the potential to be fish bearing but the gradient is steep. The bank full depth is very high, with a measured average of 0.8m. There was an abundance of large woody debris that provided functionality to the stream habitat by diverting flow and providing cover. The habitat was rated as medium value as an important migration corridor containing suitable rearing habitat.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 198225 with a bridge (15m span) is recommended. The cost of the work is estimated at $375,000 for a cost benefit of 3440 linear m/$1000 and 6364 m^2/$1000.

Conclusion

There was 1.3km of habitat modelled upstream of crossing 198225 with areas surveyed rated as medium value for salmonid rearing and spawning. 198225 was ranked as a moderate priority for proceeding to design for replacement. Electrofishing upstream and downstream of the culvert is recommended to provide insight into fish community composition and density which may justify a higher priority for site remediation.

Table 5.36: Summary of habitat details for PSCIS crossing 198225.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198225	Downstream	260	7.5	5.6	0.4	5.6	trace	medium
198225	Upstream	500	12.2	5.5	0.4	4.4	abundant	medium

Figure 5.21: Left: Typical habitat downstream of PSCIS crossing 198225. Right: Typical habitat downstream of PSCIS crossing 198225.

Figure 5.22: Left: Typical habitat upstream of PSCIS crossing 198225. Right: Typical habitat upstream of PSCIS crossing 198225.

Figure 5.23: Left: Typical habitat upstream of PSCIS crossing 198225. Right: Typical habitat upstream of PSCIS crossing 198225.

Tributary to Kitwanga River - 198236 - Appendix

Site Location

PSCIS crossing 198236 is located on Tributary to Kitwanga River, on the Kitwancool Branch 2 FSR 4.3km upstream from the confluence with the Kitwanga River at a location 1.5km upstream of Kitwanga Lake (a.k.a Kitwancool Lake or Gitanyow Lake). There are two modelled crossing locations between the subject site and the Kitwanga River that have not yet been inventoried. The first unasssessed crossing (modelled_crossing_id 8301996) is located on the Kitwancool Branch 2 FSR 2.0km downstream of the subject site with the second a modelled crossing (modelled_crossing_id 8300438) on an unnamed road. Although field crews overlooked assessment of modelled crossing 8301996 they did attempt to access crossing 8300438 however this road had been deactivated with concrete blocks preventing all vehicle access including ATVs. Review of aerial imagery indicates that the crossing structures (including 8300438) have been removed and fish access through this area is not likely hindered.

Background

At crossing 198236, Tributary to Kitwanga River is a third order stream with a watershed area upstream of the crossing of approximately 4.8km^2. The elevation of the watershed ranges from a maximum of 1760m to 449m near the crossing (Table 5.37). At the time of reporting, there was no fisheries information available for the areas upstream of crossing 198236.

Table 5.37: Summary of derived upstream watershed statistics for PSCIS crossing 198236.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
198236	4.8	449	528	1760	1001	916	SE

* Elev P60 = Elevation at which 60% of the watershed area is above

This tributary joins with the Kitwanga River before draining into Kitwanga Lake. This lake has an important value to fisheries in the area. Using salmon enumeration facilities to trap and count upstream migrating salmon, the Gitanyow Fisheries Authorities have proven that Kitwanga Lake is one of the most productive sockeye nursery lakes for its size in all of BC (Gitanyow Fisheries Authority 2023). The Kitwanga River salmon enumeration facility is located approximately 4km north of the confluence with the Skeena river. This facility provides counts of five species of salmon: sockeye, chinook, coho, chum, and pink. In response to rapid declines in sockeye stocks, the Kitwanga Lake Sockeye Restoration project was started in 2006. Restoration efforts include environmental monitoring of the lake, assessment of sockeye spawning and rearing habitat, and hatchery rearing (Allen Gottesfeld, Barnes, and Soto 2009).

PSCIS stream crossing 198236 was ranked as a moderate priority for follow up by the Society for Ecosystem Restoration in Northern BC. A Fish Habitat Assessment Procedure was completed at this site in 2008 by members of the Skeena Fisheries Commission. At the time of assessment, it was concluded that the culvert presented a velocity barrier to juveniles. The habitat upstream was modelled at 8%. A summary of habitat modelling outputs is presented in Table 5.38. A map of the watershed is provided in map attachment 103P.115.

Table 5.38: Summary of fish habitat modelling for PSCIS crossing 198236.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	2.4	2.4	100
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.1	0.1	100
ST Slopeclass08 (km)	1.4	1.4	100
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	0.0	0.0	–
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	0.0	0.0	–
CO Spawning (km)	0.0	0.0	–
CO Rearing (km)	0.0	0.0	–
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 198236 was un-embedded, non-backwatered and ranked as a barrier barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.39). There was low flow through both culverts at the time of survey. Water temperature was 8°C, pH was 8.3 and conductivity was 149uS/cm.

Table 5.39: Summary of fish passage assessment for PSCIS crossing 198236.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-09-09	Crossing Sub Type	Round Culvert
PSCIS ID	198236	Diameter (m)	1.7
External ID	–	Length (m)	10
Crew	AI JO	Embedded	No
UTM Zone	9	Depth Embedded (m)	–
Easting	550300	Resemble Channel	No
Northing	6140708	Backwatered	No
Stream	Tributary to Kitwanga River	Percent Backwatered	–
Road	Kitwancool Branch 2 FSR	Fill Depth (m)	0.45
Road Tenure	MoF 8687	Outlet Drop (m)	0.24
Channel Width (m)	2.3	Outlet Pool Depth (m)	0.22
Stream Slope (%)	1	Inlet Drop	Yes
Beaver Activity	Yes	Slope (%)	2
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	26	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Location and Stream Data	•	Crossing Characteristics	–
Comments: Two culverts side by side (0.85m each). 14:23			
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 198236 for 200m (Figure 5.24). Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris.The dominant substrate was cobbles with gravels sub-dominant.The average channel width was 3.8m, the average wetted width was 2.3m, and the average gradient was 2.4%. There was abundant overhanging vegetation and a lot of downed trees. The stream mainly consisted of gravels and cobbles. There were infrequent shallow pools suitable for rearing. The habitat was rated as high value for salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 198236 for 500m (Figure 5.25). The dominant substrate was gravels with cobbles sub-dominant.The average channel width was 3m, the average wetted width was 2.6m, and the average gradient was 5.8%.Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, deep pools, and overhanging vegetation. There were abundant gravels suitable for resident and anadromous salmonid spawning. There were frequent deep pools due to large woody debris in the canyon that was not logged. Overall, the habitat was rated as high value.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 198236 with a bridge (15m span) is recommended. The cost of the work is estimated at $375,000 for a cost benefit of 0 linear m/$1000 and 0 m^2/$1000.

Conclusion

There was 0km of habitat modelled upstream of crossing 198236 with areas surveyed rated as high value for salmonid rearing and spawning. Crossing 198236 was ranked as a moderate priority for proceeding to design for replacement.

Table 5.40: Summary of habitat details for PSCIS crossing 198236.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198236	Downstream	200	3.8	2.3	0.3	2.4	moderate	high
198236	Upstream	500	3.0	2.6	0.4	5.8	moderate	high

Figure 5.24: Left: Typical habitat downstream of PSCIS crossing 198236. Right: Typical habitat downstream of PSCIS crossing 198236.

Figure 5.25: Left: Typical habitat upstream of PSCIS crossing 198236. Right: Typical habitat upstream of PSCIS crossing 198236.

Figure 5.26: Left: Typical habitat upstream of PSCIS crossing 198236. Right: Typical habitat upstream of PSCIS crossing 198236.

Sandstone Creek - 8530 - Appendix

Site Location

PSCIS crossing 8530 is located on Sandstone Creek approximately 5km west of the town of Smithers, on Mcdonell FSR. This crossing is located approximately 650m upstream from the confluence with the Zymoetz River.

Background

At crossing 8530, Sandstone Creek is a third order stream with a watershed area upstream of the crossing of approximately 14.2km^2. The elevation of the watershed ranges from a maximum of 1282m to 814m at the crossing (Table 5.41). Upstream of crossing 8530, dolly varden, rainbow trout, and cutthroat trout have previously been recorded (MoE 2020b; Norris 2022). The mainstem of Sandstone Creek is 9.8km in length and is fed by 13 tributaries. Sandstone Lake is located approximately 4km upstream of crossing 8530, and has an area of 67ha. According to historical records, dolly varden and cutthroat trout have been known to reside in Sandstone Lake.

Table 5.41: Summary of derived upstream watershed statistics for PSCIS crossing 8530.

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
8530	14.2	814	1282	1040	1029	SSW

* Elev P60 = Elevation at which 60% of the watershed area is above

Triton Environmental Consultants Ltd. (1998) conducted a reconnaissance level fish and fish habitat inventory on Sandstone Creek. In 1996, they conducted fish sampling at two sites located downstream of crossing 8530 and caught cutthroat trout. In 1997, Rainbow trout were caught by electrofishing upstream of Sandstone Lake and cutthroat trout were caught by electrofishing in a tributary located approximately 800m upstream of crossing 8530. At that time, Sandstone Creek was generally a low gradient stream with areas of moderate confinement. Upstream of Sandstone Lake, the stream flows for approximately 2.5km through an area of fisheries sensitive wetlands before draining a small unnamed lake.

PSCIS stream crossing 8530 was ranked as a high priority for follow up by the Society for Ecosystem Restoration in Northern BC because of significant amounts of habitat modelled upstream of the crossing. Viveiros (2011) assessed crossing 8530 in 2010. At the time of survey, it was recommended that the material in the pipe be embedded to reduce water velocity. A summary of habitat modelling outputs is presented in Table 5.42. A map of the watershed is provided in map attachment 093L.121.

Table 5.42: Summary of fish habitat modelling for PSCIS crossing 8530.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	24.0	22.6	94
ST Lake Reservoir (ha)	71.8	71.8	100
ST Wetland (ha)	86.3	86.3	100
ST Slopeclass03 Waterbodies (km)	8.4	0.0	0
ST Slopeclass03 (km)	3.2	3.2	100
ST Slopeclass05 (km)	5.7	5.5	96
ST Slopeclass08 (km)	5.7	4.4	77
ST Spawning (km)	1.2	1.2	100
ST Rearing (km)	5.7	5.7	100
CH Spawning (km)	0.8	0.8	100
CH Rearing (km)	0.8	0.8	100
CO Spawning (km)	2.6	2.6	100
CO Rearing (km)	2.6	2.6	100
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

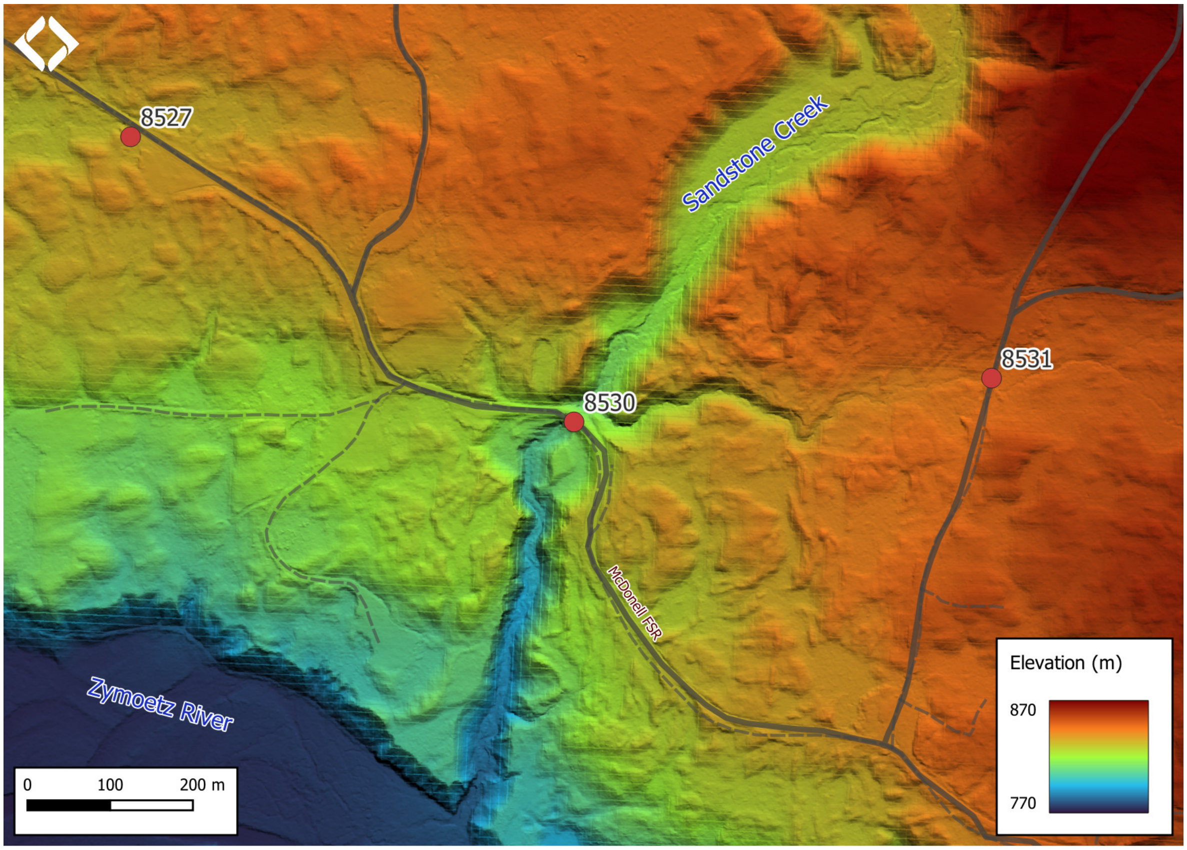


Figure 5.27: Lidar generated digital elevation model of Sandstone Creek at McDonell FSR (using elevation data from 2018).

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 8530 was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.43). Water temperature was 6.4°C, pH was 7.4 and conductivity was 90uS/cm.

Table 5.43: Summary of fish passage assessment for PSCIS crossing 8530.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-09-12	Crossing Sub Type	Round Culvert
PSCIS ID	8530	Diameter (m)	2.4
External ID	–	Length (m)	28
Crew	MW	Embedded	No
UTM Zone	9	Depth Embedded (m)	–

Stream Characteristics at Crossing

Location and Stream Data	•	Crossing Characteristics	–
Stream	Sandstone Creek	Percent Backwatered	–
Road	Mcdonell FSR	Fill Depth (m)	3
Road Tenure	MoF 7552	Outlet Drop (m)	0.3
Channel Width (m)	3.4	Outlet Pool Depth (m)	0.2
Stream Slope (%)	3	Inlet Drop	No
Beaver Activity	No	Slope (%)	3
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	39	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Location and Stream Data	•	**Crossing Characteristics**	–
Comments: Channel is steeper downstream of culvert. Very deep fill with a small outlet drop. 10:59			
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.			

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 8530 for 275m (Figure 5.29). The dominant substrate was large rock/bedrock with cobbles sub-dominant.Total cover amount was rated as abundant with boulders dominant. Cover was also present as small woody debris, large woody debris, undercut banks, deep pools, and overhanging vegetation.The average channel width was 4m, the average wetted width was 3.2m, and the average gradient was 2.8%. There was good flow at the time of survey. Riparian vegetation was healthy, providing plenty of shade and cover. There were small packets of gravel suitable for spawning. Large woody debris jams and cascades were present that could act as a natural barrier to fish passage. However, during periods of high flow there's a good chance that strong fish can traverse these barriers. Plenty of pools were available for fish rearing. There was abundant functional woody debris and boulders present that added complexity to the stream habitat. The stream was confined in a bed rock canyon, with overhanging vegetation and shrubs dominating the riparian zone. The habitat was rated as medium value for salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 8530 for 600m (Figure 5.30). Total cover amount was rated as moderate with small woody debris dominant. Cover was also present as large woody debris, undercut banks, and overhanging vegetation.The average channel width was 3.8m, the average wetted width was 2.3m, and the average gradient was 3.2%.The dominant substrate was cobbles with gravels sub-dominant. There was abundant cover from woody debris, overhanging veg and undercut banks at the time of survey. The channel was wide throughout with graveled areas suitable for spawning. There was trace amounts of deep pools suitable for rearing. A couple smaller cascades (<1m in height) were present that may block the upstream migration of smaller fish. The habitat was rated as high value as an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

Fish Sampling

Electrofishing was conducted with results summarised in Tables 5.45 - 5.46 and Figure 5.28. Dolly varden and cutthroat trout were caught both downstream and upstream of the culvert, while rainbow trout were only caught upstream (Figure 5.32).

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 8530 with a bridge (15m span) is recommended. The cost of the work is estimated at $375,000 for a cost benefit of 15200 linear m/$1000 and 25840 m^2/$1000.

Conclusion

There was 5.7km of habitat modelled upstream of crossing 8530 with areas surveyed rated as high value for salmonid rearing and spawning. Crossing 8530 was ranked as a high priority for proceeding to design for replacement. Sandstone Creek is a large system with habitat suitable for numerous species including cutthroat and dolly varden. Development of a plan to replace the crossing with a bridge would be a key step in eliminating an outlet drop and reducing flow velocities at the highway crossing.

Table 5.44: Summary of habitat details for PSCIS crossing 8530.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
8530	Downstream	275	4.0	3.2	0.4	2.8	abundant	medium
8530	Upstream	600	3.8	2.3	0.6	3.2	moderate	high

Table 5.45: Fish sampling site summary for 8530.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
8530_ds_ef1	1	14	2.40	33.6	Open
8530_ds_ef2	1	15	3.33	50.0	Open
8530_ds_ef3	1	11	4.15	45.7	Open
8530_us_ef1	1	17	2.40	40.8	Open
8530_us_ef2	1	21	2.40	50.4	Open
8530_us_ef3	1	21	2.80	58.8	Open

Table 5.46: Fish sampling density results summary for 8530.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
8530_ds_ef1	CT	fry	6	17.9	FALSE
8530_ds_ef1	CT	parr	1	3.0	FALSE
8530_ds_ef2	CT	fry	2	4.0	FALSE
8530_ds_ef2	CT	parr	3	6.0	FALSE
8530_ds_ef2	CT	juvenile	1	2.0	FALSE
8530_ds_ef2	CT	adult	1	2.0	FALSE
8530_ds_ef2	DV	parr	1	2.0	FALSE
8530_ds_ef3	CT	fry	11	24.1	FALSE
8530_ds_ef3	CT	parr	2	4.4	FALSE
8530_ds_ef3	DV	juvenile	1	2.2	FALSE
8530_us_ef1	CT	fry	1	2.5	FALSE
8530_us_ef1	CT	parr	4	9.8	FALSE
8530_us_ef1	CT	juvenile	1	2.5	FALSE
8530_us_ef1	RB	juvenile	1	2.5	FALSE
8530_us_ef1	TR	fry	1	2.5	FALSE
8530_us_ef2	CT	fry	3	6.0	FALSE
8530_us_ef2	CT	parr	2	4.0	FALSE
8530_us_ef2	CT	juvenile	1	2.0	FALSE
8530_us_ef2	DV	fry	1	2.0	FALSE
8530_us_ef2	DV	juvenile	1	2.0	FALSE
8530_us_ef2	RB	adult	1	2.0	FALSE
8530_us_ef3	CT	fry	5	8.5	FALSE
8530_us_ef3	CT	parr	3	5.1	FALSE
8530_us_ef3	CT	juvenile	2	3.4	FALSE
8530_us_ef3	CT	adult	1	1.7	FALSE
8530_us_ef3	DV	fry	5	8.5	FALSE

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
8530_us_ef3	DV	parr	2	3.4	FALSE

* nfc_pass FALSE means fish were captured in final pass indicating more fish of this species/lifestage may have remained in site. Mark-recaptured required to reduce uncertainties.

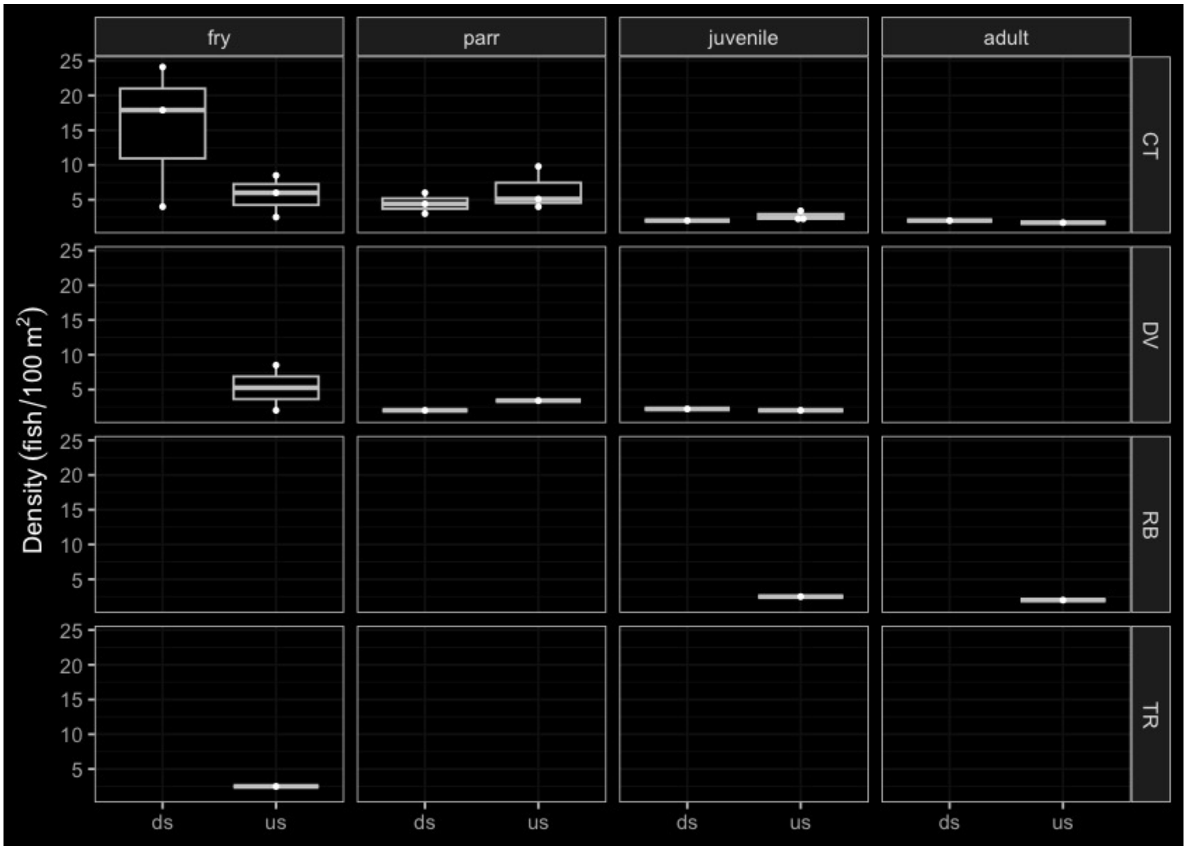


Figure 5.28: Densites of fish (fish/100m2) captured upstream of PSCIS crossing 8530.

Figure 5.29: Left: Typical habitat downstream of PSCIS crossing 8530. Right: Large woody debris jam downstream of PSCIS crossing 8530.

Figure 5.30: Left: Typical habitat upstream of PSCIS crossing 8530. Right: Area with suitable spawning gravels, upstream of PSCIS crossing 8530.

Figure 5.31: Left: Typical habitat upstream of PSCIS crossing 8530. Right: Typical habitat upstream of PSCIS crossing 8530.

Figure 5.32: Left: Dolly Varden captured upstream of PSCIS crossing 8530. Right: Cutthroat trout captured downstream of PSCIS crossing 8530.

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Session Info

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Attachment 1 - Maps

All georeferenced field maps are presented at:

- ’https://hillcrestgeo.ca/outgoing/fishpassage/projects/morr/archive/2022-09-06/
- https://hillcrestgeo.ca/outgoing/fishpassage/projects/zymo/archive/2022-09-06/
- https://hillcrestgeo.ca/outgoing/fishpassage/projects/kisp/archive/2022-09-06/

Maps are also available zipped for bulk download at:

- https://hillcrestgeo.ca/outgoing/fishpassage/projects/morr/archive/2022-09-06/2022-09-06.zip
- https://hillcrestgeo.ca/outgoing/fishpassage/projects/zymo/archive/2022-09-06/2022-09-06.zip
- https://hillcrestgeo.ca/outgoing/fishpassage/projects/kisp/archive/2022-09-06/2022-09-06.zip

Attachment 2 - Phase 1 Data and Photos

Data and photos for all Phase 1 (fish passage assessments) are provided in [Attachment 2 - https://github.com/NewGraphEnvironment/fish_passage_skeena_2022_reporting/raw/main/docs/Attachment_2.pdf](https://github.com/NewGraphEnvironment/fish_passage_skeena_2022_reporting/raw/main/docs/Attachment_2.pdf)

Attachment 3 - Habitat Assessment Data

Raw habitat assessment data included in digital format at https://github.com/NewGraphEnvironment/fish_passage_skeena_2022_reporting/raw/master/data/habitat_confirmations.xls

Attachment 4 - Bayesian analysis to map stream discharge and temperature causal effects pathways

We are working with Poisson Consulting to map stream discharge and temperature causal effects pathways with the intent of focusing aquatic restoration actions in areas of highest potential for positive impacts on fisheries values at https://github.com/poissonconsulting/fish-passage-22