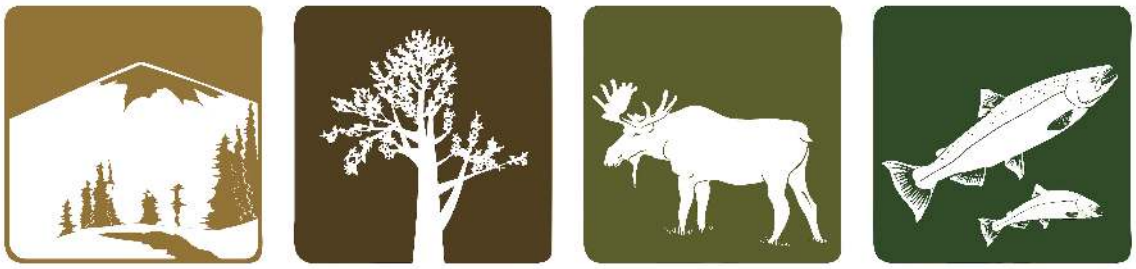

SOCIETY FOR ECOSYSTEM RESTORATION
IN NORTHERN BRITISH COLUMBIA

Restoring Fish Passage in the Fraser Region - 2023

Prepared for
Ministry of Transportation and Infrastructure

and

Society for Ecosystem Restoration in Northern BC (SERNbc)

Prepared by
Al Irvine, B.Sc., R.P.Bio. and Lucy Schick, B.Sc.
New Graph Environment Ltd.

on behalf of

Society for Ecosystem Restoration in Northern BC (SERNbc)

Version 0.0.1 2025-04-14

new graph environment

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Acknowledgement

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

Executive Summary

This report is available as a PDF and as an online interactive report at https://www.newgraphenvironment.com/fish_passage_fraser_2023_reporting. We recommend viewing online as the web-hosted HTML version contains more features and is more easily navigable. Please reference the website for the latest PDF from fish_passage_fraser_2023.pdf.

Since 2023, the Society for Ecosystem Restoration Northern British Columbia (SERNbc), with funding from the Ministry of Transportation and Infrastructure, has been actively involved in planning, coordinating, and conducting fish passage restoration efforts within the Nechako River, Lower Chilako River, Morkhill River, Upper Fraser River, and François Lake watershed groups which are sub-basins of the Upper Fraser River watershed.

The primary objective of this project is to identify and prioritize fish passage barriers within these study areas, develop comprehensive restoration plans to address these barriers, and foster momentum for broader ecosystem restoration initiatives. While the primary focus is on fish passage, this work also serves as a lens through which to view the broader ecosystems, leveraging efforts to build capacity for ecosystem restoration and improving our understanding of watershed health. We recognize that the health of life - such as our own - and the health of our surroundings are interconnected, with our overall well-being dependent on the health of our environment.

Fish passage assessment procedures conducted through SERNbc in the Upper Fraser River Watershed since 2023 are amalgamated online within the Results and Discussion section of the report found here which includes links to project reporting for each site. A summary of activities included in this report is provided below:

- Field assessments were conducted from September 09, 2023-October 09, 2024, by Allan Irvine, R.P.Bio., Mateo Winterscheidt, B.Sc, and Lucy Schick, B.Sc.
- A total of 186 Fish Passage Assessments were completed across the 2023 and 2024 field seasons, including 184 Phase 1 assessments and 2 reassessments.
- During the 2024 field assessments, habitat confirmation assessments were conducted at 13 sites within the Nechako River, Lower Chilako River, Morkhill River, Upper Fraser River, and François Lake watershed groups. A total of approximately 14 km of stream was assessed.

A major challenge in advancing fish passage restoration is the complexity of working across jurisdictions and with multiple stakeholders—rail and highway authorities, forestry ministries, licensees, and private landowners. These partners are often being asked to accommodate priorities that originate outside their mandates and budgets. Convincing them to invest in difficult, high-cost

interventions—like modifying crossings or relocating infrastructure—requires navigating uncertainty about costs and ecological outcomes, as well as a disconnect between the benefits to watershed health and the internal pressures or performance goals of these agencies. It's a tough ask: to take on massive, uncertain projects when they're already stretched thin with their own responsibilities.

Fish passage restoration within the Upper Fraser River watershed and across British Columbia is further complicated by the legacy of infrastructure deeply embedded in the landscape. Roads, railways, highways, community infrastructure and private assets often constrain floodplains and disrupt natural hydrological processes. While targeted repairs to individual barriers are essential, they won't resolve the broader systemic issues without rethinking and restructuring how infrastructure interacts with watershed function. Loss of riparian vegetation and intensive beaver management only add to the degradation. Addressing these challenges means making strategic, well-communicated choices—picking battles carefully, building trust, and staying committed to a longer-term transformation.

All field activities from 2023 and 2024—including fish passage assessments, habitat confirmation assessments, and drone imagery collection—were consolidated into a centralized interactive table. This tool enables multi-criteria querying (e.g., by watershed group, stream name, road name, PSCIS ID, or top-ranked sites) with direct links to supporting documentation.

While preliminary top remediation priorities are provided by watershed group, these rankings are inherently subjective and can depend on the capacity and willingness of infrastructure owners and tenure holders to support implementation—both financially and over the often multi-year project timelines. In practice, we must often act opportunistically, pursuing simpler, lower-cost options to maintain momentum and achieve near-term progress.

Government, community groups, landowners, non-profits, industry and other stakeholders should work collaboratively to address high and moderate priority barriers identified online within the Results and Discussion section of the report found here. Although the table presents many options, linked reports specify whether each site is a low, moderate, or high priority. Progress on any front is meaningful, and aiming to remediate at least one high-priority site per year per watershed group—regardless of its overall rank—is a practical and effective approach.

Of key importance as well - the placement and design of infrastructure often drives floodplain disconnection and watershed degradation. Thus, sustainable restoration must extend beyond culvert upgrades toward reimagining how infrastructure interacts with the landscape—supporting reconnection of floodplains, wetland restoration, and coexistence with keystone species such as beaver, which create wetlands and slow flows, and salmon, which deliver marine nutrients and cultural richness to upstream ecosystems. Foundation species like cottonwood and old-growth conifers further support watershed health by stabilizing banks, shading streams, and contributing

organic material, and their restoration and conservation must be integrated alongside fish passage reconnection in any comprehensive watershed planning effort.

Although subject to revisions and updates, this report provides a snapshot of the current state of fish passage restoration within study area watershed groups in the Upper Fraser River watershed. It is intended to inform and engage stakeholders, including indigenous communities, government agencies, and the public, in the ongoing work of restoring fish passage and improving watershed health. We hope that this report will inspire further collaboration and action to address the challenges of fish passage restoration in the context of overall watershed health.

Recommendations for collaborative enhancement of fish passage restoration in the Upper Fraser River Region include:

- Maintain strong partnerships to support funding, site selection, remediation, and monitoring through adaptive management informed by traditional knowledge and real-time data.
- Coordinate with the Ministry of Transportation to pursue funding for engineering designs at the following crossings:
    - PSCIS crossing 199171 on Burnt Cabin Creek along Gala Bay Road, in the Francois Lake watershed group.
    - PSCIS crossing 199173 on a tributary to the Nechako River, on Dog Creek Road, in the Nechako River watershed group
- Use climate modeling to prioritize crossings that enable access to cold, drought-resistant habitats.
- Integrate fish passage restoration planning with other restoration and enhancement initiatives in the region to maximize benefits to fish populations as well as for communities within the Upper Fraser River watershed. This includes working with the Rivershed Society of BC, Nechako Environment and Watershed Stewardship Society (NEWSS), University of Northern British Columbia, Fisheries and Oceans Canada, Ministry of Transportation, provincial regulators, and others to leverage funding, knowledge, and resources for fish passage restoration towards other projects related to watershed health in the region. Examples of where this is already taking in place in other watersheds includes:
    - Leveraging of Morice River watershed group fish passage sites into the Bii Wenii Kwa Restoration/Recovery Plan
    - Incorporation of Upper Bulkley River sites into the Neexdzii Kwah Restoration Planning (Irvine and Schick 2025).
- Develop strategies to explore cost and fisheries production benefits of stream crossing structure upgrades alongside alternative/additional restoration and enhancement investments such as land conservation/procurement/covenant, cattle exclusion, riparian restoration, habitat complexing, water conservation, commercial/recreational fishing management, water treatment and research. Ideentify and pursue opportunities to

collaborate and leverage initiatives together in study area watersheds (ex. fish passage rehabilitation, riparian restoration and cattle exclusion) for maximum likely restoration benefits.

Introduction

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

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

Please note that at the time of reporting this document can be considered a living document. Version numbers are logged for each release with modifications, enhancements, and other changes tracked in the Changelog (page 187) with issues and proposed/planned enhancements tracked here.

1 Background

1.1 Project Location

Select sites were assessed between Burns Lake and Valemount, British Columbia within the Nechako River, Lower Chilako River, François Lake, Morkhill River and Upper Fraser River watershed groups.

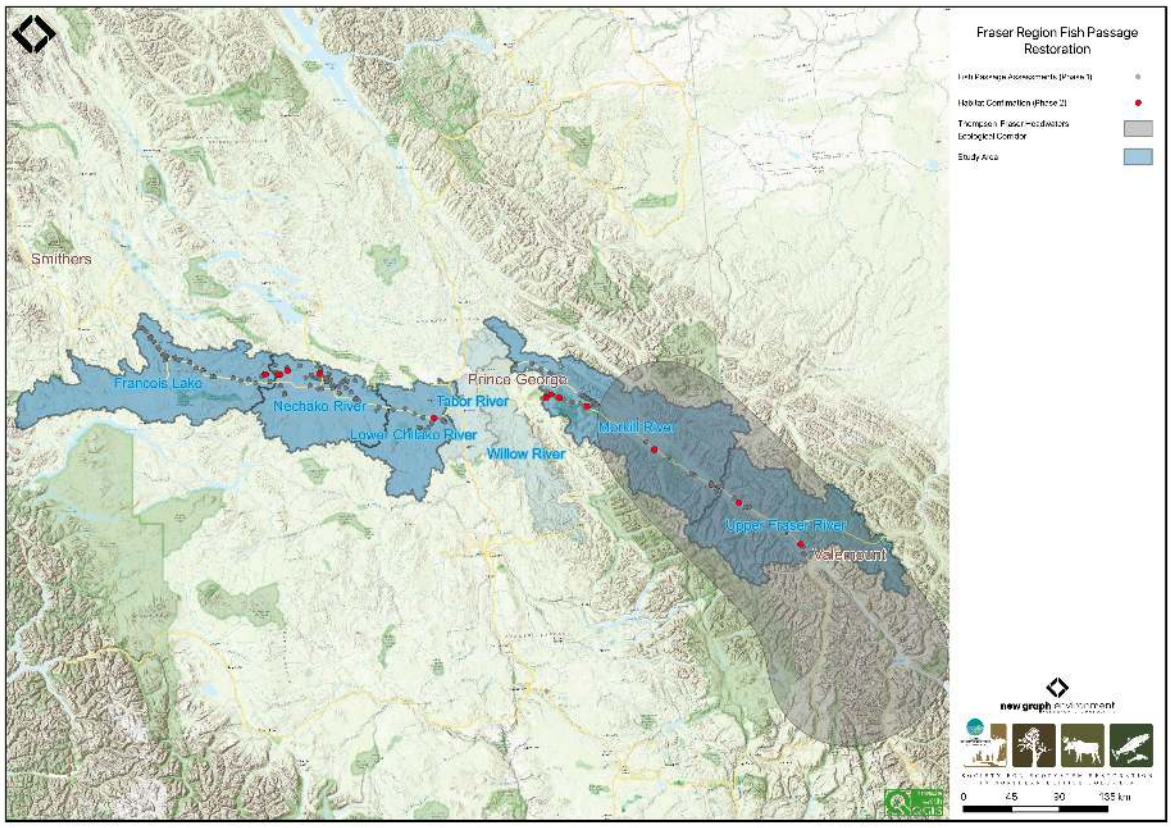


Figure 1.1: Overview map of the Fraser Region study areas

1.2 Lhtakoh

Known as the Lhtakoh, meaning “rivers within one another” to the Dakelh (Carrier) people, the Fraser River stretches nearly 1,400 kilometers from the Rocky Mountains of Mount Robson Provincial Park to the Strait of Georgia near Vancouver. As the largest salmon-producing river on Canada’s west coast (Bradford and Taylor 2023; “Dakleh Placenames” n.d.), it plays a crucial economic role in supporting forestry, agriculture, and hydroelectric power generation. Additionally, the Fraser River is vital for fisheries, especially for salmon populations, which are essential to both the local ecosystem and indigenous communities.

The Upper Fraser River is commonly defined as the section of the mainstem north of Quesnel, flowing through the Cariboo and Fraser Plateau regions. Major tributaries include the Nechako, Quesnel, and McGregor rivers (D. P. Shaw and Tuominen, n.d.). This vast expanse supports many indigenous groups who utilize the land for cultural, spiritual, and economic practices.

The Upper Fraser River, an 8th order stream, drains an area of 232,134 km^2 upstream of the McGregor River confluence. The seasonal hydrograph has a single broad peak in early summer due to snow and glacial melt from surrounding mountain ranges (Figure 1.2). The mean annual discharge at station 08KA005 in McBride, located roughly 200km southeast of Prince George, is 200.9 m^3/.

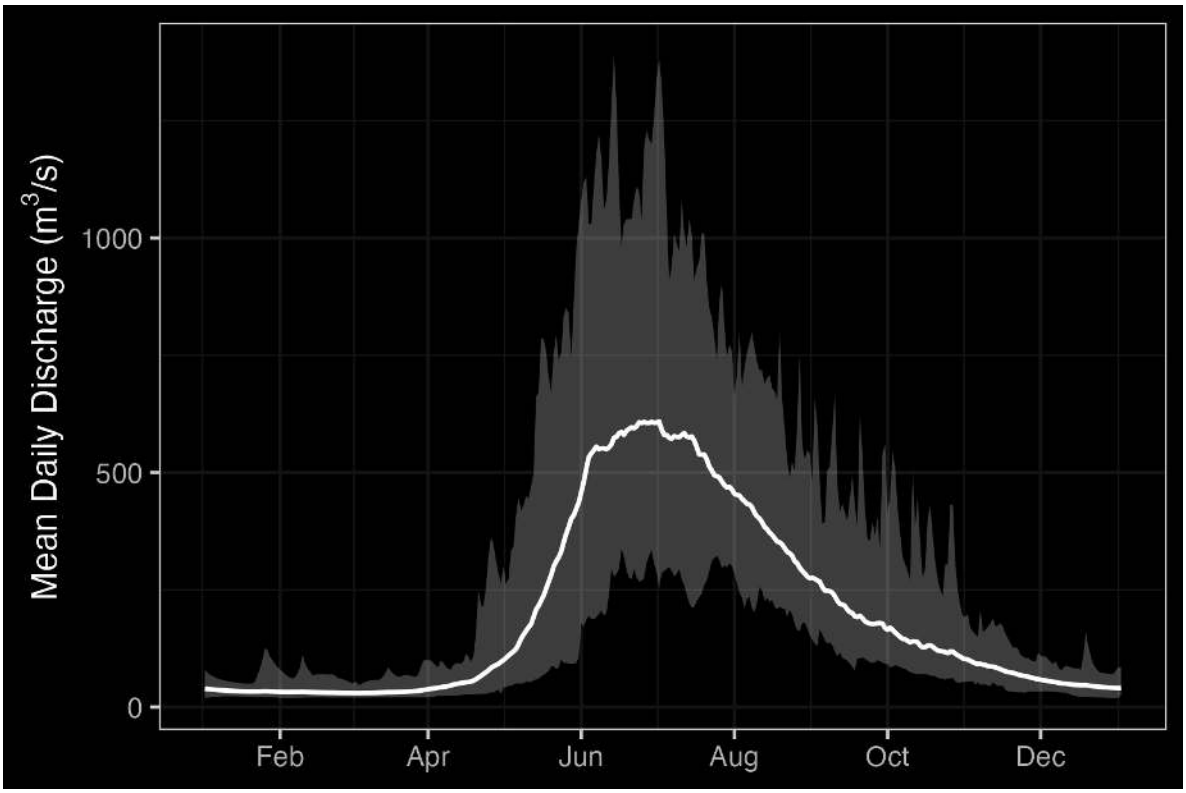


Figure 1.2: Fraser River At Mcbride (Station #08KA005 - Lat 53.30172 Lon -120.14092). Available mean daily discharge data from 1953 to 2021.

1.3 Nechakoh

The Nechako River is an 8th order stream that drains an area of 47,269km^2. Beginning at the Nechako Plateau, it flows north towards Fort Fraser then east to its confluence with the Fraser River in Prince George. The Nachako River has three main tributaries: the Stuart River, the Endako River, and the Chilako River. It has a mean annual discharge of 141.3 m^3/s at station 08JC001 located in Vanderhoof and 278.5 m^3/s at station 08JC002 located in Isle Pierre, ~25km downstream of the Stuart River confluence. Flow patterns at Isle Pierre are heavily influenced by inflows from the Stuart River (enters downstream of Vanderhoof) resulting in higher peak levels and average discharge (Figure 1.3). The hygrograph at station 08JC001 in Vanderhoof peaks in June and August, with lower peak levels and average discharge (Figure 1.3).

The Nechako River, meaning “Blackwater people’s river”, is home to the Cheslatta Carrier Nation who are part of the Dakelh people. Traditionally, they lived off the land near Tsetl’adak Bunk’ut “Peak Rock Lake” (Cheslatta Lake), however, in 1952, the construction of the Kenney Dam by the Aluminum Company of Canada (now Rio Tinto Alcan) and the subsequent flooding of the Nechako Reservoir forced the Cheslatta Carrier people to abandon their ancestral lands (“The History of the Cheslatta Carrier Nation” n.d.; “Dakleh Placenames” n.d.). This relocation was done with little notice or compensation, causing significant disruptions to their community, culture, and way of life. Despite these challenges, the Cheslatta Carrier Nation has worked to preserve their cultural heritage and advocate for their rights and land restoration.

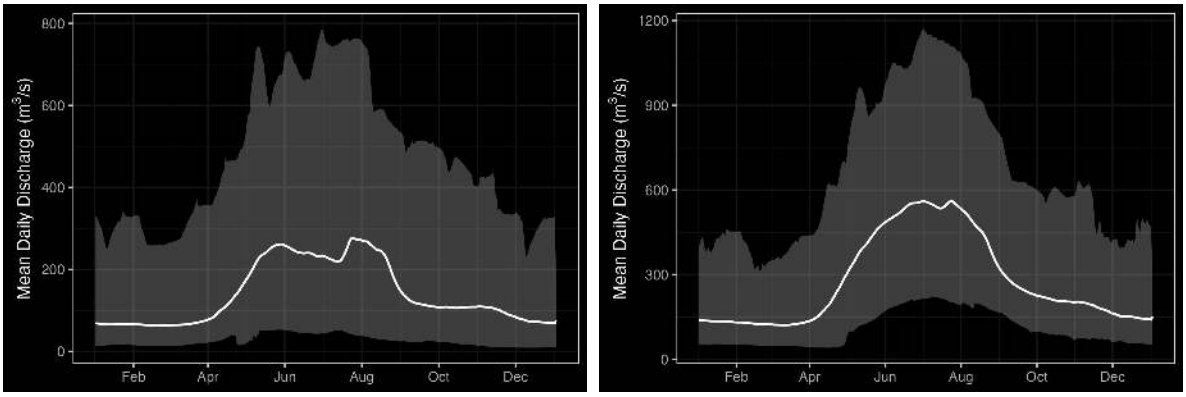


Figure 1.3: Hydrograph for Nechako River at Vanderhoof (Station #08JC001)(left) and at Isle Pierre (Station #08JC002)(right).

1.4 Endako River

The Endako River is a 6th order stream that flows south east from Burns Lake to Fraser Lake. It drains an area of 5,970km^2. There is one hydrometric station on the Endako River located in

Endako, but it was only active for one year during 1951. Given the one year of data, the mean annual discharge is 12.7 m^3/s at station 08JB004. The hydrograph peaks in May-June (Figure 1.4).

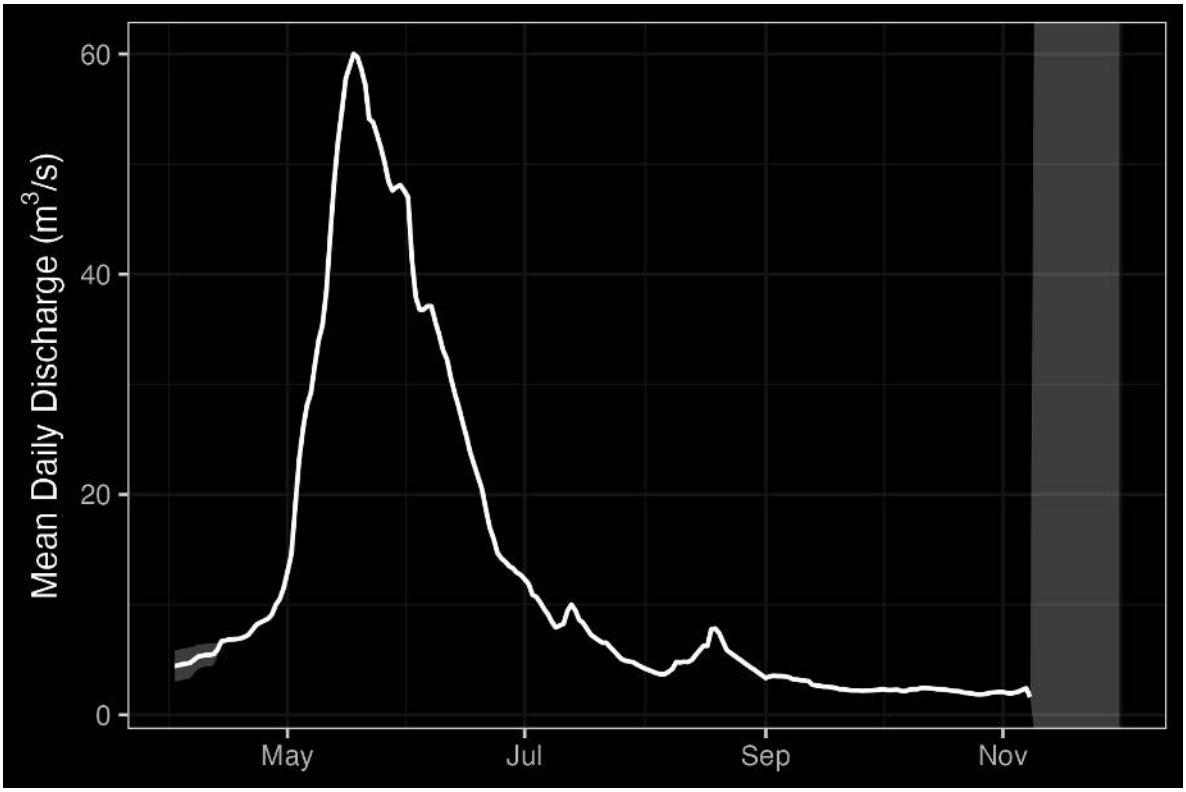


Figure 1.4: Endako River At Endako (Station #08JB004 - Lat 54.08194 Lon -125.021111). Available mean daily discharge data from 1950 to 1951.

1.5 Tsalakoh

The Chilako River, known as the Tsalakoh by the Dakelh people, translates to the “beaver paw river”. It is a 6th order stream that flows north from the Nechako Plateau to the Nechako River and drains an area of 3,634km^2. There is one hydrometric station on the Chilako River located ~10km upstream of the mouth, but it was only active from 1960-1974. Given this data, the hydrograph peaks in May-June (Figure 1.5).

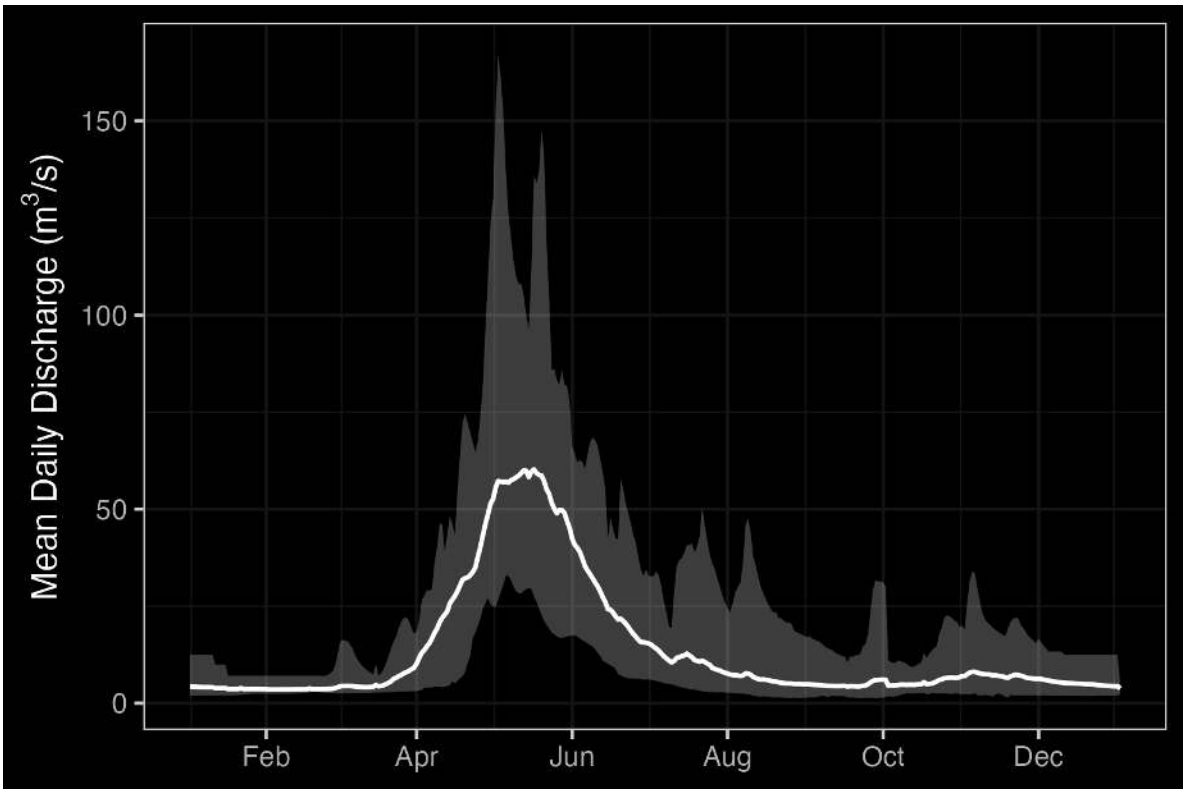


Figure 1.5: Chilako River Near Prince George (Station #08JC005 - Lat 53.808891 Lon -122.988892). Available mean daily discharge data from 1960 to 1974.

1.6 Fisheries

The Fraser River watershed is the largest salmon-producing river system in British Columbia and one of the most significant on the Pacific Coast. It provides critical habitat for anadromous salmonids, resident freshwater species, and other aquatic organisms. The river supports indigenous, commercial, and recreational fisheries, with Pacific salmon (Oncorhynchus spp.) playing a key ecological and economic role.

1.6.1 Lhtakoh

The Fraser River mainstem serves as the primary migration corridor for all anadromous fish species returning to spawn in its tributaries. Historically, the Fraser supported some of the largest sockeye and chinook salmon runs in North America. However, climate change, habitat degradation, and fisheries pressures have led to declining salmon populations in recent decades.

Upper Fraser sockeye populations have been in decline for several decades, likely due to reduced flows and altered water temperatures, affecting migration and spawning success (Levy and Nicklin 2018). The Early Stuart and Late Stuart sockeye are now classified as “Endangered” by COSEWIC (COSEWIC 2017). Under the Wild Salmon Policy, several Upper Fraser sockeye conservation units have been classified as “red-zoned” (Levy and Nicklin 2018).

The Fraser River mainstem serves as the primary migration corridor for all anadromous fish species returning to spawn in its tributaries. Historically, the Fraser supported some of the largest sockeye and chinook salmon runs in North America. However, climate change, habitat degradation, and fisheries pressures have led to declining salmon populations in recent decades.

The 2019 Big Bar landslide created a significant barrier to salmon migration in the Fraser River, further stressing already vulnerable populations. Extensive mitigation efforts, including rock removal and the construction of a fishway, have helped improve passage, with an estimated 2.9 million salmon successfully navigating the site in 2022. The Upper Fraser Fisheries Conservation Alliance (UFFCA) has played a key role in supporting emergency response and recovery planning, working with federal and provincial agencies to ensure First Nations’ interests and traditional knowledge are incorporated into long-term recovery strategies. This includes ongoing monitoring, habitat restoration, and collaborative management to mitigate future risks to Fraser salmon populations (“Upper Fraser Fisheries Conservation Alliance,” n.d.).

1.6.2 Nechakoh

The Nechako River, a tributary of the Fraser River, supports Chinook salmon populations and serves as a migration corridor for sockeye salmon that spawn in the Stuart and Nadina/Francois Basins. Since the construction of the Kenney Dam in the 1950s, flows in the Nechako River have been regulated by Rio Tinto Alcan for hydroelectric power generation at the Kemano Generating Station on the Pacific Coast. In response to concerns over impacts on Nechako Chinook and Upper Fraser sockeye, flow management practices have been implemented. Since 1987, the Nechako Fisheries Conservation Program (NFCP) has operated an annual monitoring program, focussed on Nechako Chinook and migratory sockeye salmon designed to monitor the effectiveness of conservation measures specified in the 1987 Settlement Agreement between Canada, British Columbia, and Alcan (Levy and Nicklin 2018).

The Nechako River also supports a genetically distinct and endangered population of white sturgeon with low natural recruitment. To address this decline, the Nechako White Sturgeon Recovery Initiative (NWSRI) was established, implementing conservation measures such as the Nechako White Sturgeon Conservation Centre. The facility focuses on conservation aquaculture to maintain genetic diversity and support population recovery. Since 2006, the NWSRI has been

releasing tagged juvenile sturgeon annually into the Nechako River to aid in species restoration (“Nechako White Sturgeon Recovery Initiative | Home” n.d.).

Indigenous fisheries organizations, including individual First Nations, the Carrier Sekani Tribal Council, and the Upper Fraser Fisheries Conservation Alliance (UFFCA), are actively involved in fisheries management in the Nechako watershed. These organizations work to support conservation while ensuring the sustainability of Indigenous fisheries, which have cultural and subsistence importance (“Upper Fraser Fisheries Conservation Alliance,” n.d.).

1.6.3 François Lake

François Lake is one of the largest natural lakes in BC and supports landlocked Kokanee (O. nerka), as well as migratory sockeye salmon that access the lake via the Stellako River. François Lake is a key rearing area for juvenile salmon before migrating to the Fraser River.

1.6.4 Morkill River

The Morkill River, a tributary of the Upper Fraser, supports Bull Trout, Mountain Whitefish, and Rainbow Trout. It has limited salmon presence but contributes cold water inputs to the Fraser River, which may benefit migrating fish during warm summer months.

1.6.5 Salmon Stock Assessment Data

Fisheries and Oceans Canada stock assessment data was accessed via the NuSEDS-New Salmon Escapement Database System through the Open Government Portal with results presented here. A brief memo on the data extraction process is available here.

1.6.6 Fish Species

Summary of historical fish observations in the Upper Fraser River, Nechako River, Lower Chilako River, and François Lake watershed groups (Table 1.1) (MoE 2024).

Scientific Name	Species Name	BC List	COSEWIC	Bulkley	Kispiox	Kalum	Morice	Zymoetz
Catostomus catostomus	Longnose Sucker	Yellow	–	Yes	Yes	–	Yes	Yes
Catostomus commersonii	White Sucker	Yellow	–	Yes	Yes	Yes	Yes	–
Catostomus macrocheilus	Largescale Sucker	Yellow	–	Yes	Yes	Yes	Yes	Yes
Chrosomus eos	Northern Redbelly Dace	Yellow	–	Yes	–	–	–	–
Coregonus clupeaformis	Lake Whitefish	Yellow	–	Yes	Yes	–	Yes	–
Coregonus sardinella	Least Cisco	Blue	–	–	–	Yes	–	–
Cottus aleuticus	Coastrange Sculpin (formerly Aleutian Sculpin)	Yellow	–	Yes	Yes	Yes	Yes	–
Cottus asper	Prickly Sculpin	Yellow	–	Yes	Yes	Yes	Yes	Yes
Cottus cognatus	Slimy Sculpin	Yellow	–	–	Yes	Yes	–	–
Couesius plumbeus	Lake Chub	Yellow	DD	Yes	Yes	Yes	Yes	–
Entosphenus tridentatus	Pacific Lamprey	Yellow	–	Yes	–	Yes	Yes	–
Gasterosteus aculeatus	Threespine Stickleback	Yellow	–	–	Yes	Yes	–	–
Hybognathus hankinsoni	Brassy Minnow	No Status	–	Yes	–	–	–	–
Lampetra ayresii	River Lamprey	Yellow	–	–	–	Yes	–	–
Lota lota	Burbot	Yellow	–	Yes	Yes	Yes	Yes	Yes
Mylocheilus caurinus	Peamouth Chub	Yellow	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus clarkii	Cutthroat Trout	No Status	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus clarkii	Cutthroat Trout (Anadromous)	No Status	–	Yes	Yes	–	–	Yes
Oncorhynchus clarkii clarkii	Coastal Cutthroat Trout	Blue	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus clarkii lewisi	Westslope (Yellowstone) Cutthroat Trout	Blue	SC (Nov 2016)	–	Yes	Yes	–	–
Oncorhynchus gorbuscha	Pink Salmon	Not Reviewed	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus keta	Chum Salmon	Not Reviewed	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus kisutch	Coho Salmon	Not Reviewed	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus mykiss	Rainbow Trout	Yellow	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus mykiss	Steelhead	Yellow	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus mykiss	Steelhead (Summer-run)	Yellow	–	Yes	–	–	Yes	–

Scientific Name	Species Name	BC List	COSEWIC	Bulkley	Kispiox	Kalum	Morice	Zymoetz
Oncorhynchus nerka	Kokanee	Not Reviewed	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus nerka	Sockeye Salmon	Not Reviewed	–	Yes	Yes	Yes	Yes	Yes
Oncorhynchus tshawytscha	Chinook Salmon	Not Reviewed	E/T/SC/DD/NAR (Nov 2020)	Yes	Yes	Yes	Yes	Yes
Prosopium coulterii	Pygmy Whitefish	Yellow	NAR (Nov 2016)	Yes	Yes	–	Yes	–
Prosopium coulterii pop. 3	Giant Pygmy Whitefish	Yellow	NAR (Nov 2016)	Yes	–	–	–	–
Prosopium cylindraceum	Round Whitefish	Yellow	–	–	–	Yes	–	–
Prosopium williamsoni	Mountain Whitefish	Yellow	–	Yes	Yes	Yes	Yes	Yes
Ptychocheilus oregonensis	Northern Pikeminnow	Yellow	–	Yes	Yes	–	Yes	Yes
Pungitius pungitius	Ninespine Stickleback	Unknown	–	Yes	–	–	–	–
Rhinichthys cataractae	Longnose Dace	Yellow	–	Yes	Yes	Yes	Yes	Yes
Rhinichthys falcatus	Leopard Dace	Yellow	NAR (May 1990)	–	–	–	Yes	–
Richardsonius balteatus	Redside Shiner	Yellow	–	Yes	Yes	Yes	Yes	Yes
Salvelinus confluentus	Bull Trout	Blue	SC (Nov 2012)	Yes	Yes	Yes	Yes	Yes
Salvelinus fontinalis	Brook Trout	Exotic	–	Yes	–	–	Yes	–
Salvelinus malma	Dolly Varden	Yellow	–	Yes	Yes	Yes	Yes	Yes
Salvelinus namaycush	Lake Trout	Yellow	–	Yes	Yes	–	Yes	–
–	All Salmon	–	–	–	Yes	Yes	–	–
–	Arctic Char	–	–	–	–	–	Yes	–
–	Chub (General)	–	–	–	Yes	–	–	–
–	Cutthroat/Rainbow cross	–	–	Yes	Yes	Yes	–	–
–	Dace (General)	–	–	–	–	–	Yes	–
–	Lamprey (General)	–	–	Yes	Yes	Yes	Yes	–
–	Minnow (General)	–	–	Yes	Yes	–	Yes	–
–	Mottled Sculpin	–	–	Yes	–	–	–	–
–	Salmon (General)	–	–	Yes	Yes	–	Yes	Yes
–	Sculpin (General)	–	–	Yes	Yes	Yes	Yes	Yes
–	Squanga	–	–	–	Yes	–	–	–
–	Stickleback (General)	–	–	–	Yes	Yes	–	–
–	Sucker (General)	–	–	Yes	Yes	Yes	Yes	Yes

Scientific Name	Species Name	BC List	COSEWIC	Bulkley	Kispiox	Kalum	Morice	Zymoetz
–	Whitefish (General)	–	–	Yes	Yes	Yes	Yes	Yes

* COSEWIC abbreviations :
SC - Special concern
DD - Data deficient
NAR - Not at risk
E - Endangered
T - Threatened

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

A review of available fisheries data, for the Nechako River, Lower Chilako River, François Lake, Morkill River and Upper Fraser River watershed groups, 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 1.6 - 1.7 - 1.8). 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 1.2: Summary of historic fish observations vs. stream gradient category for the Nechako River, Lower Chilako River, François Lake, Morkill River and Upper Fraser River watershed groups.

species_code	Gradient	Count	total_spp	Percent
BT	0 - 3 %	304	446	68
BT	03 - 5 %	53	446	12
BT	05 - 8 %	36	446	8
BT	08 - 15 %	42	446	9
BT	15 - 22 %	7	446	2
BT	22+ %	4	446	1
CH	0 - 3 %	745	800	93
CH	03 - 5 %	26	800	3
CH	05 - 8 %	16	800	2
CH	08 - 15 %	12	800	2
CH	15 - 22 %	1	800	0
CM	0 - 3 %	42	49	86

1.6 Fisheries

species_code	Gradient	Count	total_spp	Percent
CM	05 - 8 %	1	49	2
CM	08 - 15 %	3	49	6
CM	22+ %	1	49	2
CO	0 - 3 %	113	137	82
CO	03 - 5 %	8	137	6
CO	05 - 8 %	7	137	5
CO	08 - 15 %	7	137	5
CO	15 - 22 %	1	137	1
CO	22+ %	1	137	1
CT	0 - 3 %	266	284	94
CT	03 - 5 %	7	284	2
CT	05 - 8 %	5	284	2
CT	08 - 15 %	5	284	2
CT	15 - 22 %	1	284	0
DV	0 - 3 %	200	322	62
DV	03 - 5 %	60	322	19
DV	05 - 8 %	32	322	10
DV	08 - 15 %	26	322	8
DV	15 - 22 %	3	322	1
DV	22+ %	1	322	0
PK	0 - 3 %	44	48	92
PK	03 - 5 %	1	48	2
PK	05 - 8 %	2	48	4
PK	08 - 15 %	1	48	2
RB	0 - 3 %	3942	4621	85
RB	03 - 5 %	320	4621	7
RB	05 - 8 %	217	4621	5
RB	08 - 15 %	118	4621	3
RB	15 - 22 %	18	4621	0
RB	22+ %	6	4621	0
SK	0 - 3 %	51	52	98
SK	08 - 15 %	1	52	2
ST	0 - 3 %	59	63	94

species_code	Gradient	Count	total_spp	Percent
ST	05 - 8 %	1	63	2
ST	08 - 15 %	1	63	2

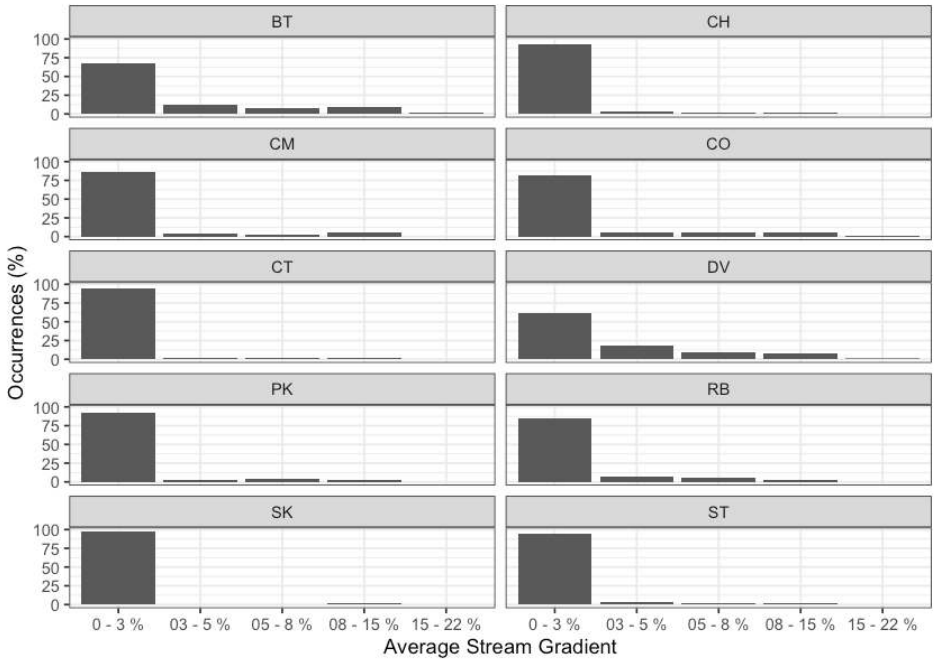


Figure 1.6: Summary of historic fish observations vs. stream gradient category for the Nechako River, Lower Chilako River, François Lake, Morkill River and Upper Fraser River watershed groups.

Table 1.3: Summary of historic fish observations vs. channel width category for the Nechako River, Lower Chilako River, François Lake, Morkill River and Upper Fraser River watershed groups.

species_code	Width	Count	total_spp	Percent
BT	0 - 2m	12	446	3
BT	02 - 04m	58	446	13
BT	04 - 06m	37	446	8
BT	06 - 10m	102	446	23
BT	10 - 15m	34	446	8
BT	15m+	184	446	41
BT	–	19	446	4

species_code	Width	Count	total_spp	Percent
CH	0 - 2m	14	800	2
CH	02 - 04m	17	800	2
CH	04 - 06m	21	800	3
CH	06 - 10m	60	800	8
CH	10 - 15m	30	800	4
CH	15m+	629	800	79
CH	–	29	800	4
CM	0 - 2m	4	49	8
CM	02 - 04m	2	49	4
CM	04 - 06m	9	49	18
CM	06 - 10m	4	49	8
CM	10 - 15m	4	49	8
CM	15m+	23	49	47
CM	–	3	49	6
CO	0 - 2m	14	137	10
CO	02 - 04m	21	137	15
CO	04 - 06m	15	137	11
CO	06 - 10m	22	137	16
CO	10 - 15m	22	137	16
CO	15m+	41	137	30
CO	–	2	137	1
CT	0 - 2m	107	284	38
CT	02 - 04m	21	284	7
CT	04 - 06m	8	284	3
CT	06 - 10m	22	284	8
CT	10 - 15m	48	284	17
CT	15m+	48	284	17
CT	–	30	284	11
DV	0 - 2m	76	322	24
DV	02 - 04m	95	322	30
DV	04 - 06m	37	322	11
DV	06 - 10m	23	322	7
DV	10 - 15m	18	322	6

species_code	Width	Count	total_spp	Percent
DV	–	20	322	6
PK	0 - 2m	2	48	4
PK	02 - 04m	5	48	10
PK	04 - 06m	10	48	21
PK	06 - 10m	7	48	15
PK	10 - 15m	4	48	8
PK	15m+	13	48	27
PK	–	7	48	15
RB	0 - 2m	468	4621	10
RB	02 - 04m	1377	4621	30
RB	04 - 06m	339	4621	7
RB	06 - 10m	660	4621	14
RB	10 - 15m	259	4621	6
RB	15m+	583	4621	13
RB	–	935	4621	20
SK	0 - 2m	1	52	2
SK	02 - 04m	3	52	6
SK	06 - 10m	4	52	8
SK	10 - 15m	3	52	6
SK	15m+	40	52	77
SK	–	1	52	2
ST	0 - 2m	1	63	2
ST	02 - 04m	5	63	8
ST	04 - 06m	3	63	5
ST	06 - 10m	2	63	3
ST	10 - 15m	20	63	32
ST	15m+	18	63	29
ST	–	14	63	22

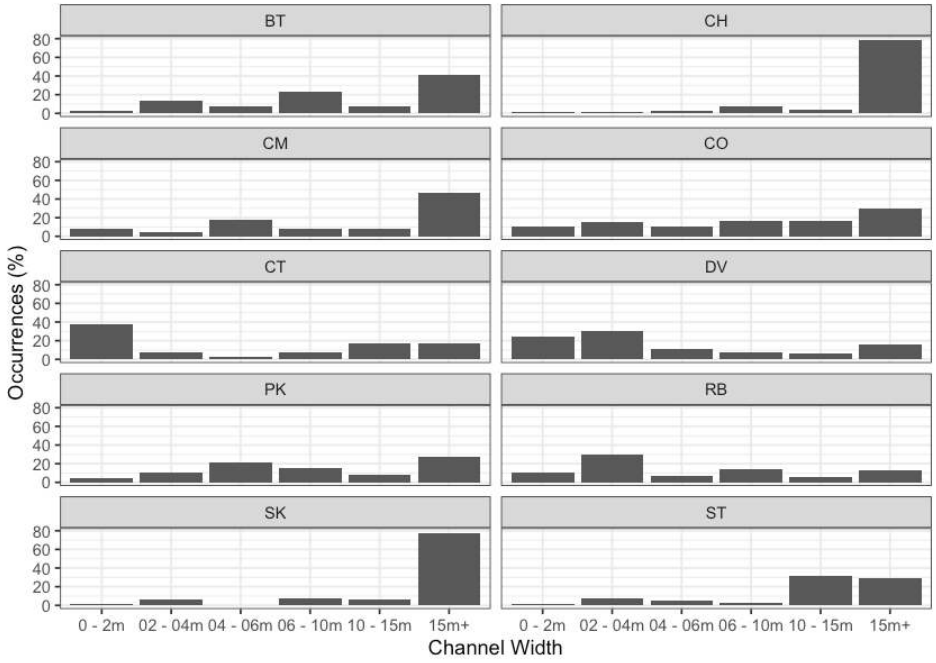


Figure 1.7: Summary of historic fish observations vs. channel width category for the Parsnip River watershed group.

Table 1.4: Summary of historic fish observations vs. watershed size category for the Nechako River, Lower Chilako River, François Lake, Morkill River and Upper Fraser River watershed groups.

species_code	Watershed	count_wshd	total_spp	Percent
BT	0 - 25km2	165	446	37
BT	25 - 50km2	62	446	14
BT	50 - 75km2	12	446	3
BT	75 - 100km2	14	446	3
BT	100km2+	193	446	43
CH	0 - 25km2	76	800	10
CH	25 - 50km2	31	800	4
CH	50 - 75km2	32	800	4
CH	75 - 100km2	4	800	0
CH	100km2+	657	800	82
CM	0 - 25km2	12	49	24
CM	25 - 50km2	6	49	12

species_code	Watershed	count_wshd	total_spp	Percent
CM	50 - 75km2	4	49	8
CM	75 - 100km2	2	49	4
CM	100km2+	25	49	51
CO	0 - 25km2	35	137	26
CO	25 - 50km2	22	137	16
CO	50 - 75km2	14	137	10
CO	75 - 100km2	11	137	8
CO	100km2+	55	137	40
CT	0 - 25km2	158	284	56
CT	25 - 50km2	15	284	5
CT	50 - 75km2	5	284	2
CT	75 - 100km2	9	284	3
CT	100km2+	97	284	34
DV	0 - 25km2	210	322	65
DV	25 - 50km2	23	322	7
DV	50 - 75km2	8	322	2
DV	75 - 100km2	22	322	7
DV	100km2+	59	322	18
PK	0 - 25km2	15	48	31
PK	25 - 50km2	15	48	31
PK	50 - 75km2	1	48	2
PK	75 - 100km2	1	48	2
PK	100km2+	16	48	33
RB	0 - 25km2	2867	4621	62
RB	25 - 50km2	308	4621	7
RB	50 - 75km2	190	4621	4
RB	75 - 100km2	395	4621	9
RB	100km2+	861	4621	19
SK	0 - 25km2	5	52	10
SK	25 - 50km2	2	52	4
SK	75 - 100km2	2	52	4
SK	100km2+	43	52	83
ST	0 - 25km2	22	63	35

species_code	Watershed	count_wshd	total_spp	Percent
ST	50 - 75km2	1	63	2
ST	75 - 100km2	3	63	5
ST	100km2+	33	63	52

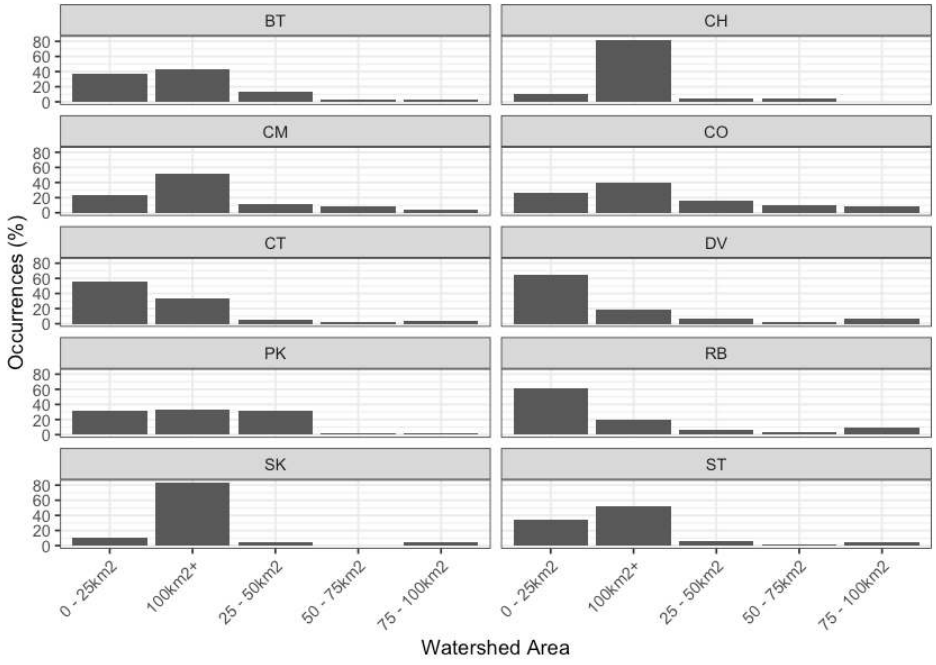


Figure 1.8: Summary of historic fish observations vs. watershed size category for the Nechako River, Lower Chilako River, François Lake, Morkill River and Upper Fraser River watershed groups.

2 Methods

2.1 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 and is served on the cloud using source code stored here. This environment is intended to be a space where project team members can access, 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 on 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 the scripts used for GIS project creation and updates 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.

2.1.1 Mapping

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.

2.2 Planning

2.2.1 Habitat Modelling

Habitat modelling used to help guide planning for field assessments is generated by `bcfishpass` (Norris [2020] 2024) which has been designed to prioritize potential fish passage barriers for assessment or remediation by generating a simple model of aquatic habitat connectivity. We utilize the `bcfishpass` access model, linear spawning/rearing habitat model and lateral habitat connectivity for planning purposes. These models provide a valuable starting point, but their results are not definitive and should always be considered with professional judgment. Detailed information regarding model methodology, select parameters and known model limitations are detailed in Norris ([2020] 2024) with key documentation linked below:

- Access model
- Linear spawning/rearing habitat models
- Lateral habitat model

Table 2.1 documents the custom species-specific thresholds for stream gradient and channel width applied to the linear spawning and rearing habitat model for this year's project planning. Although parameter values were often modified to provide a more conservative estimate of habitat, the thresholds used in the model are loosely based on the references provided in Table 2.2.

2.2.1.1 Statistical Support for `bcfishpass` Fish Habitat Modelling Updates

This project provided the statistical background for updates to `bcfishpass` that facilitated incorporation of channel width (observed or predicted) into species specific linear spawning/rearing habitat models. 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 (J. Thorley and Irvine 2021). In December of 2021, J. Thorley and Irvine (2021) methods were updated using a power model derived by Finnegan et al. (2005) which relates stream discharge to watershed area and mean annual precipitation resulting in J. L. Thorley, Norris, and Irvine (2021) which was utilized for channel width estimates within `bcfishpass` modelling at the time of reporting. More detailed documentation of the methodology used to facilitate both the data collection and statistical analysis can be sourced in Irvine ([2021] 2022) and J. L. Thorley, Norris, and Irvine (2021).

In 2024, in collaboration with Poisson Consulting - stream discharge and temperature causal effects pathways were mapped with the intent of focusing aquatic restoration actions in areas of highest potential for positive impacts on fisheries values (ie. elimination of areas from intrinic models where water temperatures are likely too cold to support fish production). The project began with a custom mechanistic model (visually represented here), but the model struggled to converge. The project then shifted to the air2stream model, which offers a middle ground between fully mechanistic

models—often data-intensive and reliant on quantities that are difficult to measure or estimate—and purely statistical models, which lack physical justification and perform poorly when extrapolated to new conditions (Toffolon and Piccolroaz (2015)). After several adaptations, the expected stream temperatures were best modeled using the four-parameter version of the air2stream model, with added random effects by site for each of the four parameters (Hill, Thorley, and Irvine (2024)). The data used for the model were sourced from the following locations, for years 2019-2021:

- Water temperature data collected in the Nechako Watershed were downloaded from Zenodo (Gilbert et al. 2022).
- Hourly air temperature data were obtained from the ERA-5-Land dataset via the Copernicus Climate Change Service (Muñoz Sabater (2019))
- Daily baseflow and surface runoff data were sourced from the Pacific Climate Impacts Consortium's Gridded Hydrologic Model Output using the ACCESS1-0_rcp85 scenario (Pacific Climate Impacts Consortium (n.d.)).

Table 2.1: Stream gradient and channel width thresholds used to model potentially highest value fish habitat.

Variable	Bull Trout	Chinook Salmon	Coho Salmon	Sockeye Salmon	Steelhead
Spawning Gradient Max (%)	5.5	4.5	5.5	2.5	4.5
Spawning Width Min (m)	2	4	2	2	4
Rearing Width Min (m)	1.5	1.5	1.5	1.5	1.5
Rearing Gradient Max (%)	10.5	5.5	5.5	–	8.5

*

Table 2.2: References considered for stream gradient and channel width thresholds used to model potentially highest value fish habitat. Preliminary and subject to revisions.

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

* The maximum gradient for steelhead rearing has been adjusted to 8.5% based on professional judgment, although references indicate 7.49%

2.3 Fish Passage Assessments

2.3.1 Natural Barriers to Fish Passage

Our assessments may include natural features such as waterfalls that could limit fish passage. This informs whether upstream culvert upgrades would restore access for anadromous species (e.g., salmon) or primarily benefit resident fish already upstream. We document these features by measuring height, gradient, and pool depth, recording field observations, capturing site photographs, and reviewing background sources for context.

2.3.2 Road Stream Crossings

In the field, crossings prioritized for follow-up were first assessed for fish passage following the procedures outlined in “Field Assessment for Determining Fish Passage Status of Closed Bottomed Structures” (MoE 2011). The reader is referred to (MoE 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, road 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 2.3).

Table 2.3: 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 MoE (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 (Tables 2.4 - 2.5). 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). For crossings determined to be potential barriers or barriers based on the data, a culvert fix and recommended diameter/span was proposed.

Table 2.4: 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 2.5: Fish Barrier Scoring Results (MoE 2011).

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

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

For reporting of Phase 1 - fish passage assessments within the body of this report (Table 2.4), a "total" value of habitat <20% output from `bcfishpass` was used to estimate the amount of habitat upstream of each crossing less than 20% gradient before a falls of height >5m - as recorded in MoE (2020) or documented in other `bcfishpass` online documentation. For Phase 2 - habitat confirmation sites, conservative estimates of the linear quantity of habitat to be potentially gained by fish passage restoration, steelhead rearing maximum gradient threshold (8.5%) 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 MoE (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..

2.3.3 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 help refine estimates which have since been adjusted for inflation in 2020 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 $30000/linear m and

assumed that the road could be closed during construction and a minimum bridge span of 15m. For streams with channel widths <2m, embedded culverts were reported as an effective solution with total installation costs estimated at $100k/crossing (pers. comm. Phil MacDonald, Steve Page then adjusted for inflation in 2020). 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 15 times more than forest service roads due to expenses associate with design/engineering requirements, traffic control and paving. The cost multiplier table (Table 2.6) should be considered very approximate with refinement recommended for future projects.

Table 2.6: 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
Resource	Rough	1	1	450,000	100,000
Permit	Unknown	1	1	450,000	100,000
Permit	Loose	1	1	450,000	100,000
Permit	Rough	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	150,000
Unclassified	Unknown	1	2	750,000	150,000
Local	Loose	4	1	1,500,000	200,000
Local	Paved	4	2	3,000,000	400,000
Collector	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

2.3.4 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 2.7). This project is still in its early stages with methodology changes going forward.

Table 2.7: 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

2.4 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 2.3).

During habitat confirmations, to standardize data collected and facilitate submission of the data to provincial databases, information was collected on digital field forms adapted from provincial "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 a minimum distance 300m 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.

2.4.1 Aerial Imagery

Scripted processing and serving of UAV imagery collected during the project is available at https://github.com/NewGraphEnvironment/stac_uav_bc/ (Irvine [2025] 2025). `OpenDroneMap` was utilized to produce orthomosaics, digital surface models (DSMs), and digital terrain models (DTMs) (OpenDroneMap Authors [2014] 2025). To support efficient web-based access - imagery products were converted to cloud-optimized GeoTIFFs (COGs) using `rio-cogeo`, then collated accordiong to the SpatioTemporal Asset Catalog (STAC) specification with `pystac` and uploaded to S3 storage Amazon Web Services (2025). A `titiler` tile server was set up to facilitate interactive viewing of the orthoimagery and an Application Program Interface (API) leveraging `stac-fastapi-pgstac` is served at https://images.a11s.one to enable linking of collection images through QGIS as well as remote spatial and temporal querying using open source software such as `rstac` (Development Seed [2019] 2025; stac-utils 2025; Simoes et al. 2021).

3 Results and Discussion

3.1 Site Assessment Data Since 2023

Fish passage assessment procedures conducted through SERNbc in the Upper Fraser River Watershed since 2023 are amalgamated
online within the Results and Discussion section of the report found here.

Since 2023, orthoimagery and elevation model rasters have been generated and stored as Cloud Optimized Geotiffs on a cloud service provider (AWS) with select imagery linked to in the collaborative GIS project. Additionally - a tile service has been set up to facilitate viewing and downloading of individual images, provided
athttps://www.newgraphenvironment.com/fish_passage_fraser_2023_reporting/results-and-discussion.html.

3.2 Collaborative GIS Environment

In addition to numerous layers documenting fieldwork activities since 2023, a summary of background information spatial layers and tables loaded to the collaborative GIS project (sern_fraser_2024) at the time of writing (2025-04-14) are included online here.

3.3 Planning

3.3.1 Habitat Modelling

Habitat modelling from `bcfishpass` including access model, linear spawning/rearing habitat model and lateral habitat connectivity models for watershed groups within our study area were updated for the spring of 2025 and are included spatially in the collaborative GIS project. A snapshot of these outputs related to each modeled and PSCIS stream crossing structure are also included within an `sqlite` database within this year's project reporting/code repository here.

3.3.1.1 Statistical Support for `bcfishpass` Fish Habitat Modelling Updates

Initial mapping of stream discharge and temperature causal effects pathways for the future purpose of focusing aquatic restoration actions in areas of highest potential for positive impacts on fisheries values (ie. elimination of areas from intrinsic models where water temperatures are likely too cold to support fish production) are detailed in Hill, Thorley, and Irvine (2024) which is included as Attachment - Water Temperature Modelling (page 201).

3.4 Fish Passage Assessments

Field assessments were conducted from September 09, 2023- October 09, 2024, by Allan Irvine, R.P.Bio., Mateo Winterscheidt, B.Sc, and Lucy Schick, B.Sc.

3.4.1 Road Stream Crossings

A total of 186 Fish Passage Assessments were completed, including 184 Phase 1 assessments and 2 reassessments.

Of the 186 sites where fish passage assessments were completed, 184 were not yet inventoried in the PSCIS system. This included 20 crossings considered “passable”, 31 crossings considered “potential” barriers, and 128 crossings considered “barriers” according to threshold values based on culvert embedment, outlet drop, slope, diameter (relative to channel size) and length (MoE 2011). Additionally, although all were considered fully passable, 5 crossings assessed were fords and were ranked as “unknown” according to the provincial protocol.

Reassessments were completed at 2 sites where PSICS data required updating.

A summary of crossings assessed, a rough cost estimate for remediation, and a priority ranking for follow-up for Phase 1 sites is presented in Table 3.1. Detailed data with photos are presented in Attachment - Phase 1 Data and Photos (page 197).

The “Barrier” and “Potential Barrier” rankings used in this project followed MoE (2011) and represent an assessment of passability for juvenile salmon or small resident rainbow trout under any flow conditions that may occur 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; E. A. 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 3.1: Upstream habitat estimates and cost benefit analysis for Phase 1 assessments ranked as a ‘barrier’ or ‘potential’ barrier. NA

PSCIS ID	External ID	Stream	Road	Barrier Result	Habitat value	Habitat Upstream (km)	Stream Width (m)	Priority	Fix	Cost Est ($K)
4931	–	Teepee Creek	Mount Tinsley Pit Road	Barrier	High	0.00	5.6	Moderate	OBS	450
7620	–	Teepee Creek	Railway	Barrier	Medium	1.27	7.5	Low	OBS	–
199163	5400442	Tributary to Endako River	Highway 16	Barrier	Medium	45.71	10.0	Low	OBS	11250
199164	24707052	Tributary to Endako River	West Decker Road	Potential	Medium	45.96	4.0	Moderate	OBS	3000
199165	5400216	Tributary to Endako River	Highway 16	Barrier	Medium	1.31	2.6	Low	OBS	11250
199166	5400121	Tributary to Endako River	Priestly Station Road	Barrier	Medium	4.11	1.8	High	SS-CBS	200
199167	5400192	Sam Ross Creek	Highway 16	Barrier	Medium	17.36	1.6	Low	SS-CBS	1500
199168	5400235	Alf Creek	Highway 16	Barrier	Low	9.08	1.0	Low	SS-CBS	1500
199169	5400045	Tributary to Fraser Lake	Highway 16	Barrier	Medium	46.08	4.0	Moderate	OBS	26625
199170	5400003	Perry Creek	Stella Road	Barrier	Low	13.25	1.0	Low	SS-CBS	400
199171	5400202	Tributary to Fraser Lake	Gala Bay Road	Barrier	High	3.86	1.7	High	SS-CBS	200
199172	5400203	Scotch Creek	Stella Road	Barrier	High	11.80	2.6	High	OBS	4200
199173	15600277	Tributary to Nechako River	Dog Creek Road	Barrier	High	32.92	2.7	High	OBS	1500
199174	15604478	Tributary to Nechako River	Sutherland FSR	Barrier	Medium	27.43	2.5	High	OBS	450
199175	9903437	Aird Creek	Upper Mud River Road	Barrier	Low	6.55	1.2	Moderate	SS-CBS	200
199176	9901826	Chilako Creek	Upper Mud River Road	Barrier	Low	16.54	1.7	Low	SS-CBS	–
199177	9903963	Tributary to Chelako River	McBride Timber Road	Barrier	Low	15.81	1.7	Moderate	SS-CBS	100
199178	9900367	Beaverley Creek	Blackwater Road	Potential	High	369.48	5.0	Low	OBS	–
199179	24716727	Murray Creek	Loop Rd	Barrier	High	213.03	6.2	Moderate	OBS	3000

PSCIS ID	External ID	Stream	Road	Barrier Result	Habitat value	Habitat Upstream (km)	Stream Width (m)	Priority	Fix	Cost Est ($K)
199182	15600107	East Murray Creek	Snell Rd E	Potential	Low	160.98	1.7	Low	SS-CBS	200
199183	15600190	McIntosh Creek	Mcleod Pit Rd	Potential	Low	25.18	1.6	Low	SS-CBS	200
199184	15603995	McIntosh Creek	Stringer Rd	Barrier	Low	3.43	0.7	Low	SS-CBS	200
199185	15600011	Knight Creek	Gulbranson Rd	Potential	Medium	128.02	1.7	Low	SS-CBS	200
199186	15600572	Tributary to Tritt Creek	Sturgeon Pt Rd	Barrier	Low	31.31	3.0	Low	OBS	–
199187	15600483	Clear Creek	Braeside Rd	Barrier	High	139.48	4.7	Moderate	OBS	3000
199188	15600493	Tributary to Clear Creek	Blue Mountain Road	Barrier	Medium	7.08	1.1	Low	SS-CBS	200
199189	15600520	Clear Creek	Highway 27 S	Potential	Medium	65.51	2.2	Low	OBS	11250
199190	15600119	Clear Creek	Highway 27 S	Barrier	High	103.17	2.5	Moderate	OBS	11250
199191	24716705	Moss Creek	Braeside Rd	Barrier	Medium	25.22	2.2	High	OBS	3000
199192	15600122	Redmond Creek	Braeside Rd	Barrier	High	57.76	1.9	High	SS-CBS	400
199193	15600124	Redmond Creek	Walker Rd	Barrier	Medium	20.89	0.9	Low	SS-CBS	200
199194	15600362	Tributary to Hulatt Creek	Barsness Rd	Potential	Low	24.31	0.8	Low	SS-CBS	200
199195	15600434	Gilbert Creek	Gilbert Rd	Barrier	Low	21.62	1.9	Low	SS-CBS	200
199196	15600431	Gilbert Creek	Sturgeon Point Rd	Barrier	Medium	23.69	1.2	Low	SS-CBS	400
199197	15600311	Knight Creek	Bave Rd	Barrier	Medium	63.97	1.3	Low	SS-CBS	200
199199	15600305	Leduc Creek	Sackner Rd	Potential	Low	21.07	1.0	Low	SS-CBS	400
199200	15600459	East Murray Creek	Strieger Rd	Potential	Low	125.98	2.6	Low	OBS	1500
199201	15600182	Tributary to Nechako River	Sackner Rd	Barrier	Medium	13.17	1.3	Moderate	SS-CBS	400
199202	15600490	Tributary to Clear Creek	Highway 27 S	Barrier	Medium	6.58	1.1	Moderate	SS-CBS	1500
199203	15603729	Nine Mile Creek	Dog Creek FSR	Potential	High	102.14	2.4	Moderate	OBS	450
199204	15600285	Nine Mile Creek	Settlement Rd	Barrier	Medium	127.47	3.0	Moderate	OBS	1500

PSCIS ID	External ID	Stream	Road	Barrier Result	Habitat value	Habitat Upstream (km)	Stream Width (m)	Priority	Fix	Cost Est ($K)
199206	15600478	Croft Creek	Landaluza Rd	Potential	Medium	17.32	0.9	Low	SS-CBS	200
199207	5400450	Endako River	Highway 16 W	Barrier	High	0.00	3.1	Moderate	OBS	11250
199208	5400445	Allen Creek	Highway 16 W	Barrier	Medium	0.00	3.4	Low	OBS	11250
199209	5400440	Powder House Creek	Highway 16 W	Barrier	Medium	35.21	3.5	Low	OBS	11250
199210	5406295	Powder House Creek	Rail	Barrier	Medium	35.28	4.1	Moderate	OBS	11250
199211	5400044	Decker Creek	Highway 16 W	Barrier	Medium	51.74	4.3	Low	OBS	11250
199212	5400227	Gauvin Creek	Highway 16 W	Barrier	Low	2.08	1.1	Low	SS-CBS	1500
199213	5400286	Guyishton Creek	Highway 35	Barrier	High	31.35	2.8	Moderate	OBS	11250
199214	5400042	Wardrop Creek	Highway 16	Barrier	High	23.87	2.4	Moderate	OBS	13500
199215	5400157	Sheraton Creek	Highway 16	Barrier	High	5.39	6.5	High	OBS	13500
199216	5401774	Sheraton Creek	Unnamed	Barrier	High	5.69	5.6	High	OBS	450
199217	5400019	Four Mile Creek	Highway 16	Barrier	Low	6.00	1.1	Low	SS-CBS	1500
199218	5400239	Robertson Creek	Highway 16	Barrier	Low	68.64	2.3	Low	OBS	15750
199219	15600265	Tributary to Nechako River	Lily Lake Rd	Barrier	Low	6.12	1.9	Low	SS-CBS	200
199220	15600301	Tributary to Smith Creek	Lily Lake Rd	Barrier	Medium	49.52	1.2	Moderate	SS-CBS	200
199221	15600302	Smith Creek	Lily Lake Road	Barrier	Medium	304.60	6.1	Low	OBS	1500
199222	15600624	Neuro Creek	Ens Rd	Barrier	Low	16.78	0.9	Low	SS-CBS	400
199223	15600626	Tributary to Neuco Creek	Ens Rd	Barrier	Low	16.53	1.6	Low	SS-CBS	400
199224	15600076	Tributary to Hulatt Creek	Highway 16	Barrier	Low	25.43	1.2	Low	SS-CBS	1500
199225	15600629	Hulatt Creek	Highway 16	Barrier	Low	51.51	3.3	Low	SS-CBS	1500
199226	15600057	Tributary to Cluculz Lake	Highway 16	Barrier	Medium	20.71	2.6	Moderate	OBS	15750
199227	15603872	Norman Creek	Lloyd Dr	Potential	Medium	123.33	3.1	Moderate	OBS	2100

PSCIS ID	External ID	Stream	Road	Barrier Result	Habitat value	Habitat Upstream (km)	Stream Width (m)	Priority	Fix	Cost Est ($K)
Bednesti Lake	Highway 16	Barrier	Medium	23.84	1.7	Moderate	SS-CBS	1500		
199229	9903105	Zelkwas Creek	Isle Pierre Rd	Barrier	Medium	36.19	2.2	Low	OBS	1500
199230	9900404	Sweden Creek	Highway 16	Barrier	Medium	52.91	2.2	Low	SS-CBS	1500
199231	9900446	Kellogg Creek	Highway 16	Barrier	Medium	84.78	4.1	Moderate	OBS	15750
199232	9902577	Beaverley Creek	Highway 16	Barrier	High	525.10	7.6	High	OBS	11250
199233	9900262	Little Beaverley Creek	Highway 16	Barrier	Medium	11.30	0.8	Low	SS-CBS	1500
199234	9900380	Tributary to Chelako River	Upper Mud River Rd	Barrier	Medium	14.23	1.6	Moderate	SS-CBS	200
199235	9900385	Tributary to Chelako River	Upper Mud River Rd	Barrier	Low	12.28	1.4	Low	SS-CBS	200
199236	9900277	Tributary to Beaverley Creek	East Beaverley Rd	Potential	Medium	41.34	2.3	Low	OBS	1500
199237	13900100	Snowshoe Creek	Highway 16a	Barrier	High	72.49	15.0	Moderate	OBS	14625
199238	13900026	Tributary to Fraser River	Penny Rd	Barrier	Medium	6.12	1.4	Low	SS-CBS	200
199239	13905537	Tributary to Fraser River	Railway	Barrier	Medium	9.10	3.3	Moderate	SS-CBS	1500
199240	13900027	72 Mile Creek	Penny Rd	Barrier	Medium	7.57	3.1	Moderate	OBS	1500
199241	13905538	Tributary to Fraser River	Railway	Barrier	Medium	7.54	3.1	Low	SS-CBS	1500
199242	13900309	Tributary to Fraser River	Penny Rd	Barrier	High	3.40	3.8	Moderate	OBS	1500
199243	13900306	Tributary to Fraser River	Penny Rd	Barrier	Medium	2.25	3.0	Low	OBS	1500
199244	13900305	Tributary to Fraser River	Penny Rd	Barrier	Low	3.19	2.2	Moderate	OBS	450
199245	13903451	Tributary to Fraser River	Penny Rd	Barrier	Medium	2.89	1.4	Moderate	SS-CBS	100
199246	13903452	Tributary to Fraser River	Penny Rd	Barrier	Medium	0.77	3.2	High	OBS	450
199247	13903450	Tributary to Fraser River	Penny Rd	Barrier	Medium	8.75	1.9	Moderate	SS-CBS	100
199248	13903449	Tributary to Fraser River	Penny Rd	Barrier	Low	0.41	0.7	Moderate	SS-CBS	100

3.4 Fish Passage Assessments

PSCIS ID	External ID	Stream	Road	Barrier Result	Habitat value	Habitat Upstream (km)	Stream Width (m)	Priority	Fix	Cost Est ($K)
199250	13900052	Robinson Creek	Upper Fraser Rd	Barrier	Medium	3.15	1.6	Low	SS-CBS	1500
199251	13905581	Robinson Creek	Rail	Potential	Low	3.30	1.1	Low	SS-CBS	1500
199252	13900094	Tributary to Fraser River	Upper Fraser Road	Barrier	Medium	2.46	1.8	Low	SS-CBS	1500
199253	13903446	Tributary to Fraser River	Upper Fraser Road	Barrier	Medium	15.02	2.0	Moderate	OBS	11250
199254	13900043	Tributary to Fraser River	Upper Fraser Rd	Barrier	Medium	1.97	2.3	Moderate	OBS	13500
199255	13903617	Tributary to Kenneth Creek	Bowron FSR	Barrier	Medium	1.63	2.6	Moderate	OBS	450
199256	13903184	Kenneth Creek	Highway 16	Barrier	High	171.12	9.4	High	OBS	11250
199257	13903183	Tributary to Kenneth Creek	Highway 16	Barrier	Medium	4.21	2.2	Moderate	OBS	12375
199258	13900192	Tributary to Kenneth Creek	Highway 16	Barrier	High	2.56	2.3	Moderate	OBS	11250
199259	13900261	Tributary to Sugarbowl Creek	Highway 16	Barrier	Medium	0.13	2.5	High	SS-CBS	1500
199260	13900260	Tributary to Sugarbowl Creek	Highway 16	Barrier	High	2.30	5.2	High	OBS	22500
199261	13900270	Tributary to Sugarbowl Creek	Highway 16	Barrier	Medium	3.92	3.7	Moderate	OBS	18000
199262	13900196	Hungary Creek	Highway 16	Barrier	High	13.41	11.6	Low	OBS	12375
199263	13900198	Lunate Creek	Highway 16	Barrier	Medium	6.31	2.4	Moderate	SS-CBS	1500
199264	13903179	Tributary to Fraser River	Penny Access Road	Barrier	Medium	10.73	1.6	Low	SS-CBS	200
199265	13900200	Tributary to Driscoll Creek	Highway 16	Barrier	Low	2.70	1.1	Low	SS-CBS	1500
199266	13900053	Tributary to Fraser River	Penny Access Road	Potential	Medium	9.37	2.0	Low	OBS	–
199267	13900201	Driscoll Creek	Highway 16	Barrier	High	35.68	6.4	Moderate	OBS	12375
199268	13900157	Catfish Creek	Highway 16	Barrier	High	0.00	6.7	Moderate	OBS	26625
199269	13900019	Tributary to Fraser River	Highway 16	Barrier	High	0.00	3.9	Low	OBS	11250

PSCIS ID	External ID	Stream	Road	Barrier Result	Habitat value	Habitat Upstream (km)	Stream Width (m)	Priority	Fix	Cost Est ($K)
199270	13900066	Clyde Creek	Highway 16	Barrier	High	4.06	6.4	Low	OBS	26625
199271	13900064	McIntosh Creek	Highway 16	Barrier	High	0.00	6.2	Low	OBS	26625
199272	22200151	Cranberry Creek	Pine Road	Barrier	High	15.87	4.0	Moderate	OBS	3000
199273	13900077	Hankins Creek	Eddy Rd	Barrier	High	7.71	6.7	Moderate	OBS	3000
199274	13900003	Dominion Creek	1st Ave	Barrier	High	5.89	2.3	Moderate	OBS	3000
199275	13900030	Tributary to Dominion Creek	Horseshoe Lake Rd	Barrier	Low	6.88	0.9	Low	SS-CBS	200
199276	22200081	Crooked Creek	Loseth Road	Barrier	Medium	0.51	3.4	Moderate	OBS	3000
199277	22201951	Crooked Creek	Railway	Barrier	Medium	0.50	3.6	Moderate	OBS	11250
199278	22201176	Teepee Creek	Highway 5	Barrier	High	0.54	4.5	High	OBS	11250
199279	22200022	Tributary to Fraser river	Hinkelman Rd	Barrier	Low	0.76	1.4	Low	SS-CBS	400
199280	22200075	L,ÄôEsrange Creek	L,Äôheureux Road	Barrier	Medium	1.11	2.2	Moderate	OBS	1500
199281	22201218	Goslin Creek	Highway 16	Barrier	Medium	1.51	1.0	Moderate	SS-CBS	1500
199282	22201229	Holliday Creek	Highway 16	Barrier	High	9.58	10.8	Moderate	OBS	11250
199283	22200029	Tributary to Fraser River	River Rd	Potential	Low	1.64	1.2	Low	SS-CBS	200
199284	22200067	Spittal Creek	Care Road	Barrier	High	–	5.8	Moderate	OBS	–
199285	22200051	Tributary to Fraser River	Read Rd	Barrier	Medium	0.23	2.5	Low	OBS	3000
199286	22200061	Spittal Creek	Highway 16	Barrier	High	1.80	5.8	Low	OBS	450
199287	5400446	Rentoul Creek	Highway 16	Barrier	High	0.00	3.8	High	OBS	11250
199288	5400589	Tributary to Endako River	West Decker Rd	Potential	Medium	46.58	4.5	Moderate	OBS	–
199289	5400423	Stearns Creek	Tintagel Road	Barrier	High	32.19	5.0	Moderate	OBS	3000
199290	5400024	Endako River	Highway 16	Barrier	High	641.19	17.0	Low	OBS	16500
199291	15600273	Tahultzu Creek	Zalenski Road	Potential	Medium	94.93	3.0	High	OBS	1500
199292	24727338	Ormond Creek	Stella Road	Barrier	High	318.01	6.0	Low	OBS	–
199295	15600106	East Murray Creek	Northside Rd	Barrier	Low	159.95	2.5	Low	OBS	3000
199296	15600488	Tributary to Clear Creek	Highway 27S	Barrier	Medium	13.06	1.3	Moderate	SS-CBS	1500
199297	15600120	Clear Creek	Fourteen Mile Rd	Potential	Medium	92.61	2.5	Low	OBS	1500

3.4 Fish Passage Assessments

PSCIS ID	External ID	Stream	Road	Barrier Result	Habitat value	Habitat Upstream (km)	Stream Width (m)	Priority	Fix	Cost Est ($K)
199299	15605366	Tributary to Nechako River	Rail	Potential	Low	15.92	1.3	Low	SS-CBS	1500
199300	15600112	Goldie Creek	Highway 27 S	Barrier	Medium	171.13	2.2	Low	OBS	13500
199301	5400448	Relief Creek	Highway 16 W	Barrier	High	0.00	2.4	Moderate	OBS	13500
199302	5400181	Wardrop Creek	Roumieu drive	Barrier	Medium	24.57	0.8	Low	SS-CBS	200
199303	5403082	Steams Creek	Highway 16	Barrier	High	37.74	3.1	Moderate	OBS	11250
199304	5400193	Tchesinkut Creek	Highway 16	Barrier	Medium	409.10	8.4	Low	OBS	11250
199305	9905144	Tributary to Chilako River	Gregg FSR	Barrier	Low	14.40	1.0	Low	SS-CBS	200
199306	13900028	Tributary to Fraser River	Penny street	Barrier	Medium	–	3.4	Low	OBS	–
199307	13900308	Tributary to Fraser River	Penny Rd	Potential	High	5.56	5.9	Low	OBS	1500
199308	13900252	Wolfe Creek	Upper Fraser Rd	Potential	High	3.22	4.1	Low	OBS	11250
199309	13900050	Tributary to Fraser River	Upper Fraser Rd	Barrier	Low	1.41	1.2	Low	SS-CBS	1500
199311	13903627	Tributary to Kenneth Creek	Bowron FSR	Barrier	Low	3.04	2.1	Moderate	OBS	450
199312	13903618	Tributary to Kenneth Creek	Bowron FSR	Barrier	Medium	1.75	1.8	Low	SS-CBS	100
199313	13900193	Tributary to Kenneth Creek	Highway 16	Barrier	High	1.04	2.1	Low	OBS	11250
199314	13903148	Dominion Creek	Highway 16	Barrier	Low	14.66	2.9	Moderate	OBS	11250
199315	22200015	Crooked Creek	Highway 5	Barrier	Medium	1.02	1.8	Moderate	SS-CBS	1500
199318	15600154	Trankle Creek	Braeside Rd	Potential	Low	36.64	1.0	Low	SS-CBS	200
199319	5400028	Tintagel Creek	Highway 16	Potential	High	5.39	3.6	Low	OBS	11250
199321	13900265	Sugarbowl Creek	Highway 16	Potential	High	0.48	6.2	Low	OBS	11250
199322	13900025	Shelby Creek	Airport Rd	Potential	Medium	6.75	1.4	Low	SS-CBS	200
199324	13900015	Dominion Creek	2nd Ave	Potential	High	6.02	3.4	Low	OBS	3000
199325	13900073	Teare Creek	Jeck Rd	Potential	Medium	1.72	3.1	Low	OBS	3000

PSCIS ID	External ID	Stream	Road	Barrier Result	Habitat value	Habitat Upstream (km)	Stream Width (m)	Priority	Fix	Cost Est ($K)
199326	13900012	Teare Creek	Highway 16	Potential	Medium	0.82	2.8	Low	OBS	11250
203296	2024100701	Tributary To Kenneth Creek	Bowron FSR	Barrier	Medium	–	0.0	Low	SS-CBS	–
203297	2024100450	Scotch Creek	Private Driveway	Barrier	Medium	11.67	2.5	Moderate	OBS	450
203298	9902948	Tributary To Beaverley Creek	Muralt Road	Potential	Low	12.73	1.8	Low	SS-CBS	400
203302	22202142	Teepee Creek	Railway	Barrier	Medium	0.32	4.2	Moderate	OBS	11250

3.5 Habitat Confirmation Assessments

During the 2024 field assessments, habitat confirmation assessments were conducted at 13 sites within the Nechako River, Lower Chilako River, Upper Fraser River, Morkill River, and Francois Lake watershed groups. A total of approximately 14 km of stream was assessed.

As collaborative decision making was ongoing at the time of reporting, site prioritization can be considered preliminary. Results are summarized in Table 3.2 with raw habitat data included in Attachment - Data (page 199). A summary of preliminary modeling results illustrates the estimated chinook, coho, and steelhead spawning and rearing habitat potentially available upstream of each crossing, based on measured/modelled channel width and upstream accessible stream length, as presented in Figure 3.1. Detailed information for each site assessed with Phase 2 assessments (including maps) are presented within site specific appendices to this document.

Table 3.2: Overview of habitat confirmation sites. Chinook rearing model used for habitat estimates (total length of stream network

PSCIS ID	Stream	Road	Tenure	UTM	UTM zone	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
7622	Burnt Cabin Creek	Stella Road	MoTI	388735 5997152	10	–	0.0	Medium	High	A high-quality stream with a relatively steep gradient and abundant functional large woody debris creating steps and pools 20–30mm deep. In some sections, the stream widened and became shallow, with abundant gravels suitable for spawning. Overhead cover was extensive. Near the upper end of the site, the forest had been cleared for pipeline use, resulting in significant bank erosion. and ripiran removal. A large pipe crossed the

PSCIS ID	Stream	Road	Tenure	UTM	UTM zone	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
surveyed from Stella Road up to the pipeline, ~500m.										
199171	Burnt Cabin Creek	Gala Bay Road	MOTI	388944 5997001	10	–	0.0	Medium	High	A small stream with good flow and abundant gravels, flowing through several private properties with newly established quad and foot traffic trails. Pools were limited and predominantly shallow. A significant outlet drop was present at the downstream culvert on Gala Bay Road, while the upstream culvert on Stella Road had an even larger drop, both indicating the pipes were undersized for the watershed's flow capacity. Anecdotal information from a neighboring landowner suggested the stream below Gala Bay Road had been diverted to accommodate a driveway for a recreational property.
199172	Scotch Creek	Stella Road	MoTi	388269 5996948	10	–	0.0	Medium	High	The stream provided excellent habitat, with abundant functional large woody debris creating occasional pools 20–30mm deep, suitable for overwintering juvenile fish. Overhead cover was extensive, and occasional gravels were suitable for spawning. A small, broken plastic pipe was present in the first 150m upstream of the culvert, likely a former water intake for adjacent properties. PSCIS crossing 203297 was located 150m upstream of Stella Road on private property, where the culvert had a significant outlet drop, creating a likely fish passage barrier. Approximately 400m upstream, the stream transitioned to a beaver-impounded area with four consecutive 1–1.5m high dams holding back a large volume of water, but flow over or under allowed possible fish passage. The impoundment area extended as far as the surveyed area. A fish (~40mm) was observed after the second beaver dam. The top of the site was marked at WP 400.
199328	Scotch Creek	Gala Bay Road	MoTi	388380 5996779	10	–	–	Medium	–	–

PSCIS ID	Stream	Road	Tenure	UTM	UTM zone	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
199204	Nine Mile Creek	Settlement Road	MOTI	403906 5998777	10	RB	24.1	Medium	Moderate	The stream was a larger system with significant beaver activity, creating impoundments behind dams ranging from 0.3 to 1.5m in height. Heavy cattle use was evident in riparian areas, with trampled banks, extensive browsing of riparian shrubs, and a significant amount of manure within seasonally inundated areas. The survey extended from Settlement Road to a large beaver dam and impoundment. Nutrient loading to the stream appeared high, with large amounts of algae present on the primarily gravel substrates in sections of the channel linking beaver-impounded areas.
199190	Clear Creek	Highway 27	MOTI	425557 5996165	10	LKC;LSU	6.2	Medium	Moderate	The stream had good flow and provided high-quality habitat for the first 100m before beginning to run subsurface. At approximately 200m upstream of the highway, adjacent to a quarry, the stream was fully dewatered to the top of the site. The channel was highly confined and lacked complexity. Although some small and large woody debris were present, they did not appear to function in creating habitat during periods of flow. The stream was primarily a straight channel with a coarse cobble and boulder substrate. A large pile of riprap was placed at the culvert outlet, possibly to reduce the outlet drop,

PSCIS ID	Stream	Road	Tenure	UTM	UTM zone	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
though its placement appeared unusual and could inhibit fish passage.										
199232	Beaverley Creek	Highway 16	MOti	502374 5962501	10	BB;CAS;CBC;CH;CSU;DV;KO;LNC;MW;NSC;PC;PRC;RB;SC;SU	40.1	Medium	Medium	A large stream with abundant gravels suitable for Chinook spawning. Pools were infrequent, primarily located on outside bends and behind large woody debris. Some evidence of anthropogenic manipulation was observed, including cut cottonwood trees that had fallen into the channel. The riparian zone was in good condition, with mature shrub communities and old-growth cottonwood that should contribute to future habitat complexity. The culvert appeared to have been modified in the past to attempt backwatering, with boulder lines present downstream. Heavy rainfall over the previous evening and preceding weeks had raised water levels to moderate conditions. The stream was a major tributary to the Chilako River, with documented Chinook presence. The watershed was within Prince George city limits, presenting opportunities for community engagement, trail network development, educational programs, and stewardship initiatives. A significant slump on the highway

PSCIS ID	Stream	Road	Tenure	UTM	UTM zone	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
approximately 300m upstream of the culvert was actively eroding; however, a healthy young deciduous and shrub-dominated riparian zone at this location likely provided some filtration and protection of water quality.										
199256	Kenneth Creek	Highway 16	MOTI	582279 5975090	10	BT;CC;CCG;CH;LSU;RB	71.6	High	Moderate	The stream was large and gravel-dominated, with extensive deep runs, deep pools, large woody debris, and multiple channels throughout. Gravels were suitable for Chinook and resident salmonid spawning. A Chinook spawner was observed upstream of the culvert in 2022. Heavy rains over the past two weeks had significantly raised water levels. A beaver dam was present within side channels at the upper end of the surveyed site. The riparian area was intact throughout, consisting of a mix of shrub-dominated wetland areas and mature mixed forest.

PSCIS ID	Stream	Road	Tenure	UTM	UTM zone	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
199260	Tributary To Sugarbowl Creek	Highway 16	MOTI	587916 5972449	10	–	0.0	High	High	The stream was a larger, steeper system with intact, mature coniferous cedar-hemlock riparian cover, primarily stable banks, and abundant large woody debris throughout. A step-pool morphology was present, with pools up to 80cm deep. Numerous debris jam steps ranged from 30–60cm. Habitat appeared suitable for large bull trout spawning and rearing.
199255	Tributary To Kenneth Creek	Bowron FSR	MoF	578664 5972996	10	LSU	0.8	Medium	Moderate	Small stream with good flow and abundant gravels suitable for bull trout and cutthroat trout spawning. Occasional shallow pools provided habitat for juvenile salmonid rearing. Banks were stable, with an intact mixed mature forest. The stream had some short sections with gradients up to 5% but was primarily a low-gradient riffle-gravel system.
199267	Driscoll Creek	Highway 16	MoTi	606378 5965782	10	CCG;RB	8.2	Medium	Moderate	The stream was a low-gradient, gravel-dominated system with an extensive shrub-sedge wetland area and beaver activity in the lower 200m. Deep pools up to 1m were present throughout, influenced by abundant large woody debris contributed from the adjacent mature, primarily coniferous forest. The stream was surveyed for 600m upstream of the highway, and the west fork was surveyed.
199237	Snowshoe Creek	Highway 16	MoTi	650786 5934862	10	EB;LKC;RB;RSC;ST	22.3	High	Moderate	The stream was surveyed upstream for 750m, following the west fork at the junction. The east fork was surveyed separately (13900100_us2). The

PSCIS ID	Stream	Road	Tenure	UTM	UTM zone	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
stream was a large, low-gradient gravel riffle-pool system with abundant large woody debris throughout. Banks were stable, with an intact mature coniferous riparian zone. High flows due to heavy rains over the past two weeks made pool delineation difficult, so residual depth was estimated. Gravel and small cobbles were present, likely suitable for Chinook spawning. Extensive areas of high-value habitat were observed for juvenile rearing and resident salmonid spawning.										
199174	Tributary To Nechako River	Sutherland FSR	MoF	397160 5996574	10	SP	0.0	–	High	Medium-value habitat. The stream had been heavily impacted by cattle throughout the surveyed area, with evidence of bank trampling and extensive low-gradient muddy sections. Upstream of the culvert, the stream was primarily dry for the first 300m, with young forest and shrubs. At this point, intermittent pools began to appear, associated with beaver activity. At approximately 450–500m upstream, the stream became almost entirely watered, with pools up to 40cm deep. Many surveyed areas resembled wetland habitat, with spirea, willow, alder, and trembling aspen throughout. The last 200m of

PSCIS ID	Stream	Road	Tenure	UTM	UTM zone	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
										the stream was incorrectly mapped in the BC Freshwater Atlas, as it flowed more directly southeast to join the Nechako River rather than following the mapped route, which runs east along Dog Creek Road before joining the Nechako River.
199173	Tributary To Nechako River	Dog Creek Road	MOTI	398923 5996362	10	SP	0.0	Medium	High	Heavy cattle impacts were observed throughout the surveyed area, with the most pronounced damage in low-gradient sections with easily accessible banks. The stream changed character at a beaver dam located approximately 300–350m upstream, transitioning from a channelized stream to beaver-impounded wetland areas. A fence intended to restrict cattle access had been breached. A series of beaver dams began approximately 300m upstream of the road, with over three dams observed, some up to 1.5m high. The dams were mature, well-developed, and had vegetation growing through them. Fish were observed throughout the survey area. The habitat was of medium value for rearing rainbow trout and potentially Chinook, with some pockets of gravels present. However, heavy cattle impacts had led to significant sedimentation, with fines covering much of the substrate. The beaver dams were impounding large quantities of water, likely sustaining year-round stream flow downstream at the Dog Creek Road crossing. Waypoints were taken for a breached fence line (WP 32), a slumped historic road (WP 33), and the first beaver dam (WP 34). The last 200m of the stream was incorrectly mapped in

PSCIS ID	Stream	Road	Tenure	UTM	UTM zone	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
										the BC Freshwater Atlas, as it flowed more directly southeast to join the Nechako River rather than following the mapped route, which runs east along Dog Creek Road before joining the Nechako River.
199282	Holliday Creek	Highway 16	MOTI	305946 5896010	11	–	3.3	High	Moderate	A large glaciated system with a cobble-boulder substrate and an intact mixed riparian zone, primarily deciduous. Occasional large woody debris features created deep pool habitats and likely gravel tailouts. The system had a lower gradient, with occasional pockets of gravels suitable for spawning salmonids ranging from 20cm to 100cm in size.
199278	Teepee Creek	Highway 5	MOTI	344031 5862744	11	SA	0.0	High	High	The stream was surveyed from the highway to the railway and was a mid-sized, steeper cobble-boulder step-pool system with only rare pockets of unembedded gravels. Deep pools were present, formed by boulder and large woody debris scour. A salmon point was noted near the pipeline location in FISS. Numerous small steps ranging from 30–60cm were present due to the steep, boulder-dominated nature of the stream.
203302	Teepee Creek	Railway	CN Rail	344222 5862742	11	–	–	Medium	Moderate	The site was surveyed from the railway up to PSCIS crossing 4931, where gradients increased significantly, indicating a new reach should begin. Approximately 100m before the end of the site, the stream showed signs of a large disturbance event that had incised the channel to a depth of 1.2–2m, with major

PSCIS ID	Stream	Road	Tenure	UTM	UTM zone	Fish Species	Habitat Gain (km)	Habitat Value	Priority	Comments
Teepee Creek Trail was reported to cross the stream within the site, but it was not observed during the survey. Substrates were embedded, with very rare areas of unembedded gravels. Due to heavy rain in the days prior to the survey, conditions were slightly turbid, making it difficult to assess the full extent of gravels, particularly within the tailouts of plunge pools.										

Table 3.3: Summary of Phase 2 fish passage reassessments.

PSCIS ID	Embedded	Outlet Drop (m)	Diameter (m)	SWR	Slope (%)	Length (m)	Final score	Barrier Result
7622	No	1.15	1.15	1.74	5.0	30	42	Barrier
199171	No	0.90	1.05	2.95	7.0	12	36	Barrier
199172	No	1.35	1.10	1.82	5.0	25	39	Barrier
199173	No	0.35	0.90	3.33	2.5	10	31	Barrier
199174	No	0.00	1.50	1.67	1.0	15	24	Barrier
199190	No	1.00	1.85	2.82	3.0	28	39	Barrier
199204	No	0.50	3.20	1.72	2.0	12	31	Barrier
199232	No	1.05	5.60	1.71	2.0	25	34	Barrier
199237	No	0.65	2.50	5.60	2.0	45	37	Barrier
199255	No	0.00	1.10	9.55	1.5	13	21	Barrier
199256	No	0.70	5.50	3.45	1.0	30	37	Barrier
199260	No	1.40	1.20	5.83	6.0	50	42	Barrier
199267	No	0.65	2.30	4.61	2.5	56	37	Barrier
199278	No	0.40	1.40	5.00	2.0	22	34	Barrier
199282	No	0.80	4.00	4.00	2.0	52	37	Barrier
199328	Yes	0.00	1.40	1.43	0.5	13	6	Passable
203302	No	0.75	2.70	1.56	6.0	14	36	Barrier

Table 3.4: Cost benefit analysis for Phase 2 assessments. Chinook rearing model used for habitat estimates (total length of stream network

PSCIS ID	Stream	Road	Barrier Result	Habitat value	Stream Width (m)	Fix	Cost Est ($K)	Habitat Upstream (m)	Cost Benefit (m / $K)	Cost Benefit (m2 / $K)
7622	Burnt Cabin Creek	Stella Road	Barrier	Medium	3.5	OBS	3000	0	0.0	0.0
199171	Burnt Cabin Creek	Gala Bay Road	Barrier	Medium	2.4	OBS	1500	0	0.0	0.0
199172	Scotch Creek	Stella Road	Barrier	Medium	2.6	OBS	3600	0	0.0	0.0
199173	Tributary To Nechako River	Dog Creek Road	Barrier	Medium	3.0	OBS	1500	0	0.0	0.0
199174	Tributary To Nechako River	Sutherland FSR	Barrier	–	2.5	OBS	450	0	0.0	0.0
199190	Clear Creek	Highway 27	Barrier	Medium	5.2	OBS	11250	6173	548.7	1432.1
199204	Nine Mile Creek	Settlement Road	Barrier	Medium	6.2	OBS	1500	24065	16043.3	44119.2
199232	Beaverley Creek	Highway 16	Barrier	Medium	11.9	OBS	11250	43112	3832.2	18394.5
199237	Snowshoe Creek	Highway 16	Barrier	High	12.3	OBS	14250	22288	1564.1	10948.5
199255	Tributary To Kenneth Creek	Bowron FSR	Barrier	Medium	3.4	OBS	450	848	1884.4	9893.3
199256	Kenneth Creek	Highway 16	Barrier	High	22.8	OBS	18000	71570	3976.1	37773.1
199260	Tributary To Sugarbowl Creek	Highway 16	Barrier	High	6.1	OBS	24750	0	0.0	0.0
199267	Driscoll Creek	Highway 16	Barrier	Medium	8.9	OBS	11250	8227	731.3	3875.8
199278	Teepee Creek	Highway 5	Barrier	High	5.3	OBS	11250	0	0.0	0.0
199282	Holliday Creek	Highway 16	Barrier	High	11.8	OBS	15750	3264	207.2	1657.9
199328	Scotch Creek	Gala Bay Road	Passable	Medium	–	–	–	0	–	–
203302	Teepee Creek	Railway	Barrier	Medium	5.4	OBS	11250	–	–	–

Table 3.5: Summary of Phase 2 habitat confirmation details.

PSCIS ID	Length surveyed upstream (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
7622	500	3.5	1.4	0.2	7.0	abundant	high
199171	275	2.4	1.2	0.1	4.5	moderate	medium
199172	550	2.6	1.5	0.2	4.3	abundant	medium
199173	575	3.0	1.5	0.3	2.4	moderate	medium
199174	650	2.5	0.9	0.3	1.2	moderate	medium
199190	550	5.2	3.1	0.3	1.3	trace	low
199204	425	6.2	4.4	0.8	3.0	moderate	medium
199232	725	11.9	8.0	0.4	0.6	moderate	high
199237	750	12.3	11.6	0.8	0.7	moderate	high
199255	650	3.4	2.8	0.3	2.8	moderate	medium
199256	950	22.8	16.7	0.8	0.8	moderate	high
199260	650	6.1	5.1	0.4	7.1	moderate	medium
199267	600	8.9	8.7	0.7	0.5	moderate	high
199278	310	5.3	3.3	0.4	7.2	moderate	medium
199282	800	11.8	8.9	0.8	2.5	moderate	medium
203302	600	5.4	3.9	0.4	6.8	moderate	medium

Table 3.6: Summary of watershed area statistics upstream of Phase 2 crossings.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
199171	4.5	683	675	1237	942	881	SSW
199172	8.6	692	676	1091	834	796	S
199173	15.0	680	671	1191	814	801	SE
199174	12.8	723	696	1191	830	821	SE
199190	54.9	730	660	987	859	848	S
199204	62.4	754	715	1317	905	876	S
199232	215.6	638	579	1079	763	748	S
199237	76.7	829	648	2491	1268	1073	SE
199255	1.1	723	957	1343	1181	1127	E
199256	172.0	655	619	1886	841	805	S
199260	4.4	776	726	1801	1160	1058	NE
199267	34.3	683	621	1795	960	871	SE
199278	11.0	798	988	2648	1949	1874	SW
199282	55.2	777	721	2553	1846	1725	SSW
199328	9.1	680	676	1091	834	795	S
203302	11.0	811	988	2648	1949	1874	SW
7622	3.6	696	779	1237	1009	984	SSW

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

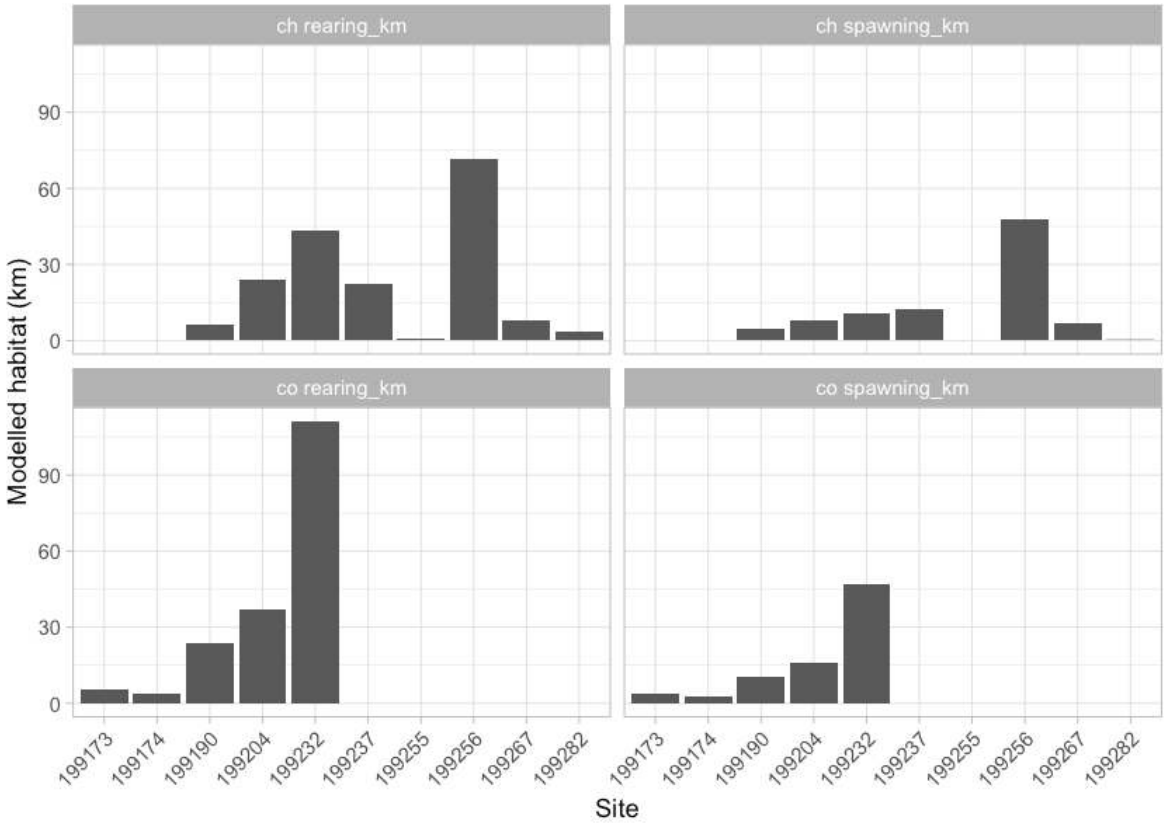


Figure 3.1: Summary of potential rearing and spawning habitat upstream of habitat confirmation assessment sites. See Table 2.1 for modelling thresholds.

4 Recommendations

A major challenge in advancing fish passage restoration is the complexity of working across jurisdictions and with multiple stakeholders—rail and highway authorities, forestry ministries, licensees, and private landowners. These partners are often being asked to accommodate priorities that originate outside their mandates and budgets. Convincing them to invest in difficult, high-cost interventions—like modifying crossings or relocating infrastructure—requires navigating uncertainty about costs and ecological outcomes, as well as a disconnect between the benefits to watershed health and the internal pressures or performance goals of these agencies. It's a tough ask: to take on massive, uncertain projects when they're already stretched thin with their own responsibilities.

Fish passage restoration within the Upper Fraser River and across British Columbia is further complicated by the legacy of infrastructure deeply embedded in the landscape. Roads, railways, highways, community infrastructure and private assets often constrain floodplains and disrupt natural hydrological processes. While targeted repairs to individual barriers are essential, they won't resolve the broader systemic issues without rethinking and restructuring how infrastructure interacts with watershed function. Loss of riparian vegetation and intensive beaver management only add to the degradation. Addressing these challenges means making strategic, well-communicated choices—picking battles carefully, building trust, and staying committed to a longer-term transformation.

While preliminary top remediation priorities are provided by watershed group, these rankings are inherently subjective and can depend on the capacity and willingness of infrastructure owners and tenure holders to support implementation—both financially and over the often multi-year project timelines. In practice, we must often act opportunistically, pursuing simpler, lower-cost options to maintain momentum and achieve near-term progress.

Government, community groups, landowners, non-profits, industry and other stakeholders should work collaboratively to address high and moderate priority barriers identified online within the Results and Discussion section of the report found here. Although the table presents many options, linked reports specify whether each site is a low, moderate, or high priority. Progress on any front is meaningful, and aiming to remediate at least one high-priority site per year per watershed group—regardless of its overall rank—is a practical and effective approach.

Recommendations for collaborative enhancement of fish passage restoration in the Upper Fraser River Region include:

- Maintain strong partnerships to support funding, site selection, remediation, and monitoring through adaptive management informed by traditional knowledge and real-time data.
- Coordinate with the Ministry of Transportation to pursue funding for engineering designs at the following crossings:

    - PSCIS crossing 199171 on Burnt Cabin Creek along Gala Bay Road, in the Francois Lake watershed group.
    - PSCIS crossing 199173 on a tributary to the Nechako River, on Dog Creek Road, in the Nechako River watershed group

- Use climate modeling to prioritize crossings that enable access to cold, drought-resistant habitats.

- Integrate fish passage restoration planning with other restoration and enhancement initiatives in the region to maximize benefits to fish populations as well as for communities within the Upper Fraser River watershed. This includes working with the Rivershed Society of BC, Nechako Environment and Watershed Stewardship Society (NEWSS), University of Northern British Columbia, Fisheries and Oceans Canada, Ministry of Transportation, provincial regulators, and others to leverage funding, knowledge, and resources for fish passage restoration towards other projects related to watershed health in the region. Examples of where this is already taking in place in other watersheds includes:

    - Leveraging of Morice River watershed group fish passage sites into the Bii Wenii Kwa Restoration/Recovery Plan
    - Incorporation of Upper Bulkley River sites into the Neexdzii Kwah Restoration Planning (Irvine and Schick 2025).

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

Burnt Cabin Creek - 199171 & 7622 - Appendix

Site Location

PSCIS crossings 199171 and 7622 are located on Burnt Cabin Creek which flows into the northern side of Fraser Lake, BC, approximately 8km northwest of the Nadleh Whut'en First Nations community, in the Francois Lake watershed group (Figure 4.1). Crossing 199171 is located 50m upstream of Fraser Lake, on Gala Bay Road, and is the responsibility of the Ministry of Transportation and Infrastructure (`chris_culvert_id`: 1790951). Approximately 275m further upstream, PSCIS crossing 7622 is located on Stella Road and is the responsibility of the Ministry of Transportation and Infrastructure (`chris_culvert_id`: 1794196).

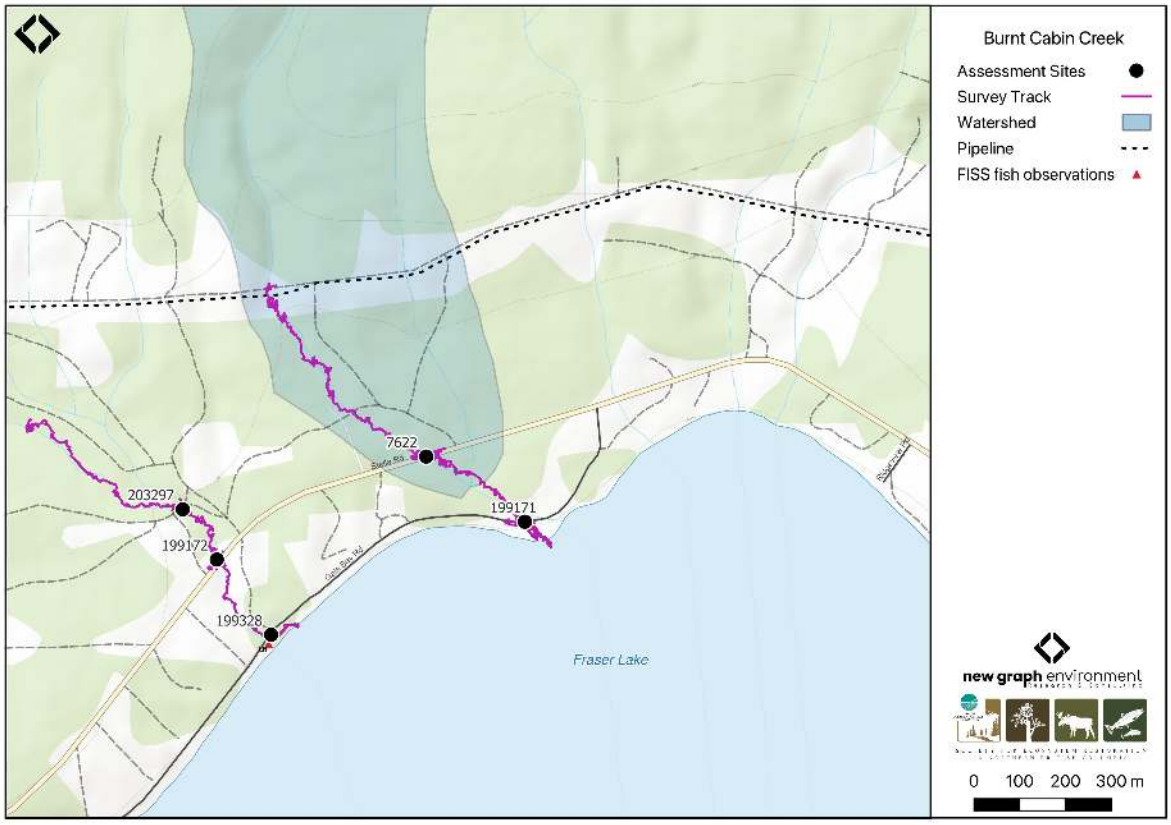


Figure 4.1: Map of Burnt Cabin Creek

Background {.unnumbered}

At the location of these crossings, Burnt Cabin Creek is a third order stream and drains a watershed of approximately 4.5km^2. The watershed ranges in elevation from a maximum of 1237m to 683m near the lower crossing (Table 4.1).

PSCIS crossing 7622 was first assessed with a fish passage assessment in 2004 (MoE 2023). Both crossings 199171 and 7622 were reassessed in 2023 and prioritized for follow-up due to the presence of high-value habitat and historical reports of sockeye spotted along the shoreline by the adjacent landowner. A habitat confirmation assessment encompassing both sites was conducted in 2024. No fisheries information is documented for the stream; however, downstream in Fraser Lake, white sturgeon, rainbow trout, kokanee, sockeye salmon, chinook salmon, bull trout, dolly varden, and other species have been previously recorded (Norris [2018] 2024; MoE 2024).

Table 4.1: Summary of derived upstream watershed statistics for PSCIS crossing 199171.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
199171	4.5	683	675	1237	942	881	SSW

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

Aerial Imagery

An aerial survey was conducted with a remotely piloted aircraft and the resulting imagery was processed into an orthomosaic available to view and download here.

Stream Characteristics at Crossings 199171 and 7622

At the time of the 2024 assessment, both PSCIS crossings 199171 and 7622 were un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Tables 4.2 - 4.3). Crossing 199171 had a 0.9m outlet drop, while crossing 7622 had an even larger 1.15m outlet drop.

At all crossings, the water temperature was 5°C, pH was 8.5 and conductivity was 333 uS/cm.

Table 4.2: Summary of fish passage assessment for PSCIS crossing 199171.

Location and Stream Data	•	Crossing Characteristics	–
Date	2024-10-03	Crossing Sub Type	Round Culvert
PSCIS ID	199171	Diameter (m)	1.05
External ID	–	Length (m)	12
Crew	LS	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	388944	Resemble Channel	No
Northing	5997001	Backwatered	No
Stream	Burnt Cabin Creek	Percent Backwatered	–
Road	Gala Bay Road	Fill Depth (m)	0.5
Road Tenure	MOTI	Outlet Drop (m)	0.9
Channel Width (m)	3.1	Outlet Pool Depth (m)	0.35
Stream Slope (%)	3	Inlet Drop	No
Beaver Activity	No	Slope (%)	7
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	36	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Location and Stream Data **Crossing Characteristics** –

Comments: The local name of the stream is Burnt Cabin Creek. It had a large outlet drop and a heavily eroded outlet pool, indicating the culvert was undersized. The stream provided complex habitat for fish with abundant cover. The low-traffic dirt road had minimal road fill, making construction relatively straightforward.
MoTi chris_culvert_id: 1790951

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

Table 4.3: Summary of fish passage assessment for PSCIS crossing 7622.

Location and Stream Data		Crossing Characteristics	–
Date	2024-10-03	Crossing Sub Type	Round Culvert
PSCIS ID	7622	Diameter (m)	1.15
External ID	–	Length (m)	30
Crew	AI SC	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	388735	Resemble Channel	No
Northing	5997152	Backwatered	No
Stream	Burnt Cabin Creek	Percent Backwatered	–
Road	Stella Road	Fill Depth (m)	2.2
Road Tenure	MoTI	Outlet Drop (m)	1.15
Channel Width (m)	2	Outlet Pool Depth (m)	0.43
Stream Slope (%)	5	Inlet Drop	No
Beaver Activity	No	Slope (%)	5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	42	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Location and Stream Data **Crossing Characteristics** –

Comments: The culvert is undersized for current flow volumes, as indicated by a very large 1.15m outlet drop. Habitat confirmation was completed upstream, downstream, and below Gala Bay Road. MoTi chris_culvert_id: 1794196

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

Stream Characteristics Downstream of Crossing 199171

The stream was surveyed downstream from crossing 199171 for 50m (Figure 4.2). The stream was highly channelized due to residential properties on both sides. The habitat was rated as medium with minimal cover and few pools suitable for fish, but gravels were present for spawning. Anecdotal information from a neighboring landowner suggested the stream below Gala Bay Road had been diverted to accommodate a driveway for a recreational property. Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris and undercut banks.The average channel width was 2.4m, the average wetted width was 1.4m, and the average gradient was 1.3%.The dominant substrate was gravels with fines sub-dominant.

Stream Characteristics Upstream of Crossing 199171 and Downstream of Crossing 7622

The stream was surveyed upstream from crossing 199171 for 275m , all the way to crossing 7622 on Stella Road (Figure 4.2 The habitat was rated as medium value, with good flow and abundant gravels, flowing through several private properties with newly established quad and foot traffic trails. Pools were limited and predominantly shallow. Total cover amount was rated as moderate with small woody debris dominant. Cover was also present as large woody debris, undercut banks, and overhanging vegetation.The average channel width was 2.4m, the average wetted width was 1.2m, and the average gradient was 4.5%.The dominant substrate was gravels with cobbles sub-dominant.

Stream Characteristics Upstream of Crossing 7622

The stream was surveyed upstream from crossing 7622 for 500m (Figure 4.3). The habitat was rated as high value with relatively steep gradients and abundant functional large woody debris creating steps and pools 20–30mm deep. In some sections, the stream widened and became shallow, with abundant gravels suitable for spawning. Overhead cover was extensive. Near the upper end of the site, the forest had been cleared for pipeline use, resulting in significant bank erosion and ripirian removal (Figure 4.3). The average channel width was 3.5m, the average wetted width was 1.4m, and the average gradient was 7%.The dominant substrate was gravels with fines sub-dominant.Total cover amount was rated as abundant with large woody debris dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the Gala Bay Road crossing (199171) with a bridge (15 m span) is recommended. This culvert had a 0.9m outlet drop, likely inhibiting fish passage. At the time of reporting in 2025, the cost of the work is estimated at $ 1,500,000.

Should restoration/maintenance activities proceed, replacement of the Stella Road crossing (7622) with a bridge (15 m span) is recommended. This culvert had a 1.15m outlet drop, very likely inhibiting fish passage. At the time of reporting in 2025, the cost of the work is estimated at $ 3,000,000.

Conclusion

Burnt Cabin Creek is a small stream that flows into Fraser Lake, with reports of historical sockeye spawning by the adjacent landowner. The downstream crossing on Gala Bay Road had a 0.9m outlet drop, while the Stella Road crossing had an even larger 1.15m outlet drop, both of which are likely inhibiting upstream fish passage. Fish sampling is recommended to determine whether fish are able to ascend past the Gala Bay Road crossing. Both crossing's are a high priority for replacement.

Table 4.4: Summary of habitat details for PSCIS crossings 199171 and 7622.

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
7622	Upstream	500	3.5	1.4	0.2	7.0	abundant	high
199171	Downstream	50	2.4	1.4	0.1	1.3	moderate	medium
199171	Upstream	275	2.4	1.2	0.1	4.5	moderate	medium

Figure 4.2: Left: Typical habitat downstream of PSCIS crossing 199171. Right: Typical habitat upstream of PSCIS crossing 199171 and downstream of PSCIS crossing 7622.

Figure 4.3: Left: Typical habitat upstream of PSCIS crossing 7622. Right: Bank erosion and ripirian removal at the pipeline upstream of crossing 7622.

Scotch Creek - 199328 & 199172 - Appendix

Site Location

PSCIS crossings 199328 and 199172 are located on Scotch Creek which flows into the northern side of Fraser Lake, BC, approximately 8km northwest of the Nadleh Whut'en First Nations community, in the Francois Lake watershed group (Figure 4.4). Crossing 199328 is located 230m upstream of Fraser Lake, on Gala Bay Road, and is the responsibility of the Ministry of Transportation and Infrastructure (`chris_culvert_id`: 1790947 and 3365573). A further 270m upstream, PSCIS crossing 199172 is located on Stella Road and is the responsibility of the Ministry of Transportation and Infrastructure (`chris_culvert_id`: 1794199).

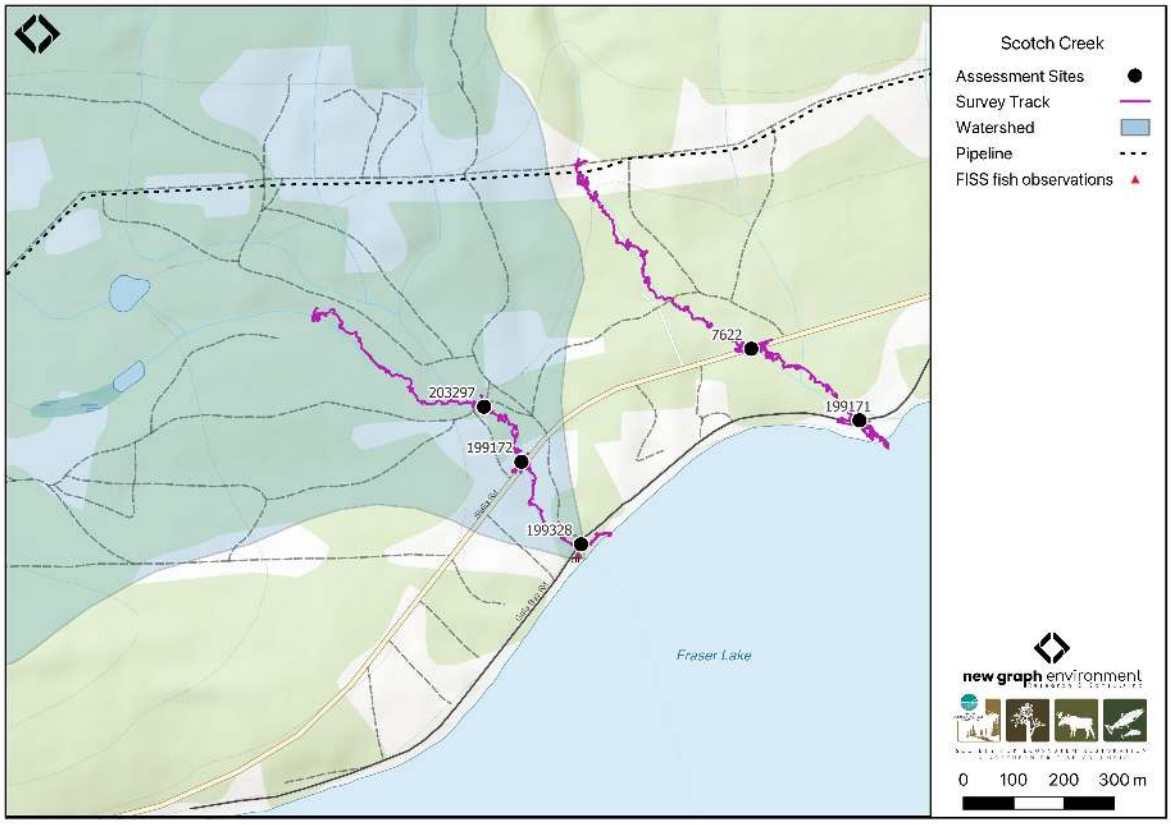


Figure 4.4: Map of Scotch Creek

Background

At the location of these crossings, Scotch Creek is a third order stream and drains a watershed of approximately 9.1km^2. The watershed ranges in elevation from a maximum of 1091m to 680m near the lower crossing (Table 4.5).

In 2023, both crossings were assessed with fish passage assessments and prioritized for follow-up due to the presence of high-value habitat and a chinook observation from 2018 documented adjacent to crossing 199328 in the FISS database (Norris [2018] 2024; MoE 2024). A habitat confirmation assessment encompassing both crossings was conducted in 2024. Downstream in Fraser Lake, white sturgeon, chinook, bull trout, rainbow trout, kokanee, and other species have been previously recorded (Norris [2018] 2024; MoE 2024).

Table 4.5: Summary of derived upstream watershed statistics for PSCIS crossing 199328.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
199328	9.1	680	676	1091	834	795	S

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

Stream Characteristics at Crossings 199328 and 199172

At the time of the 2024 assessment, PSCIS crossing 199328 on Gala Bay Road was embedded, 100% backwatered, and ranked as passable to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.6).

Further upstream, PSCIS crossing 199172 on Stella Road was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.7). This culvert had a significant 1.35m outlet drop.

In 2024, a third crossing (PSCIS 203297) was assessed on a private road approximately 150m upstream of Stella Road, with results provided in Table 4.8. Two pipes were present, with the larger culvert having a significant 0.7m outlet drop. The inlet side of the road had completely eroded into the stream, obscuring the inlet from view. The road was heavily overgrown, collapsing, and appeared to be unused.

At all crossings, the water temperature was 5°C, pH was 7.8 and conductivity was 208 uS/cm.

Table 4.6: Summary of fish passage assessment for PSCIS crossing 199328.

Location and Stream Data	•	Crossing Characteristics	–
Date	2024-10-04	Crossing Sub Type	Round Culvert
PSCIS ID	199328	Diameter (m)	1.4
External ID	–	Length (m)	13
Crew	AI	Embedded	Yes
UTM Zone	10	Depth Embedded (m)	0.35
Easting	388380	Resemble Channel	Yes
Northing	5996779	Backwatered	Yes
Stream	Scotch Creek	Percent Backwatered	100
Road	Gala Bay Road	Fill Depth (m)	1.5
Road Tenure	MoTi	Outlet Drop (m)	0
Channel Width (m)	2	Outlet Pool Depth (m)	0.1
Stream Slope (%)	1.5	Inlet Drop	No
Beaver Activity	No	Slope (%)	0.5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	6	Barrier Result	Passable
Fix type	–	Fix Span / Diameter	–

Location and Stream Data **Crossing Characteristics** –

Comments: Two fully embedded PVC pipes, each 0.7m in diameter. One pipe was completely backwatered. Medium-value habitat was observed, with extensive gravels suitable for spawning upstream and downstream. A historic Chinook spawning point was recorded adjacent to the road. Habitat confirmations were conducted upstream, downstream, and above Stella Road. MoTi chris_culvert_id: 1790947

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

Table 4.7: Summary of fish passage assessment for PSCIS crossing 199172.

Location and Stream Data	•	Crossing Characteristics	–
Date	2024-10-04	Crossing Sub Type	Round Culvert
PSCIS ID	199172	Diameter (m)	1.1
External ID	–	Length (m)	25
Crew	AI	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	388269	Resemble Channel	No
Northing	5996948	Backwatered	No
Stream	Scotch Creek	Percent Backwatered	–
Road	Stella Road	Fill Depth (m)	4
Road Tenure	MoTi	Outlet Drop (m)	1.35
Channel Width (m)	2	Outlet Pool Depth (m)	0.28
Stream Slope (%)	0	Inlet Drop	No
Beaver Activity	No	Slope (%)	5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	39	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	18

Location and Stream Data **Crossing Characteristics** –

Comments: The culvert was very undersized for the stream, as evidenced by the large outlet drop. The stream had a good amount of flow for the time of year. Habitat was of medium value, with abundant large woody debris creating complex habitat and pools, providing ample cover for fish. Adjacent landowners reported that the stream was previously used as a water source for bottling and distribution across the province. Habitat confirmation was completed upstream and downstream. MoTi chris_culvert_id: 1794199

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

Table 4.8: Summary of fish passage assessment for PSCIS crossing 203297.

Location and Stream Data		**Crossing Characteristics**	**–**
Date	2024-10-04	Crossing Sub Type	Round Culvert
PSCIS ID	203297	Diameter (m)	1.05
External ID	2024100450	Length (m)	8
Crew	LS	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	388199	Resemble Channel	No
Northing	5997060	Backwatered	No
Stream	Scotch Creek	Percent Backwatered	–
Road	Private Driveway	Fill Depth (m)	2
Road Tenure	Private	Outlet Drop (m)	0.7
Channel Width (m)	2.5	Outlet Pool Depth (m)	0.55
Stream Slope (%)	4	Inlet Drop	No
Beaver Activity	No	Slope (%)	2
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	31	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Comments: Two pipes, 0.6m and 0.45m in diameter, were present. There was a 0.7m outlet drop, and only the larger pipe conveyed flow. The inlet side of the road had completely eroded into the stream, obstructing the view of the inlet. No light was visible through the culverts from the outlet side, though water was still flowing. A landowner had placed a barricade across the road, likely to prevent access due to severe erosion of the road. The stream provided high-quality habitat with abundant large woody debris creating pools and gravels suitable for spawning. Just downstream, a functioning water intake shack was located in the middle of the stream, likely supplying the adjacent landowner's property. Plastic pipes extended from the intake shack downstream to the lower Stella Road crossing. The heavily overgrown and collapsing road appeared to be private access and would be a good candidate for removal. Due to inlet erosion, culvert length and slope were estimated as the inlet could not be located.

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

Location and Stream Data **Crossing Characteristics** –

Stream Characteristics Downstream of Crossing 199328

The stream was surveyed downstream from crossing 199328 for 230m (Figure 4.5). The stream was small, low-gradient, and gravel-dominated, with habitat rated as medium value for spawning and rearing. Channelization with riprap was present near the upstream end of the survey and again near the mouth at Fraser Lake. A possible algal bloom was observed along the lake shoreline (Figure 4.5). Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as .The dominant substrate was gravels with fines sub-dominant.The average channel width was 2.9m, the average wetted width was 1.6m, and the average gradient was 1.8%.

Stream Characteristics Upstream of Crossing 199328 and Downstream of Crossing 199172

The stream was surveyed from Gala Bay Road upstream to Stella Road, a distance of approximately 270m (Figure 4.6) The habitat was rated as medium value, with limited pools; however, abundant overhanging vegetation and small woody debris provided cover, and gravels suitable for resident salmonid spawning were present. Incision was evident, beginning with a deep cut at the culvert outlet under Stella Road and continuing downstream to Gala Bay Road. The riparian area was generally intact through most of the survey, except for the downstream 75m, where private land development on the north side had resulted in a lawn and riparian vegetation removal up to the channel edge. Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris and undercut banks.The average channel width was 2.1m, the average wetted width was 1.3m, and the average gradient was 3%.The dominant substrate was gravels with cobbles sub-dominant.

Stream Characteristics Upstream of Crossing 199172

The stream was surveyed upstream from crossing 199172 for 550m (Figure 4.6). The habitat was rated as medium value, with abundant functional large woody debris creating pools 20–30cm deep, suitable for overwintering juvenile fish. Overhead cover was extensive, and occasional gravels were suitable for spawning. Approximately 400m upstream of Stella Road, the stream transitioned into a beaver-impounded area with four consecutive dams (1–1.5m high) impounding a large volume of water. Flow was maintained over or under the dams and the impounded area extended to the upper end of the surveyed area. A fish (~40mm) was observed after the second dam. The dominant substrate was gravels with fines sub-dominant.Total cover amount was rated as abundant with large woody debris dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation.The average channel width was 2.6m, the average wetted width was 1.5m, and the average gradient was 4.3%.

PSCIS crossing 203297 was located approximately 150m upstream of Stella Road on a private road, where the culvert had a significant outlet drop, severe erosion at the inlet, and the road was

collapsing.

Structure Remediation and Cost Estimate

A the time of reporting in 2025, crossing 199328 on Gala Bay Road was ranked as passable to upstream fish passage according to the provincial protocol and no remediation is required (MoE 2011).

Should restoration/maintenance activities proceed upstream, replacement of the Stella Road crossing (199172) with a bridge (18 m span) is recommended. This culvert had a 1.35m outlet drop, very likely inhibiting fish passage. At the time of reporting in 2025, the cost of the work is estimated at $ 3,600,000.

Further upstream, PSCIS crossing 203297 was located on a private road that appeared unused and was collapsing. With a 0.7m outlet drop, the site is a strong candidate for deactivation or removal. Follow-up engagement with the landowners is recommended to assess interest in restoration or road deactivation.

Conclusion

Scotch Creek is a small stream that flows into Fraser Lake, with a documented chinook observation from 2018 near the outflow into the lake (Norris [2018] 2024; MoE 2024). The downstream crossing on Gala Bay Road was ranked as passable; however, PSCIS crossing 199172 on Stella Road had a significant 1.35m outlet drop and presented a clear barrier to upstream fish passage. Fish sampling is recommended to determine whether fish are able to ascend past the Stella Road crossing. The crossing is a high priority for replacement. A further 150m upstream of Stella Road, PSCIS crossing 203297 was an additional barrier to fish passage, with a 0.7m outlet drop and severe erosion obstructing the inlet. The road was heavily overgrown and collapsing, appeared to be unused, and would be a strong candidate for deactivation and removal.

Table 4.9: Summary of habitat details for PSCIS crossings 199328 and 199172.

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
199172	Downstream	270	2.1	1.3	0.3	3.0	moderate	medium
199172	Upstream	550	2.6	1.5	0.2	4.3	abundant	medium
199328	Downstream	230	2.9	1.6	0.2	1.8	moderate	medium

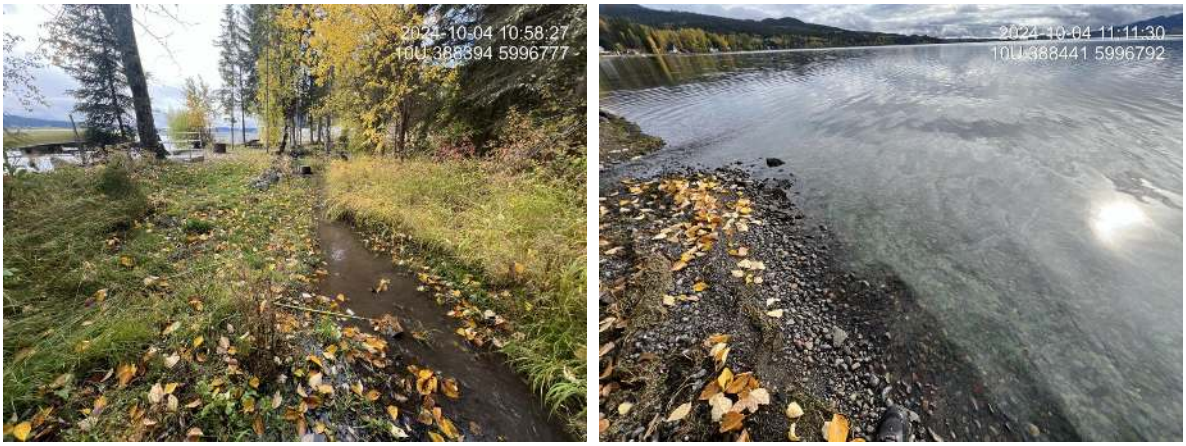


Figure 4.5: Left: Typical habitat downstream of PSCIS crossing 199328. Right: Algal bloom observed downstream of PSCIS crossing 199328 in Fraser Lake.

Figure 4.6: Left: Typical habitat upstream of PSCIS crossing 199328 and downstream of PSCIS crossing 199172. Right: Typical habitat upstream of PSCIS crossing 199172.

Tributary To Nechako River - 199173 & 199174 - Appendix

Site Location

PSCIS crossings 199173 and 199174 are located on Tributary To Nechako River, approximately 4km northeast of the Nadleh Whut'en First Nations community near Fraser Lake, BC, in the Nechako River watershed group (Figure 4.7). Crossing 199173 is located 115m upstream of the Nechako River, on Dog Creek Road, and is the responsibility of the Ministry of Transportation and Infrastructure (`chris_culvert_id`: 1794340). A further 2km upstream, PSCIS crossing 199174 is located on Sutherland FSR and is the responsibility of the Ministry of Forests. The last 200m of the stream is incorrectly mapped in the BC Freshwater Atlas, and flows directly south to join the Nechako River (see Survey Track in Figure 4.7) rather than following the mapped route, which runs east along Dog Creek Road before joining the Nechako River.

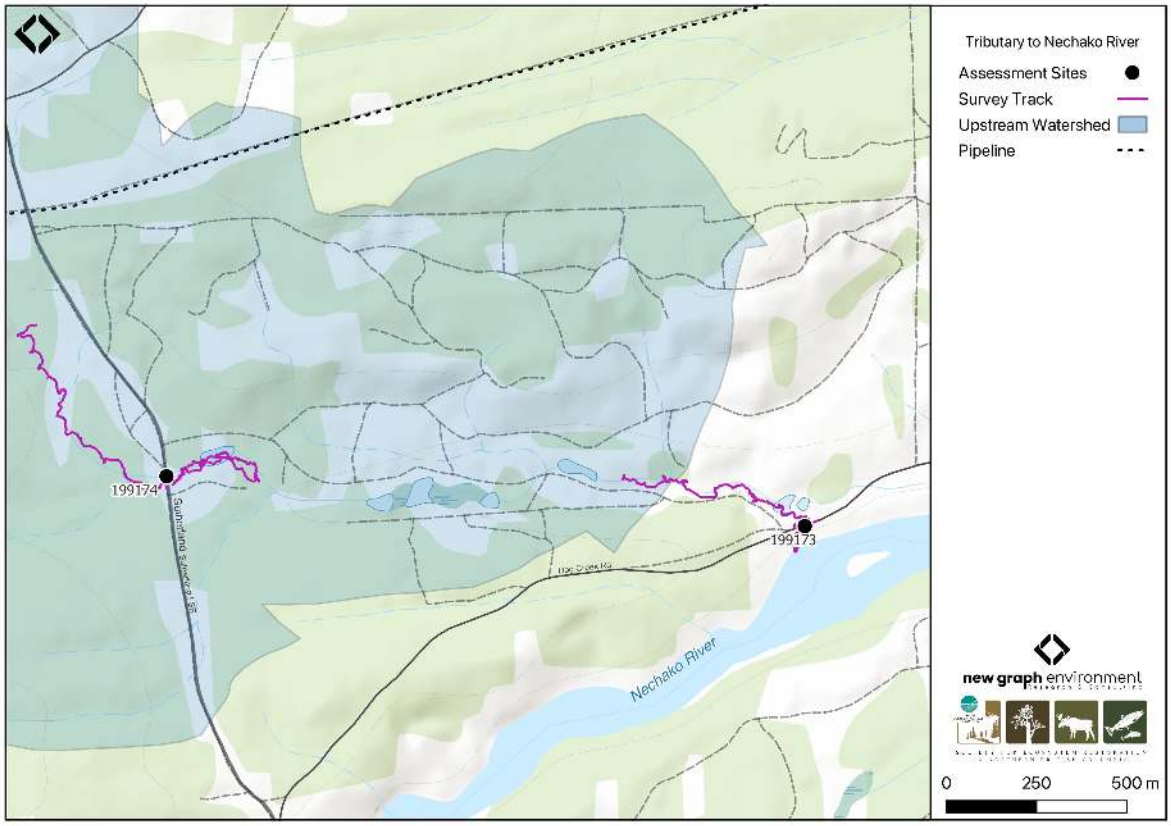


Figure 4.7: Map of tributary to Nechako River

Background

At the location of these crossings, Tributary To Nechako River is a third order stream and drains a watershed of approximately 15km^2. The watershed ranges in elevation from a maximum of 1191m to 680m near the downstream crossing (Table 4.10).

Since 2020, an ongoing environmental DNA (eDNA) project led by Dr. Brent Murray and Barry Booth at UNBC, in collaboration with School District (SD) 91, has conducted fish sampling in the Nechako River watershed, including on Tributary To Nechako River. Minnow trapping in 2022 captured chinook just upstream of the crossing on Dog Creek Road (Booth 2023). Additionally, minnow trapping in 2021 and 2023 captured chinook in the ~100m section of stream from Dog Creek Road downstream to the Nechako River (Booth 2022, 2024), with eDNA results from 2021 and 2023 also showing a strong detection for chinook in this section (B. Murray and Booth 2024; B. W. Murray and Booth 2023).

Motivated by these findings, in 2023, both crossings were assessed with fish passage assessments and prioritized for follow-up due to the presence of high-value habitat. A habitat confirmation assessment encompassing both sites was conducted in 2024.

A summary of habitat modelling outputs for the crossing are presented in Table 4.11.

Table 4.10: Summary of derived upstream watershed statistics for PSCIS crossing 199173.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
199173	15	680	671	1191	814	801	SE

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

Table 4.11: Summary of fish habitat modelling for PSCIS crossing 199173.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0.0	0.0	–
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Slopeclass05 (km)	0.0	0.0	–
ST Slopeclass08 (km)	0.0	0.0	–
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	0.0	0.0	–
CH Spawning (km)	0.0	0.0	–
CH Rearing (km)	0.0	0.0	–
CO Spawning (km)	4.0	0.6	15
CO Rearing (km)	5.5	0.6	11
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

Aerial Imagery

Aerial surveys were conducted with a remotely piloted aircraft and the resulting imagery was processed into orthomosaics. Imagery is available to view and download for PSCIS crossing 199173 on Dog Creek Road here, and PSCIS crossing 199174 on Sutherland FSR here.

Stream Characteristics at Crossings 199173 and 199174

At the time of the 2024 assessment, PSCIS crossing 199173 on Dog Creek Road was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.12). The culvert had a moderate 0.35m outlet drop.

PSCIS crossing 199174 on Sutherland FSR was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.13). The crossing was dry at the time of assessment.

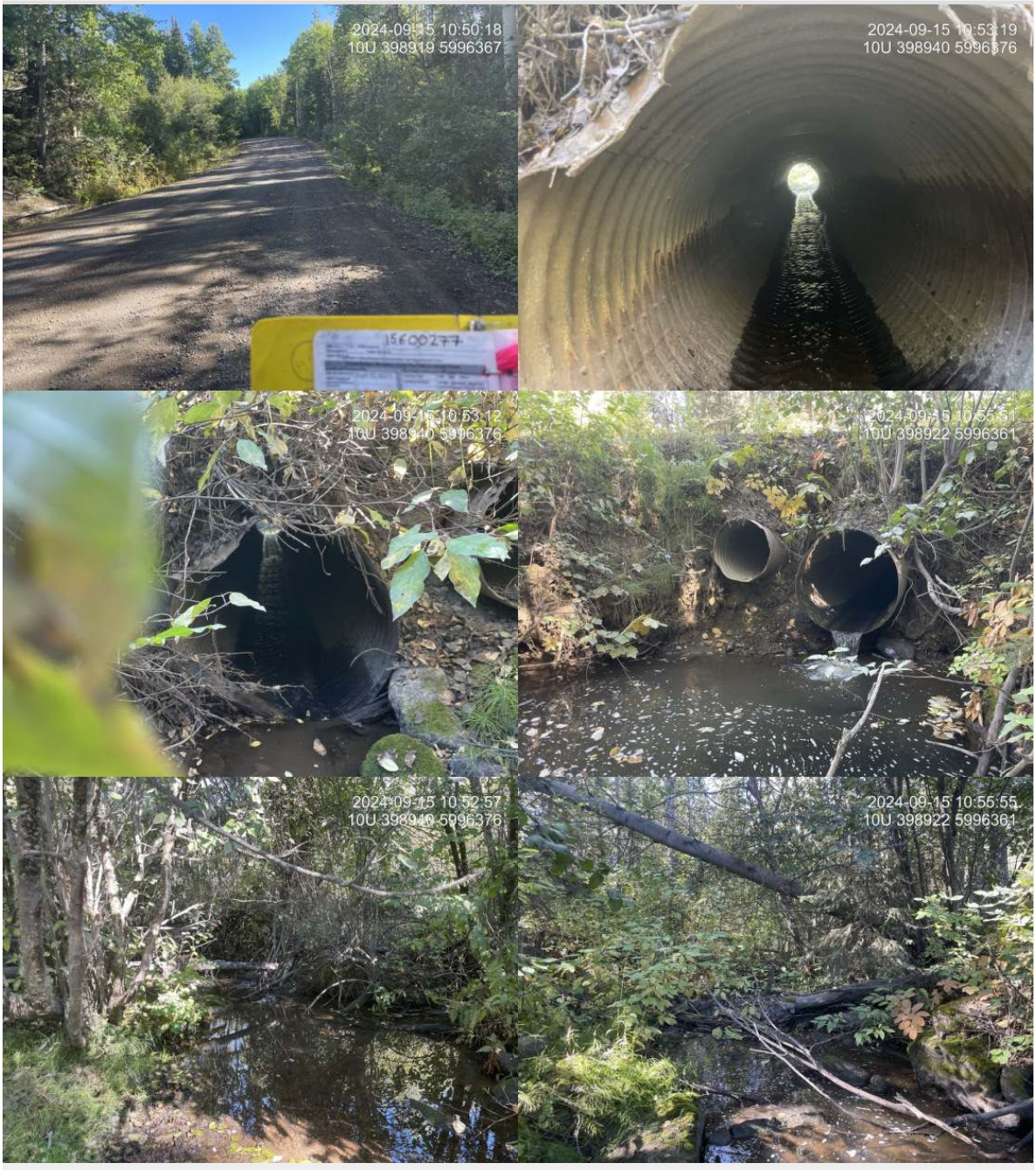
At all crossings, the water temperature was 6°C, pH was 8.2 and conductivity was 34 uS/cm.

Table 4.12: Summary of fish passage assessment for PSCIS crossing 199173.

Location and Stream Data		**Crossing Characteristics**	–
Date	2024-09-15	Crossing Sub Type	Round Culvert
PSCIS ID	199173	Diameter (m)	0.9
External ID	–	Length (m)	10
Crew	LS, AI	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	398923	Resemble Channel	No
Northing	5996362	Backwatered	No
Stream	Tributary To Nechako River	Percent Backwatered	–
Road	Dog Creek Road	Fill Depth (m)	1
Road Tenure	MOTI	Outlet Drop (m)	0.35
Channel Width (m)	3	Outlet Pool Depth (m)	0.7
Stream Slope (%)	4	Inlet Drop	No
Beaver Activity	Yes	Slope (%)	2.5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	31	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Comments: The culvert had a moderate outlet drop with some erosion around the pipe at the outlet. The pipe was in good condition. The stream provided excellent habitat, with several pools and abundant undercut banks. Fish were observed during the assessment (~40-90mm in length). Upstream of the crossing, the stream was channelized with some pockets of gravel suitable for rearing rainbow trout and potentially Chinook. It then transitioned into beaver-impounded wetland areas storing large quantities of water, likely sustaining year-round stream flow at this crossing. There was extensive cattle trampling around the inlet of the pipe and throughout the surveyed upstream area. The crossing was located approximately 150m upstream from the Nechako River mainstem. MoTi chris_culvert_id: 1794340
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.

Location and Stream Data **Crossing Characteristics** –



Location and Stream Data	•	**Crossing Characteristics**	–
Date	2024-09-15	Crossing Sub Type	Round Culvert
PSCIS ID	199174	Diameter (m)	1.5
External ID	–	Length (m)	15
Crew	LS	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	397160	Resemble Channel	No
Northing	5996574	Backwatered	No
Stream	Tributary To Nechako River	Percent Backwatered	–
Road	Sutherland FSR	Fill Depth (m)	0.4
Road Tenure	MoF	Outlet Drop (m)	0
Channel Width (m)	2.5	Outlet Pool Depth (m)	0
Stream Slope (%)	1.2	Inlet Drop	No
Beaver Activity	No	Slope (%)	1
Habitat Value	–	Valley Fill	Deep Fill
Final score	24	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Comments: At the time of assessment, the stream was dry at the crossing; however, it contained medium-value habitat. Upstream of the culvert, the stream was primarily dry for the first 300m, then intermittent pools began to appear, associated with beaver activity. Approximately 450-500m upstream, the stream became nearly fully watered, with pools up to 40cm deep. Downstream of the crossing was dominated by beaver-impounded wetland areas, which were storing large quantities of water, likely sustaining year-round stream flow at the downstream crossing on Dog Creek Road. Further downstream, approximately 300m upstream of the crossing on Dog Creek Road, the stream transitioned to a channelized system with some pockets of gravel suitable for rearing rainbow trout and potentially Chinook. However, heavy cattle impacts were observed at both this crossing and the downstream crossing on Dog Creek Road.

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

Location and Stream Data	Crossing Characteristics
	
	
	

Stream Characteristics Downstream of Crossing 199173

The stream was surveyed downstream from crossing 199173 for 115m (Figure 4.8). The habitat was rated as medium value, with undercut banks suitable for juvenile chinook and rainbow trout rearing. No natural or man-made barriers were present between Dog Creek Road and the Nechako River. Fish (~40–90mm in length) were observed during the assessment. The average channel width was 3.5m, the average wetted width was 1.3m, and the average gradient was 6%.The dominant substrate was cobbles with fines sub-dominant.Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris and boulders.

Stream Characteristics Upstream of Crossing 199173 and Downstream of Crossing 199174

The stream was surveyed upstream from crossing 199173 for 575m (Figure 4.8 The habitat was rated as medium with pockets of gravels suitable for rainbow trout and potentially chinook rearing, and fish were observed throughout the survey area. Heavy cattle impacts were evident, particularly in low-gradient sections with easily accessible banks. Fencing intended to restrict cattle access was present but had been breached. Approximately 300–350m upstream, the stream transitioned from a channelized section to a beaver-impounded wetland, with over three mature dams—some up to 1.5m high—vegetated and well-developed. These dams impounded large volumes of water, likely sustaining year-round stream flow downstream at the Dog Creek Road crossing. Total cover amount was rated as moderate with small woody debris dominant. Cover was also present as large woody debris, deep pools, and overhanging vegetation.The average channel width was 3m, the average wetted width was 1.5m, and the average gradient was 2.4%.

The stream was surveyed downstream from crossing 199174 for 300m (Figure 4.9 The stream was intermittent for the first ~70m before transitioning into a beaver-impacted wetland area. Approximately 250m downstream of Sutherland FSR, several large, mature, consecutive beaver dams were present and appeared to continue as far as the area surveyed. Signs of cattle trampling were observed throughout the stream, and the channel frequently split into several smaller channels. The habitat was rated as medium value, with few gravels for spawning but abundant pools created by beaver dams. The average channel width was 2m, the average wetted width was 1m, and the average gradient was 1.2%.Total cover amount was rated as abundant with small woody debris dominant. Cover was also present as large woody debris, undercut banks, deep pools, and overhanging vegetation.The dominant substrate was fines with gravels sub-dominant.

Stream Characteristics Upstream of Crossing 199174

The stream was surveyed upstream from crossing 199174 for 650m (Figure 4.9). The habitat was rated as medium value and had been heavily impacted by cattle, with evidence of bank trampling and extensive low-gradient muddy sections. Upstream of the culvert, the stream was primarily dry

for the first 300m, with young forest and shrubs. At this point, intermittent pools began to appear, associated with beaver activity. At approximately 450–500m upstream, the stream became almost entirely watered, with pools up to 40cm deep. Many surveyed areas resembled wetland habitat, with spirea, willow, alder, and trembling aspen throughout. The average channel width was 2.5m, the average wetted width was 0.9m, and the average gradient was 1.2%.Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris and overhanging vegetation.The dominant substrate was fines with gravels sub-dominant.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the Dog Creek Road crossing (199173) with a bridge (15 m span) is recommended. At the time of reporting in 2025, the cost of the work is estimated at $ 1,500,000.

At the time of assessment, the upstream crossing on Sutherland FSR was unlikely a barrier to fish passage, and restoration efforts should prioritize the downstream crossing on Dog Creek Road. However, should restoration activities proceed at crossing 199174, replacement with a bridge spanning 15 m is recommended. At the time of reporting in 2025, the estimated cost for the replacement is $ 450,000.

Conclusion

Minnow trapping and eDNA sampling have confirmed the presence of chinook upstream and downstream of the Dog Creek Road crossing as recently as 2023 (Booth 2023; B. W. Murray and Booth 2023). Medium value habitat was observed throughout the sections of stream surveyed from Dog Creek Road to Sutherland FSR. No natural or man-made barriers were present between Dog Creek Road and the Nechako River, and the stream provided excellent fish habitat. At the time of assessment, the upstream crossing on Sutherland FSR (PSCIS 199174) was unlikely a barrier to fish passage, and restoration efforts should prioritize the downstream crossing on Dog Creek Road (PSCIS 199173), which had a 0.35m outlet drop and is a high priority for replacement. Of note, heavy cattle use was observed throughout the surveyed area upstream of Dog Creek Road, consistent with observations documented by Booth (2023).

Table 4.14: Summary of habitat details for PSCIS crossings 199173 and 199174.

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
199173	Downstream	115	3.5	1.3	0.3	6.0	moderate	medium
199173	Upstream	575	3.0	1.5	0.3	2.4	moderate	medium

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
199174	Upstream	650	2.5	0.9	0.3	1.2	moderate	medium

Figure 4.8: Left: Typical habitat downstream of PSCIS crossing 199173. Right: Typical habitat upstream of PSCIS crossing 199173.

Figure 4.9: Left: Typical habitat downstream of PSCIS crossing 199174. Right: Typical habitat upstream of PSCIS crossing 199174.

Clear Creek - 199190 - Appendix

Site Location

PSCIS crossing 199190 is located on Clear Creek, approximately 19km northwest of Vanderhoof, BC, in the Nechako River watershed group (Figure 4.10). The crossing is located 8.3km upstream of the Nechako River, on Highway 27, and is the responsibility of the Ministry of Transportation and Infrastructure (`chris_culvert_id`: 1806163).

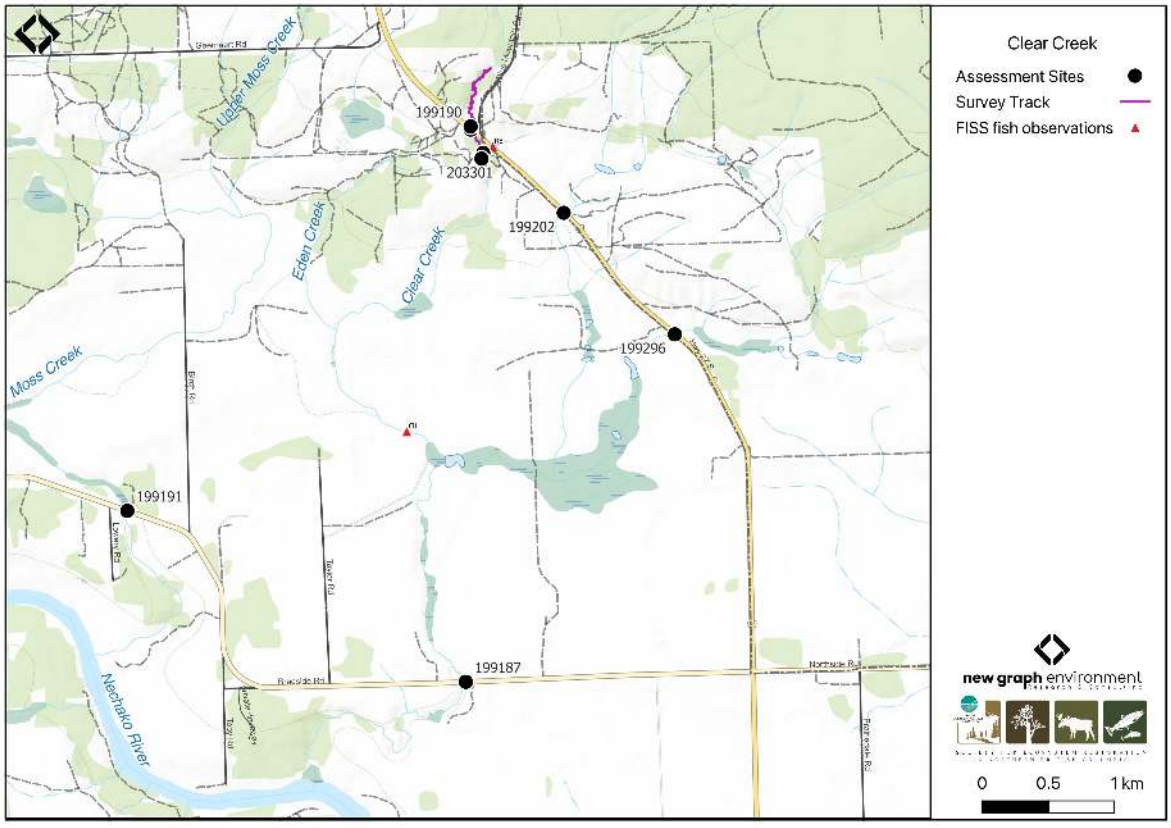


Figure 4.10: Map of Clear Creek

Background

At PSCIS crossing 199190, Clear Creek is a third order stream and drains a watershed of approximately 54.9km^2. The watershed ranges in elevation from a maximum of 987m to 730m near the crossing (Table 4.15).

Since 2020, an ongoing environmental DNA (eDNA) project led by Dr. Brent Murray and Barry Booth at UNBC, in collaboration with School District (SD) 91, has been conducting fish sampling in

the Nechako River watershed, including on Clear Creek. In the lower section of Clear Creek, downstream of Braeside Road, chinook salmon were repeatedly documented through sampling efforts in 2020, 2022, and 2023 (Booth 2023; B. W. Murray and Booth 2023). Upstream of PSCIS crossing 199296, located on a tributary to Clear Creek, coho salmon were detected using eDNA sampling in 2023 (B. W. Murray and Booth 2023). Further upstream on Clear Creek, above crossing 199190 on Highway 27, longnose sucker and lake chub have previously been recorded (Norris [2018] 2024; MoE 2024).

Motivated by these findings, and in addition to a historical chinook salmon observation recorded downstream of Highway 27 in the FISS database (MoE 2024), several crossings within the Clear Creek system were assessed with fish passage assessments in 2023 with results found in Attachment - Phase 1 Data and Photos (page 197).

Crossing 199187 on Braeside Road was found to be fully backwatered and passable, as well as crossing 199296 located on a tributary to Clear Creek which joins above Braeside Road (Figure 4.10). On the mainstem of Clear Creek, crossing 199190 on Highway 27 was ranked as a barrier, noted as being in poor condition, and was prioritized for follow-up due to the presence of high-value habitat. A habitat confirmation assessment encompassing crossing 199190 was subsequently conducted in 2024.

A summary of habitat modelling outputs for the crossing are presented in Table 4.16.

Table 4.15: Summary of derived upstream watershed statistics for PSCIS crossing 199190.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
199190	54.9	730	660	987	859	848	S

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

Table 4.16: Summary of fish habitat modelling for PSCIS crossing 199190.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0.0	0.0	–
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.0	0.0	–
ST Slopeclass08 (km)	0.0	0.0	–
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	0.0	0.0	–
CH Spawning (km)	4.4	3.2	73
CH Rearing (km)	6.2	3.2	52
CO Spawning (km)	10.2	3.2	31
CO Rearing (km)	23.8	3.2	13
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing 199190

At the time of the 2024 assessment, PSCIS crossing 199190 on Highway 27 was un-embedded, non-backwatered and ranked as barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.17). The culvert had a significant 1m outlet drop and a large pile of riprap placed at the outlet, possibly to reduce the drop, though its placement appeared unusual and may inhibit fish passage.

The water temperature was 5°C, pH was 7.9 and conductivity was 350 uS/cm.

Table 4.17: Summary of fish passage assessment for PSCIS crossing 199190.

Location and Stream Data		Crossing Characteristics	–
Date	2024-10-04	Crossing Sub Type	Round Culvert
PSCIS ID	199190	Diameter (m)	1.85
External ID	–	Length (m)	28
Crew	LS	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	425557	Resemble Channel	No
Northing	5996165	Backwatered	No
Stream	Clear Creek	Percent Backwatered	–
Road	Highway 27	Fill Depth (m)	3
Road Tenure	MOTI	Outlet Drop (m)	1
Channel Width (m)	5.22	Outlet Pool Depth (m)	0.2
Stream Slope (%)	1.25	Inlet Drop	No
Beaver Activity	No	Slope (%)	3
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	39	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Location and Stream Data **Crossing Characteristics** –

Comments: The bottom of the culvert had been reinforced with concrete, likely to address holes noted in the previous assessment. A large pile of riprap was placed at the outlet, possibly to reduce the outlet drop, though its placement appeared unusual and could inhibit fish passage. The habitat was high quality, with a large pool just downstream of the culvert and abundant gravels suitable for spawning fish. MoTi chris_culvert_id: 1806163

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

Stream Characteristics Downstream of Crossing 199190

The stream was surveyed downstream from crossing 199190 for 335m (Figure 4.11). The habitat was rated as high value for salmonid spawning an rearing. The stream contained frequent pools suitable for overwintering fish, with abundant cobbles but limited gravels. Evidence of extreme seasonal flows was observed, including large eroding banks, extensive gravel deposits from channel widening (20–30m), and significant log jams. The average channel width was 5.4m, the average wetted width was 4m, and the average gradient was 1.2%.The dominant substrate was cobbles with fines sub-dominant.Total cover amount was rated as abundant with large woody debris dominant. Cover was also present as small woody debris and undercut banks.

Stream Characteristics Upstream of Crossing 199190

The stream was surveyed upstream from crossing 199190 for 550m (Figure 4.11). The habitat was rated as low value. The stream had good flow and provided high-quality habitat for the first 100m before transitioning to subsurface flow. Approximately 200m upstream of the highway, adjacent to a quarry, the stream was fully dewatered to the top of the surveyed reach. The channel was highly confined, lacked complexity, and consisted primarily of a straight, coarse cobble and boulder substrate. While some small and large woody debris were present, they did not appear to contribute to habitat formation during periods of flow. Total cover amount was rated as trace with boulders dominant. Cover was also present as overhanging vegetation.The dominant substrate was cobbles with boulders sub-dominant.The average channel width was 5.2m, the average wetted width was 3.1m, and the average gradient was 1.3%.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the Highway 27 crossing (199190) with a bridge (15 m span) is recommended. At the time of reporting in 2025, the cost of the work is estimated at $ 11,250,000.

Conclusion

Although the habitat upstream of 199190 on Highway 27 was documented as low value for salmonid spawning and rearing, downstream habitat was of high quality, and chinook salmon have been detected downstream as recently as 2023 (B. W. Murray and Booth 2023). Given these factors, follow-up fish sampling (electrofishing or eDNA sampling) at the crossing is recommended. The crossing had a significant outlet drop, with a large pile of riprap placed at the outlet, possibly to reduce the drop, though its placement appeared unusual and may inhibit fish passage.

Table 4.18: Summary of habitat details for PSCIS crossing 199190.

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
199190	Downstream	335	5.4	4.0	0.4	1.2	abundant	high
199190	Upstream	550	5.2	3.1	0.3	1.3	trace	low

Figure 4.11: Left: Typical habitat downstream of PSCIS crossing 199190. Right: Typical habitat upstream of PSCIS crossing 199190.

Nine Mile Creek - 199204 - Appendix

Site Location

PSCIS crossing 199204 is located on Nine Mile Creek, approximately 11km northeast of the Nadleh Whut'en First Nations community near Fraser Lake, BC, in the Nechako River watershed group (Figure 4.12). The crossing is 4.6km upstream of the confluence of Nine Mile Creek and the Nechako River. The crossing is situated on Settlement Road, which is the responsibility of the Ministry of Transportation and Infrastructure (`chris_culvert_id`: 1793923).

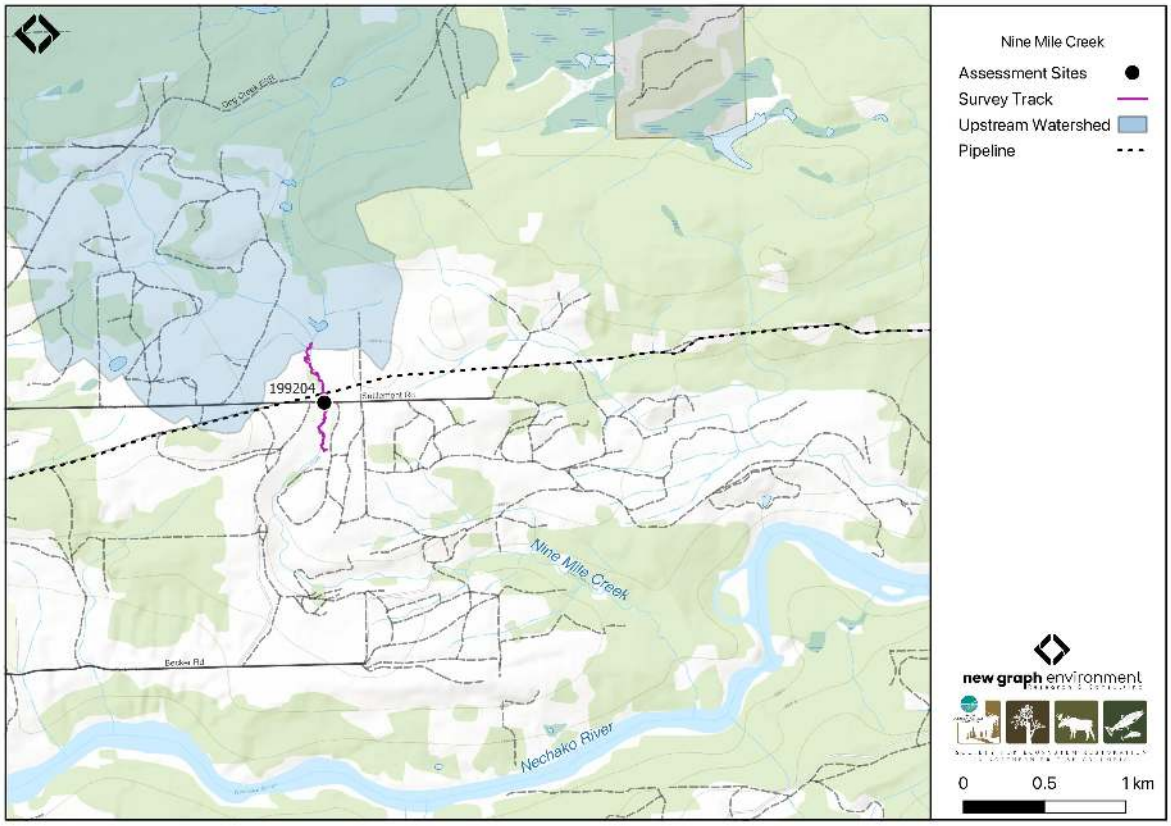


Figure 4.12: Map of Nine Mile Creek

Background

At PSCIS crossing 199204, Nine Mile Creek is a fifth order stream and drains a watershed of approximately 62.4km^2. The watershed ranges in elevation from a maximum of 1317m to 754m near the crossing (Table 4.19).

Since 2020, an ongoing environmental DNA (eDNA) project led by Dr. Brent Murray and Barry Booth at UNBC, in collaboration with School District (SD) 91, has been conducting fish sampling in the Nechako River watershed, including on Nine Mile Creek. Minnow trapping by Booth (2022) in 2021 captured chinook just downstream of this crossing but not upstream, despite the presence of suitable habitat. The study suggested that these culverts may be a barrier to further upstream movement of chinook (Booth 2022). eDNA results from 2021 showed a strong detection for chinook immediately downstream of the Settlement Road crossing, while 2023 results showed a weaker detection at the same location (B. Murray and Booth 2024; B. W. Murray and Booth 2023). Additonally, a strong detection for chinook was observed near the confluence of Nine Mile Creek and the Nechako River in 2023 (B. W. Murray and Booth 2023).

Based on these findings, in 2023, crossing 199204 on Settlement Road was assessed with a fish passage assessment and prioritized for follow-up due to the presence of high-value habitat. A habitat confirmation assessment was subsequently conducted in 2024. Upstream of the Settlement Road, rainbow trout have previously been recorded (Norris [2018] 2024; MoE 2024).

A summary of habitat modelling outputs for the crossing are presented in Table 4.20.

Table 4.19: Summary of derived upstream watershed statistics for PSCIS crossing 199204.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
199204	62.4	754	715	1317	905	876	S

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

Table 4.20: Summary of fish habitat modelling for PSCIS crossing 199204.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0.0	0.0	–
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.0	0.0	–
ST Slopeclass08 (km)	0.0	0.0	–

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Rearing (km)	0.0	0.0	–
CH Spawning (km)	8.0	2.1	26
CH Rearing (km)	24.1	4.0	17
CO Spawning (km)	16.0	2.4	15
CO Rearing (km)	36.8	4.0	11
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing 199204

At the time of the 2024 assessment, PSCIS crossing 199204 on Settlement Road was un-embedded, non-backwatered and ranked as barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.21). Two 1.6m diameter pipes were present, with both inlets dammed by a beaver, causing water to back up to nearly the full height of the culverts. The culverts had a moderate 0.5m outlet drop

The water temperature was 5°C, pH was 7.9 and conductivity was 233 uS/cm.

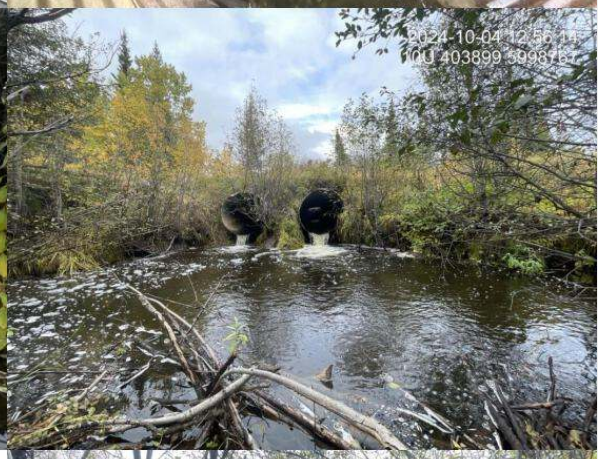
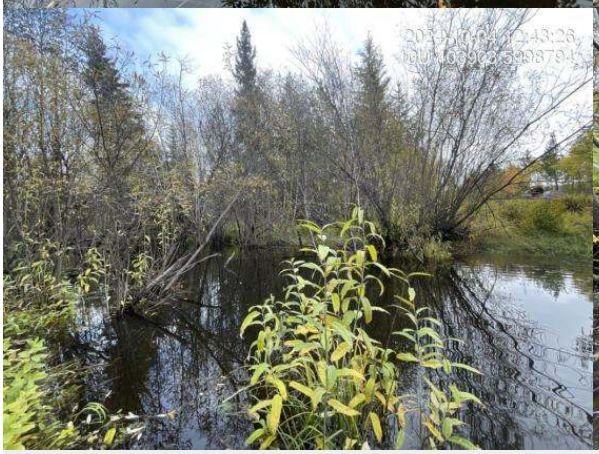
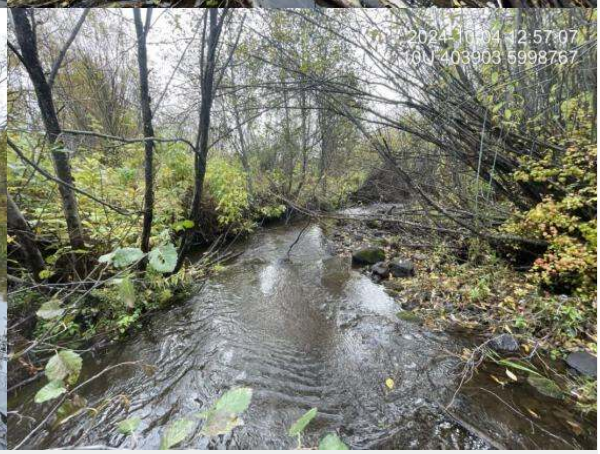
Table 4.21: Summary of fish passage assessment for PSCIS crossing 199204.

Location and Stream Data	•	Crossing Characteristics	–
Date	2024-10-04	Crossing Sub Type	Round Culvert
PSCIS ID	199204	Diameter (m)	3.2
External ID	–	Length (m)	12
Crew	LS	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	403906	Resemble Channel	No
Northing	5998777	Backwatered	No

Location and Stream Data		Crossing Characteristics	–
Road	Settlement Road	Fill Depth (m)	0.5
Road Tenure	MOTI	Outlet Drop (m)	0.5
Channel Width (m)	5.5	Outlet Pool Depth (m)	1.4
Stream Slope (%)	0.5	Inlet Drop	No
Beaver Activity	Yes	Slope (%)	2
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	31	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Comments: The inlets of both culverts were dammed by a beaver, backing up water to most of the culverts' height. Two pipes, each 1.6m in diameter, were present. A large outlet pool indicated the pipes were likely undersized for the stream. Another beaver dam was being constructed at the outlet of the pool. The dirt road had minimal road fill, making construction relatively straightforward. The road appeared to be used for pipeline access. Outlet pool depth was estimated as it was too deep to wade. Fish approximately 40mm in length were observed downstream during habitat confirmation. MoTi chris_culvert_id: 1793923

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

Location and Stream Data	Crossing Characteristics
	
	
	

Stream Characteristics Downstream of Crossing 199204

The stream was surveyed downstream from crossing 199204 for 300m (Figure 4.13). The habitat was rated as high value, with good stream flow, frequent deep pools suitable for overwintering fish, and abundant spawning gravels. Significant beaver activity was observed, including old and active dams blocking both culverts on Settlement Road. The first 150m showed signs of cattle trampling, with numerous small trails crossing the stream. Approximately 300m downstream of Settlement Road, the stream had been artificially entrenched, creating a large backwatered pool with water pipes leading in, likely related to the adjacent cut block (Figure 4.13). Despite modifications, the stream remained well-defined, providing excellent fish habitat. The east side of the stream bordered a cut block with a 30–50m buffer zone. One small fish (~40mm) was observed during the survey. The dominant substrate was gravels with fines sub-dominant.The average channel width was 5.5m, the average wetted width was 3.6m, and the average gradient was 0.8%.Total cover amount was rated as abundant with undercut banks dominant. Cover was also present as large woody debris and deep pools.

Stream Characteristics Upstream of Crossing 199204

The stream was surveyed upstream from crossing 199204 for 425m (Figure 4.14). The habitat was rated as medium value for spawning and rearing. The stream was a larger system with significant beaver activity, creating impoundments behind dams ranging from 0.3 to 1.5m in height. Heavy cattle use was evident in riparian areas, with trampled banks, extensive browsing of riparian shrubs, and a significant amount of manure within seasonally inundated areas. Nutrient loading to the stream appeared high, with large amounts of algae present on the primarily gravel substrates in sections of the channel linking beaver-impounded areas. The dominant substrate was fines with gravels sub-dominant.The average channel width was 6.2m, the average wetted width was 4.4m, and the average gradient was 3%.Total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, overhanging vegetation, and instream vegetation.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the Settlement Road crossing (199204) with a bridge (15 m span) is recommended. At the time of reporting in 2025, the cost of the work is estimated at $ 1,500,000.

Conclusion

Nine Mile Creek is a tributary to the Nechako River and a known chinook system, with chinook captured immediately downstream of the crossing in 2021 and detected through eDNA sampling as recently as 2023 (Booth 2022; B. W. Murray and Booth 2023). Medium value habitat was observed upstream of the crossing, with `bcfishpass` modeling indicating 8km of potential chinook spawning habitat and 16km of potential coho spawning habitat upstream. Downstream provided excellent fish

habitat with good stream flow, frequent deep pools suitable for overwintering fish, and abundant spawning gravels. Beaver activity and heavy cattle use was observed both upstream and downstream of the crossing. The culverts had a 0.5m outlet drop, and the crossing is a moderate priority for replacement.

Table 4.22: Summary of habitat details for PSCIS crossing 199204.

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
199204	Downstream	300	5.5	3.6	0.4	0.8	abundant	high
199204	Upstream	425	6.2	4.4	0.8	3.0	moderate	medium

Figure 4.13: Left: Typical habitat downstream of PSCIS crossing 199204. Right: Large, artificially entrenched pool located ~300m downstream of PSCIS crossing 199204.

Figure 4.14: Typical habitat upstream of PSCIS crossing 199204.

Beaverley Creek - 199232 - Appendix

Site Location

PSCIS crossing 199232 is located on Beaverley Creek, approximately 14km west of Prince George, BC, in the Lower Chilako River watershed group (Figure 4.15). The crossing is 1.9km upstream of Beaverley Creek's confluence with the Chilako River, the later of which flows into the Nechako River. It is situated on Highway 16 and falls under the responsibility of the Ministry of Transportation and Infrastructure (`chris_hwy_structure_road_id`: 4167).

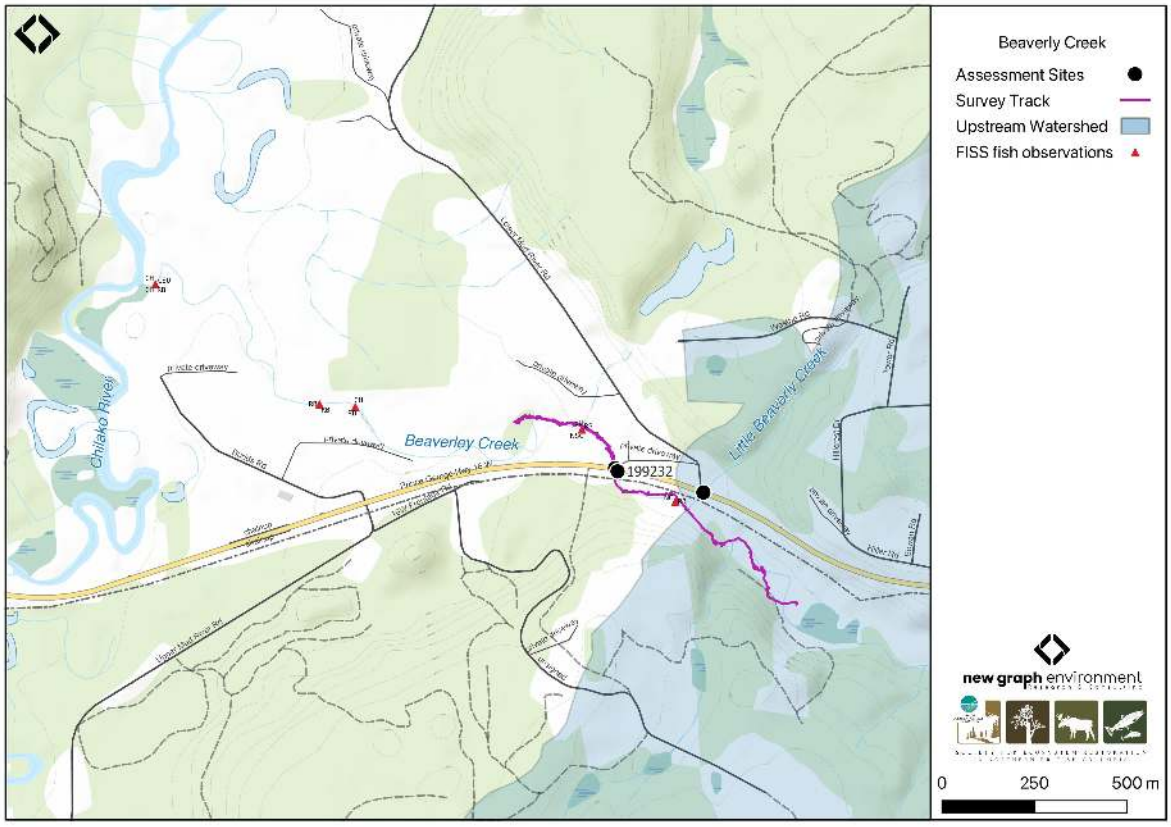


Figure 4.15: Map of Beaverly Creek

Background

At the location of PSCIS crossing 199232, Beaverley Creek is a fifth order stream and drains a watershed of approximately 215.6km^2. The watershed ranges in elevation from a maximum of 1079m to 638m near the crossing (Table 4.23).

In 2023, PSCIS crossing 199232 on Highway 16 was assessed with a fish passage assessment and prioritized for follow-up due to the presence of high-value habitat and several historical chinook observations documented downstream in the FISS database (MoE 2024). A habitat confirmation assessment was subsequently conducted in 2024. Several other crossings were assessed within the Beaverley Creek system in 2023, with results detailed in Attachment - Phase 1 Data and Photos (page 197).

Chinook fry were captured downstream of the crossing in 2010 and 2004 by members from Vancouver Island University (Godfreyson 2010; Hobson 2004). Upstream of Highway 16, sucker (general), longnose sucker, largescale sucker, chub (general), peamouth chub, northern pikeminnow, longnose dace, redside shiner, burbot, rainbow trout, kokanee, chinook salmon, mountain whitefish, dolly varden, and prickly sculpin have previously been recorded (Norris [2018] 2024; MoE 2024).

A summary of habitat modelling outputs for the crossing are presented in Table 4.24.

Table 4.23: Summary of derived upstream watershed statistics for PSCIS crossing 199232.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
199232	215.6	638	579	1079	763	748	S

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

Table 4.24: Summary of fish habitat modelling for PSCIS crossing 199232.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0.0	0.0	–
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.0	0.0	–
ST Slopeclass08 (km)	0.0	0.0	–
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	0.0	0.0	–

Habitat	Potential	Remediation Gain	Remediation Gain (%)
CH Spawning (km)	10.7	3.8	36
CH Rearing (km)	43.1	3.9	9
CO Spawning (km)	46.9	3.9	8
CO Rearing (km)	111.2	4.4	4
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing 199232

At the time of the 2024 assessment, PSCIS crossing 199232 on Highway 16 was un-embedded, non-backwatered and ranked as barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.25). Two 2.8m diameter pipes were present, with no flow observed in the more northern pipe. The culverts had a significant 1.05m outlet drop.

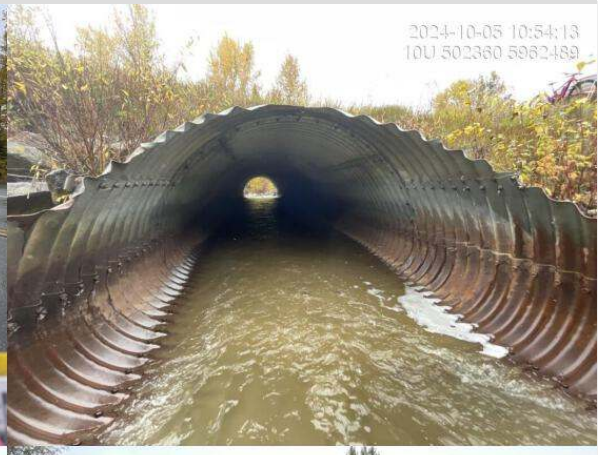
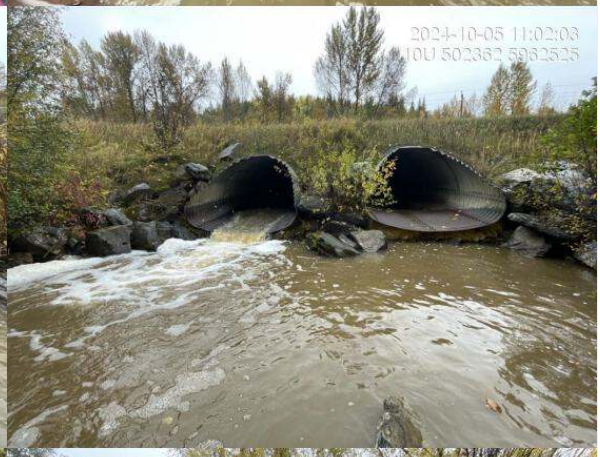
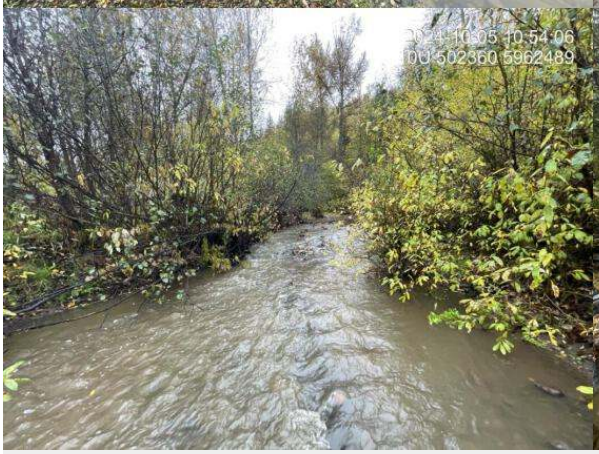
The water temperature was 5°C, pH was 8.2 and conductivity was 230 uS/cm.

Table 4.25: Summary of fish passage assessment for PSCIS crossing 199232.

Location and Stream Data		**Crossing Characteristics**	**–**
Date	2024-10-05	Crossing Sub Type	Oval Culvert
PSCIS ID	199232	Diameter (m)	5.6
External ID	–	Length (m)	25
Crew	LS	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	502374	Resemble Channel	No
Northing	5962501	Backwatered	No
Stream	Beaverley Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	1.5
Road Tenure	MOti	Outlet Drop (m)	1.05
Channel Width (m)	9.6	Outlet Pool Depth (m)	0.35
Stream Slope (%)	0.5	Inlet Drop	No
Beaver Activity	No	Slope (%)	2
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	34	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Comments: Two pipes, each 2.8m in diameter, were present. The pipe on the north side was not flowing. The gradient directly downstream of the culvert was 3-4% due to boulders placed to create backwatering, which was somewhat functioning, though the culverts were not fully backwatered, but water levels were elevated. The rest of the stream had a gradient of 0.5%. The stream provided good habitat but was fairly channelized due to residential development on both sides. Signs of high flows were evident, with eroding banks. Few pools and limited functional large woody debris were present. MoTi chris_hwy_structure_road_id: 4167

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

Location and Stream Data	Crossing Characteristics
	
	
	

Stream Characteristics Downstream of Crossing 199232

The stream was surveyed downstream from crossing 199232 for 300m (Figure 4.16). The habitat was rated as medium value due to sparse large woody debris, a lack of pools, and high turbidity from recent rainfall likely obscuring gravels. Below the outlet, large boulders were placed in rows to backwater the culvert, which was somewhat effective, though the culvert itself remained unbackwatered. This section had a steeper gradient (3–4%) before transitioning to ~0.5% for the remainder of the area surveyed. The upper section of the stream was somewhat channelized due to residences on both sides, while lower sections showed significant bank erosion. The average channel width was 9.6m, the average wetted width was 6m, and the average gradient was 2%.Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as boulders.The dominant substrate was cobbles with gravels sub-dominant.

Stream Characteristics Upstream of Crossing 199232

The stream was surveyed upstream from crossing 199232 for 725m (Figure 4.16). The habitat was rated as high value, with abundant gravels suitable for chinook spawning. Pools were infrequent, primarily located on outside bends and behind large woody debris. Some evidence of anthropogenic manipulation was observed, including cut cottonwood trees that had fallen into the channel. The riparian zone was in good condition, with mature shrub communities and old-growth cottonwood that should contribute to future habitat complexity. Water levels were elevated to moderate conditions due to heavy rainfall over the previous evening and preceding weeks. Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris and boulders.The average channel width was 11.9m, the average wetted width was 8m, and the average gradient was 0.6%.The dominant substrate was gravels with cobbles sub-dominant.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the Highway 16 crossing (199232) with a bridge (15 m span) is recommended. At the time of reporting in 2025, the cost of the work is estimated at $ 11,250,000.

Conclusion

Beaverley Creek is a large stream and a major tributary to the Chilako River, with documented chinook observations downstream, most recently in 2010 (Godfreyson 2010). The areas surveyed upstream provided high-value habitat for chinook spawning, with `bcfishpass` modeling indicating ~11km of potential chinook and ~47km of potential coho spawning habitat upstream. Both culverts had a significant 1.05m outlet drop, and the crossing is a moderate priority for replacement. The watershed is within Prince George city limits, presenting opportunities for community engagement, trail network development, educational programs, and stewardship initiatives.

Table 4.26: Summary of habitat details for PSCIS crossing 199232.

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
199232	Downstream	300	9.6	6	0.4	2.0	moderate	medium
199232	Upstream	725	11.9	8	0.4	0.6	moderate	high

Figure 4.16: Left: Typical habitat downstream of PSCIS crossing 199232. Right: Typical habitat upstream of PSCIS crossing 199232.

Snowshoe Creek - 199237 - Appendix

Site Location

PSCIS crossing 199237 is located on Snowshoe Creek, approximately 45km northwest of McBride, BC, in the Morkill River watershed group. (Figure 4.17). The crossing is located 14.3km upstream of where Snowshoe Creek joins the Fraser River. The crossing is situation on Highway 16 and is the responsibility of the Ministry of Transportation and Infrastructure (`chris_hwy_structure_road_id`: 3751).

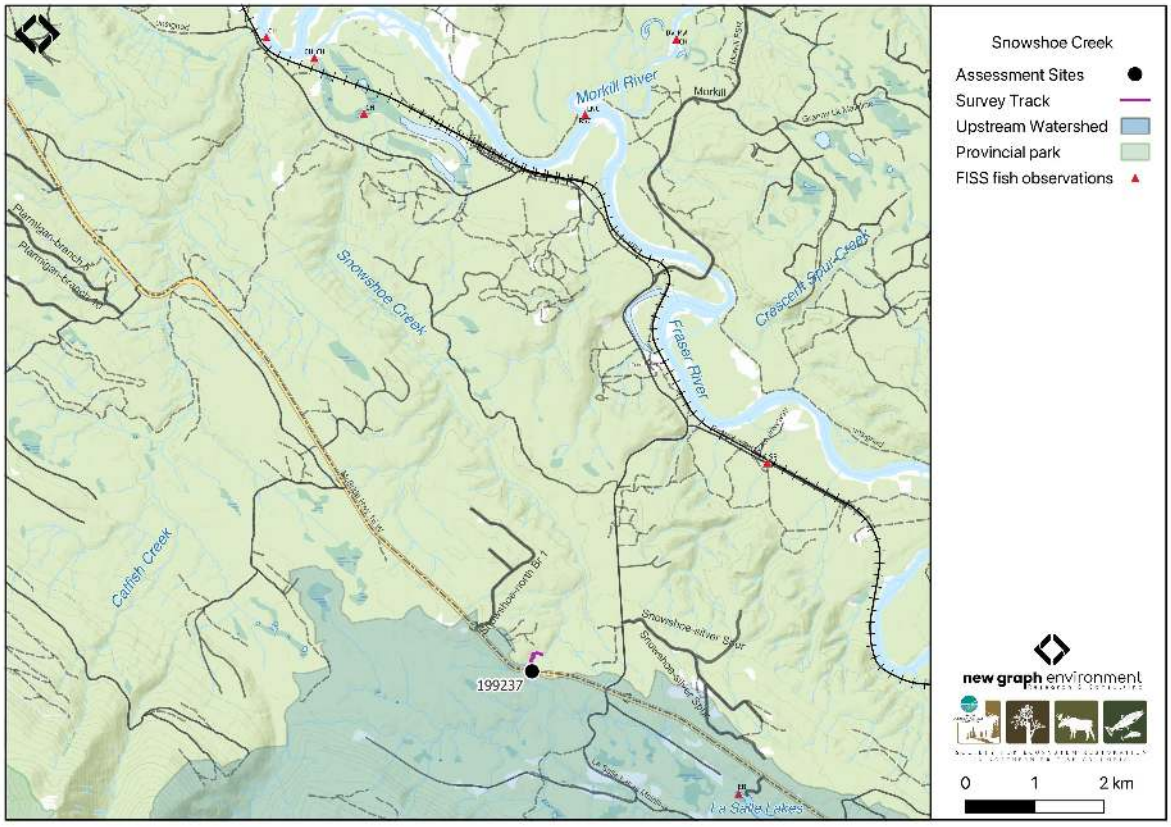


Figure 4.17: Map of Snowshoe Creek

Background

At PSCIS crossing 199237, Snowshoe Creek is a fifth order stream and drains a high elevation watershed of approximately 76.7km^2. The watershed ranges in elevation from a maximum of 2491m to 829m near the crossing (Table 4.27).

In 2023, crossing 199237 on Highway 16 was assessed with a fish passage assessment and prioritized for follow-up due to the presence of high-value habitat and historical salmon observations documented downstream in the FISS database (MoE 2024). A habitat confirmation assessment was subsequently conducted in 2024.

Chinook spawners have been historically documented at the confluence of Snowshoe Creek and the Fraser River in the Pacific Salmon Explorer (Salmon Watersheds Program 2025). Upstream of Highway 16, lake chub, redside shiner, rainbow trout, steelhead, and brook trout have previously been recorded (Norris [2018] 2024; MoE 2024).

A summary of habitat modelling outputs for the crossing are presented in Table 4.28.

Table 4.27: Summary of derived upstream watershed statistics for PSCIS crossing 199237.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
199237	76.7	829	648	2491	1268	1073	SE

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

Table 4.28: Summary of fish habitat modelling for PSCIS crossing 199237.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0.0	0.0	–
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.0	0.0	–
ST Slopeclass08 (km)	0.0	0.0	–
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	0.0	0.0	–
CH Spawning (km)	12.2	8.0	66
CH Rearing (km)	22.3	11.6	52
CO Spawning (km)	0.0	0.0	–

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

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing 199237

At the time of the 2024 assessment, PSCIS crossing 199237 on Highway 16 was un-embedded, non-backwatered and ranked as barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.29). The culvert had a significant 0.65m outlet drop. Photos were limited due to the surveyor's phone falling in the river.

The water temperature was 6°C, pH was 7.6 and conductivity was 138 uS/cm.

Table 4.29: Summary of fish passage assessment for PSCIS crossing 199237.

Location and Stream Data		Crossing Characteristics	–
Date	2024-10-08	Crossing Sub Type	Round Culvert
PSCIS ID	199237	Diameter (m)	2.5
External ID	–	Length (m)	45
Crew	LS	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	650786	Resemble Channel	No
Northing	5934862	Backwatered	No
Stream	Snowshoe Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	–
Road Tenure	MoTi	Outlet Drop (m)	0.65
Channel Width (m)	14	Outlet Pool Depth (m)	1.9
Stream Slope (%)	0.6	Inlet Drop	No
Beaver Activity	No	Slope (%)	2
Habitat Value	High	Valley Fill	Deep Fill
Final score	37	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	19

Location and Stream Data	Crossing Characteristics	–

Comments: The culvert had a deep outlet pool and a very large outlet drop. The stream contained functional large woody debris creating complex cover and pools.No photos are available because the surveyors phone fell into the stream. MoTi chris_hwy_structure_road_id: 3751

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

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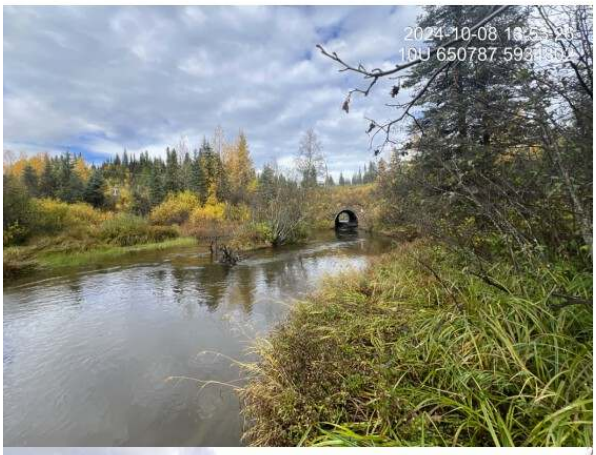

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Stream Characteristics Downstream of Crossing 199237

The stream was surveyed downstream from crossing 199237 for 300m . The habitat was rated as high value. Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris and overhanging vegetation.The average channel width was 14m, the average wetted width was 12.4m, and the average gradient was 0.7%.The dominant substrate was fines with gravels sub-dominant. No photos were available due to the surveyor's phone falling in the river.

Stream Characteristics Upstream of Crossing 199237

The stream was surveyed upstream from crossing 199237 for 750m , following the west fork at the junction (Figure 4.18). The habitat was rated as high value. Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris, undercut banks, deep pools, and overhanging vegetation.The average channel width was 12.3m, the average wetted width was 11.6m, and the average gradient was 0.7%.The dominant substrate was gravels with fines sub-dominant.

The east fork of Snowshoe Creek was surveyed upstream for 230m (Figure 4.18). The habitat was rated as high value. The dominant substrate was gravels with fines sub-dominant.The average channel width was 6.8m, the average wetted width was 5.5m, and the average gradient was 1.3%.Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris, undercut banks, deep pools, overhanging vegetation, and instream vegetation.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the Highway 16 crossing with a bridge (19 m span) is recommended. At the time of reporting in 2025, the cost of the work is estimated at $ 14,250,000.

Conclusion

PSCIS crossing 199237 on Highway 16 had a significant 0.65m outlet drop and is a moderate priority for replacement. Downstream of Highway 16, chinook have historically spawned at the confluence of Snowshoe Creek and the Fraser River (Salmon Watersheds Program 2025), indicating this stream has provided valuable spawning habitat. Given that the habitat upstream of Highway 16 was rated as high value for spawning and rearing during the 2024 assessment, fish sampling is recommended to further assess whether the crossing is inhibiting fish passage.

Table 4.30: Summary of habitat details for PSCIS crossing 199237.

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
199237	Downstream	300	14.0	12.4	0.6	0.7	moderate	high
199237	Upstream	750	12.3	11.6	0.8	0.7	moderate	high
199237	us2	230	6.8	5.5	0.8	1.3	moderate	high

Figure 4.18: Left: Typical habitat upstream of PSCIS crossing 199237 on the west fork on Snowshoe Creek. Right: Typical habitat upstream of PSCIS crossing 199237 on the east fork on Snowshoe Creek.

Tributary To Kenneth Creek - 199255 - Appendix

Site Location

PSCIS crossing 199255 is located on a Tributary To Kenneth Creek, approximately 65km east of Prince George, BC, in the Morkill River watershed group (Figure 4.19). The crossing is located 3.7km upstream of the tributary's confluence with Kenneth Creek, which subsequently flows into the Fraser River approximately 9km downstream. The crossing is situated on Bowron FSR, which is under the jurisdiction of the Ministry of Forests.

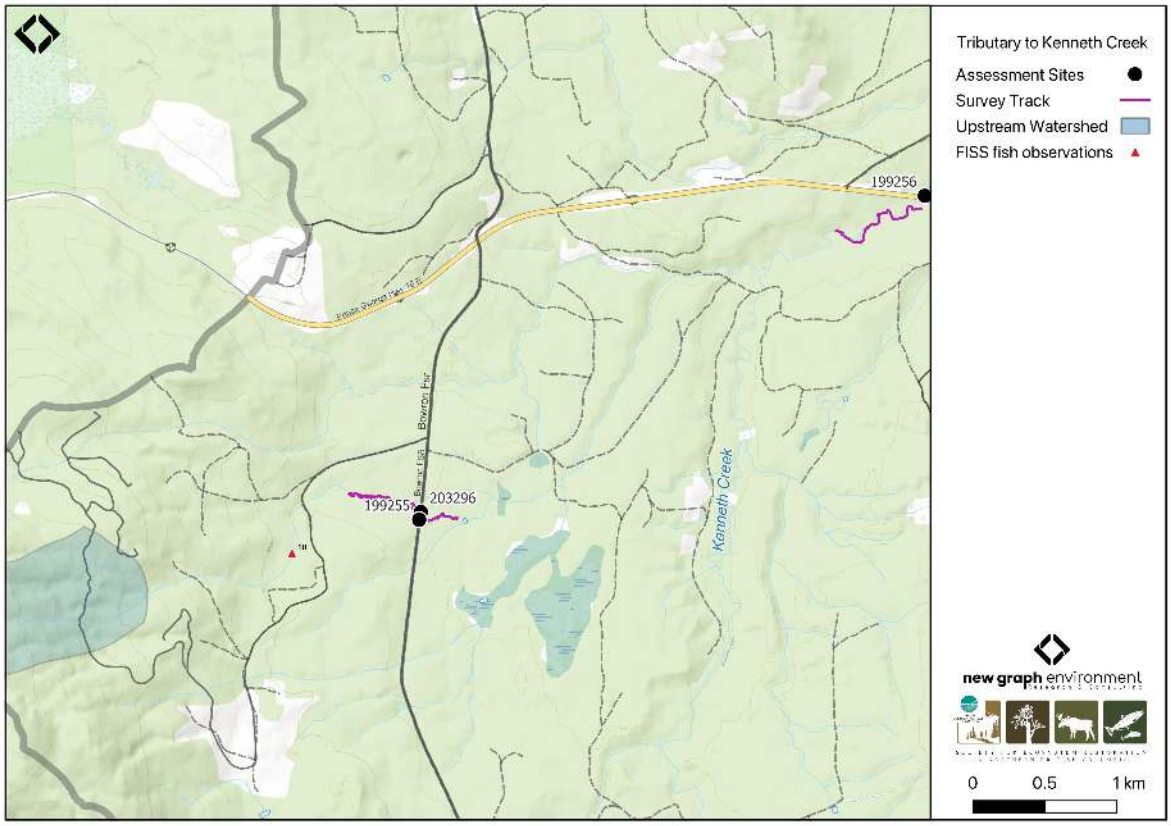


Figure 4.19: Map of Tributary to Kenneth Creek

Background

At PSCIS crossing 199255, Tributary To Kenneth Creek is a second order stream and drains a watershed of approximately 1.1km^2. The watershed ranges in elevation from a maximum of 1343m to 723m near the crossing (Table 4.31).

In 2023, crossing 199255 on Bowron FSR was assessed with a fish passage assessment and prioritized for follow-up due to the presence of high-value habitat and its proximity to Kenneth Creek, which has chinook observations documented in the FISS database (MoE 2024). A habitat confirmation assessment was subsequently conducted in 2024.

Chinook spawners have been historically documented at the confluence of Kenneth Creek and the Fraser River in the Pacific Salmon Explorer (Salmon Watersheds Program 2025). Upstream of Bowron FSR, longnose sucker have previously been recorded (Norris [2018] 2024; MoE 2024).

A summary of habitat modelling outputs for the crossing are presented in Table 4.32.

Table 4.31: Summary of derived upstream watershed statistics for PSCIS crossing 199255.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
199255	1.1	723	957	1343	1181	1127	E

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

Table 4.32: Summary of fish habitat modelling for PSCIS crossing 199255.

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

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

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing 199255

At the time of the 2024 assessment, PSCIS crossing 199255 on Bowron FSR was un-embedded, non-backwatered and ranked as barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.33). The outlet of the culvert was plugged with beaver sticks, and it appeared the beaver had dammed the culvert entirely, creating a large pond area upstream of the inlet with the inlet completely submerged. Despite this, the culvert still had flow. A new culvert had been installed 60m north on the FSR (PSCIS 203296), with flow from that crossing entering the outlet pool from the north.

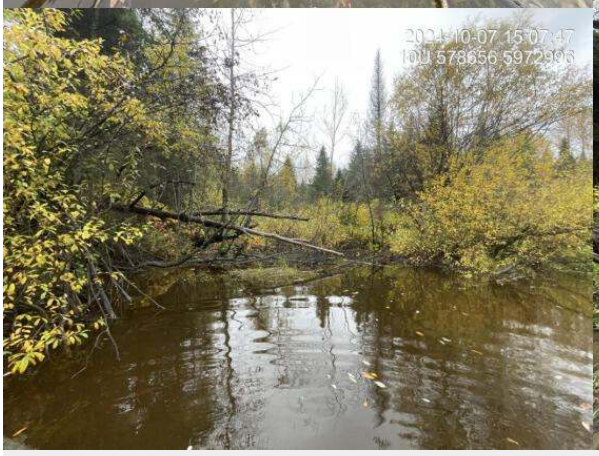
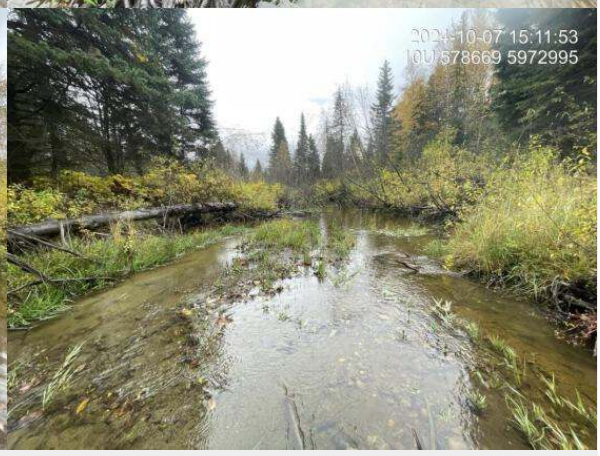
The water temperature was 7°C, pH was 7.4 and conductivity was 80 uS/cm.

Table 4.33: Summary of fish passage assessment for PSCIS crossing 199255.

Location and Stream Data		**Crossing Characteristics**	**–**
Date	2024-10-07	Crossing Sub Type	Round Culvert
PSCIS ID	199255	Diameter (m)	1.1
External ID	–	Length (m)	13
Crew	LS	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	578664	Resemble Channel	No
Northing	5972996	Backwatered	No
Stream	Tributary To Kenneth Creek	Percent Backwatered	–
Road	Bowron FSR	Fill Depth (m)	1.5
Road Tenure	MoF	Outlet Drop (m)	0
Channel Width (m)	10.5	Outlet Pool Depth (m)	0.25
Stream Slope (%)	0.5	Inlet Drop	No
Beaver Activity	Yes	Slope (%)	1.5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	21	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Comments: The inlet of the culvert was completely submerged, with a large beaver pond area just upstream. The outlet was plugged with beaver sticks, and it appeared the beaver had dammed the culvert entirely, creating a large pool at the inlet. Despite this, the culvert still had flow. A beaver dam approximately 0.7m in height was located about 40m downstream. A new culvert had been installed 60m north on the FSR, with flow from that crossing entering the outlet pool from the north. Downstream of the culvert, the stream flowed through the forest with minimal defined channel. Where a defined channel was present, it ranged from 13m wide, but most of the area consisted of 15-17m of wetted forest with some flow. Culvert slope was estimated due to the submerged inlet. Habitat confirmations were conducted upstream and downstream.

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

Location and Stream Data	Crossing Characteristics
	
	
	

Stream Characteristics Downstream of Crossing 199255

The stream was surveyed downstream from crossing 199255 for 270m (Figure 4.20). The habitat was rated as low value for spawning and rearing with no gravels or cobbles observed and the substrate consisting entirely of fine mud. Fish habitat was limited, with very few pools present. The first 130m of the stream was a beaver-affected area, with a beaver dam approximately 0.7m high located ~40m downstream of the culvert. The dam had flooded the surrounding forest, with no main channel observed. Occasional sections had a somewhat defined channel, but the majority of the surveyed area consisted of water flowing through a wet forest. The dominant substrate was fines with fines sub-dominant.The average channel width was 10.3m, the average wetted width was 7m, and the average gradient was 0.8%.Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris, undercut banks, and instream vegetation..

Stream Characteristics Upstream of Crossing 199255

The stream was surveyed upstream from crossing 199255 for 650m (Figure 4.20). The habitat was rated as medium value with good flow and abundant gravels suitable for bull trout and cutthroat trout spawning. Occasional shallow pools provided habitat for juvenile salmonid rearing. Banks were stable, with an intact mixed mature forest. The stream was small and had some short sections with gradients up to 5% but was primarily a low-gradient riffle-gravel system. Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, and overhanging vegetation.The dominant substrate was gravels with cobbles sub-dominant.The average channel width was 3.4m, the average wetted width was 2.8m, and the average gradient was 2.8%.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the Bowron FSR crossing (199255) with a bridge (15 m span) is recommended. At the time of reporting in 2025, the cost of the work is estimated at $ 450,000.

Conclusion

Although the culvert ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011), blockage due to beaver activity is a greater issue than the culvert itself. The outlet was plugged with beaver sticks, and it appeared the beaver had dammed the culvert entirely, creating a large pond upstream with the inlet completely submerged. Despite this, some flow remained. The habitat surveyed downstream was low value but could change if beaver activity decreased; however, most of the area consisted of water flowing through a wet forest with a substrate of fine mud. Upstream habitat was rated as medium value, with good flow and abundant gravels suitable for bull trout and cutthroat trout spawning, making the crossing a moderate priority for replacement.

Table 4.34: Summary of habitat details for PSCIS crossing 199255.

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
199255	Downstream	270	10.3	7.0	0.2	0.8	moderate	low
199255	Upstream	650	3.4	2.8	0.3	2.8	moderate	medium

Figure 4.20: Left: Typical habitat downstream of PSCIS crossing 199255. Right: Typical habitat upstream of PSCIS crossing 199255.

Kenneth Creek - 199256 - Appendix

Site Location

PSCIS crossing 199256 is located on Kenneth Creek, approximately 80km east of Prince George, BC, in the Morkill River watershed group (Figure 4.21). The crossing is located 9.8km upstream of the confluence of Kenneth Creek and the Fraser River. The crossing is situated on Highway 16, and is the responsibility of the Ministry of Transportation and Infrastructure (`chris_hwy_structure_road_id`: 3750).

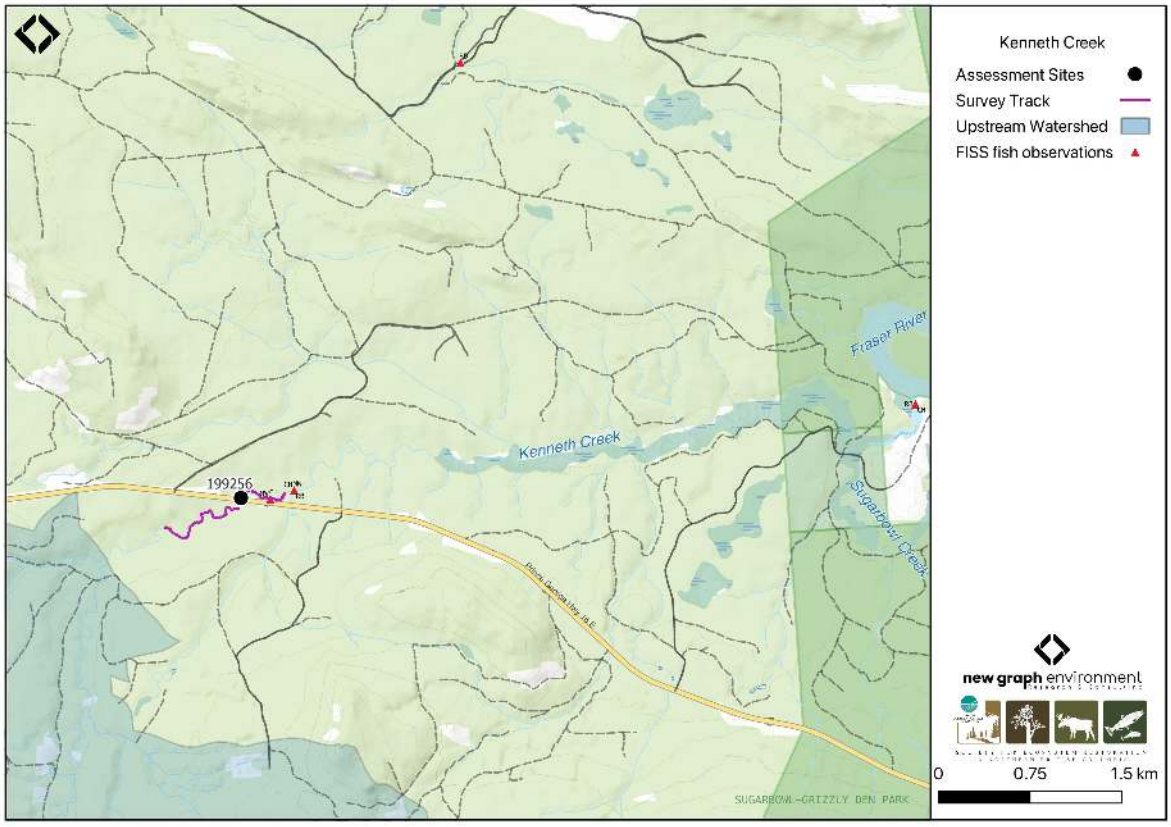


Figure 4.21: Map of Kenneth Creek

Background

At PSCIS crossing 199256, Kenneth Creek is a fifth order stream and drains a watershed of approximately 172km^2. The watershed ranges in elevation from a maximum of 1886m to 655m near the crossing (Table 4.35).

In 2023, crossing 199256 on Highway 16 was assessed with a fish passage assessment and prioritized for follow-up due to the presence of high-value habitat and chinook observations documented downstream in the FISS database (MoE 2024). Additionally, a dead chinook spawner was observed upstream of the Highway 16 culvert during an informal site visit in 2022. A habitat confirmation assessment was subsequently conducted in 2024.

Chinook spawners have been historically documented at the confluence of Kenneth Creek and the Fraser River in the Pacific Salmon Explorer (Salmon Watersheds Program 2025). Upstream of the Highway 16, longnose sucker, rainbow trout, chinook salmon, bull trout, sculpin (general), and slimy sculpin have previously been recorded (Norris [2018] 2024; MoE 2024).

A summary of habitat modelling outputs for the crossing are presented in Table 4.36.

Table 4.35: Summary of derived upstream watershed statistics for PSCIS crossing 199256.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
199256	172	655	619	1886	841	805	S

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

Table 4.36: Summary of fish habitat modelling for PSCIS crossing 199256.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0.0	0.0	–
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.0	0.0	–
ST Slopeclass08 (km)	0.0	0.0	–
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	0.0	0.0	–
CH Spawning (km)	47.6	42.1	88
CH Rearing (km)	71.6	49.6	69

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

* Model data is preliminary and subject to adjustments.

Aerial Imagery

An aerial survey was conducted with a remotely piloted aircraft and the resulting imagery was processed into an orthomosaic available to view and download here.

Stream Characteristics at Crossing 199256

At the time of the 2024 assessment, PSCIS crossing 199256 on Highway 16 was un-embedded, non-backwatered and ranked as barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.37). The culvert had a significant 0.7m outlet drop.

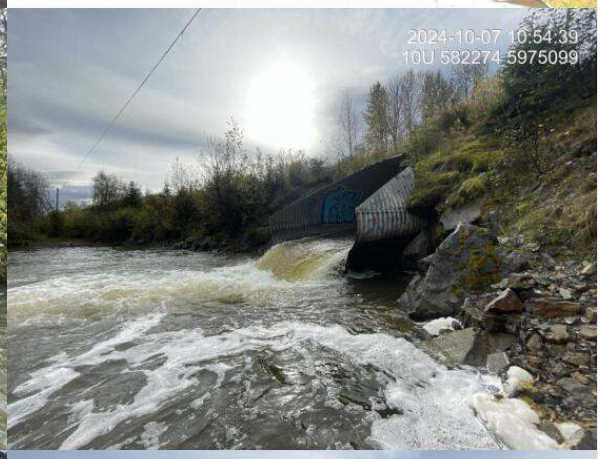
The water temperature was 6°C, pH was 7.8 and conductivity was 201 uS/cm.

Table 4.37: Summary of fish passage assessment for PSCIS crossing 199256.

Location and Stream Data		**Crossing Characteristics**	**–**
Date	2024-10-07	Crossing Sub Type	Oval Culvert
PSCIS ID	199256	Diameter (m)	5.5
External ID	–	Length (m)	30
Crew	LS	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	582279	Resemble Channel	No
Northing	5975090	Backwatered	No
Stream	Kenneth Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	1.5
Road Tenure	MOTI	Outlet Drop (m)	0.7
Channel Width (m)	19	Outlet Pool Depth (m)	2
Stream Slope (%)	0.5	Inlet Drop	No
Beaver Activity	No	Slope (%)	1
Habitat Value	High	Valley Fill	Deep Fill
Final score	37	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	24

Comments: Large multi-plate oval culvert with a substantial 50m-wide outlet pool. The stream had high flow at the time of assessment. Culvert slope and outlet pool depth were estimated as the pool was too deep to wade. Deep pools over 1m, formed by functional large woody debris, provided good overwintering habitat for fish of all ages. Gravels suitable for spawning were present. Downstream of the culvert, the stream ran parallel to the highway with banks reinforced by riprap and large wood secured with metal wiring to create habitat and reduce flow. MoTi chris_hwy_structure_road_id: 3750

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

Location and Stream Data	Crossing Characteristics
	
	
	

Stream Characteristics Downstream of Crossing 199256

The stream was surveyed downstream from crossing 199256 for 370m (Figure 4.22). The habitat was rated as high value, with abundant spawning gravels and deep pools (>1m) formed by functional large woody debris, providing high-quality overwintering habitat for fish of all ages. 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, deep pools, and overhanging vegetation.The average channel width was 19m, the average wetted width was 16.1m, and the average gradient was 0.7%.

Downstream of the culvert, the stream ran parallel to the highway, with banks reinforced by riprap. Large wood, secured with metal wiring, was placed to create habitat and reduce flow, arranged in three sets of two logs spaced approximately 5m apart (Figure 4.23). These structures were likely installed to mitigate habitat loss caused by the riprapped banks.

Stream Characteristics Upstream of Crossing 199256

The stream was surveyed upstream from crossing 199256 for 950m (Figure 4.22). The habitat was rated as high value, with gravels suitable for chinook and resident salmonid spawning. The stream was large and gravel-dominated, with extensive deep runs, deep pools, large woody debris, and multiple channels throughout. The riparian area was intact throughout, consisting of a mix of shrub-dominated wetland areas and mature mixed forest. The average channel width was 22.8m, the average wetted width was 16.7m, and the average gradient was 0.8%.The dominant substrate was gravels with cobbles sub-dominant.Total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, large woody debris, undercut banks, and overhanging vegetation.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the Highway 16 crossing (PSCIS 199256) with a bridge (24 m span) is recommended. At the time of reporting in 2025, the cost of the work is estimated at $ 18,000,000.

Conclusion

Kenneth Creek is a large, gravel-dominated stream with high-value habitat for salmonid spawning and rearing. Chinook and bull trout have been documented upstream (Norris [2018] 2024; MoE 2024), and a dead chinook spawner was observed upstream of the Highway 16 culvert during an informal site visit in 2022. The crossing had a significant 0.7m outlet drop, and fish sampling is recommended to determine if it is currently inhibiting fish passage. Additionally, `bcfishpass`

modeling indicates nearly 50km of potential chinook spawning habitat upstream. The crossing is a moderate priority for replacement.

Table 4.38: Summary of habitat details for PSCIS crossing 199256.

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
199256	Downstream	370	19.0	16.1	1.0	0.7	abundant	high
199256	Upstream	950	22.8	16.7	0.8	0.8	moderate	high

Figure 4.22: Left: Typical habitat downstream of PSCIS crossing 199256. Right: Typical habitat upstream of PSCIS crossing 199256.

Figure 4.23: Ripwrapped banks and large wood structures secured with metal wiring located downstream of crossing 199256.

Tributary To Sugarbowl Creek - 199260 - Appendix

Site Location

PSCIS crossing 199260 is located on Tributary To Sugarbowl Creek, approximately 100km east of Prince George, BC, in the Morkill River watershed group (Figure 4.24). The crossing is located 2.4km upstream of Sugarbowl Creek, which flows into Kenneth Creek before joining the Fraser River. The crossing is situated on Highway 16 and is under the jurisdiction of the Ministry of Transportation and Infrastructure (`chris_culvert_id`: 1992815).

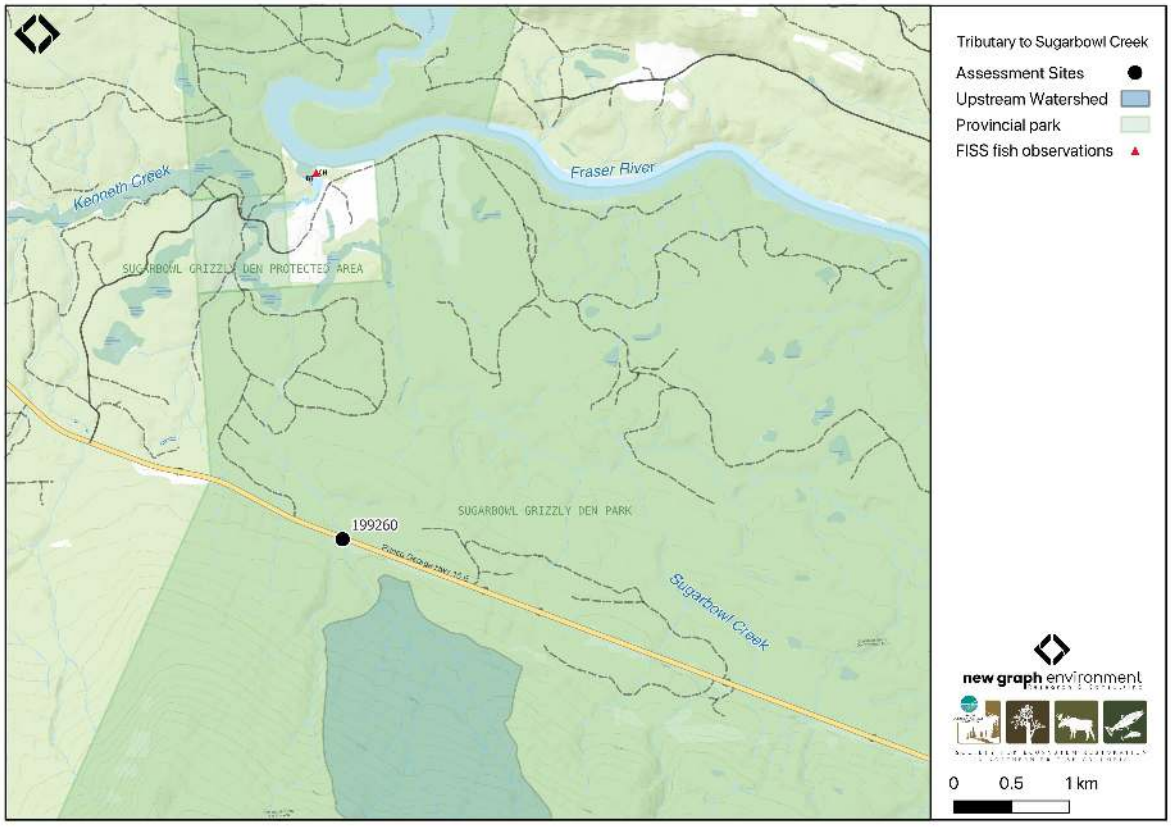


Figure 4.24: Map of Tributary to Sugarbowl Creek

Background

At the crossing location, Tributary To Sugarbowl Creek is a third order stream and drains a high elevation watershed of approximately 4.4km^2. The watershed ranges in elevation from a maximum of 1801m to 776m near the crossing (Table 4.39).

In 2023, crossing 199260 on Highway 16 was assessed with a fish passage assessment and prioritized for follow-up due to the presence of high-value habitat. A habitat confirmation assessment was subsequently conducted in 2024.

Approximately 4.5km downstream of the crossing, near the confluence of Kenneth Creek and the Fraser River, chinook and bull trout have previously been recorded (Figure 4.24)(Norris [2018] 2024; MoE 2024). At this same location, chinook spawners have been historically documented in the Pacific Salmon Explorer (Salmon Watersheds Program 2025).

This crossing is located in the Sugarbowl-Grizzly Den Provincial Park which is within the traditional territory of the Lheidli T'enneh. The park protects a significant area of old-growth interior cedar-hemlock forest, provides high-quality habitat for wildlife, including grizzly bear, marten, and caribou, and serves as an important movement corridor for caribou. Additionally, the area features a trail system that supports popular alpine backcountry recreation opportunities near Prince George ("Sugarbowl-Grizzly Den Park" n.d.; "Sugarbowl-Grizzly Den Cabins – PGBRS" n.d.).

Table 4.39: Summary of derived upstream watershed statistics for PSCIS crossing 199260.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
199260	4.4	776	726	1801	1160	1058	NE

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

Stream Characteristics at Crossing 199260

At the time of the 2024 assessment, PSCIS crossing 199260 on Highway 16 was un-embedded, non-backwatered and ranked as barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.40). The culvert had a significant 1.4m outlet drop.

The water temperature was 5°C, pH was 7.8 and conductivity was 208 uS/cm.

Table 4.40: Summary of fish passage assessment for PSCIS crossing 199260.

Location and Stream Data	•	Crossing Characteristics	–
Date	2024-10-07	Crossing Sub Type	Round Culvert
PSCIS ID	199260	Diameter (m)	1.2
External ID	–	Length (m)	50
Crew	LS	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	587916	Resemble Channel	No
Northing	5972449	Backwatered	No
Stream	Tributary To Sugarbowl Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	9
Road Tenure	MOTI	Outlet Drop (m)	1.4
Channel Width (m)	7	Outlet Pool Depth (m)	0.9
Stream Slope (%)	5	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	6
Habitat Value	High	Valley Fill	Deep Fill
Final score	42	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	33

Location and Stream Data **Crossing Characteristics** –

Comments: The culvert had a significant 1.4m outlet drop, and inlet drop due to a small debris jam. The stream flowed through mature old-growth forest and provided high-quality habitat with steep gradients, step pools, and cascade pools, suggesting the potential presence of bull trout. The highway crossing had a large amount of road fill, making construction difficult and expensive. The site would be a good candidate for replacement if feasible. The riparian area at the outlet had been cleared due to overhead powerlines. MoTi chris_culvert_id: 1992815

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

Stream Characteristics Downstream of Crossing 199260

The stream was surveyed downstream from crossing 199260 for 320m (Figure 4.25). The habitat was rated as high value, with gravels suitable for spawning and occasional pools ranging from 0.2–0.4m deep providing overwintering habitat. The stream flowed through a healthy, mature old-growth forest. The dominant substrate was cobbles with boulders sub-dominant.The average channel width was 7m, the average wetted width was 4.2m, and the average gradient was 5.3%.Total cover amount was rated as abundant with large woody debris dominant. Cover was also present as small woody debris and boulders.

Stream Characteristics Upstream of Crossing 199260

The stream was surveyed upstream from crossing 199260 for 650m (Figure 4.25). The habitat was rated as medium value, and appeared suitable for large bull trout spawning and rearing. The stream was a larger, steeper system with intact, mature coniferous cedar-hemlock riparian cover, primarily stable banks, and abundant large woody debris throughout. A step-pool morphology was present, characterized by pools up to 80cm deep and debris jam steps ranging from 30–60cm. The average channel width was 6.1m, the average wetted width was 5.1m, and the average gradient was 7.1%.Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris, boulders, undercut banks, deep pools, and overhanging vegetation.The dominant substrate was cobbles with gravels sub-dominant.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the Highway 16 crossing (199260) with a bridge (33 m span) is recommended. At the time of reporting in 2025, the cost of the work is estimated at $ 24,750,000.

Conclusion

PSCIS crossing 199260 had a substantial 1.4m outlet drop and is a high priority for replacement. Average gradients were generally above the maximum thresholds for chinook spawning and rearing (4.5% and 5.5%, respectively), but fell within the suitable range for bull trout spawning and rearing (5.5% and 10.5%, respectively). The habitat upstream was rated as medium value for bull trout spawning and rearing, with `bcfishpass` modeling indicating ~900m of potential bull trout rearing habitat upstream of the crossing. Given the crossings location within Sugarbowl-Grizzly Den Provincial Park and the park's ecological significance, restoration efforts could align with broader conservation initiatives and public engagement, increasing the likelihood of funding and project momentum.

Table 4.41: Summary of habitat details for PSCIS crossing 199260.

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
199260	Downstream	320	7.0	4.2	0.3	5.3	abundant	high
199260	Upstream	650	6.1	5.1	0.4	7.1	moderate	medium

Figure 4.25: Left: Typical habitat downstream of PSCIS crossing 199260. Right: Typical habitat upstream of PSCIS crossing 199260.

Driscoll Creek - 199267 - Appendix

Site Location

PSCIS crossing 199267 is located on Driscoll Creek, approximately 100km northwest of McBride, BC, in the Morkill River watershed group (Figure 4.31). The crossing is located 7.7km upstream of where Driscoll Creek joins the Fraser River. Situation on Highway 16, the crossing is the responsibility of the Ministry of Transportation and Infrastructure (`chris_culvert_id`: 1992674).

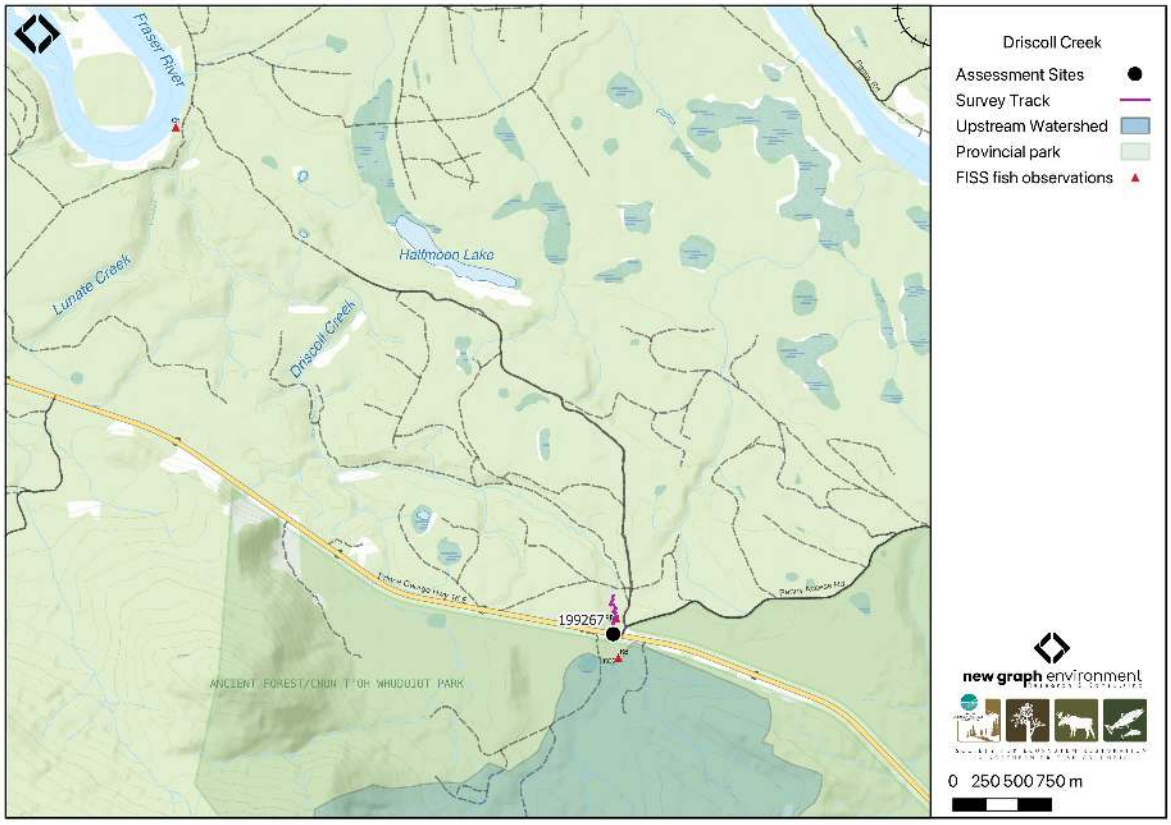


Figure 4.26: Map of Driscoll Creek

Background

At PSCIS crossing 199267, Driscoll Creek is a fourth order stream and drains a high elevation watershed of approximately 34.3km^2. The watershed ranges in elevation from a maximum of 1795m to 683m near the crossing (Table 4.42).

In 2023, crossing 199267 on Highway 16 was assessed with a fish passage assessment and prioritized for follow-up due to the presence of high-value habitat and a historical chinook observations documented downstream in the FISS database (MoE 2024). A habitat confirmation assessment was subsequently conducted in 2024.

Chinook spawners have been historically documented at the confluence of Driscoll Creek and the Fraser River in the Pacific Salmon Explorer (Salmon Watersheds Program 2025). Upstream of the Highway 16, rainbow trout and slimy sculpin have previously been recorded (Norris [2018] 2024; MoE 2024).

This crossing is located on the boundary of the Chun T'oh Whudujut (Ancient Forest), a Provincial Park and Protected Area within the traditional territory of the Lheidli T'enneh. The park has thousand-year-old western red cedars and a rich biodiversity of plants, mosses, lichens and fungi which can be explored through the trail network. Historically, Lheidli people would visit the stands from summer fishing camps along the upper Fraser River as well as gather medicinal plants, some of which were thought to be extinct. However, the park was not always a protected area and was initially slated for logging until a UNBC graduate student studying lichen biodiversity identified the ancient stands of western red cedars. Recognizing their ecological and cultural significance, trails were developed to highlight the cedars and advocate for their protection. Through partnerships with local hiking groups, UNBC, Lheidli T'enneh, and the Provincial Government, the Ancient Forest biodiversity assessment project has contributed to conservation efforts and tourism-based economic development in the Prince George area ("Chun t'oh Whudujut (Ancient Forest)" 2025).

A summary of habitat modelling outputs for the crossing are presented in Table 4.43.

Table 4.42: Summary of derived upstream watershed statistics for PSCIS crossing 199267.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
199267	34.3	683	621	1795	960	871	SE

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

Table 4.43: Summary of fish habitat modelling for PSCIS crossing 199267.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0.0	0.0	–

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.0	0.0	–
ST Slopeclass08 (km)	0.0	0.0	–
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	0.0	0.0	–
CH Spawning (km)	6.9	1.8	26
CH Rearing (km)	8.2	2.1	26
CO Spawning (km)	0.0	0.0	–
CO Rearing (km)	0.0	0.0	–
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing 199267

At the time of the 2024 assessment, PSCIS crossing 199267 on Highway 16 was un-embedded, non-backwatered and ranked as barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.44). The culvert had a significant 0.65m outlet drop. Photos were limited due to the surveyor's phone falling in the river.

The water temperature was 6°C, pH was 7.5 and conductivity was 245 uS/cm.

Table 4.44: Summary of fish passage assessment for PSCIS crossing 199267.

Location and Stream Data	•	Crossing Characteristics	–
Date	2024-10-08	Crossing Sub Type	Round Culvert
PSCIS ID	199267	Diameter (m)	2.3
External ID	–	Length (m)	56
Crew	LS	Embedded	No
UTM Zone	10	Depth Embedded (m)	–
Easting	606378	Resemble Channel	No
Northing	5965782	Backwatered	No
Stream	Driscoll Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	1
Road Tenure	MoTi	Outlet Drop (m)	0.65
Channel Width (m)	10.6	Outlet Pool Depth (m)	1.25
Stream Slope (%)	0.6	Inlet Drop	No
Beaver Activity	Yes	Slope (%)	2.5
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	37	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Location and Stream Data	Crossing Characteristics	–

Comments: The culvert had a deep outlet pool and a very large outlet drop. The stream was banked with a well-developed, healthy, riparian zone consisting of old-growth forest. A beaver dam was located just upstream of the culvert inlet. No photos are available because the surveyors phone fell into the stream. MoTi chris_culvert_id: 1992674

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

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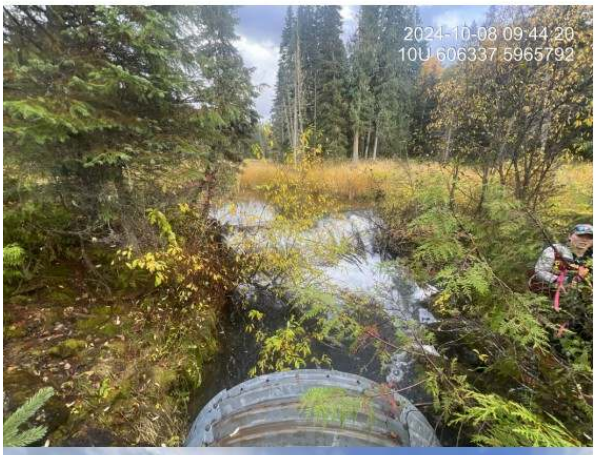

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Stream Characteristics Downstream of Crossing 199267

The stream was surveyed downstream from crossing 199267 for 300m . The habitat was rated as high value for spawning and rearing. The surrounding riparian area consisted of a healthy old-growth forest on both sides of the stream. Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation.The dominant substrate was gravels with fines sub-dominant.The average channel width was 10.7m, the average wetted width was 7.5m, and the average gradient was 0.6%. No photos were available due to the surveyor's phone falling in the river.

Stream Characteristics Upstream of Crossing 199267

The stream was surveyed upstream from crossing 199267 for 600m (Figure 4.27). The habitat was rated as high value for spawning and rearing. The stream was a low-gradient, gravel-dominated system with an extensive shrub-sedge wetland area and beaver activity in the lower 200m. Deep pools up to 1m were present throughout, influenced by abundant large woody debris contributed from the adjacent mature, primarily coniferous forest. Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris, undercut banks, deep pools, and overhanging vegetation.The average channel width was 8.9m, the average wetted width was 8.7m, and the average gradient was 0.5%.The dominant substrate was gravels with cobbles sub-dominant.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the Highway 16 crossing (199267) with a bridge (15 m span) is recommended. At the time of reporting in 2025, the cost of the work is estimated at $ 11,250,000.

Conclusion

PSCIS crossing 199267 on Highway 16 had a significant 0.65m outlet drop and is a moderate priority for replacement. Downstream of Highway 16, chinook have historically spawned at the confluence of Driscoll Creek and the Fraser River (Salmon Watersheds Program 2025), indicating that this stream has provided valuable spawning habitat. Additionally, modelling from bcfishpass indicates there is ~7km of potential chinook spawning habitat available upstream of the crossing. The habitat upstream of Highway 16 was rated as moderate value for spawning and rearing during the 2024 assessment, and fish sampling is recommended to further assess whether the crossing is inhibiting fish passage. Given the crossing's proximity to Chun T'oh Whudujut (Ancient Forest) Provincial Park and its location within the traditional territory of the Lheidli T'enneh, restoration efforts could align with broader conservation initiatives and community engagement, increasing the likelihood of funding and project momentum.

Table 4.45: Summary of habitat details for PSCIS crossing 199267.

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
199267	Downstream	300	10.7	7.5	0.5	0.6	moderate	high
199267	Upstream	600	8.9	8.7	0.7	0.5	moderate	high

Figure 4.27: Left: Typical habitat upstream of PSCIS crossing 199267. Right: Typical habitat upstream of PSCIS crossing 199267.

Teepee Creek - 199278 & 203302 - Appendix

Site Location

PSCIS crossings 199278 and 203302 are located on Teepee Creek, which flows into the McLennan River approximately 7km north of Valemount, BC, in the Upper Fraser River watershed group (Figure 4.28). Crossing 199278 is located 2.4km upstream of the McLennan River, on Highway 5, and is the responsibility of the Ministry of Transportation and Infrastructure (`chris_culvert_id`: 1467202). Approximately 300m upstream, PSCIS crossing 203302 is located on and is the responsibility of the CN Railway.

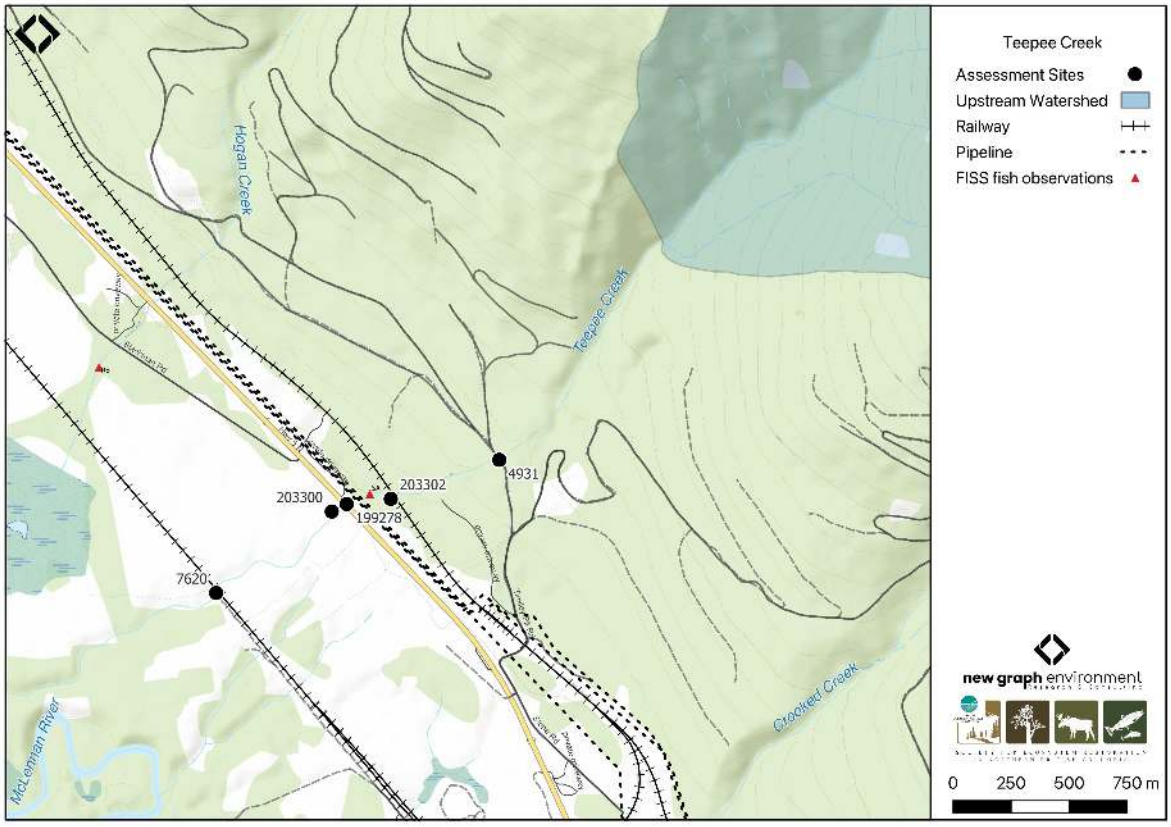


Figure 4.28: Map of Teepee Creek

Background

At PSCIS crossing 199278, Teepee Creek is a third order stream and drains a high elevation watershed of approximately 11km^2. The watershed ranges in elevation from a maximum of 2648m to 798m near crossing 199278 (Table 4.46).

In 2023, crossing 199278 was assessed with fish passage assessments and prioritized for follow-up due to the presence of high-value habitat and a salmon observation recorded upstream in the FISS database (MoE 2024). A habitat confirmation assessment encompassing both crossings 199278 and 203302 was conducted in 2024.

Downstream of Highway 5 on the CN railway, PSCIS crossing 7620 was initially assessed in 2007, and upstream of the highway, PSCIS crossing 4931 was initially assessed by Cliff Jackman Contracting Ltd. in 2010 (MoE 2023). Both crossings were reassessed during the 2024 field visit.

As previously mentioned, a salmon observation from 2012 is documented upstream of Highway 5 in the FISS database (MoE 2024). Additionally, in 2004, bull trout were captured upstream and downstream of crossing 199278 by Triton Environmental Consultants Ltd. (Manson 2005).

Table 4.46: Summary of derived upstream watershed statistics for PSCIS crossing 199278.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
199278	11	798	988	2648	1949	1874	SW

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

Stream Characteristics at Crossings 199278 and 203302

At the time of the 2024 assessment, PSCIS crossing 199278 on Highway 5 was un-embedded, non-backwatered and ranked as barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.47). The culvert had a moderate 0.4m outlet drop.

PSCIS crossing 203302 on the CN Railway was un-embedded, non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.48). This culvert had a significant 0.75m outlet drop.

In 2024, three other PSCIS crossings were assessed on Teepee Creek and can be found in Attachment - Phase 1 Data and Photos (page 197) (Figure 4.28). Approximately 700m downstream of Highway 5, PSCIS crossing 7620 was located on the CN Railway. Although the crossing ranked was as barrier to upstream fish passage according to the provincial protocol (MoE 2011), the culvert

was embedded, 100% backwatered, and was not a barrier to fish passage at the time of the survey. Roughly 70m downstream of Highway 5, there was a small bridge on private land (PSCIS 203300). Approximately 600m upstream of PSCIS crossing 203302 on the CN Railway, PSCIS crossing 4931 was located on Mount Tinsley Pit Road, which falls under the road tenure of Carrier Lumber R13564. The culvert had a significant 1.3m outlet drop.

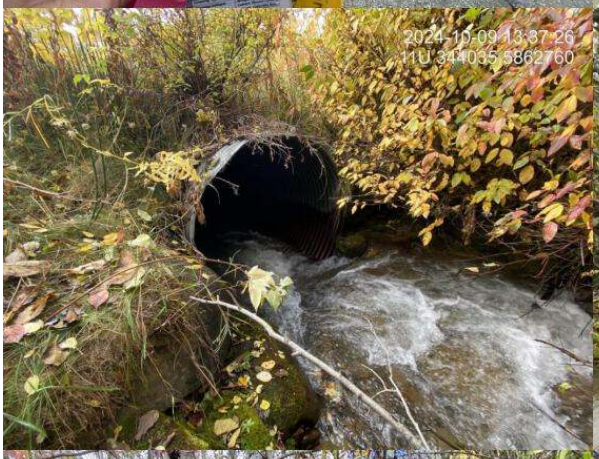
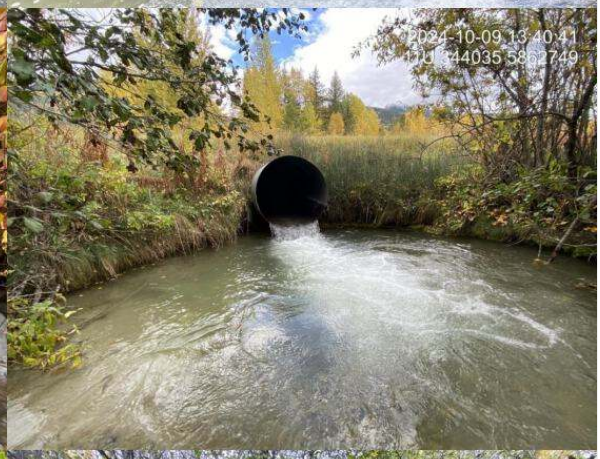
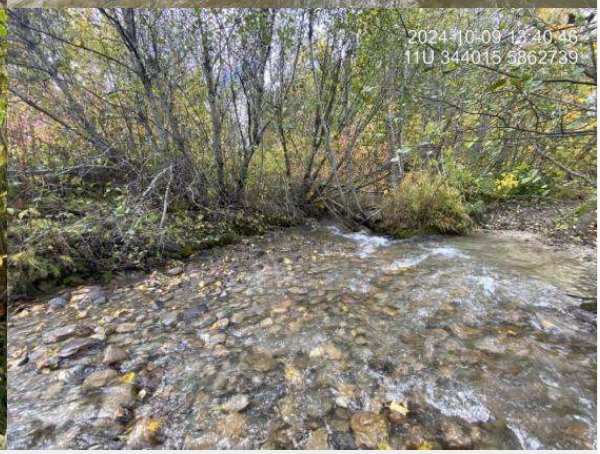
At all crossings, the water temperature was 4°C, pH was 7.7 and conductivity was 243 uS/cm.

Table 4.47: Summary of fish passage assessment for PSCIS crossing 199278.

Location and Stream Data		**Crossing Characteristics**	**–**
Date	2024-10-09	Crossing Sub Type	Round Culvert
PSCIS ID	199278	Diameter (m)	1.4
External ID	–	Length (m)	22
Crew	LS	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	344031	Resemble Channel	No
Northing	5862744	Backwatered	No
Stream	Teepee Creek	Percent Backwatered	–
Road	Highway 5	Fill Depth (m)	0.7
Road Tenure	MOTI	Outlet Drop (m)	0.4
Channel Width (m)	7	Outlet Pool Depth (m)	1
Stream Slope (%)	2.5	Inlet Drop	No
Beaver Activity	No	Slope (%)	2
Habitat Value	High	Valley Fill	Deep Fill
Final score	34	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Comments: A moderate outlet drop was present and would be substantial at lower flows. Flow was steady at the time of assessment. The culvert was in good condition. A large, deep outlet pool indicated the culvert was likely undersized for the stream. Additionally, minimal road fill made this crossing a significant flood hazard, which could wash out Highway 5. Downstream, the stream had frequent pools 0.3-0.5m deep, providing good overwintering habitat for fish, and abundant gravels suitable for spawning. Roughly 150m downstream of the culvert, several cattle pens crossed the stream and appeared to be set up to provide cattle access for drinking. These areas were visibly trampled, with significant loss of riparian vegetation. Upstream, the stream was relatively confined, with only rare pockets of unembedded gravels. Deep pools were present, formed by boulder and large woody debris scour. A salmon point was noted near the pipeline location in FISS. Numerous small steps, ranging from 30-60cm, were present due to the steep, boulder-dominated nature of the stream. Electrofishing would be beneficial for further assessment. The site was a highway crossing, making replacement difficult. A small ford was located approximately 5m downstream of the culvert outlet. MoTi chris_culvert_id: 1467202

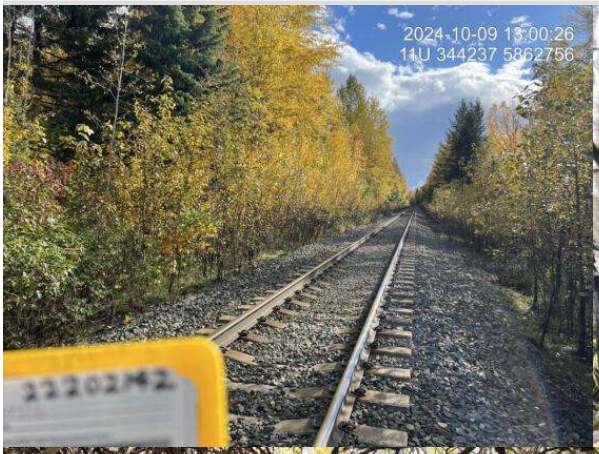
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.

Location and Stream Data	Crossing Characteristics
	
	
	

Location and Stream Data	•	Crossing Characteristics	–
Date	2024-10-09	Crossing Sub Type	Round Culvert
PSCIS ID	203302	Diameter (m)	2.7
External ID	–	Length (m)	14
Crew	AI	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	344222	Resemble Channel	No
Northing	5862742	Backwatered	No
Stream	Teepee Creek	Percent Backwatered	–
Road	Railway	Fill Depth (m)	2
Road Tenure	CN Rail	Outlet Drop (m)	0.75
Channel Width (m)	4.2	Outlet Pool Depth (m)	0.25
Stream Slope (%)	7	Inlet Drop	Yes
Beaver Activity	No	Slope (%)	6
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	36	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	15

Comments: Three concrete pipes, each 0.9m in diameter, were present, along with two 0.9m corrugated overflow pipes above. A stamp on the structure indicated it was built in 1944. All three concrete pipes were clogged at the inlet, ranging from 80% to 100% clogged with debris. This was a known fish-bearing stream, with a salmon point documented ~100m downstream in the FISS database. At this location, the stream was a mid-sized, steeper cobble-boulder step-pool system with only rare pockets of unembedded gravels. Deep pools were present, formed by boulder and large woody debris scour. Numerous small steps, ranging from 30-60cm, were present due to the steep, boulder-dominated nature of the stream. Downstream of the highway crossing, the stream had a lower gradient with frequent pools 0.3-0.5m deep, providing good overwintering habitat for fish and abundant gravels suitable for spawning.

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

Location and Stream Data	Crossing Characteristics
	
	
	

Stream Characteristics Downstream of Crossing 199278

The stream was surveyed downstream from crossing 199278 for 150m (Figure 4.29).. The habitat was rated as high value, with with frequent pools 0.3–0.5m deep suitable for overwintering fish and abundant gravels for spawning. The average channel width was 7.1m, the average wetted width was 4.5m, and the average gradient was 2.5%.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, undercut banks, and overhanging vegetation.. Roughly 150m downstream of the culvert, several cattle pens crossed the stream and appeared to be set up to provide cattle access for drinking. These areas were visibly trampled, with significant loss of riparian vegetation.

Stream Characteristics Upstream of Crossing 199278 and Downstream of Crossing 203302

The stream was surveyed upstream from crossing 199278 on Highway 5 to crossing 203302 on the CN Railway, a distance of approximately 300m (Figure 4.29 The habitat was rated as medium value for spawning and rearing, with frequent deep pools formed by boulders and large woody debris, but only limited pockets of unembedded gravels. Numerous small steps ranging from 30–60cm were present due to the steep, boulder-dominated nature of the stream. Total cover amount was rated as moderate with boulders dominant. Cover was also present as large woody debris, undercut banks, and overhanging vegetation.The dominant substrate was cobbles with boulders sub-dominant.The average channel width was 5.3m, the average wetted width was 3.3m, and the average gradient was 7.2%.

Stream Characteristics Upstream of Crossing 203302

The stream was surveyed upstream from crossing 203302 for 600m (Figure 4.30). The habitat was rated as medium value for spawning and rearing, with few unembedded gravels; however, recent heavy rain caused slight turbidity making it difficult to assess the subtrate. The average channel width was 5.4m, the average wetted width was 3.9m, and the average gradient was 6.8%.Total cover amount was rated as moderate with boulders dominant. Cover was also present as .The dominant substrate was cobbles with boulders sub-dominant. Approximately 100m before the end of the site, the stream showed signs of a large disturbance event that had incised the channel to a depth of 1.2–2m, with major areas of aggregation where the channel was widened and uniform.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the Highway 5 crossing (199278) with a bridge (15 m span) is recommended. At the time of reporting in 2025, the cost of the work is estimated at $ 11,250,000.

Should restoration/maintenance activities proceed, replacement of the Railway crossing (203302) with a bridge (15 m span) is recommended. At the time of reporting in 2025, the cost of the work is estimated at $ 11,250,000.

Conclusion

PSCIS crossing 199278 on Highway 5 had a moderate 0.4m outlet drop that could be substantial at lower flows. A large, deep outlet pool indicated the culvert was likely undersized for the stream, and minimal road fill made this crossing a significant flood hazard, which could wash out Highway 5. The crossing is a high priority for replacement. Further upstream, PSCIS crossing 203302 on the CN Railway had a significant 0.75m outlet drop, likely inhibiting fish passage. This crossing is a moderate priority for replacement.

Bull trout captured upstream and downstream of the crossing in 2004, along with a salmon observation documented upstream of Highway 5 in 2012 MoE (2024), indicate that this stream provides valuable fish habitat. Given the species present in the system and the outlet drops at both crossings, fish sampling is recommended to assess whether the culverts are impeding fish passage.

Table 4.49: Summary of habitat details for PSCIS crossings 199278 and 203302.

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
199278	Downstream	150	7.1	4.5	0.3	2.5	abundant	high
199278	Upstream	310	5.3	3.3	0.4	7.2	moderate	medium
203302	Upstream	600	5.4	3.9	0.4	6.8	moderate	medium

Figure 4.29: Left: Typical habitat downstream of PSCIS crossing 199278. Right: Typical habitat upstream of PSCIS crossing 199278 and downstream of PSCIS crossing 203302.

Figure 4.30: Left: Typical habitat upstream of PSCIS crossing 203302. Right: Typical habitat upstream of PSCIS crossing 199278 and downstream of PSCIS crossing 203302.

Holliday Creek - 199282 - Appendix

Site Location

PSCIS crossing 199282 is located on Holliday Creek, approximately 23km southeast of McBride, BC, in the Upper Fraser River watershed group (Figure 4.31). The crossing is located 2.4km upstream of where Holliday Creek joins the Fraser River. Situated on Highway 16, the crossing is the responsibility of the Ministry of Transportation and Infrastructure (`chris_culvert_id`: 29925).

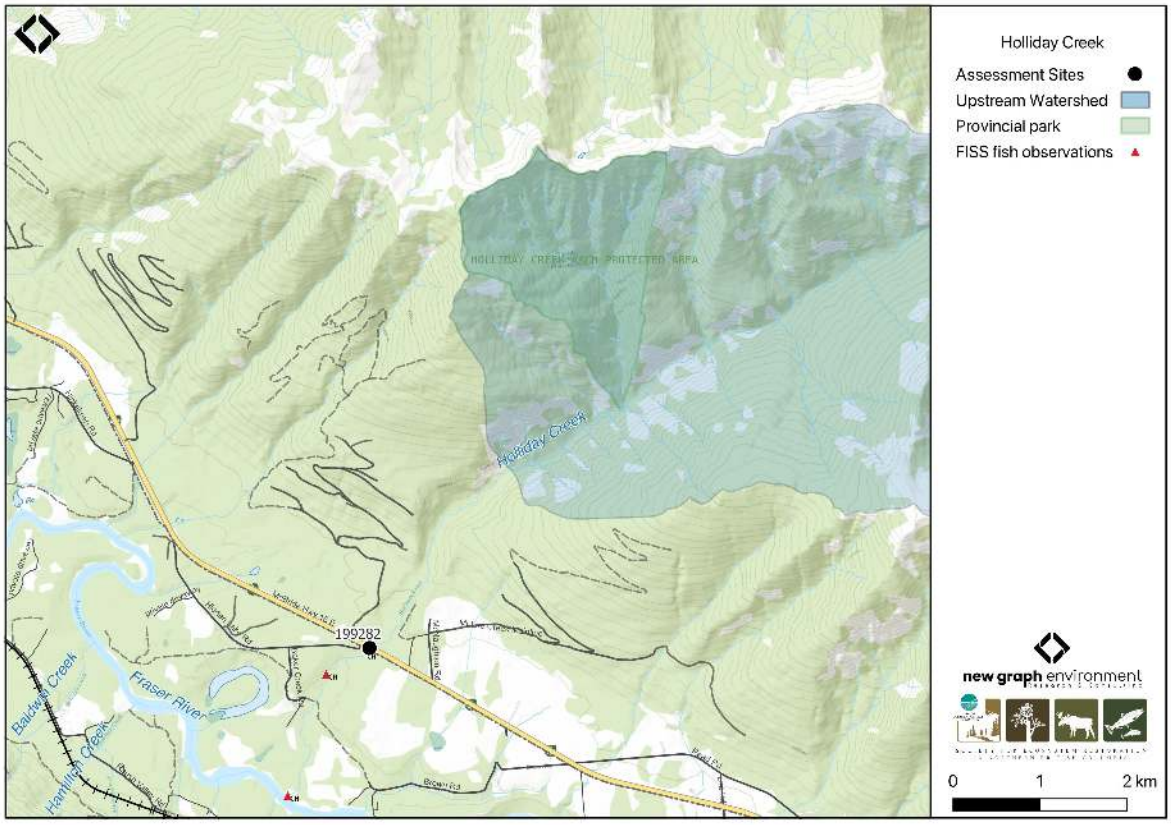


Figure 4.31: Map of Holliday Creek

Background

At PSCIS crossing 199282, Holliday Creek is a large, glaciated, fourth order stream that drains a high elevation watershed of approximately 55.2km^2. The watershed ranges in elevation from a maximum of 2553m to 777m near the crossing (Table 4.50).

In 2023, crossing 199282 was assessed with a fish passage assessment and prioritized for follow-up due to the presence of high-value habitat and a historical chinook salmon observation recorded downstream in the FISS database (MoE 2024). A habitat confirmation assessment was subsequently conducted in 2024.

Chinook spawners have been documented at the confluence of Holliday Creek and the Fraser River in the Pacific Salmon Explorer (Salmon Watersheds Program 2025). In 2004, chinook and bull trout were captured upstream and downstream of the Highway 16 crossing by Triton Environmental Consultants Ltd. (Manson 2005).

Upstream of this crossing is the Holliday Creek Arch Protected Area, a small, 395-hectare protected area showcasing a 80 m wide and 18 m high natural stone arch ("Holliday Creek Arch Protected Area" n.d.). The park can be accessed via the Natural Arch Trail, which starts on Mt.Baker Mainline FSR near Highway 16 and climbs ~1000m to an alpine lookout ("Holliday Creek Arch Protected Area" n.d.). Outside of the park on the west side of the valley, the Groeneveld Trail also provides hiking access to beautiful views (Recreation Sites and Trails BC, n.d.).

A summary of habitat modelling outputs for the crossing are presented in Table 4.51.

Table 4.50: Summary of derived upstream watershed statistics for PSCIS crossing 199282.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
199282	55.2	777	721	2553	1846	1725	SSW

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

Table 4.51: Summary of fish habitat modelling for PSCIS crossing 199282.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0.0	0.0	–
ST Lake Reservoir (ha)	0.0	0.0	–
ST Wetland (ha)	0.0	0.0	–
ST Slopeclass03 Waterbodies (km)	0.0	0.0	–
ST Slopeclass03 (km)	0.0	0.0	–
ST Slopeclass05 (km)	0.0	0.0	–

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Slopeclass08 (km)	0.0	0.0	–
ST Spawning (km)	0.0	0.0	–
ST Rearing (km)	0.0	0.0	–
CH Spawning (km)	0.2	0.2	100
CH Rearing (km)	3.3	3.3	100
CO Spawning (km)	0.0	0.0	–
CO Rearing (km)	0.0	0.0	–
CO Rearing (ha)	0.0	0.0	–
SK Spawning (km)	0.0	0.0	–
SK Rearing (km)	0.0	0.0	–
SK Rearing (ha)	0.0	0.0	–

* Model data is preliminary and subject to adjustments.

Stream Characteristics at Crossing 199282

At the time of the 2024 assessment, PSCIS crossing 199282 on Highway 16 was un-embedded, non-backwatered and ranked as barrier to upstream fish passage according to the provincial protocol (MoE 2011) (Table 4.52). The culvert had a significant 0.8m outlet drop and was undersized for the stream.

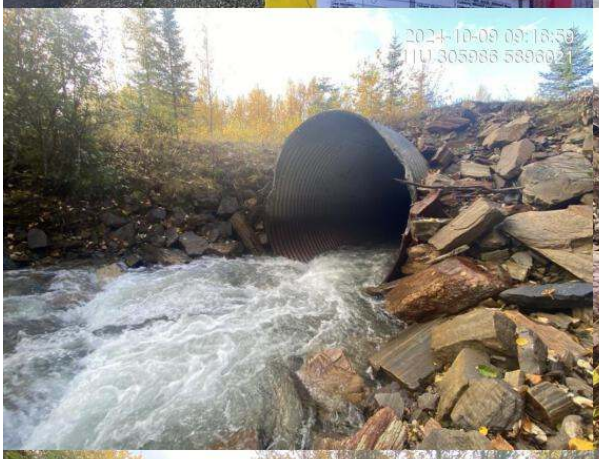
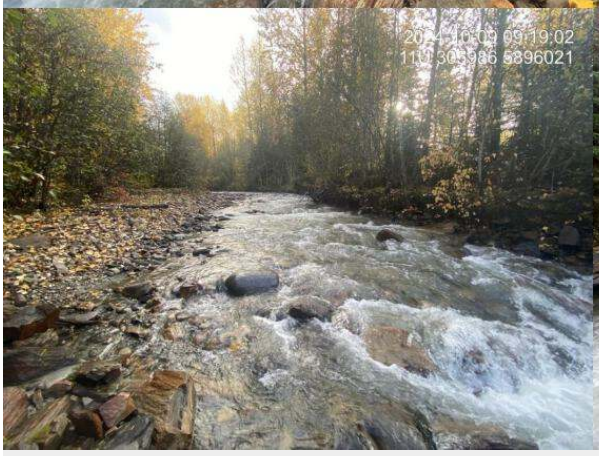
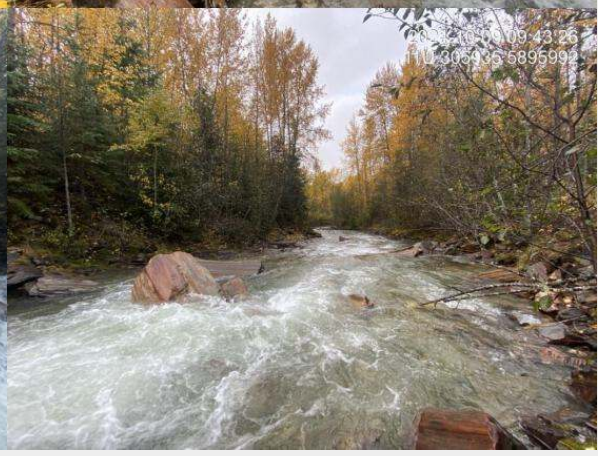
The water temperature was 3°C, pH was 7.5 and conductivity was 162 uS/cm.

Table 4.52: Summary of fish passage assessment for PSCIS crossing 199282.

Location and Stream Data		**Crossing Characteristics**	**–**
Date	2024-10-09	Crossing Sub Type	Round Culvert
PSCIS ID	199282	Diameter (m)	4
External ID	–	Length (m)	52
Crew	LS	Embedded	No
UTM Zone	11	Depth Embedded (m)	–
Easting	305946	Resemble Channel	No
Northing	5896010	Backwatered	No
Stream	Holliday Creek	Percent Backwatered	–
Road	Highway 16	Fill Depth (m)	2
Road Tenure	MOTI	Outlet Drop (m)	0.8
Channel Width (m)	16	Outlet Pool Depth (m)	0.5
Stream Slope (%)	3	Inlet Drop	No
Beaver Activity	No	Slope (%)	2
Habitat Value	High	Valley Fill	Deep Fill
Final score	37	Barrier Result	Barrier
Fix type	Replace with New Open Bottom Structure	Fix Span / Diameter	21

Comments: A significant outlet drop was present. Flow was high at the time of assessment, and at lower flows, the outlet drop would be even more substantial. Although the culvert was large, it was still likely undersized for the stream. The stream was a large glaciated system with a cobble-boulder substrate and an intact mixed riparian zone, primarily deciduous. Occasional large woody debris features created deep pool habitats and pockets of gravels were present suitable for spawning salmonids. A fish (~60mm) was observed during habitat confirmation. MoTi chris_hwy_structure_road_id: 29925

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

Location and Stream Data	Crossing Characteristics
	
	
	

Stream Characteristics Downstream of Crossing 199282

The stream was surveyed downstream from crossing 199282 for 350m (Figure 4.32). The habitat was rated as high value with frequent gravels suitable for spawning and occasional pools available for overwintering. The dominant substrate was cobbles with boulders sub-dominant.The average channel width was 16m, the average wetted width was 9.3m, and the average gradient was 2.8%.Total cover amount was rated as abundant with large woody debris dominant. Cover was also present as boulders and undercut banks.

Stream Characteristics Upstream of Crossing 199282

The stream was surveyed upstream from crossing 199282 for 800m (Figure 4.32). The habitat was rated as medium value for spawning and rearing. Occasional large woody debris features created deep pools, with pockets of gravels suitable for spawning. The average channel width was 11.8m, the average wetted width was 8.9m, and the average gradient was 2.5%.Total cover amount was rated as moderate with boulders dominant. Cover was also present as .The dominant substrate was cobbles with boulders sub-dominant.

Structure Remediation and Cost Estimate

Should restoration/maintenance activities proceed, replacement of the Highway 16 crossing (PSCIS 199282) with a bridge (21 m span) is recommended. At the time of reporting in 2025, the cost of the work is estimated at $ 15,750,000.

Conclusion

Holliday Creek is a large, glaciated tributary to the Fraser River. Chinook and bull trout were captured both upstream and downstream of the PSCIS crossing 199282 in 2004, indicating this stream has provided valuable fish habitat (Manson 2005). Habitat modeling from bcfishpass identified 3.3km of potential chinook rearing habitat and 9km of potential bull trout spawning habitat upstream of the crossing, with no other barriers identified upstream of Highway 16. Given the documented species presence and available habitat upstream, fish sampling is recommended to assess whether the 0.8m outlet drop is impeding fish passage. With the Holliday Creek Arch Protected Area and trails located upstream, crossing replacement could gain momentum as part of broader conservation and recreational initiatives (“Holliday Creek Arch Protected Area” n.d.).

Table 4.53: Summary of habitat details for PSCIS crossing 199282.

Site	Location	Length Surveyed (m)	Average Channel Width (m)	Average Wetted Width (m)	Average Pool Depth (m)	Average Gradient (%)	Total Cover	Habitat Value
199282	Downstream	350	16.0	9.3	0.4	2.8	abundant	high

Figure 4.32: Left: Typical habitat downstream of PSCIS crossing 199282. Right: Typical habitat upstream of PSCIS crossing 199282.

References

Amazon Web Services. 2025. “Aws/Aws-Cli: Universal Command Line Interface for Amazon Web Services.”https://github.com/aws/aws-cli.

Bell, M. C. 1991. “Fisheries Handbook of Engineering Requirements and Biological Criteria.”https://www.fs.fed.us/biology/nsaec/fishxing/fplibrary/Bell_1991_Fisheries_handbook_of_engineering_requirements_and.pdf.

Booth, Barry. 2022. “Summary of Minnow Trapping Component of the SD 91/UNBC eDNA Project.”https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=61991.

———. 2023. “Summary of Minnow Trapping Component of the SD 91/UNBC eDNA Project.”https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=61202.

———. 2024. “Summary of Minnow Trapping Component of the SD 91/UNBC eDNA Project.” 2024. https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=62942.

Bourne, Christina, Dan Kehler, Yolanda Wiersma, and David Cote. 2011. “Barriers to Fish Passage and Barriers to Fish Passage Assessments: The Impact of Assessment Methods and Assumptions on Barrier Identification and Quantification of Watershed Connectivity.”*Aquatic Ecology* 45: 389–403. https://doi.org/10.1007/s10452-011-9362-z.

Bradford, Michael J., and Garth C. Taylor. 2023. “Diversity in Freshwater Life History in Spring and Summer Chinook Salmon from the Fraser River, Canada.”*Transactions of the American Fisheries Society* 152 (2): 129–44. https://doi.org/10.1002/tafs.10396.

Bramblett, Robert G., Mason D. Bryant, Brenda E. Wright, and Robert G. White. 2002. “Seasonal Use of Small Tributary and Main-Stem Habitats by Juvenile Steelhead, Coho Salmon, and Dolly Varden in a Southeastern Alaska Drainage Basin.”*Transactions of the American Fisheries Society* 131 (3): 498–506. https://doi.org/10.1577/1548-8659(2002)131<0498:SUOSTA>2.0.CO;2.

“Chun t’oh Whudujut (Ancient Forest).” 2025. Lheidli T’enneh. https://lheidli.ca/about/ancient-forest/.

Clarkin, K, A Connor, M Furniss, B Gubernick, M Love, K Moynan, and S WilsonMusser. 2005. “National Inventory and Assessment Procedure For Identifying Barriers to Aquatic Organism Passage at Road-Stream Crossings.” United States Department of Agriculture, Forest Service, National Technology; Development Program. https://www.fs.fed.us/biology/nsaec/fishxing/publications/PDFs/NIAP.pdf.

cogeotiff. (2018) 2025. “Cogeotiff/Rio-Cogeo.” cogeotiff. https://github.com/cogeotiff/rio-cogeo.

COSEWIC. 2017. “COSEWIC Assessment and Status Report on the Sockeye Salmon Oncorhynchus Nerka, 24 Designatable Units in the Fraser River Drainage Basin, in Canada.”

Cote, David, P Frampton, M Langdon, and R Collier. 2005. *Fish Passage and Stream Habitat Restoration in Terra Nova National Park Highway Culverts*.

“Dakleh Placenames.” n.d. Accessed July 29, 2024. https://www.ydli.org/dakinfo/DakelhPlacenames.html.

Development Seed. (2019) 2025. “Developmentseed/Titiler.” Development Seed. https://github.com/developmentseed/titiler.

Diebel, M. W., M. Fedora, S. Cogswell, and J. R. O’Hanley. 2015. “Effects of Road Crossings on Habitat Connectivity for Stream-Resident Fish: STREAM-RESIDENT FISH HABITAT CONNECTIVITY.”*River Research and Applications* 31 (10): 1251–61. https://doi.org/10.1002/rra.2822.

Finnegan, Noah J., Gerard Roe, David R. Montgomery, and Bernard Hallet. 2005. “Controls on the Channel Width of Rivers: Implications for Modeling Fluvial Incision of Bedrock.”*Geology* 33 (3): 229–32. https://doi.org/10.1130/G21171.1.

Fish Passage Technical Working Group. 2011. “A Checklist for Fish Habitat Confirmation Prior to the Rehabilitation Fo a Stream Crossing.”https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/land-based-investment/forests-for-tomorrow/checklist-for-fish-habitat-confirmation-201112.pdf.

FLNRORD. 2020a. “Digital Road Atlas (DRA) - Master Partially-Attributed Roads - Data Catalogue.” 2020. https://catalogue.data.gov.bc.ca/dataset/digital-road-atlas-dra-master-partially-attributed-roads.

———. 2020b. “Forest Tenure Road Section Lines - Data Catalogue.” 2020. https://catalogue.data.gov.bc.ca/dataset/forest-tenure-road-section-lines.

Gilbert, D. E., J. E. Morris, A. R. Kaveney, and J. D. Dery. 2022. “Sub-Hourly Water Temperature Data Collected Across the Nechako Watershed, 2019-2021 | Elsevier Enhanced Reader.” 2022. https://doi.org/10.1016/j.dib.2022.108425.

Godfreyson, C. 2010. “Scientific Fish Collection Permit NASUKACBSMPGPE10-60669: Electrofishing Course Field Component Malaspina Vancouver Island University; DFO Permit XE 19 2010 & XE13 2010.” Vancouver Island University. https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=37144.

Hill, N. H., J. L. Thorley, and A. Irvine. 2024. “Spatial Stream Network Analysis of Nechako Watershed Stream Temperatures 2022b.” Poisson Consulting Analysis Appendix. https://www.poissonconsulting.ca/f/1295467017.

Hobson, Alan. 2004. “Scientific Fish Collection Permit PG04-6043 Beaverly Creek, McPhee Creek, and the Salmon River.” Malaspina University College. https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=16413.

“Holliday Creek Arch Protected Area.” n.d. BC Parks. Accessed March 17, 2025. https://bcparks.ca/holliday-creek-arch-protected-area/.

Irvine. (2021) 2022. “Bulkley River and Morice River Watershed Groups Fish Passage Restoration Planning 2021.”https://github.com/NewGraphEnvironment/fish_passage_skeena_2021_reporting.

———. (2025) 2025. “NewGraphEnvironment/Stac_uav_bc.”https://github.com/NewGraphEnvironment/stac_uav_bc.

Irvine, A, and L Schick. 2025. “Neexdzii Kwah Restoration Planning 2024.”https://www.newgraphenvironment.com/restoration_wedzin_kwa_2024/.

Kemp, P. S., and J. R. O’Hanley. 2010. “Procedures for Evaluating and Prioritising the Removal of Fish Passage Barriers: A Synthesis: EVALUATION OF FISH PASSAGE BARRIERS.”*Fisheries Management and Ecology*, no–. https://doi.org/10.1111/j.1365-2400.2010.00751.x.

Levy, David A, and Peter Nicklin. 2018. “Chinook and Sockeye Salmon Conservation in the Netʃa Koh (Nechako) River in Northern BC.”

Mahlum, Shad, David Cote, Yolanda Wiersma, Dan Kehler, and K. Clarke. 2014. “Evaluating the Barrier Assessment Technique Derived from FishXing Software and the Upstream Movement of Brook Trout Through Road Culverts.”*Transactions of the American Fisheries Society* 143. https://doi.org/10.1080/00028487.2013.825641.

Manson, Rachel. 2005. “Fish Collection Permit No. VIPGFJ041888, File: 34770-20.” British Columbia, Canada: Ministry of Transportation and Highways. https://a100.gov.bc.ca/pub/acat/documents/r16449/VIPGFJ041888_Hwy16_97_1246939039378_a86f9034ac3c792806465638afb4a96186ab34e09ad949eb02597c2f10.pdf.

MoE. 2011. “Field Assessment for Determining Fish Passage Status of Closed Bottom Structures.” BC Ministry of Environment (MoE). https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/land-based-investment/forests-for-tomorrow/field-assessment-for-determining-fish-passage-status-of-cbs.pdf.

———. 2020. “Provincial Obstacles to Fish Passage - Data Catalogue.” Ministry of Environment and Climate Change Strategy - Knowledge Management. 2020. https://catalogue.data.gov.bc.ca/dataset/provincial-obstacles-to-fish-passage.
———. 2023. “PSCIS Assessments - Data Catalogue.” Ministry of Environment - Knowledge Management (MoE). 2023. https://catalogue.data.gov.bc.ca/dataset/pscis-assessments.
———. 2024. “Known BC Fish Observations and BC Fish Distributions.” 2024. https://catalogue.data.gov.bc.ca/dataset/known-bc-fish-observations-and-bc-fish-distributions.
Muñoz Sabater, Joaquín. 2019. “ERA5-Land Hourly Data from 1950 to Present.” Copernicus Climate Change Service (C3S) Climate Data Store (CDS). https://doi.org/10.24381/cds.e2161bac.
Murray, Brent W., and Barry Booth. 2023. “Report on the 2023 eDNA Survey of Study Creeks in Nechako Watershed from Prince George to the Upper Fraser.” Prince George, BC: University of Northern British Columbia, Department of Ecosystem Science and Management. https://www.newssociety.org/uploads/images/News%20report%20Images/e-DNA%20summary-%20UNBC-NEWSS%202023.pdf.
Murray, Brent, and Barry Booth. 2024. “NEWSS Salmon Recovery Projects: eDNA Research.”UNBC Ecosystem and Science Management. https://newssociety.org/uploads/news/News%20Links/Activity%23%22%20BCRSIF%20report.pdf.
“Nechako White Sturgeon Recovery Initiative | Home.” n.d. Nechako White Sturgeon Recovery Initiative. Accessed March 4, 2025. https://www.nechakowhitesturgeon.org/.
Norris, Simon. (2018) 2024. “Smnorris/Bcfishobs.”https://github.com/smnorris/bcfishobs.
———. (2020) 2024. “Smnorris/Bcfishpass.”https://github.com/smnorris/bcfishpass.
OpenDroneMap Authors. (2014) 2025. “OpenDroneMap/ODM.” OpenDroneMap. https://github.com/OpenDroneMap/ODM.
Pacific Climate Impacts Consortium. n.d. “Gridded Hydrologic Model Output.” Accessed March 26, 2025. https://data.pacificclimate.org/portal/hydro_model_out/map/.
PySTAC Authors. (2017) 2025. “Stac-Utils/Pystac.” stac-utils. https://github.com/stac-utils/pystac.
Radiantearth. 2024. “STAC: SpatioTemporal Asset Catalogs.” 2024. https://stacspec.org/en/.
Recreation Sites and Trails BC. n.d. “Groeneveld Trail (McBride).”https://www.sitesandtrailsbc.ca/search/search-result.aspx?site=REC1338&type=Trail.
Salmon Watersheds Program, Pacific Salmon Foundation (PSF). 2025. “Spawner Abundance for Salmon and Steelhead Streams (Stream Spawner Surveys).”https://data.salmonwatersheds.ca/result?datasetid=2.
Shaw, D Patrick, and Taina Tuominen. n.d. “Water Quality In The Fraser River Basin.”
Shaw, Edward A., Eckart Lange, James D. Shucksmith, and David N. Lerner. 2016. “Importance of Partial Barriers and Temporal Variation in Flow When Modelling Connectivity in Fragmented River Systems.”*Ecological Engineering* 91: 515–28. https://doi.org/10.1016/j.ecoleng.2016.01.030.
Simoes, Rolf, Felipe Souza, Matheus Zaglia, Gilberto Ribeiro de Queiroz, Rafael dos Santos, and Karine Ferreira. 2021. “Rstac: An R Package to Access Spatiotemporal Asset Catalog Satellite Imagery.” In *2021 IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*, 7674–77. https://doi.org/10.1109/IGARSS47720.2021.9553518.
Slaney, P. A, Daiva O Zaldokas, and Watershed Restoration Program (B.C.). 1997. *Fish Habitat Rehabilitation Procedures*. Vancouver, B.C.: Watershed Restoration Program. https://www.for.gov.bc.ca/hfd/library/FFIP/Slaney_PA1997_A.pdf.
stac-utils. 2025. “Stac-Utils/Stac-Fastapi-Pgstac: PostgreSQL Backend for Stac-Fastapi Using Pgstac (https://github.com/stac-utils/pgstac).”https://github.com/stac-utils/stac-fastapi-pgstac.
“Sugarbowl-Grizzly Den Cabins – PGBRS.” n.d. Accessed March 18, 2025. https://www.pgbrs.org/sugarbowl-grizzly-den-cabin-bookings/.

“Sugarbowl-Grizzly Den Park.” n.d. BC Parks. Accessed March 18, 2025. https://bcparks.ca/sugarbowl-grizzly-den-park/.
Swales, Stephen, and C. Levings. 1989. “Role of Off-Channel Ponds in the Life Cycle of Coho Salmon (Oncorhynchus Kisutch) and Other Juvenile Salmonids in the Coldwater River, British Columbia.”*Canadian Journal of Fisheries and Aquatic Sciences - CAN J FISHERIES AQUAT SCI* 46: 232–42. https://doi.org/10.1139/f89-032.
“The History of the Cheslatta Carrier Nation.” n.d. The History of the Cheslatta Carrier Nation. Accessed July 29, 2024. https://www.cheslatta.com/history.
Thompson, Richard. 2013. “Assessing Fish Passage at Culverts â€“ the Method, Its Metrics and Preliminary Findings from over 4,000 Assessments.”https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/fish-passage/assessing_fish_passage_at_culverts.pdf.
Thorley, J. L., S. Norris, and A. Irvine. 2021. “Channel Width 2021b.”https://www.poissonconsulting.ca/f/859859031.
Thorley, J, and A Irvine. 2021. “Channel Width 2021.” Poisson Consulting. 2021. https://poissonconsulting.ca/temporary-hidden-link/1792764180/channel-width-21/.
Toffolon, Marco, and Sebastiano Piccolroaz. 2015. “A Hybrid Model for River Water Temperature as a Function of Air Temperature and Discharge.”*Environmental Research Letters* 10 (11): 114011. https://doi.org/10.1088/1748-9326/10/11/114011.
“Upper Fraser Fisheries Conservation Alliance.” n.d. Website. https://upperfraser.ca.
Washington Department of Fish & Wildlife. 2009. “Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual.” Washington Department of Fish; Wildlife. Olympia, Washington. https://wdfw.wa.gov/sites/default/files/publications/00061/wdfw00061.pdf.

Changelog

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- push for permit

Session Info

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 ui       RStudio
 language (EN)
 collate  en_US.UTF-8
 ctype    en_US.UTF-8
 tz       America/Vancouver
 date     2025-04-14
 rstudio  2024.12.1+563 Kousa Dogwood (desktop)
 pandoc   3.2 @
/Applications/RStudio.app/Contents/Resources/app/quarto/bin/tools/aarch6-
```

```
 4/ (via rmarkdown)

─ Packages
──────────────────────────────────────────────────────────────────────────────
```

```
─ Session info ─────────────────────────────────────────────────────────────
 package         * version    date (UTC) lib source
 archive           1.1.9      2024-09-12 [2] CRAN (R 4.4.1)
 bit               4.5.0.1    2024-12-03 [1] CRAN (R 4.4.1)
 bit64             4.6.0-1    2025-01-16 [1] CRAN (R 4.4.1)
 blob              1.2.4      2023-03-17 [1] CRAN (R 4.4.0)
 bookdown        * 0.42       2025-01-07 [1] CRAN (R 4.4.1)
 bslib             0.9.0      2025-01-30 [1] CRAN (R 4.4.1)
 cachem            1.1.0      2024-05-16 [1] CRAN (R 4.4.1)
 cellranger        1.1.0      2016-07-27 [1] CRAN (R 4.4.0)
 chk               0.10.0     2025-01-24 [1] CRAN (R 4.4.1)
 chromote          0.4.0      2025-01-25 [1] CRAN (R 4.4.1)
 class             7.3-22     2023-05-03 [2] CRAN (R 4.4.0)
 classInt          0.4-11     2025-01-08 [1] CRAN (R 4.4.1)
 cli               3.6.3      2024-06-21 [1] CRAN (R 4.4.1)
 codetools         0.2-20     2024-03-31 [2] CRAN (R 4.4.0)
 colorspace        2.1-1      2024-07-26 [1] CRAN (R 4.4.1)
 crayon            1.5.3      2024-06-20 [1] CRAN (R 4.4.1)
 curl              6.2.0      2025-01-23 [1] CRAN (R 4.4.1)
 DBI               1.2.3      2024-06-02 [1] CRAN (R 4.4.1)
 dbplyr            2.5.0      2024-03-19 [1] CRAN (R 4.4.0)
 devtools          2.4.5      2022-10-11 [2] CRAN (R 4.4.0)
 digest            0.6.37     2024-08-19 [1] CRAN (R 4.4.1)
 dplyr           * 1.1.4      2023-11-17 [1] CRAN (R 4.4.0)
 e1071             1.7-16     2024-09-16 [1] CRAN (R 4.4.1)
 ellipsis          0.3.2      2021-04-29 [2] CRAN (R 4.4.0)
 english           1.2-6      2021-08-21 [2] CRAN (R 4.4.0)
 evaluate          1.0.3      2025-01-10 [1] CRAN (R 4.4.1)
 farver            2.1.2      2024-05-13 [1] CRAN (R 4.4.1)
 fasstr            0.5.3      2024-09-27 [1] CRAN (R 4.4.1)
 fastmap           1.2.0      2024-05-15 [1] CRAN (R 4.4.1)
 fishbc            0.2.1      2021-05-12 [1] CRAN (R 4.4.0)
 forcats         * 1.0.0      2023-01-29 [1] CRAN (R 4.4.0)
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 fs                1.6.5      2024-10-30 [1] CRAN (R 4.4.1)
 generics          0.1.3      2022-07-05 [1] CRAN (R 4.4.1)
 ggdark          * 0.2.1      2019-01-11 [1] CRAN (R 4.4.0)
 ggplot2         * 3.5.1      2024-04-23 [1] CRAN (R 4.4.0)
 glue              1.8.0      2024-09-30 [1] CRAN (R 4.4.1)
 gtable            0.3.6      2024-10-25 [1] CRAN (R 4.4.1)
 here              1.0.1      2020-12-13 [1] CRAN (R 4.4.1)
 hms               1.1.3      2023-03-21 [1] CRAN (R 4.4.0)
 htmltools         0.5.8.1    2024-04-04 [1] CRAN (R 4.4.1)
 htmlwidgets       1.6.4      2023-12-06 [1] CRAN (R 4.4.0)
 httpuv            1.6.15     2024-03-26 [1] CRAN (R 4.4.0)
 httr              1.4.7      2023-08-15 [1] CRAN (R 4.4.0)
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jquerylib         0.1.4      2021-04-26 [1] CRAN (R 4.4.0)
 jsonlite           1.8.9      2024-09-20 [1] CRAN (R 4.4.1)
 kableExtra         1.4.0.3    2025-03-03 [1] Github
(haozhu233/kableExtra@a9c509a)
 KernSmooth         2.23-22    2023-07-10 [2] CRAN (R 4.4.0)
 knitr            * 1.49       2024-11-08 [1] CRAN (R 4.4.1)
 labeling           0.4.3      2023-08-29 [1] CRAN (R 4.4.1)
 later              1.4.1      2024-11-27 [1] CRAN (R 4.4.1)
 lifecycle          1.0.4      2023-11-07 [1] CRAN (R 4.4.1)
 lubridate        * 1.9.4      2024-12-08 [1] CRAN (R 4.4.1)
 magick             2.8.5      2024-09-20 [1] CRAN (R 4.4.1)
 magrittr           2.0.3      2022-03-30 [1] CRAN (R 4.4.1)
 memoise            2.0.1      2021-11-26 [1] CRAN (R 4.4.0)
 mime               0.12       2021-09-28 [1] CRAN (R 4.4.1)
 miniUI             0.1.1.1    2018-05-18 [2] CRAN (R 4.4.0)
 munsell            0.5.1      2024-04-01 [1] CRAN (R 4.4.1)
 ngr              * 0.0.0.9002 2025-03-03 [1] Github
(newgraphenvironment/ngr@b888f82)
 pagedown         * 0.22       2025-01-07 [1] CRAN (R 4.4.1)
 pillar             1.10.1     2025-01-07 [1] CRAN (R 4.4.1)
 pkgbuild           1.4.6      2025-01-16 [1] CRAN (R 4.4.1)
 pkgconfig          2.0.3      2019-09-22 [1] CRAN (R 4.4.1)
 pkgload            1.4.0      2024-06-28 [1] CRAN (R 4.4.0)
 poisutils          0.0.0.9010 2024-05-14 [2] Github
(poissonconsulting/poisutils@8310dc4)
 processx           3.8.5      2025-01-08 [1] CRAN (R 4.4.1)
 profvis            0.3.8      2023-05-02 [2] CRAN (R 4.4.0)
 promises           1.3.2      2024-11-28 [1] CRAN (R 4.4.1)
 proxy              0.4-27     2022-06-09 [1] CRAN (R 4.4.1)
 ps                 1.8.1      2024-10-28 [1] CRAN (R 4.4.1)
 purrr            * 1.0.4      2025-02-05 [1] CRAN (R 4.4.1)
 R6                 2.6.0      2025-02-12 [1] CRAN (R 4.4.1)
 rappdirs           0.3.3      2021-01-31 [1] CRAN (R 4.4.1)
 rbbt               0.0.0.9000 2025-02-13 [1] Github
(NewGraphEnvironment/rbbt@f14a53c)
 Rcpp               1.0.14     2025-01-12 [1] CRAN (R 4.4.1)
 RcppRoll           0.3.1      2024-07-07 [1] CRAN (R 4.4.1)
 readr            * 2.1.5      2024-01-10 [1] CRAN (R 4.4.0)
 readwritesqlite * 0.2.0      2022-10-16 [2] CRAN (R 4.4.0)
 readxl             1.4.3      2023-07-06 [1] CRAN (R 4.4.0)
 remotes            2.5.0      2024-03-17 [2] CRAN (R 4.4.0)
 rlang              1.1.5      2025-01-17 [1] CRAN (R 4.4.1)
 rmarkdown        * 2.29       2024-11-04 [1] CRAN (R 4.4.1)
 roxygen2           7.3.1      2024-01-22 [2] CRAN (R 4.4.0)
 RPostgres        * 1.4.8      2025-02-25 [1] CRAN (R 4.4.1)
 rprojroot          2.0.4      2023-11-05 [1] CRAN (R 4.4.1)
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RSQLite           2.3.9      2024-12-03 [1] CRAN (R 4.4.1)
 rstudioapi        0.17.1     2024-10-22 [1] CRAN (R 4.4.1)
 rvest             1.0.4      2024-02-12 [1] CRAN (R 4.4.0)
 s2                1.1.7      2024-07-17 [1] CRAN (R 4.4.0)
 sass              0.4.9      2024-03-15 [1] CRAN (R 4.4.0)
 scales            1.3.0      2023-11-28 [1] CRAN (R 4.4.0)
 sessioninfo       1.2.2      2021-12-06 [2] CRAN (R 4.4.0)
 sf              * 1.0-19     2024-11-05 [1] CRAN (R 4.4.1)
 shiny             1.10.0     2024-12-14 [2] CRAN (R 4.4.1)
 shrtcts           0.1.2      2024-05-14 [2] Github
(gadenbuie/shrtcts@41051cf)
 snakecase         0.11.1     2023-08-27 [1] CRAN (R 4.4.0)
 staticimports   * 0.0.0.9001 2025-04-11 [1] local
 stringi           1.8.4      2024-05-06 [1] CRAN (R 4.4.1)
 stringr         * 1.5.1      2023-11-14 [1] CRAN (R 4.4.0)
 svglite           2.1.3      2023-12-08 [1] CRAN (R 4.4.0)
 systemfonts       1.2.1      2025-01-20 [1] CRAN (R 4.4.1)
 terra             1.8-29     2025-02-26 [1] CRAN (R 4.4.1)
 tibble          * 3.2.1      2023-03-20 [1] CRAN (R 4.4.0)
 tidyhydat         0.7.0      2024-10-04 [1] CRAN (R 4.4.1)
 tidyr           * 1.3.1      2024-01-24 [1] CRAN (R 4.4.1)
 tidyselect        1.2.1      2024-03-11 [1] CRAN (R 4.4.0)
 tidyverse       * 2.0.0      2023-02-22 [1] CRAN (R 4.4.0)
 tidyxl            1.0.10     2025-03-03 [1] Github
(nacnudus/tidyxl@7e2fbe7)
 timechange        0.3.0      2024-01-18 [1] CRAN (R 4.4.1)
 tzdb              0.4.0      2023-05-12 [1] CRAN (R 4.4.0)
 units             0.8-5      2023-11-28 [1] CRAN (R 4.4.1)
 urlchecker        1.0.1      2021-11-30 [2] CRAN (R 4.4.0)
 usethis           2.2.3      2024-02-19 [2] 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 4.4.1)
 vroom             1.6.5      2023-12-05 [1] CRAN (R 4.4.0)
 websocket         1.4.2      2024-07-22 [1] CRAN (R 4.4.1)
 withr             3.0.2      2024-10-28 [1] CRAN (R 4.4.1)
 wk                0.9.4      2024-10-11 [1] CRAN (R 4.4.1)
 xfun              0.50       2025-01-07 [1] CRAN (R 4.4.1)
 xml2              1.3.6      2023-12-04 [1] CRAN (R 4.4.1)
 xtable            1.8-4      2019-04-21 [2] CRAN (R 4.4.0)
 yaml              2.3.10     2024-07-26 [1] CRAN (R 4.4.1)
 yesno             0.1.2      2020-07-10 [2] CRAN (R 4.4.0)

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

Attachment - Phase 1 Data and Photos

Data and photos for all Phase 1 - fish passage assessments are provided online at https://www.newgraphenvironment.com/fish_passage_fraser_2023_reporting/appendix---phase-1-fish-passage-assessment-data-and-photos.html - with a pdf version available at https://github.com/NewGraphEnvironment/fish_passage_fraser_2023_reporting/raw/main/docs/Appendix_1.pdf

Attachment - Habitat Assessment and Fish Sampling Data

All field data collected is available here.

Habitat assessment data is available for download here.

Attachment - Water Temperature Modelling

Details of this bayesian analysis to map stream discharge and temperature causal effects pathways can be reviewed in the report Spatial Stream Network Analysis of Nechako Watershed Stream Temperatures 2022b (Hill, Thorley, and Irvine 2024). At the time of reporting, ongoing work regarding the project was tracked https://github.com/poissonconsulting/fish-passage-22/issues and https://github.com/poissonconsulting/fish-passage-22b/issues.