FWCP
Fish & Wildlife
COMPENSATION PROGRAM

SOCIETY FOR ECOSYSTEM RESTORATION
IN NORTHERN BRITISH COLUMBIA

Restoring Fish Passage in the Peace Region - 2023

Prepared for
Fish and Wildlife Compensation Program
and
Fish Passage Technical Working Group

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on behalf of
Society for Ecosystem Restoration in Northern BC

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new graph environment
Research & Consulting

Table of Contents

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.

Executive Summary

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. Upgrading or removing road crossing structures presents numerous opportunities to restore connectivity by incorporating fish passage considerations into repair, replacement, relocation, and deactivation designs.

The Society for Ecosystem Restoration in Northern BC (SERNbc) is collaborating with the McLeod Lake Indian Band, the Peace Region Fish and Wildlife Compensation Program (FWCP), the Provincial Fish Passage Technical Working Group (FPTWG), road/rail tenure holders, and other FWCP stakeholders/partners to prioritize, plan, and fund the restoration of fish passage at road crossing structure barriers within the Parsnip River, Carp River, and Crooked River watershed groups.

The project engages FWCP partners and stakeholders to clearly communicate fish passage issues in FWCP Peace Region watersheds while collaboratively planning and executing the steps necessary to achieve fish passage restorations. The work completed and ongoing aligns with the Fish and Wildlife Compensation Program Rivers, Lakes and Reservoirs Action Plan (Fish and Wildlife Compensation Program 2020) sub-objective 6 of addressing fish passage issues in streams to enhance the productivity of priority species. Project activities undertaken address the following actions:

- PEA.RLR.S06.RI.20 - Conducting engagement to prioritize options for fish passage improvement-P1
- PEA.RLR.S06.RI.19 - Conducting research to prioritize fish passage actions-P1
- PEA.RLR.S06.HB.21 - Restoring fish access to streams-P1

This project builds on the work of the Society for Ecosystem Restoration Northern BC (SERNbc) in 2019 - 2020 (A. Irvine 2020), 2021 - 2022(A. Irvine 2022), and 2022 - 2023 (Allan Irvine and Winterscheidt 2023).

Through 2023/2024 project activities, numerous project partners were engaged, and we identified and conducted fish passage planning/restoration activities at multiple priority sites:

- In addition to numerous small-scale presentations and meetings, we conducted an online presentation through FWCP to showcase the project on February 23, 2024, with over 70 people in attendance. A presentation to the FWCP Peace board detailing project progress, goals, and budgets was also completed on February 6, 2024.
- To facilitate the planning and implementation of restoration activities, a collaborative GIS environment has been established as a space where project team members and

collaborators can access, view, and contribute to spatial datasets and the development of restoration/monitoring plans for the project.

- BCTS used our project documentation to justify investments in road deactivation, leading to the restoration of fish passage at numerous crossings in the Parsnip River watershed, including two priority sites documented in the FWCP-funded (A. Irvine 2020).
- In 2024, Canfor plans to replace crossing 125231 (Tributary to Table River) at km21 on the Chuchinka-Table FSR with a bridge. An engineering design is complete, materials are sourced, and a contract with Canfor is in place for installation preparations (engineering design, environmental management planning/permitting, and material acquisition). The estimated replacement cost is $410,000, with Canfor committing $205,000. To proceed in 2024, FWCP support is necessary to cover the remaining 50% ($90,000) of project costs. Fish sampling with PIT tagging of target species and the acquisition of aerial imagery took place in 2023 as part of baseline monitoring for the site.
- Fish sampling with PIT tagging of target species and the acquisition of aerial imagery took place at Fern Creek located at km2.1 of the Chuchinka-Table FSR as part of baseline monitoring for the site, tentatively scheduled to be replaced in 2025.
- McLeod Lake's capacity to engage in fisheries management and restoration activities within their territory is building through training, fieldwork, and inclusion in planning and communication processes.
- To diversify potential partners for implementation and funding, planning and field assessments were conducted at 80 sites in the Carp River, Crooked River, and Parsnip River watershed groups. This included initial surveys on numerous Ministry of Transportation and Infrastructure sites, incorporating recently adapted assessments that include climate change risk assessment metrics.

Recommendations going forward include:

- Continue to engage partners to raise funds for remediations, identify sites for restoration, conduct remedial works, and assess the effectiveness of works.
- Continue to conduct detailed assessments where blockages are present and large amounts of habitat are potentially available within the Parsnip River and neighboring watershed groups. As timelines for remediations can be extensive, planning onerous, and the costs of remedial works significant, continuing assessments throughout the greater area will provide more options for remediation and engage additional funding partners (e.g., Ministry of Transportation and Infrastructure, alternative forest licensees). Identifying areas of concern near the community of McLeod Lake is expected to further engage community members and most effectively promote restoration activities.
- Conduct effectiveness monitoring where sites have been remediated, prioritized, and where remediations are planned. Electrofishing surveys, including tagging of target species with PIT tags, are recommended to understand the extent of connectivity impairments, track fish movement/health over time, and inform adaptive management. Detailed habitat assessments and acquisition of temperature data can be considered along with photo documentation of stream morphology near crossings.
- Collaborate with UNBC and expert consultants to integrate Arctic grayling research into fish passage restoration planning.

- Continue to develop a cost-effective, robust effectiveness monitoring program that will allow for assessment of productivity gains associated with fish passage improvements (e.g., before/after monitoring of fish abundance, productivity etc.).
- Utilize climate modelling data to support prioritization of crossings (e.g., to support access to cold, drought resistant areas)

1 Introduction

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.

The Society for Ecosystem Restoration in Northern BC (SERNbc) is working together with the McLeod Lake Indian Band, the Peace Region Fish and Wildlife Compensation Program (FWCP), the Provincial Fish Passage Technical Working Group (FPTWG), road/rail tenure holders and other stakeholders/partners to prioritize, plan and fund the restoration of fish passage at road crossing structure barriers within the Parsnip River, Carp River and Crooked River watershed groups.

This project builds on Society for Ecosystem Restoration Northern BC (SERNbc) work in 2019 - 2020 (A. Irvine 2020), 2021 - 2022(A. Irvine 2022) and 2022 - 2023 (Allan Irvine and Winterscheidt 2023).

Through this year's project activities (2023/2024) we engaged numerous project partners and were able to identify, complete and catalyze fish passage restoration activities at multiple priority sites.

Through the ongoing development of open source analysis, data presentation and project collaboration tools we are identifying new restoration opportunities, clarifying restoration benefits, communicating with the broader community and implementing on the ground works.

This report is available as pdf and as an online interactive report at https://newgraphenvironment.github.io/fish_passage_peace_2023_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 most up to date pdf from https://github.com/NewGraphEnvironment/fish_passage_peace_2023_reporting/raw/main/docs/Peace2023.pdf

This document can be considered a living document. Version numbers are logged for each release with modifications, enhancements and other changes tracked here with issues and proposed/planned enhancements tracked here.

2 Background

The study area includes the FWCP Peace Region with a focus to date on traditional territories of the Tse'khene First Nations. In 2023, field assessments were completed with the Parsnip River, Carp River and Crooked River watershed groups (Figure 2.1).

In 2019/2020, following a literature review, analysis of fish habitat modelling data, the Provincial Stream Crossing Inventory System (PSCIS) and a community scoping exercise within the McLeod Lake Indian Band habitat confirmation assessments were conducted at 17 sites throughout the Parsnip River watershed with 10 crossings rated as high priorities for rehabilitation and three crossings rated as moderate priorities for restoration. An engineering design for site 125179 on a tributary to the Missinka River was also completed through the 2019/2020 project. In 2021/2022, project activities reconvened through FWCP directed project PEA-F22-F-3577-DCA. Partners were engaged, funding was raised, planning was conducted and reporting was completed to initiate restoration activities of high priority crossings. Materials were purchased and permitting was put in place to prep for replacement of the twin culverts on the Missinka River tributary with a clear-span bridge.

In 2022/2023, this collaborative project leveraged ongoing connectivity restoration initiatives in the province and engaged multiple partners to catalyze fish passage restoration activities at high-priority sites identified in 2019/2020 and 2021/2022. Key accomplishments include the replacement of PSCIS crossing 125179, prioritization of two crossings on the Chuchinka-Table FSR for replacement in 2024-2025 (with engineering designs commissioned and materials purchased), and field assessments including fish sampling at high priority crossing 125000 on a tributary to the Parsnip River near Arctic Lake.

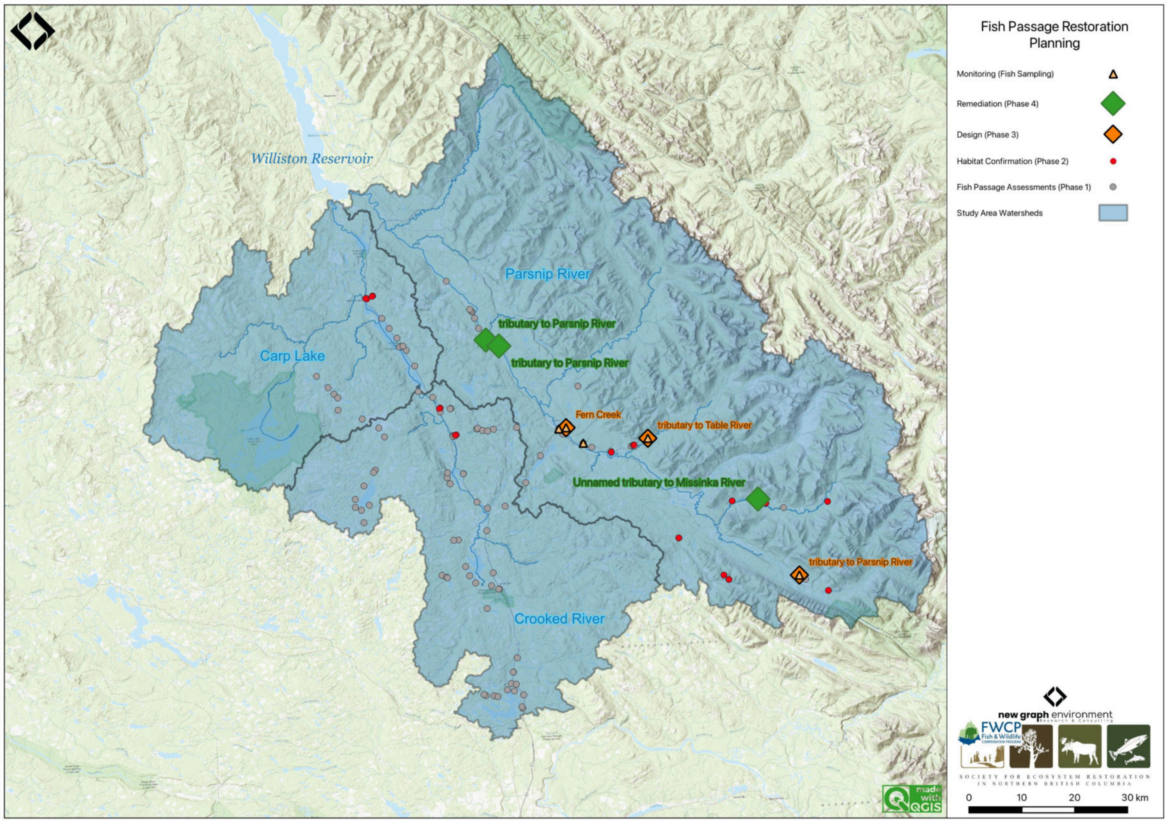

Figure 2.1: Overview map of Study Area

2.1 Tse'khene

The Parsnip River watershed is located within the south-eastern portion of the 108,000 km^2 traditional territory of the Tse'khene from the McLeod Lake Indian Band. The Tse'khene *"People of the Rocks"* are a south westerly extension of the Athabascan speaking people of northern Canada. They were nomadic hunters whose language belongs to the Beaver-Sarcee-Tse'khene branch of Athapaskan ("History Who We Are" 2023). Extensive work is underway to preserve the language with resources such as First Voices available online and in app form for iphone and ipad devices.

The continental divide separates watersheds flowing north into the Arctic Ocean via the Mackenzie River and south and west into the Pacific Ocean via the Fraser River (Figure 2.1). The Parsnip River is a 6th order stream with a watershed that drains an area of 5597km^2. The mainstem of the river flows within the Rocky Mountain Trench in a north direction into Williston Reservoir starting from the continental divide adjacent to Arctic Lakes. Major tributaries include the Misinchinka, Colbourne, Reynolds, Anzac, Table, Hominka and Missinka sub-basins which drain the western slopes of the Hart Ranges of the Rocky Mountains. The Parsnip River has a mean annual discharge of 150.4 m^3/s with flow patterns typical of high elevation watersheds on the west side of the northern Rocky Mountains 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).

Construction of the 183 m high and 2134 m long W.A.C. Bennett Dam was completed in 1967 at Hudson's Hope, BC, creating the Williston Reservoir (Hirst 1991). Filling of the 375km^2 reservoir was complete in 1972 and flooded a substantial portion of the Parsnip River and major tributary valleys forming what is now known as the Peace and Parsnip reaches. The replacement of riverine habitat with an inundated reservoir environment resulted in profound changes to the ecology, resource use and human settlement patterns in these systems (Hagen et al. 2015a; Pearce et al. 2019; Stamford, Hagen, and Williamson 2017). Prior to the filling of the reservoir, the Pack River, into which McLeod Lake flows, was a major tributary to the Parsnip River. The Pack River currently enters the Williston Reservoir directly as the historic location of the confluence of the two rivers lies within the reservoir's footprint.

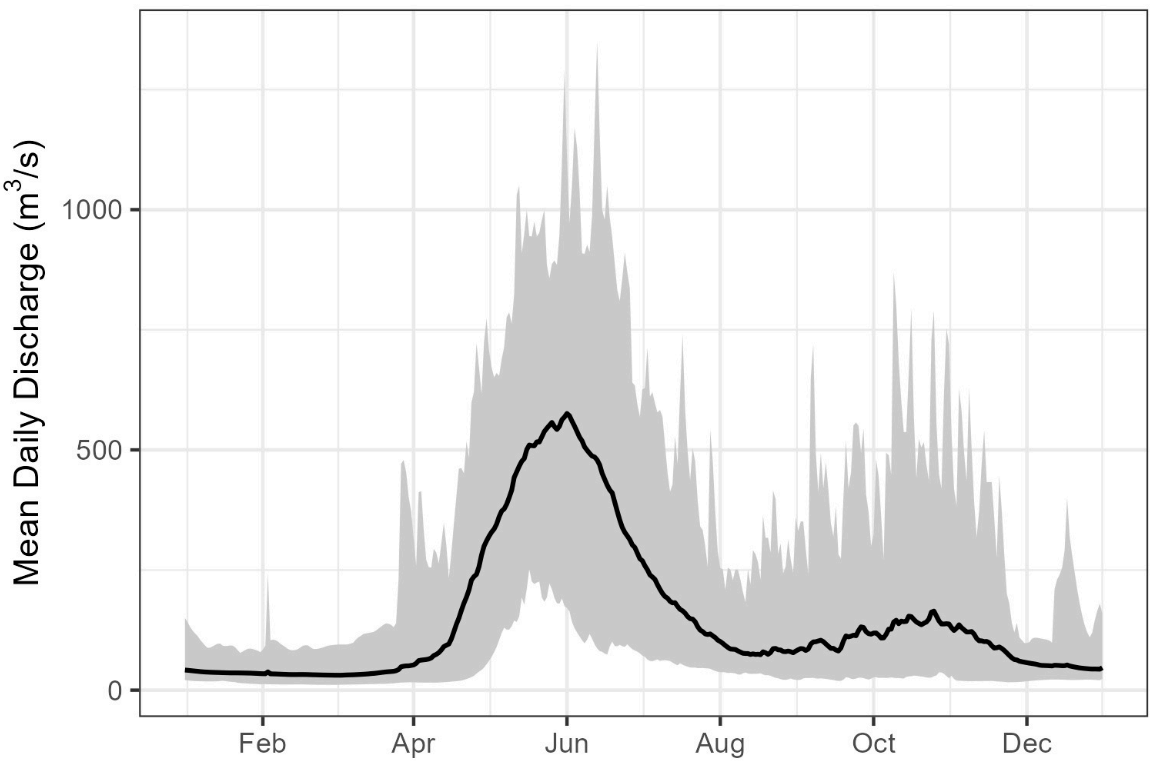

Figure 2.2: Parsnip River Above Misinchinka River (Station #07EE007 - Lat 55.08194 Lon -122.913063). Available daily discharge data from 1967 to 2019.

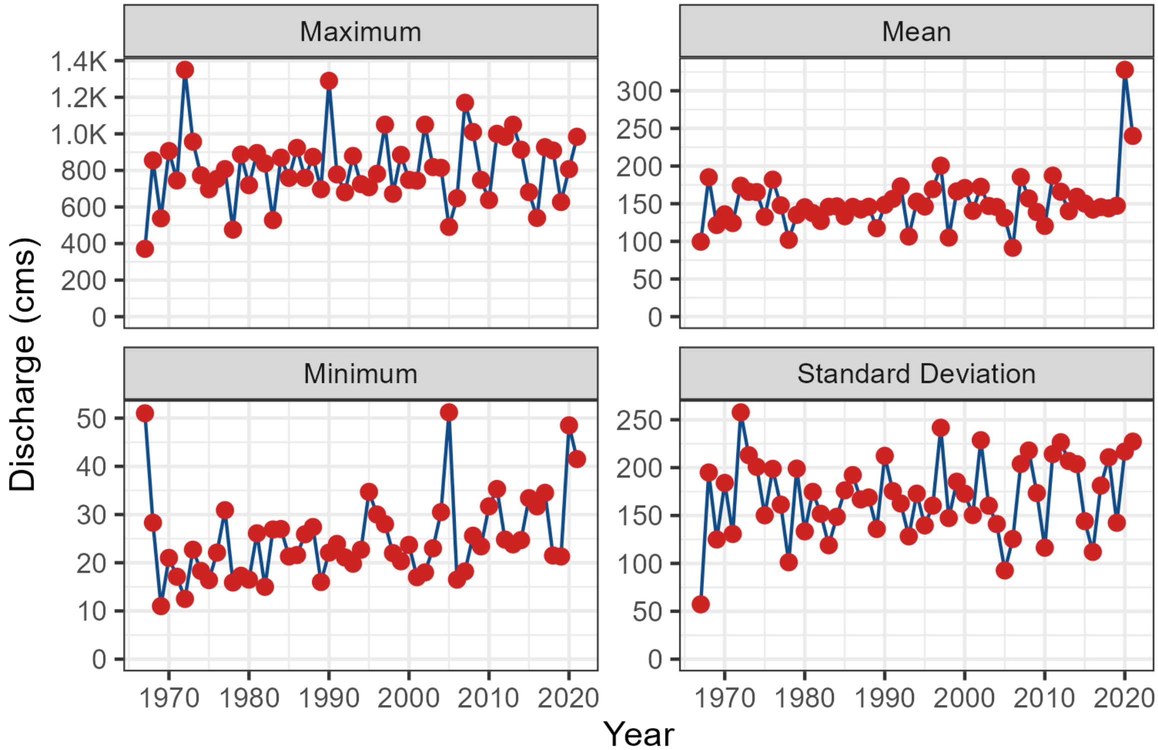

Figure 2.3: Summary discharge statistics (annual maximum, minimum, mean and standard deviation) for Parsnip River at hydrometric station #07EE007.

2.2 Fisheries

Fish species recorded in the Parsnip River watershed are detailed in Table 2.1 (MoE 2019a). In addition to flooding related to the formation of the Williston Reservoir, transmission lines, gas pipelines, rail, road networks, forestry, elevated water temperatures, interrupted connectivity, invasion from non-native species and insect infestations affecting forested areas pose threats to fisheries values in the Parsnip River watershed (Hagen et al. 2015b; Stamford, Hagen, and Williamson 2017; Hagen and Weber 2019a; Comittee on the Status of Endangered Wildlife in Canada 2012). A brief summary of trends and knowledge status related to Arctic grayling, bull trout, kokanee, mountain whitefish and rainbow trout in Williston Watershed streams is provided in Fish and Wildlife Compensation Program (2020) with a more detailed review of the state of knowledge for Parsnip River watershed populations of Arctic grayling and bull trout provided below.

Table 2.1: Fish species recorded in the Parsnip River, Carp Lake, and Crooked River watershed groups.

Scientific Name	Species Name	Species Code	BC List	Provincial FRPA	COSEWIC	SARA	Parsnip	Carp	Crooked
Catostomus catostomus	Longnose Sucker	LSU	Yellow	–	–	–	Yes	Yes	Yes
Catostomus									

2.2 Fisheries

Scientific Name	Species Name	Species Code	BC List	Provincial FRPA	COSEWIC	SARA	Parsnip	Carp	Crooked
columbianus	Bridgelip Sucker	BSU	Yellow	–	–	–	–	–	Yes
Catostomus commersonii	White Sucker	WSU	Yellow	–	–	–	Yes	Yes	Yes
Catostomus macrocheilus	Largescale Sucker	CSU	Yellow	–	–	–	Yes	Yes	Yes
Coregonus clupeaformis	Lake Whitefish	LW	Yellow	–	–	–	Yes	Yes	Yes
Cottus aleuticus	Coastrange Sculpin (formerly Aleutian Sculpin)	CAL	Yellow	–	–	–	Yes	–	–
Cottus asper	Prickly Sculpin	CAS	Yellow	–	–	–	Yes	Yes	Yes
Cottus cognatus	Slimy Sculpin	CCG	Yellow	–	–	–	Yes	Yes	–
Cottus hubbsi	Mottled Sculpin	CBA	Blue	–	SC (Nov 2010)	1-SC (Jun 2003)	Yes	–	–
Couesius plumbeus	Lake Chub	LKC	Yellow	–	DD	–	Yes	Yes	Yes
Esox lucius	Northern Pike	NP	Yellow	–	–	–	–	–	Yes
Hybognathus hankinsoni	Brassy Minnow	BMC	No Status	–	–	–	–	Yes	Yes
Lota lota	Burbot	BB	Yellow	–	–	–	Yes	Yes	Yes
Mylocheilus caurinus	Peamouth Chub	PCC	Yellow	–	–	–	Yes	Yes	Yes
Oncorhynchus mykiss	Rainbow Trout	RB	Yellow	–	–	–	Yes	Yes	Yes
Oncorhynchus nerka	Kokanee	KO	Yellow	–	–	–	Yes	–	–
Osmerus dentex	Rainbow Smelt	RSM	Unknown	–	–	–	Yes	–	–
Prosopium coulterii	Pygmy Whitefish	PW	Yellow	–	NAR (Nov 2016)	–	Yes	–	–
Prosopium cylindraceum	Round Whitefish	RW	Yellow	–	–	–	Yes	–	–
Prosopium williamsoni	Mountain Whitefish	MW	Yellow	–	–	–	Yes	Yes	Yes
Ptychocheilus oregonensis	Northern Pikeminnow	NSC	Yellow	–	–	–	Yes	Yes	Yes
Rhinichthys cataractae	Longnose Dace	LNC	Yellow	–	–	–	Yes	–	Yes
Richardsonius balteatus	Redside Shiner	RSC	Yellow	–	–	–	Yes	Yes	Yes
Salvelinus									

Scientific Name	Species Name	Species Code	BC List	Provincial FRPA	COSEWIC	SARA	Parsnip	Carp	Crooked
confluentus	Bull Trout	BT	Blue	Y (Jun 2006)	SC (Nov 2012)	–	Yes	Yes	Yes
Salvelinus fontinalis	Brook Trout	EB	Exotic	–	–	–	Yes	–	Yes
Salvelinus malma	Dolly Varden	DV	Yellow	–	–	–	Yes	Yes	Yes
Salvelinus namaycush	Lake Trout	LT	Yellow	–	–	–	Yes	Yes	Yes
Thymallus arcticus	Arctic Grayling	GR	Yellow	–	–	–	Yes	–	–
–	Chub (General)	CBC	–	–	–	–	Yes	Yes	Yes
–	Dace (General)	DC	–	–	–	–	Yes	–	–
–	Minnow (General)	C	–	–	–	–	Yes	Yes	Yes
–	Sculpin (General)	CC	–	–	–	–	Yes	Yes	Yes
–	Squanga	SQ	–	–	–	–	–	–	Yes
–	Sucker (General)	SU	–	–	–	–	Yes	Yes	Yes
–	Whitefish (General)	WF	–	–	–	–	Yes	Yes	Yes

* COSEWIC abbreviations :
SC - Special concern
DD - Data deficient
NAR - Not at risk

BC List definitions :
Yellow - Species that is apparently secure
Blue - Species that is of special concern
Exotic - Species that have been moved beyond their natural range as a result of human activity

Bull Trout - sa'ba

Tse'khene Elders from the McLeod Lake Indian Band report that sa'ba (bull trout) size and abundance has decreased in all rivers and tributaries from the reservoir with more injured and diseased fish captured in recent history than was common in the past (Pearce et al. 2019) .

Bull Trout populations of the Williston Reservoir watershed are included within the Western Arctic population 'Designatable Unit 10', which, in 2012, received a ranking of 'Special Concern' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2012a). They were added to Schedule 1 under the Species of Risk Act in 2019 (Species Registry Canada 2020) and are also considered of special concern (blue-listed) provincially (BC Species & Ecosystem Explorer 2020). Some or all of the long-term foot survey index sections of four Williston Reservoir spawning tributaries (Davis Creek, Misinchinka River, Point Creek, and Scott Creek), have been surveyed within 16 of the 19 years between 2001 and 2019 (16 of 19 in Davis River, 10 years over a 13-year period in the Misinchinka River, 11 years over a 14-year period for Point Creek, and 9 years over an 11-year period for Scott Creek (Hagen, Spendlow, and Pillipow 2020).

A study of sa'ba critical habitats in the Parsnip River was conducted in 2014 with the Misinchinka and Anzac systems identified as the most important systems for adfluvial (large bodied) bull trout spawners. The Table River was also highlighted as an important spawning destination. Other watersheds identified as containing runs of large bodied bull troutspawners included the Colbourne, Reynolds, Hominka and Missinka River with potentially less than 50 spawners utilizing each sub-basin (Hagen et al. 2015a). Hagen and Weber (2019b) have synthesized a large body of information regarding limiting factors, enhancement potential, critical habitats and conservation status for bull trout of the Williston Reservoir and the reader is encouraged to review this work for context. They have recommended experimental enhancements within a monitoring framework for Williston Reservoir bull trout (some spawning and rearing in Parsnip River mainstem and tributaries) which include stream fertilization, side channel development, riparian restoration and fish access improvement.

In 2018, sub-basins of the Anzac River watershed, Hommininka River, Missinka River and Table River watersheds were designated as fisheries sensitive watersheds under the authority of the *Forest and Range Practices Act* due to significant downstream fisheries values and significant watershed sensitivity (P. G. Beaudry 2013a, 2014a, 2014b, 2013b). Special management is required in these watersheds to protect habitat for fish species including bull trout and Arctic grayling including measures (among others) to limit equivalent clearcut area, reduce impacts to natural stream channel morphology, retain old growth attributes and maintain fish habitat/movement (Forest and Range Practices Act 2018).

Arctic Grayling - dusk'ihje

Tse'khene Elders from the McLeod Lake Indian Band report that Arctic grayling numbers have declined dramatically since the flooding of the reservoir and that few dusk'ihje (Arctic Grayling) have been caught in the territory in the past 30 years (Pearce et al. 2019).

Since impoundment of the Williston Reservoir, it appears that physical habitat and ecological changes have been the most significant factors limiting Arctic grayling productivity. Although these changes are not well understood they have likely resulted in the inundation of key low gradient juvenile rearing and overwintering habitats, isolation of previously connected populations and increases in abundance of predators such as bull trout (Shrimpton, Roberts, and Clarke 2012; Hagen, Pillipow, and Gantner 2018). Rapid increases in industrial activity and angler access in the Parsnip River watershed pose significant risks to Arctic Grayling productivity with these threats primarily linked to forestry and pipeline initiatives (Hagen and Stamford 2021).

A detailed review of dusk'ihje life history can be referenced in Stamford, Hagen, and Williamson (2017). Migration of mature adult dusk'ihje (Arctic grayling) occurs in the spring with arrival at known spawning locations coinciding with water temperatures of 4°C. Spawning in the Parsnip watershed appears to occur between late-May and late-June within sites located primarily within the lower reaches of the Anzac and Table rivers as well as within the Parsnip River mainstem. Side-channel and multiple-channel locations containing small gravels appear to be selected for spawning. Currently, the primary distribution of Williston Arctic grayling appears to be among fourth order and larger streams (Williamson and Zimmerman 2005; Stamford, Hagen, and Williamson 2017). Stewart et al. (2007) report that Arctic grayling spawn in large and small tributaries to rivers and lakes, intermittent streams, within mainstem rivers as well as lakes, most commonly at tributary mouths. Although past study results indicate that 0+ grayling appeared to overwinter in lower reaches of larger tributaries (i.e. Table, Anzac rivers) as well as the Parsnip River and that few age-1+ grayling have been sampled in tributaries, habitat use in small tributaries and the extent they are connected with the mainstem habitats of all core areas is not well understood. Between 1995 and 2019, Arctic grayling population monitoring has been conducted in the Table River in nine out of 25 years (8 years for the Anzac) using snorkel surveys. Results from 2018 and 2019 are intended to contribute to the assessment of the conservation status of the species in the Parsnip Core area (Hagen, Pillipow, and Gantner 2018). In 2019, preliminary telemetry results indicate that both Arctic grayling and bull trout rely on the Parsnip River mainstem for overwinter residencies. Arctic grayling move into the tributaries beginning in April, and become widespread across the watershed by June.

A 5 year study on Parsnip River watershed dusk'ihje abundance and trend are discussed in Hagen and Stamford (2023) where they report that the most productive habitats for Arctic grayling summer rearing are within the Anzac River and Table River. Although estimated abundance is lower than in the Anzac and Table, productive summer rearing habitats for adult Arctic grayling in the upper Parsnip River watershed are distributed between 36-25 km of the Missinka River and from 48-32 km of the Hominka River. Hagen and Stamford (2021) report that within the Anzac River, a 30-km stretch from a chute obstruction at 47 km to 16 km is assumed to provide productive summer rearing habitats for adults as it is characterized by a high abundance of Arctic grayling. Although the spatial distribution of high Arctic grayling abundance in the Table River has not been determined through reconnaissance surveys it has been observed to span at least a 20-km zone from the waterfall migration barrier at 37 km to 18 km.

Spatial ecology studies in the Parsnip between 2018 and 2021 has been reported on by Martins et al. (2022) with results related to:

- temperature modeling and spatio-temporal patterns in thermal habitat,
- telemetry data modeling and arctic grayling spatial ecology, and
- trophic relationships between Arctic grayling and bull trout

A review of available fisheries data for the Parsnip River watershed stratified by different habitat characteristics can provide insight into which habitats may provide the highest intrinsic value for fish species based on the number of fish captured in those habitats in past assessment work (Figures 2.4 - 2.6). It should be noted however that it should not be assumed that all habitat types have been sampled in a non-biased fashion or that particular sites selected do not have a disproportionate influence on the overall dataset composition (ie. fish salvage sites are often located adjacent to construction sites which are more commonly located near lower gradient stream reaches).

Table 2.2: Summary of historic salmonid observations vs. stream gradient category for the Parsnip River watershed group.

species_code	Gradient	Count	total_spp	Percent
BT	0 - 3 %	160	236	68
BT	03 - 5 %	29	236	12
BT	05 - 8 %	21	236	9
BT	08 - 15 %	20	236	8
BT	15 - 22 %	6	236	3
GR	0 - 3 %	224	230	97
GR	03 - 5 %	2	230	1
GR	05 - 8 %	2	230	1
GR	08 - 15 %	2	230	1
KO	0 - 3 %	17	17	100
RB	0 - 3 %	327	415	79
RB	03 - 5 %	32	415	8

species_code	Gradient	Count	total_spp	Percent
RB	08 - 15 %	27	415	7
RB	15 - 22 %	7	415	2

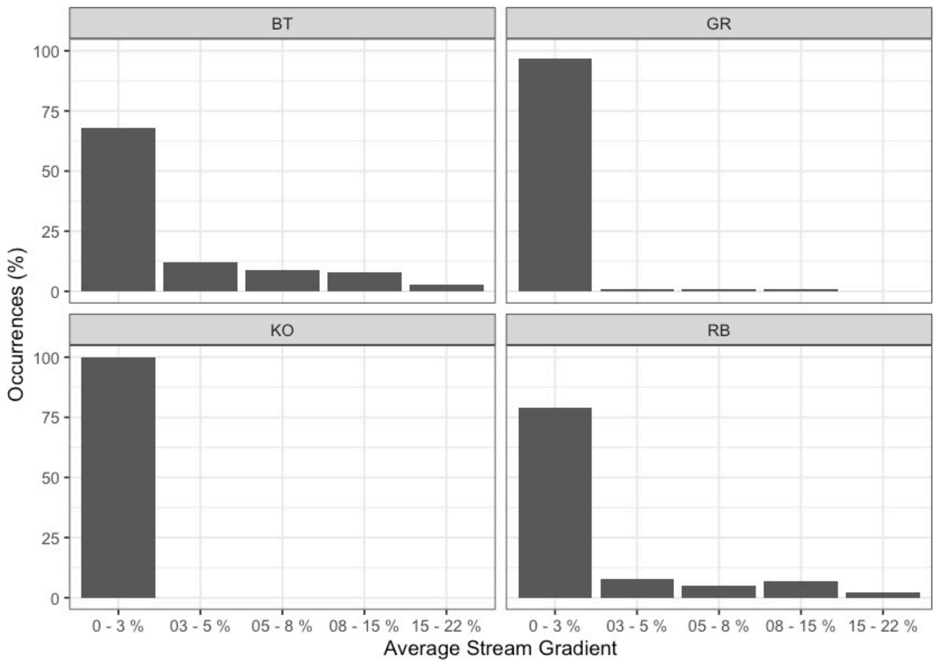

Figure 2.4: Summary of historic salmonid observations vs. stream gradient category for the Parsnip River watershed group.

Table 2.3: Summary of historic salmonid observations vs. channel width category for the Parsnip River watershed group.

species_code	Width	Count	total_spp	Percent
BT	0 - 2m	11	236	5
BT	02 - 04m	25	236	11
BT	04 - 06m	29	236	12
BT	06 - 10m	35	236	15
BT	10 - 15m	30	236	13
BT	15m+	103	236	44
BT	–	3	236	1

species_code	Width	Count	total_spp	Percent
GR	06 - 10m	7	230	3
GR	10 - 15m	14	230	6
GR	15m+	200	230	87
GR	–	4	230	2
KO	0 - 2m	1	17	6
KO	06 - 10m	3	17	18
KO	15m+	1	17	6
KO	–	12	17	71
RB	0 - 2m	23	415	6
RB	02 - 04m	51	415	12
RB	04 - 06m	37	415	9
RB	06 - 10m	36	415	9
RB	10 - 15m	34	415	8
RB	15m+	141	415	34
RB	–	93	415	22

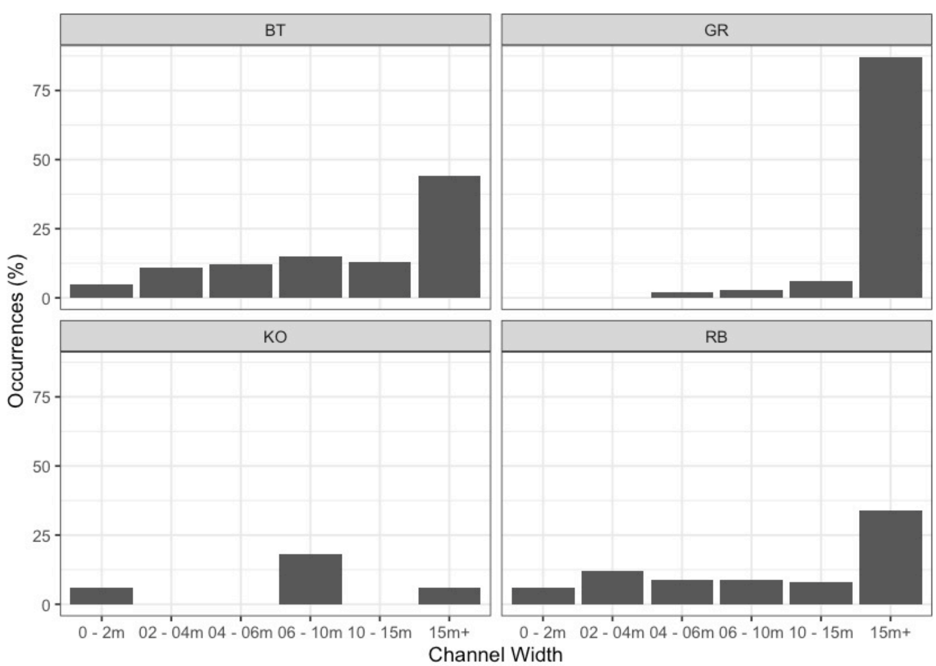

Figure 2.5: Summary of historic salmonid observations vs. channel width category for the Parsnip River watershed group.

Table 2.4: Summary of historic salmonid observations vs. watershed size category for the Parsnip River watershed group.

species_code	Watershed	count_wshd	total_spp	Percent
BT	0 - 25km2	89	236	38
BT	25 - 50km2	27	236	11
BT	50 - 75km2	12	236	5
BT	75 - 100km2	9	236	4
BT	100km2+	99	236	42
GR	0 - 25km2	7	230	3
GR	25 - 50km2	5	230	2
GR	50 - 75km2	9	230	4
GR	75 - 100km2	6	230	3
GR	100km2+	203	230	88
KO	0 - 25km2	11	17	65
KO	25 - 50km2	1	17	6
KO	50 - 75km2	2	17	12
KO	75 - 100km2	2	17	12
KO	100km2+	1	17	6
RB	0 - 25km2	210	415	51
RB	25 - 50km2	22	415	5
RB	50 - 75km2	26	415	6
RB	75 - 100km2	17	415	4
RB	100km2+	140	415	34

2.2 Fisheries

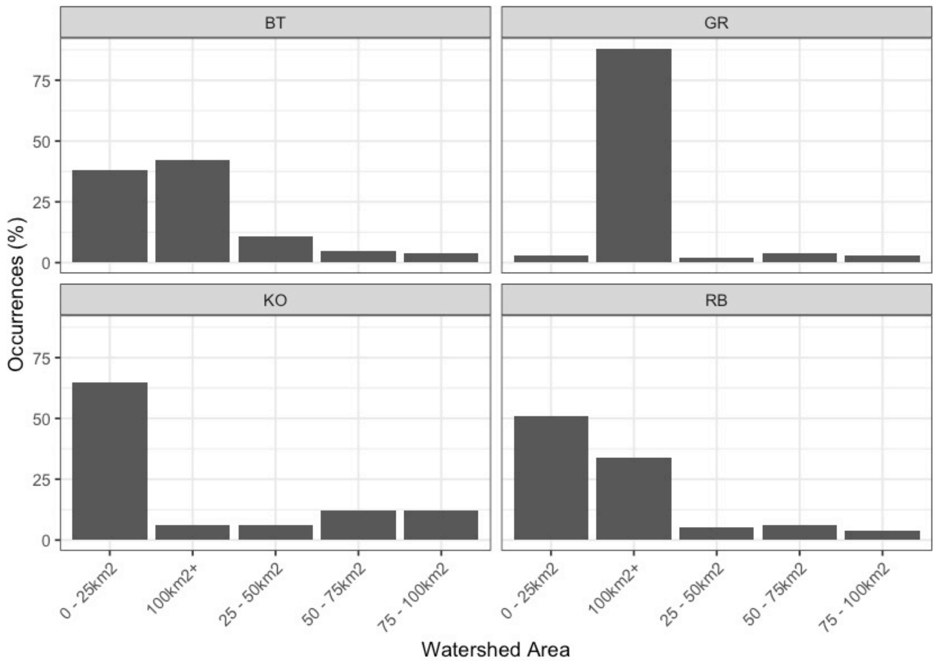

Figure 2.6: Summary of historic salmonid observations vs. watershed size category for the Parsnip River watershed group.

3 Methods

3.1 Communicate Connectivity Issues

3.1.1 Engage Partners

Engaging partners for ecosystem restoration initiatives is critical as it allows us to utilize available resources, tap into different areas of expertise, and benefit from diverse perspectives through collaboration that leads to successful outcomes. Engagement actions have included video conference calls, meetings, emails, presentations and phone calls.

3.1.2 Collaborative GIS Environment

Geographical Information Systems are essential for developing and communicating restoration plans as well as the reasons they are required and how they are developed. Without the ability to visualize the landscape and the data that is used to make decisions it is difficult to conduct and communicate the need for restoration, the details of past and future plans as well as and the potential results of physical works.

To facilitate the planning and implementation of restoration activities a collaborative GIS environment has been established using QGIS served on the cloud using source code kept stored here. This environment is intended to be a space where project team members can access and view and contribute to the amalgamation of background spatial data and the development of restoration as well as monitoring for the project. The collaborative GIS environment allows users to view, edit, and analyze shared up to date spatial data on personal computers in an office setting as well as phones and tablets in the field. At the time of reporting, the environment was being used to develop and share maps, conduct spatial analyses, communicate restoration plans to stakeholders as well as to provide a central place to store methodologies and tools for conducting field assessments on standardized pre-developed digital forms. The platform can also be used to track the progress of restoration activities and monitor changes in the landscape over time helping encourage the record keeping of past and future restoration activities in a coordinated manner.

The shared QGIS project was created using scripts currently kept in *dff-2022* with the precise calls to project creation scripts tracked in the *project_creation_and_permissions.txt* document kept in the main QGIS project directory. Information about how GIS project creation and update scripts function can be viewed here with outcomes of their use summarized below: - download and clip user specified layers from the BC Data Catalogue as well as data layers stored in custom Amazon Web Services buckets for an area of interest defined by a list of watershed groups and load to a geopackage called *background_layers.gpkg* stored in the main directory of the project.
- A project directory is created to hold the spatial data and *QGIS* project information (ie. layer symbology and naming conventions, metadata, etc.). - Metadata for individual project spatial layers is kept in the *rfp_tracking* table within the *background_layers.gpkg* along with tables related to user supplied stream width/gradient inputs to *bcfishpass* to model potentially high value habitat that is accessible to fish species of interest.

3.1.3 Issue Tracking

"Issues" logged on the online github platform are effective ways to track tasks, enhancements, and bugs related to project components. They can be referenced with the scripts, text and actions used to address them by linking documentation to the issues with text comments or programatically through *git* commit messages. Issues for this project are kept here.

3.1.4 Mapping

Maps incorporating the sa'ba (bull trout) spawning and rearing habitat model for the Parsnip River, Carp Lake and Crooked River watershed groups are served online and were generated using reproducible open source workflows developed by Hillcrest Geographics. The workflows to produce the georeferenced *pdf* maps include using a QGIS layer file defining and symbolizing all layers required and are continuously evolving. At the time of reporting - mapping scripts and associated layer file were kept under version control within *bcfishpass* here. Loading the QGIS layer file within a QGIS project, allows load and representation of all map component layers provided the user points to a postgresql database populated via *bcfishpass* outputs.

3.1.4.1 Habitat Modelling

Through this initiative, other SERNbc led initiatives (Irvine 2021, [2021] 2022), multi-decade direction from the Provincial Fish Passage Remediation Program and connectivity restoration planning conducted by Canadian Wildlife Federation and others (Mazany-Wright et al. 2021; Irvine 2022), *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 ([2020] 2021) 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 [2020] 2021). 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 numerous parameters including known fish observations upstream of identified barriers and for each crossing location, the area of lake and wetland habitat upstream, species documented upstream/downstream, and an estimate of watershed area (on 2nd order and higher streams). Furthermore, mean annual precipitation weighted to upstream watershed area, stream discharge and channel width can be collated using *bcfishpass*, *fwapg* and *bcfishobs*. This, information, can be used to provide 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.

Regarding gradients, *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 phase of the project, the user provided gradient thresholds used to delineate “potentially accessible habitat” were based on estimated max gradients that rainbow trout (20%) and bull trout (25%) are likely to be capable of ascending.

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 20% and 25% 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 2019b) 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, or multiple FISS channel widths are available a mean of the average channel widths was used. 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 downloaded to a *postgresql* database, sampled for upstream watershed areas associated with each stream segment and a mean annual precipitation weighted by upstream watershed area was calculated. In early 2021, Bayesian statistical methods were developed to predict channel width in all provincial freshwater atlas stream segments where width measurements had not previously been measured in the field. The model was based on the relationship between watershed area and mean annual precipitation weighted by upstream watershed area (Thorley and Irvine 2021). In December of 2021, Thorley and Irvine (2021) methods were updated using on a power model derived by Finnegan et al. (2005) which relates stream discharge to watershed area and mean annual precipitation. Data (n = 24849) on watershed size, mean annual precipitation and measured channel width was extracted from the provincial freshwater atlas (FLNRORD 2021; GeoBC 2022), the BC Data Catalogue fisheries datasets (MoE 2020b, 2021) and Wang et al. (2012) utilizing *bcfishpass* (Norris [2020] 2021) and *fwapg* (Norris [2019] 2021). Details of this analysis and subsequent outputs can be reviewed here (Thorley, Norris, and Irvine 2021).

bcfishpass and associated tools have been designed to be flexible in analysis, accepting user defined gradient, channel width and stream discharge categories (MoE 2019b). 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 Parsnip River watershed group have been specified and applied to model habitat upstream of stream crossing locations with the highest potential intrinsic value (Table 3.1). Definitions of modelling outputs for bull trout are presented in Table 3.2. Modelling of habitat for Arctic grayling, in the Peace region are planned for 2024-2025 with the work leveraging multiple other initiatives underway by SERNbc and others throughout British Columbia including work related to Arctic grayling habitat use and preference conducted by UNBC and others [Hagen and Stamford (2023); Bottoms et al. (2023).

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

Variable	Bull Trout	Arctic Grayling
Spawning Gradient Max (%)	5.5	2.5
Spawning Width Min (m)	2	4
Rearing Width Min (m)	1.5	1.5
Rearing Gradient Max (%)	10.5	3.5

* Models for RB, GR and KO are under a process of development and have not yet been released. All models parameters are preliminary and subject to collaborative development.

Table 3.2: bcfishpass outputs and associated definitions

Attribute	Definition
BT Rearing (km)	Length of stream upstream of point modelled as potential Bull Trout rearing habitat
BT Spawning (km)	Length of stream upstream of point modelled as potential Bull Trout spawning habitat
BT Network (km)	Bull Trout model, total length of stream network potentially accessible upstream of point
BT Stream (km)	Bull Trout model, total length of streams and rivers potentially accessible upstream of point (does not include network connectors in lakes etc)
BT Lake Reservoir (ha)	Bull Trout model, total area lakes and reservoirs potentially accessible upstream of point
BT Wetland (ha)	Bull Trout model, total area wetlands potentially accessible upstream of point
BT Slopeclass03 (km)	Bull Trout model, length of stream potentially accessible upstream of point with slope 0-3%
BT Slopeclass05 (km)	Bull Trout model, length of stream potentially accessible upstream of point with slope 3-5%
BT Slopeclass08 (km)	Bull Trout model, length of stream potentially accessible upstream of point with slope 5-8%
BT Slopeclass15 (km)	Bull Trout model, length of stream potentially accessible upstream of point with slope 8-15%

* Bull trout model uses a gradient threshold of maximum 25% 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” (BC Ministry of Environment 2011). The reader is referred to (BC Ministry of Environment 2011) for detailed methodology. 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 3.3). For crossings determined to be potential barriers or barriers based on the data (see [Barrier Scoring]), a culvert fix and recommended diameter/span was proposed.

Table 3.3: 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).

Fish passage potential was determined for each stream crossing identified as a closed bottom structure as per BC Ministry of Environment (2011). 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

Habitat gain indexes are 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 25% (for a minimimum length of 100m) intended to represent the maximum gradient of which the strongest swimmers of anadromous species (bull trout) are likely to be able to migrate upstream. This is the amount of habitat upstream of each crossing less than 25% gradient before a falls of height >5m -

as recorded in MoE (2020a) 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, bull trout rearing maximum gradient threshold (7.4%) was used. To generate estimates for area of habitat upstream (m^2), 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 BC Ministry of Environment (2011) 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..

3.2.1 Cost Estimates

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 which have since been adjusted for inflation and based on past experience.

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 10m. 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 then adjusted for inflation). For larger streams (>6m), estimated span width increased proportionally to the size of the stream. 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 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 $/15m	Streambed Simulation $
FSR	Rough	1	1	450,000	100,000
FSR	Loose	1	1	450,000	100,000
Resource	Loose	1	1	450,000	100,000
Permit	Loose	1	1	450,000	100,000
Unclassified	Loose	1	1	450,000	100,000
Unclassified	Rough	1	1	450,000	100,000
Unclassified	Paved	1	2	750,000	100,000
Unclassified	Unknown	1	2	750,000	100,000
Local	Loose	4	1	1,500,000	200,000
Local	Paved	4	2	3,000,000	400,000
Arterial	Paved	15	2	11,250,000	1,500,000
Highway	Paved	15	2	11,250,000	1,500,000
Rail	Rail	15	2	11,250,000	1,500,000

3.3 Designs

Engineering designs were conducted by consultants hired by forest licensees with tenure over the roads and/or timber harvest planned on the roads where work was conducted. Completed designs are loaded to the PSCIS data portal.

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 3.3).

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 500 - 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 PG23-813101.

3.5 Remediations

Structure replacement was conducted by contractors hired by Sinclar (forest licensee). As-built drawings were completed and loaded to the PSCIS data portal.

3.6 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 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

4 Results and Discussion

4.1 Communicate Connectivity Issues

We conducted an online presentation through FWCP to showcase the project on February 23, 2024 with over 70 people in attendance. A presentation to FWCP Peace board detailing project progress, goals and budgets was also completed on February 6, 2024.

SERNbc and McLeod Lake have been actively engaging with the following groups through numerous meetings, emails and phone calls to build awareness for the initiative, solicit input, prioritize sites, raise partnership funding and plan/implement fish passage remediations:

- McLeod Lake Indian Band members of council
- BCTS Engineering
- CN Rail
- Canadian Forest Products (Canfor)
- Sinclar Forest Projects Ltd. (Sinclar)
- Northern Engineering - Ministry of Forests
- BC Ministry of Transportation and Infrastructure
- Fish Passage Technical Working Group
- Coastal Gaslink
- British Columbia Wildlife Federation
- Planning foresters and biologists from Ministry of Forests and Ministry of Land, Water and Resource Stewardship
- Fisheries experts
- University of Northern BC

4.1.1 Collaborative GIS Environment

A summary of background information spatial layers and tables loaded to the collaborative GIS project (sern_skeena_fwcp_2023) at the time of writing (2024-07-05) are included in Table 4.1.

Table 4.1: Layers loaded to collaborative GIS project.

content	url	description
bcfishobs.fiss_fish_obsrvtn_events_vw	https://github.com/smnorris/bcfishobs	whse_fish.fiss_fish_obsrvtn_pnt_sp points referenced to their position on the FWA stream network
bcfishpass.crossings_vw	https://smnorris.github.io/bcfishpass/	Aggregated stream crossing locations. Features are aggregated from 1.PSCIS stream crossings (where possible to match to an FWA stream) 2. CABD dams (where possible to match to an FWA stream) 3. modelled road/rail/trail stream crossings 4. misc anthropogenic barriers from expert/local input
bcfishpass.streams_vw	https://smnorris.github.io/bcfishpass/	View of FWA stream networks and value-added attributes. Also see https://catalogue.data.gov.bc.ca/dataset/freshwater-atlas-stream-network.

content	url	description
/freshwater-atlas-watershed-groups/resource/7239c84e-418a-4a9e-97bf-61b166410384	whse_basemapping.fwa_watershed_groups_poly. Contains polygons delimiting the watershed group boundary which is a collection of drainage area basins. In-land groups will contain a single polygon, coastal groups may contain multiple polygons (one for each island) i.e., this is a multipart polygon feature. Spatial geometry: multipart polygon	
parameters_habitat_method	https://github.com/smnorris/bcfishpass/tree/main/parameters	List of watershed groups to process, and the IP model method to use per watershed group, where cw indicates channel width and mad indicates mean annual discharge.
parameters_habitat_thresholds	https://github.com/smnorris/bcfishpass/tree/main/parameters	Per-species thresholds to use for IP modelling
rfp_tracking	https://github.com/NewGraphEnvironment/dff-2022/tree/master/scripts/qgis	File tracking addition of layers to the *backgroun_layers.gpkg* of the project. Includes metadata related to time of creation and watershed groups used to clip layer to study area.
whse_admin_boundaries.clab_indian_reserves	https://catalogue.data.gov.bc.ca/dataset/8efe9193-80d2-4fdf-a18c-d531a94196ad	Provide the administrative boundaries (extent) of Canada Lands which includes Indian Reserves. Administrative boundaries were compiled from Legal Surveys Division's cadastral datasets and survey records archived in the Canada Lands Survey Records. See the Natural Resource Canada's GeoGratis website, Aboriginal Lands.
whse_admin_boundaries.clab_national_parks	https://catalogue.data.gov.bc.ca/dataset/88e61a14-19a0-46ab-bdae-f68401d3d0fb	This dataset provides the administrative boundaries of National Parks and National Park Reserves within the province of British Columbia. Administrative boundaries were compiled from Legal Surveys Division's cadastral datasets and survey records archived in the Canada Lands Survey Records. Canada Lands Administrative Boundaries (CLAB) were adjusted to match British Columbia's authoritative base mapping features. The Fresh Water Atlas (FWA) was used for streams, rivers, coastlines, and height of land. The Integrated Cadastral Fabric (ICF) was used for parcel boundaries. Tantalis Cadastre was used where ICF parcels were not available.
whse_basemapping.cwb_floodplains_bc_area_svw	https://catalogue.data.gov.bc.ca/dataset/cdf4900e	Historical floodplain boundaries in BC with a descriptive feature

content	url	description
name for each floodplain area (i.e., 200-year floodplain, alluvial fan, or nothing/out-of-floodplain). Digitized from hardcopy 1:5,000 Floodplain Mapsheets for each project area		
whse_basemapping.fwa_glaciers_poly	https://catalogue.data.gov.bc.ca/dataset/8f2aee65-9f4c-4f72-b54c-0937dbf3e6f7	Glaciers and ice masses for the province, derived from aerial imagery flown in the late 1980s and early 1990s. Please refer to the Glaciers dataset for recent glacier extents in British Columbia, and Historical Glaciers for a comparable historic view.
whse_basemapping.fwa_lakes_poly	https://catalogue.data.gov.bc.ca/dataset/cb1e3aba-d3fe-4de1-a2d4-b8b6650fb1f6	All lake polygons for the province
whse_basemapping.fwa_manmade_waterbodies_poly	https://catalogue.data.gov.bc.ca/dataset/055fd71e-b771-4d47-a863-8a54f91a954c	All manmade waterbodies, including reservoirs and canals, for the province
whse_basemapping.fwa_named_streams	–	–
whse_basemapping.fwa_watershed_groups_poly	https://catalogue.data.gov.bc.ca/dataset/51f20b1a-ab75-42de-809d-bf415a0f9c62	Polygons delimiting the watershed group boundary, which is a collections of drainage areas. In-land groups will contain a single polygon, coastal groups may contain multiple polygons (one for each island)
whse_basemapping.fwa_wetlands_poly	https://catalogue.data.gov.bc.ca/dataset/93b413d8-1840-4770-9629-641d74bd1cc6	All wetland polygons for the province
whse_basemapping.gba_railway_tracks_sp	https://catalogue.data.gov.bc.ca/dataset/4ff93cda-9f58-4055-a372-98c22d04a9f8	This layer contains railway tracks within BC from GeoBase's National Railway Network (NRWN) dataset.
whse_basemapping.gba_transmission_lines_sp	https://catalogue.data.gov.bc.ca/dataset/384d551b-dee1-4df8-8148-b3fcf865096a	High voltage electrical transmission lines for distributing power throughout the province. Lines were derived from several data sources representing unique inventories: BC Hydro, Private, Independent Power Producers, and Terrain Resource Information Management (TRIM). Voltage information is not currently available on the public version of this dataset as per publication agreement with BC Hydro.
whse_basemapping.transport_line	–	–
whse_basemapping.utmg_utm_zones_sp	https://catalogue.data.gov.bc.ca/dataset/fc999f51-306a-4adf-9b19-63b2d3c38348	Portions of Universal Transverse Mercator Zones 7 - 12 which cover British Columbia, Northern Hemisphere only, formed into polygons, in BC Albers projection
whse_cadastre.pmbc_parcel_fabric_poly_svw	https://catalogue.data.gov.bc.ca	

content	url	description
	/dataset/4cf233c2-f020-4f7a-9b87-1923252fbc24 ParcelMap BC is the current, complete and trusted mapped representation of titled and Crown land parcels across British Columbia, considered to be the point of truth for the graphical representation of property boundaries. It is not the authoritative source for the legal property boundary or related records attributes; this will always be the plan of survey or the related registry information. This particular dataset is a subset of the complete ParcelMap BC data and is comprised of the parcel fabric and attributes for over two million parcels published under the Open Government Licence - British Columbia. Notes: 1. Parcel title information is sourced from the BC Land Title Register. Title questions should be directed to a local Land Title Office. 2. This dataset replaces the Integrated Cadastral Fabric.	
whse_environmental_monitoring.envcan_hydrometric_stn_sp	https://catalogue.data.gov.bc.ca/dataset/4c169515-6c41-4f6a-bd30-19a1f45cad1f	BC active and discontinued hydrometric stations (surface water level and flow data) that are part of the provincial hydrometric network managed under a national program jointly administered under a federal-provincial cost-sharing agreement with Environment and Climate Change Canada (ECCC).
whse_fish.fiss_obstacles_pnt_sp	https://catalogue.data.gov.bc.ca/dataset/35bbac7c-2e2f-4587-9108-f4aa1e862809	The Provincial Obstacles to Fish Passage theme presents records of all known obstacles to fish passage from several fisheries datasets. Records from the following datasets have been included: The Fisheries Information Summary System (FISS); the Fish Habitat Inventory and Information Program (FHIIP); the Field Data Information System (FDIS) and the Resource Analysis Branch (RAB) inventory studies. The main intent of this layer is to have a single layer of all known obstacles to fish passage. It is important to note that not all waterbodies have been studied and, not all lengths of many waterbodies have been studied so there are a very high

content	url	description
number of obstacles in the real world that are not recorded in this dataset. This layer simply reports the obstacles to fish that are known. It is also very important to note that we are acknowledging these features as obstacles to fish passage versus barriers to fish passage. This is because an obstacle may be a barrier at one time of year but not at other times depending on the volume of water present and also, what is a barrier to one species of fish is not necessarily a barrier to another species.		
whse_fish.fiss_stream_sample_sites_sp	https://catalogue.data.gov.bc.ca/dataset/e616864b-8991-42d1-a2f9-4d4402c32be8	This spatial layer displays stream inventory sample sites that have had full or partial surveys, and contains measurements or indicator information of the data collected at each survey site on each date.
whse_fish.pscis_assessment_svw	https://catalogue.data.gov.bc.ca/dataset/7ecfafa6-5e18-48cd-8d9b-eae5b5ea2881	Points where a fish passage assessment has been performed on a stream crossing structure. These includes culverts, bridges, fords, etc. The assessments are carried out to determine whether fish are able to migrate through the structure.
whse_fish.pscis_design_proposal_svw	https://catalogue.data.gov.bc.ca/dataset/0c9df95f-a2da-4a7d-b9cb-fea3e8926661	Points where a fish passage assessment has been performed on a stream crossing structure and found to be a failure. Design points have been identified as a priority for remediation based on a variety of potential criteria: quality of habitat upstream, quantity of fish habitat upstream, number and importance of species present, operational plans for the road cost of the proposed remediation, etc. They are sites where the amount of habitat to be gained by remediation has been confirmed and where a design has actually been completed.
whse_fish.pscis_habitat_confirmation_svw	https://catalogue.data.gov.bc.ca/dataset/572595ab-0a25-452a-a857-1b6bb9c30495	Points where an evaluation of the fish habitat up and downstream of a road crossing have been carried out. Phase 2 of 4 in the Fish Passage Workflow, Habitat Confirmations are done at sites where the crossing structure is known to be a failure. The Habitat Confirmation is performed to ensure that the site in question is a good candidate for moving on to the Design (Phase 3) and Remediation (Phase 4) stages of the workflow. The Habitat Confirmation confirms the crossing is a barrier, places the crossing in context with respect to other roads and crossings in the watershed and also quantifies and qualifies how much habitat will be gained if the site is fixed.
whse_fish.pscis_remediation_svw	https://catalogue.data.gov.bc.ca/dataset/1596afbf-f427-4f26-9bca-d78bceddf485	Points where a barrier to fish passage has been rectified or remediated. This is the third phase in the process and can only follow after 1. An assessment has been performed on a stream crossing structure and has found that structure to be a barrier to fish passage. 2. The site has been identified as a priority for remediation based on a variety of potential criteria: quality of habitat upstream,

content	url	description
quantity of fish habitat upstream, number and importance of species present, operational plans for the road, cost of the proposed remediation, etc. 3. a design has been created for the site		
whse_forest_tenure.ften_road_section_lines_svw	https://catalogue.data.gov.bc.ca/dataset/243c94a1-f275-41dc-bc37-91d8a2b26e10	This is a spatial layer that reflects operational activities for road sections contained within a road permit. The Forest Tenures Section (FTS) is responsible for the creation and maintenance of digital Forest Atlas files for the province of British Columbia encompassing Forest and Range Act Tenures. It also supports the forest resources programs delivered by MoFR
whse_forest_vegetation.veg_burn_severity_sp	https://catalogue.data.gov.bc.ca/dataset/c58a54e5-76b7-4921-94a7-b5998484e697	This layer is the one-year-later burn severity classification for large fires (greater than 100 ha). Burn severity mapping is conducted using best available pre- and post-fire satellite multispectral imagery acquired by the MultiSpectral Instrument (MSI) aboard the Sentinel-2 satellite or the Operational Land Imager (OLI) sensor aboard the Landsat-8 and 9 satellites. The post-fire imagery is acquired during the subsequent growing season. Mapping conducted during the subsequent growing season benefits from greater post-fire image availability and is expected to be more representative of tree mortality. Every attempt is made to use cloud, smoke, shadow and snow-free imagery that was acquired prior to September 30th. Please note, this layer is 1-year-later burn severity dataset. The same-year burn severity mapping dataset (WHSE_FOREST_VEGETATION.VEG_BURN_SEVERITY_SAME_YR_SP) is considered an interim product to this layer. **4.1.1.1 Methodology:** • Select suitable pre- and post-fire imagery or create a cloud/snow/smoke-free composite from multiple images scenes • Calculate normalized burn severity ratio (NBR) for pre- and post-fire images • Calculate difference NBR (dNBR) where dNBR = pre NBR – post NBR • Apply a scaling equation (dNBR_scaled = dNBR*1000 + 275)/5) • Apply BARC thresholds (76, 110, 187) to create a 4-class image (unburned, low severity, medium severity, and high severity) • Apply region-based filters to reduce noise • Confirm burn severity analysis results through visual quality control • Produce a vector dataset and apply Euclidian distance smoothing
whse_imagery_and_base_maps.mot_culverts_sp	https://catalogue.data.gov.bc.ca/dataset/89d44ba6-7236-48ed-afab-f25a98c846ef	A Culvert is a pipe (less than 3m in diameter) or half-round flume used to transport or drain water under or away from the road and/or right of way. Culverts that are greater than or equal to 3m in diameter are stored in the MoT Bridge Structure Road Dataset. It is a Point feature
whse_imagery_and_base_maps.mot_road_structure_sp	https://catalogue.data	

4.1 Communicate Connectivity Issues

content	url	description
.gov.bc.ca/dataset/86732641-963e-4329-8aeb-5bbfe35d2dde	The Road Structures on the highway that are maintained by the Ministry. Highway structures include bridges, culverts (greater than or equal to 3m diameter), retaining walls (perpendicular height greater than or equal to 2m), sign bridges, tunnels/snowsheds. Information is recorded in the Bridge Management Information System (BMIS)	
whse_land_and_natural_resource.prot_historical_fire_polys_sp	https://catalogue.data.gov.bc.ca/dataset/22c7cb44-1463-48f7-8e47-88857f207702	Wildfire perimeters for all fire seasons before the current year. Supplied through various sources. Not to be used for legal purposes. These perimeters may be updated periodically during the year. On April 1 of each year the previous year's fire perimeters are merged into this dataset
whse_land_use_planning.rmp_ogma_non_legal_current_svw	https://catalogue.data.gov.bc.ca/dataset/f063bff2-d8dd-4cc3-b3a4-00165aba58e1	This 'Current' spatial data layer is publicly accessible, contains the most current Non-Legal Old Growth Management Area (OGMA) polygons and excludes any sensitive information. This data represents spatially defined areas of old growth forest that are identified during landscape unit planning or an operational planning process. Forest licensees are not required to follow direction provided by non-legal OGMAs when preparing FSPs, and may choose to manage required old growth biodiversity targets in other ways. OGMAs, in combination with other areas where forestry development is prevented or constrained, are used to achieve biodiversity targets. Please see the Additional Information and Object Description Comments below.
whse_legal_admin_boundaries.abms_municipalities_sp	https://catalogue.data.gov.bc.ca/dataset/e3c3c580-996a-4668-8bc5-6aa7c7dc4932	Legally defined **Municipal** polygons were drawn from metes and bounds descriptions as written in Letters Patent for Municipalities in the province of British Columbia. In the event of a discrepancy in the data, the metes and bounds description will prevail. Although the boundaries were drawn based on the legal metes and bounds descriptions, they may differ from how regional districts and their member municipalities and electoral areas currently view and/or manage their boundaries. Where discrepancies are noted, the Ministry of Municipal Affairs (the custodian) enters into discussion with the local governments whose

content	url	description
discrepancies to administrative boundaries are being resolved, boundaries may be adjusted on an ongoing basis until the requested changes are completed. The OIC_YEAR and OIC_NUMBER fields indicate the year that the boundary was passed under OIC and its associated number. The AFFECTED_ADMIN_AREA_ABRVN identifies the administrative areas that are affected by the OIC. See all of the administrative areas currently in the **Administrative Boundaries Management System (ABMS)**. The complimentary point dataset that defines the administrative areas is also available. Other individual legally defined administrative area datasets are available from the following records: Regional Districts Electoral Areas Province of British Columbia Islands Trust Local Trust Areas		
whse_mineral_tenure.og_pipeline_area_appl_sp	https://catalogue.data.gov.bc.ca/dataset/b02092f9-b053-438b-9e86-157477d78faa	Applications for land authorizations representing the right of way for pipeline activities. This dataset contains polygon features for proposed applications collected through the BC Energy Regulator’s Application Management System (AMS). This dataset is updated nightly.
whse_mineral_tenure.og_pipeline_area_permit_sp	https://catalogue.data.gov.bc.ca/dataset/e1500359-d6a6-4a80-abe6-5130361cbac5	Land authorizations representing the right of way for pipeline activities. The spatial data includes polygon data for approved and post-construction pipeline rights of way collected on or after October 30, 2006. This dataset is updated nightly.
whse_mineral_tenure.og_pipeline_segment_permit_sp	https://catalogue.data.gov.bc.ca/dataset/ecf567ea-4901-4f51-a5b0-35959ca96c47	Pipeline centre-lines associated with oil and gas pipeline activity and falling within the area representing the pipeline right of way. This dataset contains line features collected on or after July 11, 2016 for approved pipeline centre-line locations. The dataset is updated nightly.
whse_tantalis.ta_conservancy_areas_svw	https://catalogue.data.gov.bc.ca/dataset/550b3133-2004-468f-ba1f-b95d0e281e78	TA_CONSERVANCY_AREAS_SVW contains the spatial representation (polygon) of the conservancy areas designated under the Park Act or by the Protected Areas of British Columbia Act, whose management and development is constrained by the Park Act. The view was created to provide a simplified view of this data from the administrative boundaries information in the Tantalis operational system
whse_tantalis.ta_park_ecores_pa_svw	https://catalogue.data.gov.bc.ca/dataset/1130248f-f1a3-4956-8b2e-38d29d3e4af7	This dataset contains parks and protected areas managed for important conservation values and are dedicated for the preservation of their natural environments for the inspiration, use and enjoyment of the public. Places of special ecological importance are designated as ecological reserves for scientific research and educational purposes. Source data is Tantalis. *April 18, 2018: Prior to this date this dataset had one spatial boundary per park per survey plan that intersected the boundary of that park. This resulted in multiple identical boundaries for each park that had more than one

content	url	description
survey plan overlapping it's boundaries. The change aggregated the park data so that there is just one boundary per park with the plan numbers concatenated into a single column where each different plan number is separated by a comma.		
whse_wildlife_management.wcp_fish_sensitive_ws_poly	https://catalogue.data.gov.bc.ca/dataset/1a560a12-9be1-49a4-971a-dbc80875a0d7	The dataset contains approved legal boundaries for fisheries sensitive watersheds. A FSW is a mapped area with specific management objectives intended to guide development activities which may adversely impact important fish values

* Metadata information for bcfishpass and bcfishobs layers can be provided here in the future but currently can usually be sourced from https://smnorris.github.io/bcfishpass/06_data_dictionary.html .

4.2 Fish Passage Assessments

Field assessments were conducted between August 25 2023 and September 02 2023. A total of 70 Phase 1 assessments at sites not yet inventoried into the PSCIS system included 20 crossings considered “passable”, 6 crossings considered “potential” barriers and 40 crossings considered “barriers” according to threshold values based on culvert embedment, outlet drop, slope, diameter (relative to channel size) and length (BC Ministry of Environment 2011). 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 4.2. Detailed data with photos are presented in [Attachment 2](https://www.newgraphenvironment.com/fish_passage_peace_2023_reporting/appendix---phase-1-fish-passage-assessment-data-and-photos.html.

“Barrier” and “Potential Barrier” rankings used in this project followed BC Ministry of Environment (2011) 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 4.2: 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)
6539	–	Hammett Creek	Carp Lake FSR	Barrier	High	4.5	high	OBS	–
6541	–	Hammett Creek	Spur	Barrier	Medium	3.8	mod	OBS	–
6543	–	Tributary to Hammett Creek	Davie-War FSR	Barrier	High	4.7	high	OBS	300

PSCIS ID	External ID	Stream	Road	Result	Habitat value	Stream Width (m)	Priority	Fix	Cost Est ($K)
6544	–	Tributary to Crooked River	Carp Lake FSR	Barrier	Low	2.7	low	OBS	300
6546	–	Tributary to Weedon Creek	Davie-War FSR	Barrier	Medium	8.0	mod	OBS	390
6621	–	Tributary to Weedon Creek	Davie-War FSR	Barrier	Medium	5.6	mod	OBS	300
6622	–	Tributary to Weedon Creek	Davie-Weedon Lake FSR	Barrier	High	2.5	high	OBS	300
6623	–	Tributary to Weedon Lake	Davie-Weedon Lake FSR	Barrier	Medium	2.6	mod	OBS	300
198660	3700002	Copper Creek	Highway 97	Barrier	Medium	3.7	mod	OBS	10500
198662	3700010	Redrocky Creek	Highway 97	Potential	Medium	5.2	low	OBS	10500
198663	3700015	Tributary to Crooked River	Highway 97	Barrier	Low	1.1	low	SS-CBS	1500
198664	3701558	Altezega Creek	Highway 97	Barrier	High	3.5	high	OBS	10500
198666	2200002	Tributary to McLeod lake	Highway 97	Barrier	Medium	3.0	mod	SS-CBS	1500
198667	2200779	Tsatchuka Creek	Highway 97	Barrier	Medium	4.0	mod	OBS	10500
198668	2200604	Tributary to McLeod Lake	Highway 97	Barrier	Medium	1.9	mod	SS-CBS	1500
198669	2200026	Tributary to McLeod Lake	Highway 97	Barrier	Medium	3.3	mod	OBS	12000
198672	2200014	Whiskers Creek	Highway 97	Barrier	Medium	7.0	mod	OBS	12000
198673	3702044	Miller Creek	Highway 97	Potential	Low	2.1	low	OBS	12000
198674	3701553	Miller Creek	Summit Lake Rd	Barrier	Low	2.4	low	OBS	1400
198675	3701554	O'Dell Creek	Highway 97	Barrier	Medium	1.9	mod	SS-CBS	1500
198677	3702075	Witters Creek	Caine Creek FSR	Barrier	Medium	2.0	mod	OBS	420
198678	3700005	Witters Creek	Highway 97	Barrier	Low	2.3	low	OBS	10500
198679	3703410	Witters Creek	Railway	Barrier	Low	1.9	low	SS-CBS	–
198682	3700007	Tributary to Crooked River	Highway 97	Barrier	Low	1.7	low	SS-CBS	1500
198683	3700006	Tributary to Crooked River	Highway 97	Potential	Medium	3.4	low	OBS	10500
198684	3700019	Tributary to Kerry Lake	Highway 97	Barrier	Medium	5.0	mod	OBS	420
198686	3700023	Tributary to Crooked River	Highway 97	Potential	High	4.0	mod	OBS	10875

PSCIS ID	External ID	Stream	Road	Result	Habitat value	Stream Width (m)	Priority	Fix	Cost Est ($K)
198689	2200009	Tributary to McLeod Lake	Highway 97	Barrier	High	4.1	high	OBS	10500
198690	2200012	Tributary to McLeod lake	Highway 97	Barrier	Low	2.5	low	SS-CBS	1500
198691	3702657	Tributary to Kerry Lake	Kerry FSR	Barrier	Low	1.0	low	SS-CBS	100
198692	3702663	Tributary to Kerry Lake	Kerry FSR	Barrier	Medium	3.6	mod	OBS	390
198693	3702665	Tributary to Kerry Lake	Kerry FSR	Barrier	Low	3.5	low	OBS	420
198694	3703459	Tributary to Altezega Creek	Firth Lake FSR	Barrier	High	2.2	high	OBS	420
198696	3702446	Tributary to Weedon Lake	Davie-Weedon Lake FSR	Barrier	Low	0.0	low	SS-CBS	100
198697	3702959	Tributary to Weedon Creek	Davie-Weedon Lake FSR	Barrier	Medium	3.4	mod	OBS	420
198698	3702445	Tributary to Weedon Lake	Davie-Weedon Lake FSR	Barrier	Medium	3.5	mod	OBS	420
198699	3703222	Tributary to Davie Lake	Davie Lake FSR	Barrier	Medium	2.3	mod	OBS	420
198701	3703203	Tributary to Davie Lake	Davie Lake FSR	Barrier	Low	1.2	low	SS-CBS	100
198702	2200301	Tributary to Hammett Creek	Carp Lake FSR	Barrier	Medium	3.0	mod	OBS	420
198704	2200987	Tributary to Hammett Creek	Davie-War FSR	Barrier	Low	1.0	low	SS-CBS	100
198706	3702455	Tributary to Weedon Lake	David-Weedon Lake FSR	Barrier	Medium	10.0	mod	OBS	480
198708	3703210	Tributary to Davie Lake	David Lake FSR	Barrier	Medium	2.4	mod	OBS	420
198709	3703209	Tributary to Crooked River	Davie Lake FSR	Potential	Low	4.0	low	OBS	420
198711	3702919	Tributary to Crooked River	Davie-Muskeg FSR	Barrier	Medium	4.3	mod	OBS	390
198712	3702923	Tributary to Crooked River	Davie-Muskeg FSR	Barrier	Medium	2.7	mod	SS-CBS	100
198713	3702924	Tributary to Crooked River	Davie-Muskeg FSR	Barrier	Medium	3.4	mod	SS-CBS	100
198714	2023083101	Tributary to McLeod Lake	Campground Rd	Barrier	Medium	2.3	mod	OBS	–
198716	3700333	42 Mile Creek	Unnamed	Barrier	Low	1.6	low	SS-CBS	100

PSCIS ID	External ID	Stream	Road	Result	Habitat value	Stream Width (m)	Priority	Fix	Cost Est ($K)
Crooked River	Spur	Barrier	Low	1.2	low	SS-CBS	100		
198719	3702074	Balsam Creek	Caine Creek FSR	Barrier	Low	1.2	low	SS-CBS	–
198720	3702077	Enquist Creek	Caine Creek FSR	Potential	Medium	1.9	low	SS-CBS	100
198721	3702073	Tributary to Summit Lake	Caine Creek FSR	Barrier	Low	1.7	low	SS-CBS	100
198723	3701268	Tributary to Altezega Creek	Spur	Barrier	High	2.2	high	OBS	420

4.3 Habitat Confirmation Assessments

During 2023 field assessments, habitat confirmation assessments were conducted at 5 sites in the Parsnip River, Carp River and Crooked River watershed groups. A total of approximately 3km of stream was assessed. 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, 0 crossings were rated as high priorities for proceeding to design for replacement, 4 crossings were rated as moderate priorities, and 1 crossings were rated as low priorities. Results are summarized in Tables 4.3 - 4.3 with raw habitat and fish sampling data included in digital format here. A summary of preliminary modelling results illustrating quantities of bull trout 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 4.3: 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
198666	Tributary to McLeod							

PSCIS ID	Stream	Road	UTM (11U)	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
Lake	Highway 97	497881 6093710	RB	4.7	Medium	moderate	Beaver influenced wetland area upstream for entire length. Some flowing sections for the bottom 75 m or so but no gravels or well defined deep pools present. 13:33:57	
198687	42 Mile Creek	Highway 97	510950 6072479	RB	3.9	High	moderate	Few patches of gravel suitable for rainbow spawning. Very little deep pools suitable for overwintering. Moderate flow with some undercut banks and functional large woody debris. Fry spotted near culvert and ~450m upstream. Stream dewaters 550m upstream of culvert. Sporadic areas with water afterwards. Healthy deciduous riparian vegetation. 09:23:38
198694	Tributary to Altezega Creek	Firth Lake FSR	513783 6067301	–	4.4	High	moderate	Small fish spotted periodically throughout survey. A lot of blowndown first 250m, creating cover across channel and adding complexity to stream habitat. Some deep pools suitable for overwintering. A couple areas with patches of gravel for spawning. No major barriers present. Low gradient stream with riffle pool morphology, no steps or cascades. Overall, habitat rated high value. 09:47:34
198714	Tributary to McLeod Lake	Campground Rd	497758 6093674	RB	–	Medium	moderate	Nice stream with abundant gravel throughout. No pool habitat. Stream potentially dredged through campground as channel is very straight and entrenched.
198723	Tributary to Altezega Creek	Spur	513674 6067268	–	–	High	–	–

Table 4.4: Summary of Phase 2 fish passage reassessments.

PSCIS ID	Embedded	Outlet Drop (m)	Diameter (m)	SWR	Slope (%)	Length (m)	Final score	Barrier Result
198666	No	0.65	1.20	2.5	0.5	60	32	Barrier
198687	Yes	0.00	2.00	1.2	0.5	26	11	Passable
198694	No	0.00	0.75	2.9	2.0	12	21	Barrier
198714	No	0.00	1.20	1.9	5.0	8	26	Barrier

Table 4.5: Cost benefit analysis for Phase 2 assessments. Steelhead rearing model used (total length of stream segments <7.5% gradient)

PSCIS ID	Stream	Road	Result	Habitat value	Stream Width (m)	Fix	Cost Est (in $K)	Habitat Upstream (m)	Cost Benefit (m / $K)	Cost Benefit (m2 / $K)
198666	Tributary to McLeod Lake	Highway 97	Barrier	Medium	3.4	SS-CBS	1500	4680	3120.0	4680.0
198687	42 Mile Creek	Highway 97	Passable	High	3.1	–	–	3940	–	–
198694	Tributary to Altezega Creek	Firth Lake FSR	Barrier	High	2.7	OBS	420	4370	10404.8	11445.2
198714	Tributary to McLeod Lake	Campground Rd	Barrier	Medium	2.8	OBS	–	–	–	–
198723	Tributary to Altezega Creek	Spur	Barrier	High	2.4	OBS	420	–	–	–

Table 4.6: Summary of Phase 2 habitat confirmation details.

PSCIS ID	Location	Length surveyed upstream (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198666	Upstream	220	3.4	2.5	–	1.5	moderate	medium
198666	Upstream2	150	3.2	2.4	0.7	4.0	–	medium
198666	Upstream3	250	3.6	3.3	0.4	1.5	moderate	medium
198687	Downstream	200	2.9	1.6	0.6	2.2	abundant	–
198687	Upstream	600	3.1	1.7	0.3	2.8	moderate	medium
198694	Upstream	650	2.7	1.9	0.4	2.8	abundant	medium
198714	Upstream	250	2.8	1.9	–	2.7	moderate	medium
198723	Upstream	200	2.4	1.5	–	1.0	moderate	medium

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

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
125231	4.0	754	1605	1183	1115	SSE
125261	23.5	730	1137	844	835	SSW
198666	11.0	685	1128	837	796	SSW
198687	9.8	692	1066	909	892	SSW
198694	6.4	696	1082	864	840	SSW
198723	6.4	696	1082	864	840	SSW

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

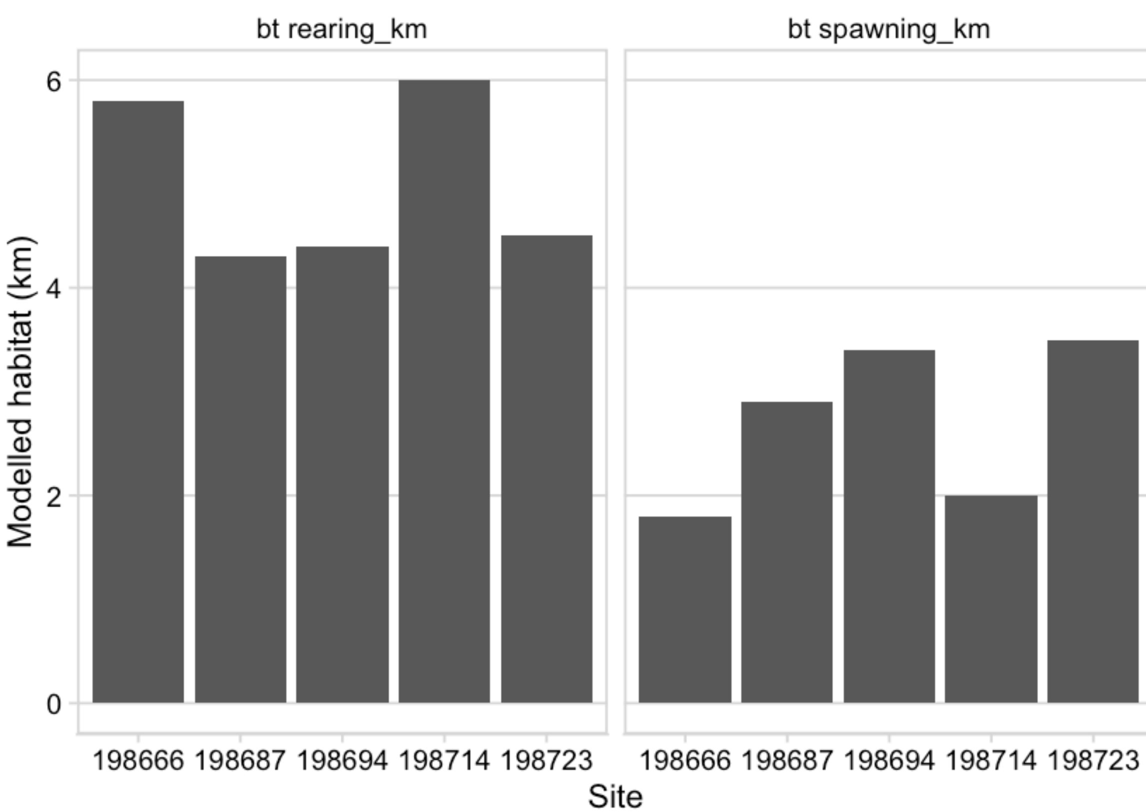

Figure 4.1: Summary of potential habitat upstream of habitat confirmation assessment sites estimated based on modelled channel width and upstream channel length.

4.4 Designs

In 2024, Canfor will replace crossing 125231 (Tributary to Table River) at km21 on the Chuchinka-Table FSR with a bridge. An engineering design was completed in 2023 with some of the materials purchased for the replacement funded through this project. More detail on the site is presented in the appendix of this report titled “Tributary to the Table River - 125231 - Appendix”.

4.5 Remediations

In 2023, BCTS was able to use our project documentation to provide justification for investments in road deactivation leading to the restoration of fish passage at numerous crossings in the Parsnip River watershed including two sites ranked as priorities as part of habitat confirmation assessments documented in the FWCP funded A. Irvine (2020).

Crossing 125345, located on a tributary to the Parsnip River, was removed (along with four other culverts) during deactivation of approximately 9km of the Chuchinka-Colbourne FSR from Reynolds Creek south to approximately 9km north of the Anzac River. The site had been prioritized in A. Irvine (2020) with that report available here.

Crossing 125403, located on a tributary to the Parsnip River, was removed (along with dozens of other culverts) during deactivation of approximately 17km of the Hodda FSR. The site had been prioritized in A. Irvine (2020) with that report available here.

4.6 Monitoring

Fish sampling was conducted at a tributary to Table River (PSCIS 125231) Fern Creek (PSCIS 125261) to serve as baseline monitoring before structure replacements. Sampling was planned at a tributary to Missinka River (PSCIS 125179) however the site was inacessible due to a forest fire in the area.

Electrofishing was conducted at 12 sites with a total of 171 fish captured. Fork length data was used to delineate rainbow trout 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.

Detailed results for tributary to Table River (PSCIS 125231) are presented in the appendix to this report titled “Tributary to the Table River - 125231 - Appendix”. Results for Fern Creek (PSCIS 125261) are presented in “Fern Creek - 125261 - Appendix”.

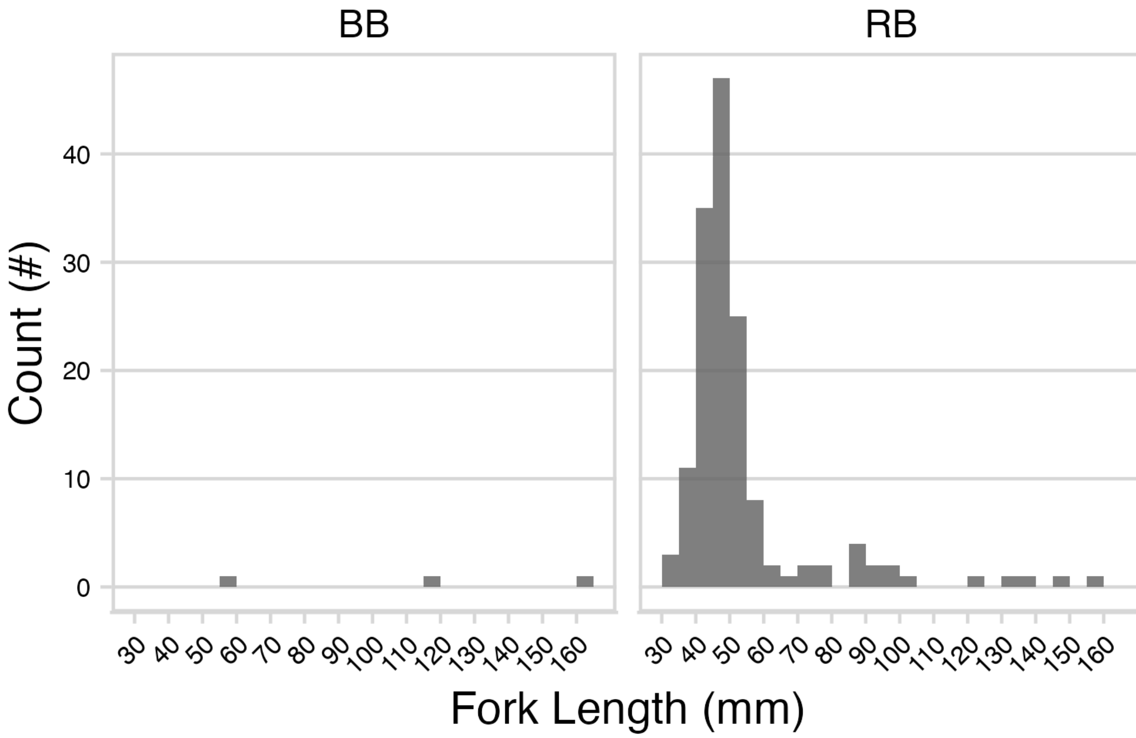

Figure 4.2: Histograms of fish lengths by species. Fish captured by electrofishing during habitat confirmation assessments.

Table 4.8: Summary of electrofishing sites.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
125231_ds_ef1	1	10	1.6	16.0	open
125231_ds_ef2	1	12	2.6	31.2	open
125231_ds_ef3	1	17	2.2	37.4	open
125231_us_ef1	1	15	1.9	28.5	open
125231_us_ef2	1	19	1.9	36.1	open
125231_us_ef3	1	29	1.7	49.3	open
125261_ds_ef1	1	21	4.3	90.3	open
125261_ds_ef2	1	35	3.5	122.5	open
125261_ds_ef3	1	14	2.8	39.2	open
125261_us_ef1	1	13	3.8	49.4	open
125261_us_ef2	1	18	2.4	43.2	open
125261_us_ef3	1	16	4.3	68.8	open

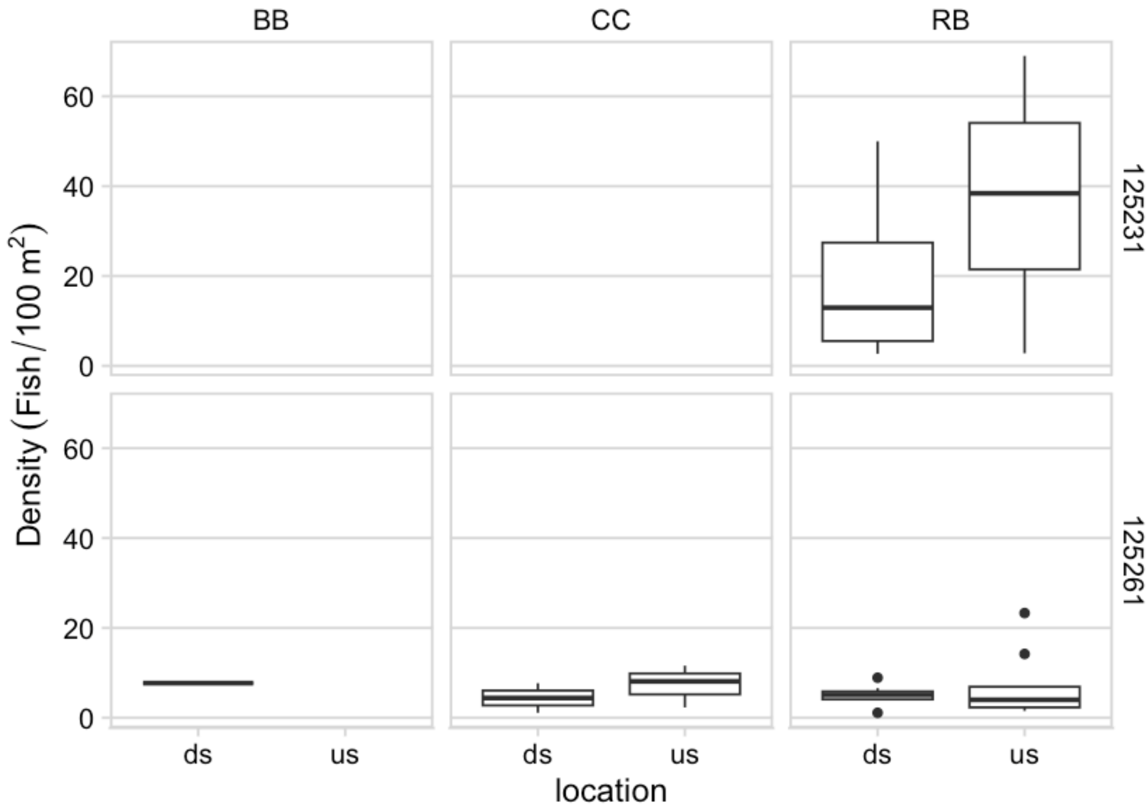

Figure 4.3: Boxplots of densities (fish/100m2) of fish captured by electrofishing during habitat confirmation assessments.

4.7 Climate Change Risk Assessment

Due to the large amount of data present, preliminary climate change risk assessment data is presented in the interactive report at https://newgraphenvironment.github.io/fish_passage_peace_2023_reporting/.

4.8 Challenges and Opportunities

4.8.1 Costs, Timing and Partnerships

Inflation has led to significant cost increases for culvert removals and bridge installations. The projected costs for replacing culverts with bridges on small streams, on unpaved resource roads, have surged from around $180,000 in 2020 to over $400,000 in 2023. These estimates are just a fraction of the costs associated with structure replacements on railways, highways, and paved roads, which can range from near a million to tens of millions of dollars per crossing. This challenge poses a significant obstacle without straightforward mitigation. We are actively seeking new funding partners and are requesting current funders consider increasing financial support for necessary actions.

Infrastructure replacements and removals, even with full funding secured, are complex, taking several years to plan and implement, often involving multiple partners with divergent perspectives. Cost estimates stay uncertain even post-design, and numerous factors can cause delays or derail plans completely. When financial support depends on annual renewals with expectations for swift outcomes, planning becomes exceptionally challenging.

Some landowners and tenure holders lack support to implement remedial actions on the infrastructure they manage, hindering progress in fish passage restoration efforts. CN Rail infrastructure, in particular, significantly contributes to fish passage issues in the FWCP Peace Region. However, representatives from the company have communicated that historically they have been supported to complete one small fish passage remediation project per year across all of western Canada. We are exploring strategies to encourage collaborative cooperation and investment from these stakeholders.

Economic uncertainty in the forestry sector, resulting from deferred cutting permits on land tracks designated as “old-growth management areas,” has significantly impacted our study area. The British Columbia government has urged licensees to postpone harvesting in these areas until a “new approach for old growth forest management” is developed and many cutting permits have been on extended hold. Despite initial plans for the remediation of site 125000 near Arctic Lake in the summer of 2023, our project partner and forest licensee in the area, Sinclar Group, communicated in the spring of 2023 that road updates were no longer practical due to the deferrals affecting logging plans beyond the culvert. Consequently, they would not be able to allocate FWCP dollars earmarked for the site from the 2021/2022 or 2022/2023 fiscal funding pots towards the project. Fortunately, we were able to reallocate their funding to Canfor to catalyze restoration on the Missinka-Table FSR watershed instead.

4.8.2 Project Complexity and Communication

It is challenging to communicate the complexity of fish passage issues to diverse partners/stakeholders. Connectivity is on a spectrum and is not often 100% or 0% with costs of remediation high. Often there are multiple crossings on the same stream with different landowners and tenure holders for each. We will continue to build relationships and tools to help understand and communicate the issues and find ways forward that involve meaningful actions.

Collecting and presenting fish passage data poses challenges for field teams due to the large size of study areas, arduous field conditions and the complexity of stream crossing and habitat data. To address this, we are developing open-source collaborative GIS projects, mobile data collection, and iterative reporting systems to facilitate collaboration and share knowledge and methodologies with diverse partners.

4.8.3 Complimentary Programs

4.8.3.1 Arctic Grayling Research

Ongoing work in the Parsnip Core area regarding Arctic grayling abundance estimates, critical habitat and spatial ecology is providing valuable information to inform fish passage restoration efforts. Consultants and researchers have been developing multiple programs in the area with the support of the FWCP Peace Region. We are working together with these teams to incorporate their findings into our fish passage restoration planning.

4.8.3.2 BCHydro Fish Passage Program

The BC Hydro Fish Passage Program is currently working with First Nations, regulators and stakeholders in the region to develop strategies to offset impacts of fish entertainment related to the Peace Canyon and WAC Bennett dams. We met with West Moberly-DWB Limited Partnership to discuss how our programs can collaborate to identify potential sites for remediation.

4.8.3.3 Climate Change

Climate change is a significant threat to fish and fish habitat. We are working with the Ministry of Transportation and Infrastructure to incorporate climate change risk assessments into our fish passage restoration planning and plan to continue the evolution of this program into the future. Additionally, we will utilize climate modelling data to support prioritization of crossings (e.g., to support access to cold, drought resistant areas). Progress on this work is underway with details of some of the work here, here and here.

5 Recommendations

To effectively enhance fish passage restoration efforts in the FWCP Peace Region, we recommend the following actions:

- Continue to engage partners to raise funds, identify sites, conduct remedial works, and assess effectiveness. This approach ensures efficient fish passage restoration incorporating adaptive management informed by traditional knowledge and real-time planning/monitoring data.
- Conduct detailed assessments in areas with blockages and significant habitat potential. Ongoing assessments throughout the greater area will provide more remediation options and attract additional funding partners, particularly near the community of McLeod Lake.
- Collaborate with UNBC and expert consultants to integrate Arctic grayling research into fish passage restoration planning.
- Utilize climate modelling data to support prioritization of crossings (e.g., to support access to cold, drought resistant areas)
- Prioritize obtaining financial commitments for the restoration of Fern Creek on the Chuchinka-Table FSR, despite uncertainties in Canfor’s harvest plans.
- Conduct effectiveness monitoring at remediated sites, prioritized sites, and planned remediation locations. Utilize electrofishing surveys, PIT tagging, habitat assessments, temperature data collection, and photo documentation.
- Follow up monitoring at site 125179 in the Missinka River watershed, including electrofishing and photo documentation. Use nearby site 125180 as a reference for comparison.
- Reassess site 125000 on the Chuchinka-Arctic FSR in 2024, focusing on the impact of the perched culvert on fish movement and health.
- Monitor PSCIS crossing 125231 on a tributary to the Table River after Canfor completes remediation in 2024, using fish sampling and aerial imagery to demonstrate the positive impact of project investments.
- Continue to develop a cost-effective, robust effectiveness monitoring program that will allow for assessment of productivity gains associated with fish passage improvements (e.g., before/after monitoring of fish abundance, productivity etc.).

Tributary to the Table River - 125231 - Appendix

Site Location

PSCIS crossing 125231 is located on a tributary to the Table River near the 21km mark of the Chuchinka-Table FSR. The culverts are located 0.7km from the confluence of the Table River and approximately 200m upstream of a CN Railway culvert (PSCIS 197493 - discussed below). Canfor Corporation are the primary forest licensee at this location with the Ministry of Forests as the road tenure holders.

The site was originally prioritized for replacement in A. Irvine (2020), following a habitat confirmation assessment which can be found here.

Background

The subject stream flows in a southern direction into the Table River at a point 7.9 km upstream from the confluence with the Parsnip River. At crossing 125231, the tributary to the Table River is a third order stream with a watershed area upstream of the crossing of approximately 4km^2. The elevation of the watershed ranges from a maximum of 1605m to 754m at the crossing (Table 5.1).

PSCIS crossing 197493 is located on the CN Railway approximately 200m downstream of the Chuckinka-Table FSR where replacement of PSCIS crossing 125231 is planned. At the time of assessments conducted in both 2019 and 2022, the fully embedded culvert was considered passable according to provincial metrics (MoE 2011). A recently installed bridge (PSCIS 197499) is located approximately 450m upstream of the crossing and there are no other anthropogenic obstructions to fish passage upstream.

Upstream of crossing 125231, rainbow trout have previously been recorded (Norris [2018] 2024; MoE 2024). A summary of habitat modelling outputs is presented in Table 5.2. A map of the watershed is provided in map attachment 093J.120.

At the time of writing, Canfor was planning to replace crossing 125231 with a bridge. An engineering design had been completed, some of the materials have been purchased (bridge structure and abutments) and contractors were selected through a tendering process led by Canfor to complete the work. Environmental management plans had been drafted for the project and permitting was underway. The cost of replacement was estimated at $410,000. Canfor had committed to paying half with FWCP pledging the remainder.

Table 5.1: Summary of derived upstream watershed statistics for PSCIS crossing 125231.

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
125231	4	754	1605	1183	1115	SSE

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

Table 5.2: Summary of fish habitat modelling for PSCIS crossing 125231.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
BT Rearing (km)	0.4	0.4	100
BT Spawning (km)	0.1	0.1	100
BT Network (km)	3.4	3.3	97
BT Stream (km)	3.4	3.3	97
BT Lake Reservoir (ha)	0.0	0.0	–
BT Wetland (ha)	0.0	0.0	–
BT Slopeclass03 (km)	0.0	0.0	–
BT Slopeclass05 (km)	0.1	0.1	100
BT Slopeclass08 (km)	0.4	0.4	100
BT Slopeclass15 (km)	2.2	2.1	95

* Model data is preliminary and subject to adjustments.

5.1 Aerial Imagery

A survey was conducted with a remotely piloted aircraft with resulting images stitched into an orthomosaic presented here and here.

Fish Sampling

A total six sites were sampled in the vicinity of crossing 125231 with three sites located upstream and three sites located downstream of the Chuckinka-Table FSR. Electrofishing results are summarised in Tables 5.3 - 5.4 and Figure 5.1. A total of 59 rainbow trout were captured upstream, and 27 rainbow trout were captured downstream (Figures 5.2 - 5.3. All fish captured with a fork length greater than 60mm were tagged with Passive Integrated Transponders (PIT tags) with data stored here.

5.2 Conclusion

As PSCIS crossing 197493 located on the CN Railway approximately 200m downstream of the Chuckinka-Table FSR where replacement of PSCIS crossing 125231 is planned, is a fully embedded culvert considered pasable at the time of assessments in 2019 and again in 2022, restoration of fish passage at the FSR provides a relatively rare opportunity in the Table River watershed toremediate fish passage on a forest service road where passage is not also impeded by a CN Railway structure. Although the stream is smaller in size, it is located within an area designated as a fisheries sensitive watershed with habitat presence suitable for bull trout (Western Arctic population) which has been assessed by the Committee on the Status of Endangered Wildlife in Canada as a species of special concern (P. Beaudry 2014; COSEWIC 2012b).

Restoration of fish passage at crossing 125231 is lined up for the summer of 2024 with a design specifications to replace the two 1.2m round pipes (outlet drops of 0.65m) with a 12.2m steel girder/timber deck bridge on spread footing. Replacement of the crossing will provide access to habitat blocked to upstream migrating fish for likely 10 - 20 years (timeline depending on the rate of down cutting caused by the outlet drops) and the stream has no other anthropogenic obstructions to fish passage. The presence of burbot in the system is of particular interest as this fish provides good food values and in general, compared to numerous other species (ex. steelhead and coho), burbot are documented as less capable swimmers considering time-to-fatigue versus swim speed (Katopodis and Gervais 2016). The presence of burbot downstream of the crossing and absence in sample sites above could indicate that the crossing is preventing some migration of this species however sample areas were small and the habitat presence/preference may have been more a determinant of presence than the passability of the crossing.

Resampling of fish at the site in future years of the project is recommended to build our understanding of fish use, movement and health in the stream providing valueable data for monitoring the effectiveness of crossing replacement. Additionally, aquisition of aerial imagery following structure replacement is recommended so that aerial imagery and 3D models generated from the data can be compared to products generated from data gathered in 2023. These comparisons will be useful for communications related to the project as well as for providing insight into changes in stream morphology, effectiveness of environmental management plans and site rehabilitation efforts following construction.

Table 5.3: Fish sampling site summary for 125231.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
125231_ds_ef1	1	10	1.6	16.0	open
125231_ds_ef2	1	12	2.6	31.2	open
125231_ds_ef3	1	17	2.2	37.4	open
125231_us_ef1	1	15	1.9	28.5	open
125231_us_ef2	1	19	1.9	36.1	open
125231_us_ef3	1	29	1.7	49.3	open

Table 5.4: Fish sampling density results summary for 125231.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
125231_ds_ef1	RB	fry	8	50.0	FALSE
125231_ds_ef1	RB	parr	2	12.5	FALSE
125231_ds_ef2	RB	fry	10	32.1	FALSE
125231_ds_ef2	RB	parr	1	3.2	FALSE
125231_ds_ef3	RB	fry	5	13.4	FALSE
125231_ds_ef3	RB	parr	1	2.7	FALSE
125231_us_ef1	RB	fry	14	49.1	FALSE
125231_us_ef2	RB	fry	10	27.7	FALSE
125231_us_ef2	RB	adult	1	2.8	FALSE
125231_us_ef3	RB	fry	34	69.0	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.

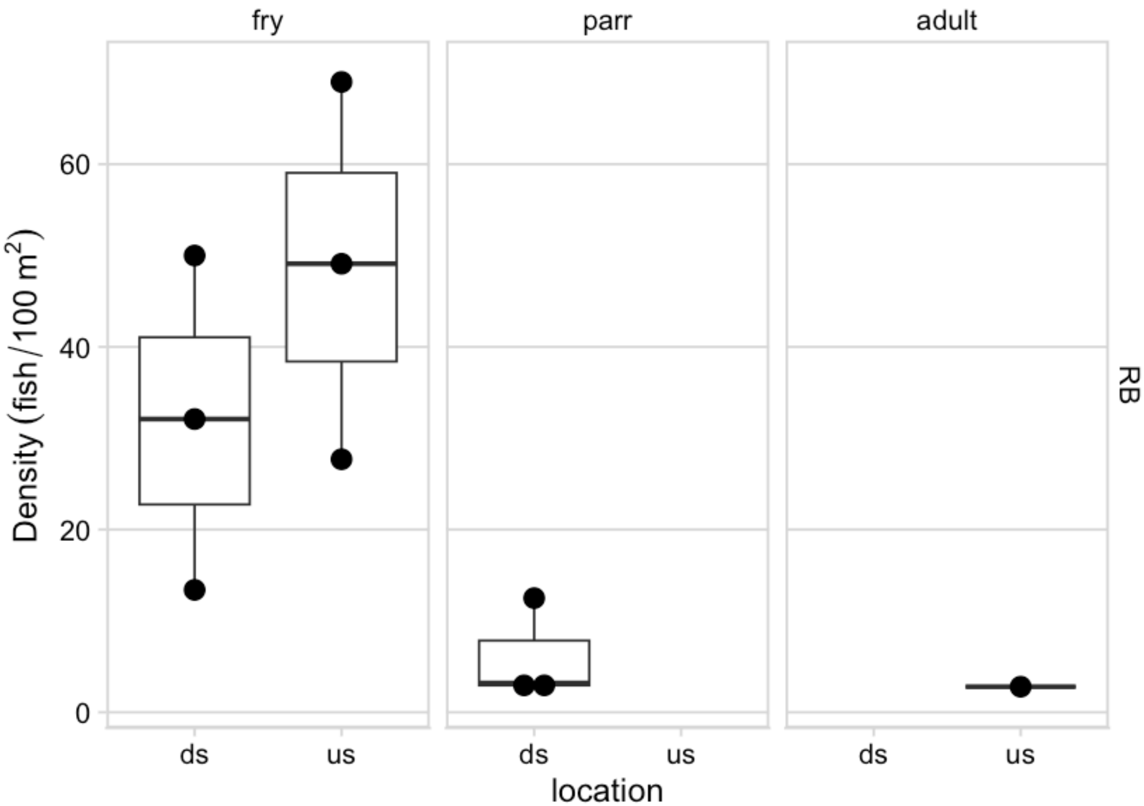

Figure 5.1: Densites of fish (fish/100m2) captured upstream and downstream of PSCIS crossing 125231.

Figure 5.2: Left: Habitat electrofished downstream of PSCIS crossing125231. Right: Habitat electrofished downstream of PSCIS crossing125231.

Figure 5.3: Left: Rainbow trout captured upstream of PSCIS crossing 125231. Right: Rainbow trout captured upstream of PSCIS crossing 125231.

Fern Creek - 125261 - Appendix

Site Location

PSCIS crossing 125261 is located on Fern Creek near the 2.1km mark of the Chuchinka-Table FSR approximately 300m upstream from the confluence with the Parsnip River. Canfor Corporation are the primary forest licensee at this location with the Ministry of Forests as the road tenure holders.The site was originally prioritized for replacement through this project in 2022 - 2023, following a habitat confirmation assessment which can be found here (A. Irvine and Wintersheidt 2023).

Background

At crossing 125261, is a fourth order stream with a watershed area upstream of the crossing of approximately 23.5km^2. The elevation of the watershed ranges from a maximum of 1137m to 730m near the crossing (Table 5.5). Fish species confirmed upstream of the FSR include burbot, rainbow trout, bull trout, sucker, reside shiner, dace and chub (Norris [2018] 2024; MoE 2024). A total of 148ha of lake and 37ha of wetland are modelled upstream. This includes Fern Lakes, a collection of three lakes that have a combined area of approximately 138ha. The outlet of the first lake in the chain is 3.3km upstream of the FSR.

It appears that there have been fish passage retoration efforts at this corossing in the past as metal bafles have been installed within the structure. As the pipe is undersized for the crossing, it has downcut an outlet drop and flow velocities within the structure are too high for the baffles to retain substrate and function effectively. Although larger fish are likely able to ascend through the crossing (depending on size of the fish, swimming ability and flow levels at the time of upstream migration) the crossing isi still considered a barrier to fish passage and likely blocks migration of all juvenile life stages at all time of year. Crossing characteristics are described in detail here.

A summary of habitat modelling outputs is presented in Table 5.6. A map of the watershed is provided in map attachment 093J.119.

At the time of writing, Canfor was going through the planning process to replace crossing 125261 with a bridge with drafts of an engineering design completed from funding provided internally from Canfor. The cost of replacement was
estimated at $430,000 however this figure can be considered preliminary and subject to change.

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
125261	23.5	730	1137	844	835	SSW

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

Table 5.6: Summary of fish habitat modelling for PSCIS crossing 125261.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
BT Rearing (km)	14.4	2.7	19
BT Spawning (km)	4.3	2.7	63
BT Network (km)	48.3	6.9	14
BT Stream (km)	38.4	6.0	16
BT Lake Reservoir (ha)	148.1	0.0	0
BT Wetland (ha)	36.6	14.9	41
BT Slopeclass03 (km)	7.2	2.7	38
BT Slopeclass05 (km)	14.9	1.3	9
BT Slopeclass08 (km)	3.9	1.0	26
BT Slopeclass15 (km)	11.5	1.1	10

* Model data is preliminary and subject to adjustments.

5.3 Aerial Imagery

A survey was conducted with a remotely piloted aircraft with resulting images stitched into an orthomosaic presented here and here.

Fish Sampling

A total six sites were sampled in the vicinity of crossing 125261 with three sites located upstream and three sites located downstream of the Chuckinka-Table FSR. Electrofishing results are summarised in Tables 5.7 - 5.8 and Figure 5.4. A total of 48 fish were captured upstream, and 37 fish were captured downstream. Fish species upstream included primarily rainbow trout with some sculpin. Downstream species assemblage was more diverse including rainbow trout, sculpin, burbot and suckers (Figures 5.5 - 5.6. Length and weight was collected for all fish captured. Rainbow trout and burbot measured with a fork length greater than 60mm were also tagged with Passive Integrated Transponders (PIT tags) (Figures 5.5 - 5.7. Data collected can be accessed here.

5.4 Conclusion

Replacement of PSCIS crossing 125261 on Fern Creek is a priority for this overall project as this is a large system likely containing no other anthropogenic obstructions to fish passage. The presence of burbot in the system is of particular interest as this fish provides good food values and in general, compared to numerous other species (ex. steelhead and coho), burbot are documented as less capable swimmers considering time-to-fatigue versus swim speed (Katopodis and Gervais 2016). The presence of burbot downstream of the crossing and absence in sample sites above could indicate that the crossing is preventing some migration of this species however sample areas were small and the habitat presence/preference may have been more a determinant of presence than the passability of the crossing.

Recapture of fish PIT tagged during 2023 fieldwork will build our understanding of fish movement and health at the site with information collected useful for monitoring the effectiveness of crossing replacement. Additionally, aerial imagery and 3D models can be used to monitor changes in stream morphology and effectiveness of environmental management plans as well as site rehabilitation efforts following construction. The work is tentatively scheduled for 2025 with engineering design led by Canfor.

Table 5.7: Fish sampling site summary for 125261.

site	passes	ef_length_m	ef_width_m	area_m2	enclosure
125261_ds_ef1	1	21	4.3	90.3	open
125261_ds_ef2	1	35	3.5	122.5	open
125261_ds_ef3	1	14	2.8	39.2	open
125261_us_ef1	1	13	3.8	49.4	open
125261_us_ef2	1	18	2.4	43.2	open
125261_us_ef3	1	16	4.3	68.8	open

Table 5.8: Fish sampling density results summary for 125261.

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
125261_ds_ef1	CC	–	1	1.1	FALSE
125261_ds_ef1	RB	fry	8	8.9	FALSE
125261_ds_ef1	RB	parr	6	6.6	FALSE
125261_ds_ef1	RB	juvenile	1	1.1	FALSE
125261_ds_ef2	RB	fry	5	4.1	FALSE
125261_ds_ef2	RB	parr	5	4.1	FALSE
125261_ds_ef3	BB	–	3	7.7	FALSE
125261_ds_ef3	CC	–	3	7.7	FALSE
125261_ds_ef3	RB	fry	2	5.1	FALSE
125261_ds_ef3	RB	parr	2	5.1	FALSE
125261_ds_ef3	SU	–	1	2.6	FALSE

local_name	species_code	life_stage	catch	density_100m2	nfc_pass
125261_us_ef1	CC	–	4	8.1	FALSE
125261_us_ef1	RB	fry	7	14.2	FALSE
125261_us_ef1	RB	parr	2	4.0	FALSE
125261_us_ef2	CC	–	1	2.3	FALSE
125261_us_ef2	RB	fry	2	4.6	FALSE
125261_us_ef2	RB	parr	3	6.9	FALSE
125261_us_ef2	RB	juvenile	1	2.3	FALSE
125261_us_ef2	RB	adult	1	2.3	FALSE
125261_us_ef3	CC	–	8	11.6	FALSE
125261_us_ef3	RB	fry	16	23.3	FALSE
125261_us_ef3	RB	parr	1	1.5	FALSE
125261_us_ef3	RB	juvenile	2	2.9	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.

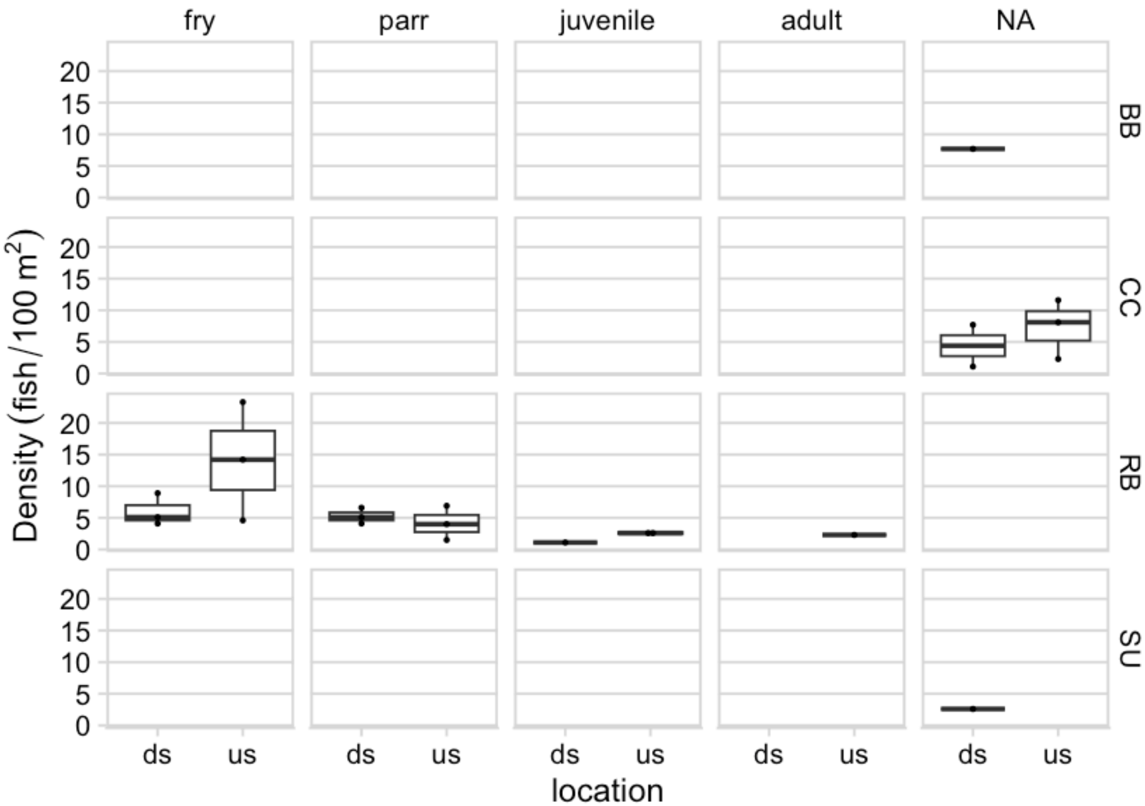

Figure 5.4: Densites of fish (fish/100m2) captured upstream and downstream of PSCIS crossing 125261.

Figure 5.5: Left: Habitat electrofished downstream of PSCIS crossing125261. Right: Habitat electrofished upstream of PSCIS crossing125261.

Figure 5.6: Left: Rainbow trout captured downstream of PSCIS crossing 125261. Right: Burbot captured downstream of PSCIS crossing 125261.

Figure 5.7: Left: Collecting length and weight of all fish captured at Fern Creek. Right: PIT taggging rainbow trout and burbot >60mm fork length at Fern Creek.

Tributary to McLeod Lake - 198714 & 198666 - Appendix

Site Location

PSCIS crossing 198714 and 198666 are located on Tributary to McLeod Lake. PSCIS crossing 198714 is located on a small private campground road immediately adjacent to the high water mark of McLeod Lake and PSCIS crossing 198666 is located approximately 150m upstream from McLeod Lake under Campground Rd. The stream is situated between McLeod Lake Store and Carp Lake Road which accesses Tse'Khene food and fuel and the residential community of McLeod Lake on the McLeod Lake 1 First Nation Reserve.

Background

At crossing 198714, Tributary to McLeod Lake is a third order stream with a watershed area upstream of the crossing of approximately 11km^2. The elevation of the watershed ranges from a maximum of 1128m to 685m at the crossing (Table 5.9). Upstream of the highway, rainbow trout have previously been recorded (Norris [2018] 2024; MoE 2024).

A summary of habitat modelling outputs for the highway crossing are presented in Table 5.10. Modelling information for culvert under the campground road crossing can be assumed to be an addition 120m for potential habitat with a calculated remediation gain of 120m. be A map of the watershed is provided in map attachment 093J.123.

Table 5.9: Summary of derived upstream watershed statistics for PSCIS crossing 198714.

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
198666	11	685	1128	837	796	SSW

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

Table 5.10: Summary of fish habitat modelling for PSCIS crossing 198666.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
BT Rearing (km)	5.8	2.4	41
BT Spawning (km)	1.8	0.8	44
BT Network (km)	24.4	4.8	20
BT Stream (km)	21.8	3.3	15
BT Lake Reservoir (ha)	0.2	0.0	0

Habitat	Potential	Remediation Gain	Remediation Gain (%)
BT Slopeclass03 (km)	4.1	1.9	46
BT Slopeclass05 (km)	4.0	1.0	25
BT Slopeclass08 (km)	3.0	0.3	10
BT Slopeclass15 (km)	10.4	0.1	1

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 198714, located within the campground was un-embedded, non-backwatered and had a culvert slope estimated at 5%. Although the crossing ranked as a barrier to upstream fish passage according to the MoE (2011) provincial protocol, juvenile (>100mm) and adult salmonids are likely able to migrate through the short pipe length (5m) with no outlet drop (Table 5.11).

A deep outlet pool (1m) and a large outlet drop (0.7m) at the Highway 97 crossing (PSCIS 198666) was an indication that the culvert is undersized for the amount of discharge in the watershed. The large outlet drop (0.7m) and extensive length (60m) of the structure likely block upstream migration for all fish life stages and species at all flows. The unembedded and non-backwaered culvert ranked as a barrier to upstream fish passage according to MoE (2011) (Table 5.12).

Water temperature was 12.7°C, pH was 7.9 and conductivity was 410uS/cm.

Stream Characteristics at Crossing

Table 5.11: Summary of fish passage assessment for PSCIS crossing 198714.

Location and Stream Data	•	**Crossing Characteristics**	**–**
Date	2023-08-31	Crossing Sub Type	Round Culvert
PSCIS ID	198714	Diameter (m)	1.2
External ID	–	Length (m)	8
Crew	AI MD	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	497758.4	Resemble Channel	No
Northing	6093674	Backwatered	No
Stream	Tributary to McLeod Lake	Percent Backwatered	–
Road	Campground Rd	Fill Depth (m)	0.5
Road Tenure	MOE	Outlet Drop (m)	0
Channel Width (m)	2.3	Outlet Pool Depth (m)	0.3
Stream Slope (%)	2	Inlet Drop	Yes
Beaver Activity	Yes	Slope (%)	5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	26	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	10

Location and Stream Data	• **Crossing Characteristics**	–

Comments: Small culvert within the campground area. Approximately 40 m upstream of the mouth of the lake. 15:29:22

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

Stream Characteristics at Crossing

Location and Stream Data	•	Crossing Characteristics	–
Date	2023-08-25	Crossing Sub Type	Round Culvert
PSCIS ID	198666	Diameter (m)	1.2
External ID	–	Length (m)	60
Crew	AI	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	497880.6	Resemble Channel	No
Northing	6093710	Backwatered	No
Stream	Tributary to McLeod Lake	Percent Backwatered	–
Road	Highway 97	Fill Depth (m)	9
Road Tenure	MOTI	Outlet Drop (m)	0.65
Channel Width (m)	3	Outlet Pool Depth (m)	1
Stream Slope (%)	0.5	Inlet Drop	No
Beaver Activity	No	Slope (%)	0.5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	32	Barrier Result	Barrier
Fix type	Replace Structure with Streambed Simulation CBS	Fix Span / Diameter	4.5

Location and Stream Data	•	Crossing Characteristics	–

Comments: Stream is located between McLeod Lake Store on Highway and TseKhene food and fuel entrance. Most of the watershed drains reservation land. Could potentially be backwatered as an interim solution. Channel width estimated upstream in wetland type habitat so difficult to tell. Upstream end of the pipe is significantly sloped in the upstream direction. Ministry of Transportation chris_culvert_id: 1997114. 12:31:49

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

Stream Characteristics Downstream of 198666

The stream was surveyed upstream from crossing 198714 for 250m (Figure 5.8). In the area surveyed, the stream was noted as having good flow and abundant gravels suitable for rainbow trout spawning. The dominant substrate was gravels with cobbles sub-dominant.Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as undercut banks.The average channel width was 2.8m, the average wetted width was 1.9m, and the average gradient was 2.7%. The habitat was rated as medium value with habitat present suitable for salmonid rearing and spawning.

Stream Characteristics Upstream of 198666

The stream was surveyed upstream from crossing 198666 for 220m beginning at a point accessed approximately 275m upstream of the highway (Figure 5.9). The dominant substrate was fines with fines sub-dominant.Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris, undercut banks, overhanging vegetation, and instream vegetation.The average channel width was 3.4m, the average wetted width was 2.5m, and the average gradient was 1.5%. It was noted that there were no gravels observed in the area surveyed within the shallow fine substrate channels connecting numerous beaver dams within a wetland type area. The habitat was rated as medium value with some very deep pool areas upstream of beaver dams.

The stream was also assessed at the location of crossing 198710 located approximately 1..7km upsteam of the highway. Crossing 198710 was found to be a washed out bridge. To help build an understanding of fish habitat values upstream of the highway crossing the stream was also surveyed at this location for a distance of 200m within a large beaver influenced wetland area containing turbid water. Numerous beaver dams were observed. No gravels were noted (Figure 5.9). Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris, deep pools, and overhanging vegetation.The dominant substrate was fines with gravels sub-dominant.The average channel width was 3.6m, the average wetted width was 3.3m, and the average gradient was 1.5%. The habitat was rated as value containing habitat suitable for rearing.

Structure Remediation and Cost Estimate

It is recommended that if 198714 is not essential for vehicle traffic that the small structure be replaced with a walking bridge or removed completely. If either of those options are not suitable, replacement of the crossing with a bridge (10m span) is estimated to cost $NA. The culvert under the highway would require extensive works to complete costing an estimated $1,500,000

Conclusion

Although the culvert at PSCIS crossing 198714 was not considered a severe barrier to upstream fish passage due to its short length and lack of outlet drop, the structure is likely undersized for the amount of discharge in the watershed. The straight and uniform channel in the areas adjacent to the lake indicate that historically the stream channel may have been dredged to confine the stream to a define channel to facilitate culvert installation and reduce maintenance. The location of this crossing within the campground and immediately adjacent to the community of McLeod Lake may present opportunities for not only the removal or replacement of the current structure but also potentially restoration of the stream channel and habitat adjacent to the lake.

There was NAkm of habitat modelled upstream of the Highway 97 crossing 198666 with areas surveyed rated as medium value for salmonid rearing with fine substrates and some habitat fragmentation due to subsurface/shallow flows within the heavily beaver influenced wetland type areas upstream. The large outlet drop and extensive length of the structure likely present a complete barrier to all fish species and life stages. The highway crossing (PSCIS 198666) was priliminarily ranked as a moderate priority for proceeding to design for replacement but 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. It is also recommended that the the local McLeod Lake community be consulted to scope for information about the site and determine the importance of the stream to the community.

Table 5.13: Summary of habitat details for PSCIS crossing 198714.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198666	Upstream	220	3.4	2.5	–	1.5	moderate	medium
198666	Upstream2	150	3.2	2.4	0.7	4.0	–	medium
198666	Upstream3	250	3.6	3.3	0.4	1.5	moderate	medium
198714	Upstream	250	2.8	1.9	–	2.7	moderate	medium

Figure 5.8: Left: Typical habitat downstream of PSCIS crossing 198714. Right: Typical habitat downstream of PSCIS crossing 198714.

Figure 5.9: Left: Typical habitat upstream of PSCIS crossing 198714. Right: Typical habitat upstream of PSCIS crossing 198714.

Figure 5.10: Left: Typical habitat upstream of PSCIS crossing 198714. Right: Typical habitat upstream of PSCIS crossing 198714.

42 Mile Creek - 198687 - Appendix

Site Location

PSCIS crossing 198687 is located on 42 Mile Creek approximately 23km south of the community of McLeod Lake. This site is located on Highway 97, approximately 1km upstream from the confluence with the Crooked River.

Background

At crossing 198687, 42 Mile Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 9.8km^2. The elevation of the watershed ranges from a maximum of 1066m to 692m at the crossing (Table 5.14). Upstream of crossing 198687, rainbow trout have previously been recorded (Norris [2018] 2024).

A summary of habitat modelling outputs is presented in Table 5.15. A map of the watershed is provided in map attachment 093J.118.

Table 5.14: Summary of derived upstream watershed statistics for PSCIS crossing 198687.

Site	Area Km	Elev Site	Elev Max	Elev Median	Elev P60	Aspect
198687	9.8	692	1066	909	892	SSW

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

Table 5.15: Summary of fish habitat modelling for PSCIS crossing 198687.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
BT Rearing (km)	4.3	2.9	67
BT Spawning (km)	2.9	1.6	55
BT Network (km)	27.9	11.2	40
BT Stream (km)	26.6	10.8	41
BT Lake Reservoir (ha)	1.5	0.1	7
BT Wetland (ha)	6.9	3.4	49
BT Slopeclass03 (km)	2.0	0.4	20
BT Slopeclass05 (km)	4.9	1.1	22
BT Slopeclass08 (km)	7.9	4.2	53

Habitat	Potential	Remediation Gain	Remediation Gain (%)
BT Slopeclass15 (km)	10.5	4.6	44

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 198687 was backwatered and embedded - ranking as a passable - according to the provincial protocol (MoE 2011) (Table 5.16). Water temperature was 7.4 $^{\circ}$C, pH was 6.8 and conductivity was 411uS/cm.

Although the crossing appeared to be passable at the time of assessment it was noted that recent work had been completed to dredge out the stream channel upstream and downstream of the highway. This indicated that the structure currently in place was not appropriate for the site and that replacement of the crossing could be beneficial from a highway maintenance perspective as well as for reducing impacts on the potentially higher value habitat located immediately adjacent to the road (extensive gravels suitable for spawning). For this reason, a habitat confirmation assessment was completed to gatehr data on the value of the habitat upstream and downstream of the crossing.

Table 5.16: Summary of fish passage assessment for PSCIS crossing 198687.

Location and Stream Data	•	Crossing Characteristics	–
Date	2023-08-26	Crossing Sub Type	Round Culvert
PSCIS ID	198687	Diameter (m)	2
External ID	–	Length (m)	26
Crew	AI	Embedded	Yes
UTM Zone	10	Depth Embedded (m)	0.25
Easting	510950.3	Resemble Channel	Yes
Northing	6072479	Backwatered	Yes
Stream	42 Mile Creek	Percent Backwatered	100
Road	Highway 97	Fill Depth (m)	1.5
Road Tenure	MOTI	Outlet Drop (m)	0
Channel Width (m)	2.5	Outlet Pool Depth (m)	0.3
Stream Slope (%)	1.5	Inlet Drop	No
Beaver Activity	No	Slope (%)	0.5
Habitat Value	High	Valley Fill	Deep Fill
Final score	11	Barrier Result	Passable
Fix type	–	Fix Span / Diameter	–

Location and Stream Data	Crossing Characteristics	–

Comments: Nice stream with good flow and abundant gravel, suitably sized for spawning. Culvert is 100% backwatered and fully embedded. It appears as though there have been some very high flow events that have moved significant amounts of gravel, substrate, upstream and downstream. See photos. Channel seems overly straight and deep so suspect machine work has been done to dredge out the crossing, upstream and downstream. Ministry of Transportation chris_culvert_id: 1997302. 13:37:33

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

Stream Characteristics Downstream

The stream was surveyed downstream from crossing 198687 for 200m (Figure 5.11). The average channel width was 2.9m, the average wetted width was 1.6m, and the average gradient was 2.2%.The dominant substrate was gravels with cobbles sub-dominant.Total cover amount was rated as abundant with overhanging vegetation dominant. Cover was also present as large woody debris. Throughout the area surveyed there were signs of beaver activity and patches of gravel present suitable for rainbow trout spawning. The habitat was rated as NA value for salmonid rearing and spawning.

Stream Characteristics Upstream

The stream was surveyed upstream from crossing 198687 for 600m (Figure 5.12). The dominant substrate was cobbles with gravels sub-dominant.Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as undercut banks and overhanging vegetation.The average channel width was 3.1m, the average wetted width was 1.7m, and the average gradient was 2.8%. Survey notes indicate patches of gravel suitable for rainbow trout spawning, few deep pools suitable for overwintering and generallly moderate flow volume. Fry were spotted near culvert and ~450m upstream of the highway. It was noted that the stream flowed subsurface at a point approximately 550m upstream of culvert. The habitat was rated as medium value as an important migration corridor containing suitable rearing and spawning habitat.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 198687 with a bridge (15m span) is recommended. The cost of the work is estimated at $11,250,000.

Conclusion

There was 3.9km of habitat modelled upstream of crossing 198687 with areas surveyed rated as medium value for salmonid rearing and spawning.

Although the fish passage assessment metrics indicated the crossing to be passable at the time of assessment it was noted that it appeared as though recent work may have been completed to dredge out the stream channel upstream and downstream of the highway. This indicated that the structure currently in place was not appropriate for the site and that replacement of the crossing could be beneficial from a highway maintenance perspective as well as for reducing impacts on the potentially higher value habitat located immediately adjacent to the road (extensive gravels suitable for spawning). For this reason, a habitat confirmation assessment was completed to gather data on the value of the habitat upstream and downstream of the crossing.

PSCIS crossing 198687 on 42 Mile Creek was ranked as a moderate priority for proceeding to design for replacement. The project team plans to follow up with the Ministry of Transportation and Infrastructure to discuss the potential for replacement of the structure and to provide the necessary data to support the replacement if it is deemed helpful.

Table 5.17: Summary of habitat details for PSCIS crossing 198687.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198687	Downstream	200	2.9	1.6	0.6	2.2	abundant	–
198687	Upstream	600	3.1	1.7	0.3	2.8	moderate	medium

Figure 5.11: Left: Typical habitat downstream of PSCIS crossing 198687. Right: Typical habitat downstream of PSCIS crossing 198687.

Figure 5.12: Left: Typical habitat upstream of PSCIS crossing 198687. Right: Typical habitat upstream of PSCIS crossing 198687.

Figure 5.13: Left: Typical habitat upstream of PSCIS crossing 198687. Right: Typical habitat upstream of PSCIS crossing 198687.

Tributary to Altezega Creek - 198723 & 198694 - Appendix

Site Location

PSCIS crossings 198723 and 198694 are located on Tributary to Altezega Creek. Crossing 198723 is located on a small spur road and crossing 198694 is located on Firth Lake FSR.
The crossings are approximately 110m apart. The subject stream is just north of the Kerry Lake East 9 First Nation reserve.

The subject stream flows into Altezega Creek approximately 300m downstream of the lower crossing (PSCIS 198723). Altezega Creek in turn flows into the Crooked River approximately 600m downstream of this confluence. A culvert crossing is present on the mainstem of Altezega Creek where crossed by the Hart Highway (PSCIS crossing 198664 located 430m upstream from the Crooked River) and was also inventoried as part of the 2023 field assessments.

Background

Upstream of the crossings no fish have previously been recorded however, within Altezega Creek - longnose sucker, burbot, and rainbow trout have been recorded upstream of the highway crossing with burbot captured near the highway in 2008 (Norris [2018] 2024; MoE 2024).

A summary of habitat modelling outputs for crossing (198694) are presented in Table 5.18. The potential gains for 198723 can be assumed to be an additional 110m. A map of the watershed is provided in map attachment 093J.119.

Table 5.18: Summary of fish habitat modelling for PSCIS crossing 198694.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
BT Rearing (km)	4.4	2.9	66
BT Spawning (km)	3.4	2.8	82
BT Network (km)	28.2	7.2	26
BT Stream (km)	26.9	6.9	26
BT Lake Reservoir (ha)	3.7	1.2	32
BT Wetland (ha)	2.5	0.9	36
BT Slopeclass03 (km)	2.4	0.4	17
BT Slopeclass05 (km)	8.5	4.6	54
BT Slopeclass08 (km)	7.6	1.2	16
BT Slopeclass15 (km)	7.5	0.6	8

Habitat	Potential	Remediation Gain	Remediation Gain (%)

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 198723 was un-embedded and 75% backwatered. Although ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) the crossing is considered likely passable to all species and life stages at most flows due to the backwatering and a lack of an outlet drop (Table 5.19).

At the time of the survey, PSCIS crossing 198694 was un-embedded and not backwatered. Although ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) the crossing is considered potentially passable to most species and life stages at moderate to low flows due a lack of an outlet drop (Table 5.12).

Water temperature was 10.2°C, pH was 8.2 and conductivity was 391uS/cm.

Table 5.19: Summary of fish passage assessment for PSCIS crossing 198723.

Location and Stream Data	•	Crossing Characteristics	–
Date	2023-09-02	Crossing Sub Type	Round Culvert
PSCIS ID	198723	Diameter (m)	1.4
External ID	–	Length (m)	5
Crew	MW	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	513674	Resemble Channel	No
Northing	6067268	Backwatered	Yes
Stream	Tributary to Altezega Creek	Percent Backwatered	75
Road	Spur	Fill Depth (m)	0.5
Road Tenure	Unclassified	Outlet Drop (m)	0
Channel Width (m)	2.2	Outlet Pool Depth (m)	0.4
Stream Slope (%)	1	Inlet Drop	No
Beaver Activity	No	Slope (%)	1
Habitat Value	High	Valley Fill	Deep Fill
Final score	21	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	14

Location and Stream Data	•	**Crossing Characteristics**	–

Comments: Two culverts, one plastic pipe and one really old metal pipe. Metal pipe is longer, outlets are at different spots. 11:58:55

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

Stream Characteristics at Crossing

Location and Stream Data	•	Crossing Characteristics	–
Date	2023-08-29	Crossing Sub Type	Round Culvert
PSCIS ID	198694	Diameter (m)	0.75
External ID	–	Length (m)	12
Crew	MW	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	513782.8	Resemble Channel	No
Northing	6067301	Backwatered	No
Stream	Tributary to Altezega Creek	Percent Backwatered	–
Road	Firth Lake FSR	Fill Depth (m)	1.5
Road Tenure	MOF 8385	Outlet Drop (m)	0
Channel Width (m)	2.2	Outlet Pool Depth (m)	0.7
Stream Slope (%)	2	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	2
Habitat Value	High	Valley Fill	Deep Fill
Final score	21	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	14

Location and Stream Data	•	Crossing Characteristics	–

Comments: High habitat value upstream. Many fish spotted in outlet pool. Tributary to big system. Culvert old and not in great shape. Needs to be replaced. Debris jam at inlet blocking small section of flow. 08:57:52

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

Stream Characteristics Downstream of 198723

The stream was assessed downstream of PSCIS crossing 198723 for a distance of ~50m. Although mapped in the freshwater atlas as crossing Firth Lake FSR, before flowing into Altezega Creek, the mapping is incorrect as the stream flows directly into Altezega Creek approximately 300m downstream.

Stream Characteristics Upstream of 198723 and downstream of 198694

The stream was surveyed upstream from crossing 198723 for 110m to the location of 198694 (Figure 5.14). Total cover amount was rated as moderate with small woody debris dominant. Cover was also present as large woody debris and overhanging vegetation.The dominant substrate was gravels with fines sub-dominant.The average channel width was 2.4m, the average wetted width was 1.5m, and the average gradient was 1%. Abundant gravels suitable for salmonid spawning were noted as present within the area surveyed. The habitat was rated as value for salmonid rearing.

Stream Characteristics Upstream of 198694

The stream was surveyed upstream from crossing 198694 for 650m (Figure 5.15). The average channel width was 2.7m, the average wetted width was 1.9m, and the average gradient was 2.8%.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 and overhanging vegetation. Small fish were spotted periodically throughout survey and significant blowdown created large woody debris cover - particularly for the first 250. Some deep pools suitable for overwintering were noted along with pockets of gravel suitable for spawning. The habitat was rated as medium value as an important migration corridor containing habitat suitable for rearing.

Structure Remediation and Cost Estimate

As the purpose for the section of road on which 198723 is located is unclear (small section of road that begins on the transmission line but loops back to the FSR), deactivation of the road could be considered. If the road is necessary, an estimate of the cost for replacement of PSCIS crossing 198723 with a bridge (14m span) is $420,000.

Replacement of crossing 198694 on Firth Lake FSR with a bridge (14m span) is estimated to cost $420,000 for a cost benefit of 10404.8 linear m/$1000 and 11445.2 m^2/$1000.

Conclusion

There was an estimated 4.4km of habitat modelled upstream of crossing 198694 with areas surveyed rated as medium value for salmonid rearing and spawning. 198723 was ranked as a priority for proceeding to design for replacement as the crossing at the time of the survey had no outlet drop and was 75% backwatered. Crossing 198694 on Firth Lake FSR 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 or lower priority for site remediation.

Table 5.21: Summary of habitat details for PSCIS crossings 198723 and 198694.

Site	Location	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198694	Upstream	650	2.7	1.9	0.4	2.8	abundant	medium
198723	Upstream	200	2.4	1.5	–	1.0	moderate	medium

Figure 5.14: Left: Typical habitat upstream of PSCIS crossing 198723 and downstream of 198694. Right: Typical habitat upstream of PSCIS crossing 198723.

Figure 5.15: Left: Typical habitat upstream of PSCIS crossing 198694. Right: Typical habitat upstream of PSCIS crossing 198694.

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Changelog

fish_passage_peace_2023_reportingv0.0.2 (2024-07-05)

- updates as per feedback from FWCP
- add static import functions

fish_passage_peace_2023_reporting v0.0.1 (2024-05-31)

- Initial draft report release

Session Info

— *Session info*

setting value
version R version 4.4.0 (2024-04-24)
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language (EN)
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tz   America/Vancouver
date   2024-07-05
rstudio 2024.04.1+748 Chocolate Cosmos (desktop)
pandoc   3.1.11 @
/Applications/RStudio.app/Contents/Resources/app/quarto/bin/tools/aarch64/ (via rmarkdown)

— Packages

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askpass		1.2.0	2023-09-03	[1]	CRAN (R 4.4.0)
base64enc		0.1-3	2015-07-28	[1]	CRAN (R 4.4.0)
bcdata	*	0.4.1	2023-03-18	[1]	CRAN (R 4.4.0)
bit		4.0.5	2022-11-15	[1]	CRAN (R 4.4.0)
bit64		4.0.5	2020-08-30	[1]	CRAN (R 4.4.0)
bitops		1.0-7	2021-04-24	[1]	CRAN (R 4.4.0)
blob		1.2.4	2023-03-17	[1]	CRAN (R 4.4.0)
bookdown	*	0.39	2024-04-15	[1]	CRAN (R 4.4.0)
brew		1.0-10	2023-12-16	[1]	CRAN (R 4.4.0)
bslib		0.7.0	2024-03-29	[1]	CRAN (R 4.4.0)
cachem		1.0.8	2023-05-01	[1]	CRAN (R 4.4.0)
cellranger		1.1.0	2016-07-27	[1]	CRAN (R 4.4.0)
chk		0.9.1.9001	2024-06-16	[1]	Github (poissonconsulting/chk@ea59f9c)
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cli		3.6.2	2023-12-11	[1]	CRAN (R 4.4.0)
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colorspace		2.1-0	2023-01-23	[1]	CRAN (R 4.4.0)
cowplot		1.1.3	2024-01-22	[1]	CRAN (R 4.4.0)
crayon		1.5.2	2022-09-29	[1]	CRAN (R 4.4.0)
crosstalk		1.2.1	2023-11-23	[1]	CRAN (R 4.4.0)
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curl		5.2.1	2024-03-01	[1]	CRAN (R 4.4.0)
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 usethis      * 2.2.3   2024-02-19 [1] CRAN (R 4.4.0)
 utf8           1.2.4   2023-10-22 [1] CRAN (R 4.4.0)
 uuid           1.2-0   2024-01-14 [1] CRAN (R 4.4.0)
 V8             4.4.2   2024-02-15 [1] CRAN (R 4.4.0)
 vctrs          0.6.5   2023-12-01 [1] CRAN (R 4.4.0)
 viridisLite    0.4.2   2023-05-02 [1] CRAN (R 4.4.0)
 vroom          1.6.5   2023-12-05 [1] CRAN (R 4.4.0)
 websocket      1.4.1   2021-08-18 [1] CRAN (R 4.4.0)
 withr          3.0.0   2024-01-16 [1] CRAN (R 4.4.0)
 wk             0.9.1   2023-11-29 [1] CRAN (R 4.4.0)
 xfun           0.44    2024-05-15 [1] CRAN (R 4.4.0)
 xml2           1.3.6   2023-12-04 [1] CRAN (R 4.4.0)
 xtable         1.8-4   2019-04-21 [1] CRAN (R 4.4.0)
 yaml           2.3.8   2023-12-11 [1] CRAN (R 4.4.0)
 yesno          0.1.2   2020-07-10 [1] CRAN (R 4.4.0)

 [1] /Library/Frameworks/R.framework/Versions/4.4-arm64/Resources/library
```

Attachment 1 - Maps

All georeferenced field maps are presented at:

- https://hillcrestgeo.ca/outgoing/fishpassage/projects/parsnip/archive/2022-05-27/

Maps are also available zipped for bulk download at:

- https://hillcrestgeo.ca/outgoing/fishpassage/projects/parsnip/archive/2022-05-27/2022-05-27.zip

Attachment 2 - Habitat Assessment and Fish Sampling Data

All field data collected is available at https://github.com/NewGraphEnvironment/fish_passage_peace_2023_reporting/raw/main/data/ with habitat assessment data (including fish sampling and PIT tagging information) can be downloaded at https://github.com/NewGraphEnvironment/fish_passage_peace_2023_reporting/raw/main/data/habitat_confirmations.xls

Attachment 3 - Phase 1 Data and Photos

Data and photos for all Phase 1 (fish passage assessments) are provided in [Attachment 3 - https://github.com/NewGraphEnvironment/fish_passage_peace_2023_reporting/raw/main/docs/Attachment_3.pdf](https://github.com/NewGraphEnvironment/fish_passage_peace_2023_reporting/raw/main/docs/Attachment_3.pdf)