



SOCIETY FOR ECOSYSTEM RESTORATION  
IN NORTHERN BRITISH COLUMBIA

## **Bulkley River and Morice River Watershed Groups Fish Passage Restoration Planning 2021**

**Prepared for  
Habitat Conservation Trust Foundation - CAT21-6-288  
BC Fish Passage Remediation Program  
Canadian Wildlife Federation**

**Prepared by  
Al Irvine, B.Sc., R.P.Bio.  
New Graph Environment Ltd.  
on behalf of  
Society for Ecosystem Restoration in Northern British Columbia**

Version 0.1.2 2022-05-16





## Table of Contents

|   |            |
|---|------------|
| Acknowledgement .....                                     | iv         |
| 1 Introduction .....                                      | 1          |
| 2 Background .....  | 3          |
| 3 Methods .....   | 17         |
| 4 Results and Discussion .....                            | 27         |
| 5 Recommendations .....                                   | 45         |
| Toboggan Creek - 57944 - Appendix .....                   | 47         |
| McDowell Creek - 123544 & 58151 - Appendix .....          | 55         |
| John Brown - 123770 - Appendix .....                      | 67         |
| Station Creek - 124420 & 124421 & 124422 - Appendix ..... | 77         |
| Owen Creek - 197370 - Appendix .....                      | 93         |
| Richfield Creek - 197662 - Appendix .....                 | 95         |
| Tributary to Maxan Creek - 197909 - Appendix .....        | 105        |
| Robert Hatch Creek - 197912 - Appendix .....              | 111        |
| Corya Creek - 197960 - Appendix .....                     | 121        |
| Peacock Creek - 197962 - Appendix .....                   | 133        |
| Taman Creek - 197967 - Appendix .....                     | 143        |
| Ailport Creek - 197976 & 197975 - Appendix .....          | 155        |
| McBride Creek - 198000 - Appendix .....                   | 169        |
| Cesford Creek - 198048 & 198049 - Appendix .....          | 175        |
| Thompson Creek - 198066 & 123377 - Appendix .....         | 189        |
| References .....  | 199        |
| Session Info .....  | 205        |
| <b>Attachment 1 - Maps .....</b>                          | <b>209</b> |
| <b>Attachment 2 - Phase 1 Data and Photos .....</b>       | <b>211</b> |
| <b>Attachment 3 - Habitat Assessment Data .....</b>       | <b>213</b> |
| <b>Attachment 4 - Richfield Fencing Report .....</b>      | <b>215</b> |



## **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.



# 1 Introduction

This report is available as both a pdf and as an online interactive report at [https://newgraphenvironment.github.io/fish\\_passage\\_skeena\\_2021\\_reporting/](https://newgraphenvironment.github.io/fish_passage_skeena_2021_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 version number and download the latest pdf from [https://github.com/NewGraphEnvironment/fish\\_passage\\_skeena\\_2021\\_reporting/raw/master/docs/skeena2021.pdf](https://github.com/NewGraphEnvironment/fish_passage_skeena_2021_reporting/raw/master/docs/skeena2021.pdf)

In April of 2020, the Society for Ecosystem Restoration Northern British Columbia (SERNbc) undertook an initiative to plan and conduct fish passage restoration planning activities in the Bulkley River and Morice River watershed groups which are sub-basins of the Skeena River watershed. The initiative was supported by a grant from the Habitat Conservation Trust Fund that leveraged funds committed in the fall of 2019 from the Provincial Fish Passage Remediation Program and the Canadian Wildlife Federation. New Graph Environment and Hillcrest Geographics were the project team subcontracted to devise the study plan, submit proposals and complete the work which included information gathering, updating/implementation of open source data analysis tools, fish passage assessments and habitat confirmation assessments. Although fish passage restoration planning was conducted for both the Morice River watershed group and the Bulkley River watershed group, on the ground surveys in 2020 focused primarily within Bulkley River tributaries.

In August of 2020, following a province wide prioritization exercise and a series of workshops, the Canadian Wildlife Federation selected the Bulkley River watershed group as a target watershed for connectivity planning efforts supported by a grant from the British Columbia Salmon Restoration and Innovation Fund. A Fish Passage Working Group consisting of First Nations, non-profits, stakeholder groups and regulators was established for the Bulkley River watershed group in the fall of 2020 as documented in Mazany-Wright et al. (2021). Recognizing synergies between the two initiatives, select project activities of both initiatives became a collaboration between SERNbc and CWF with extensive input from numerous organizations and individuals connected to the watersheds.

This report builds on reporting from the spring of 2021 (Irvine 2021) which can be viewed interactively [here](#).

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

## 1 Introduction

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

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



## **2 Background**

The study area includes the Bulkley River and Morice River watershed groups (Figure [2.1](#)) and is within the traditional territories of the Gitksan and Wet'suwet'en.

### **2.1 Wet'suwet'en**

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

### **2.2 Gitksan**

The Gitksan Laxyip (traditional territories) covers an area of 33,000km<sup>2</sup> within the Skeena River and Nass River watersheds. The Laxyip is governed by 60 Simgiigyet (Hereditary Chiefs), within the traditional hereditary system made up of Wilps (House groups). Anaat are fisheries tenures found throughout the Laxyip. Traditional governance within a matrilineal society operates under the principles of Ayookw (Gitksan law) ("Gitksan Huwilp Government" 2021).

## 2.3 Project Location

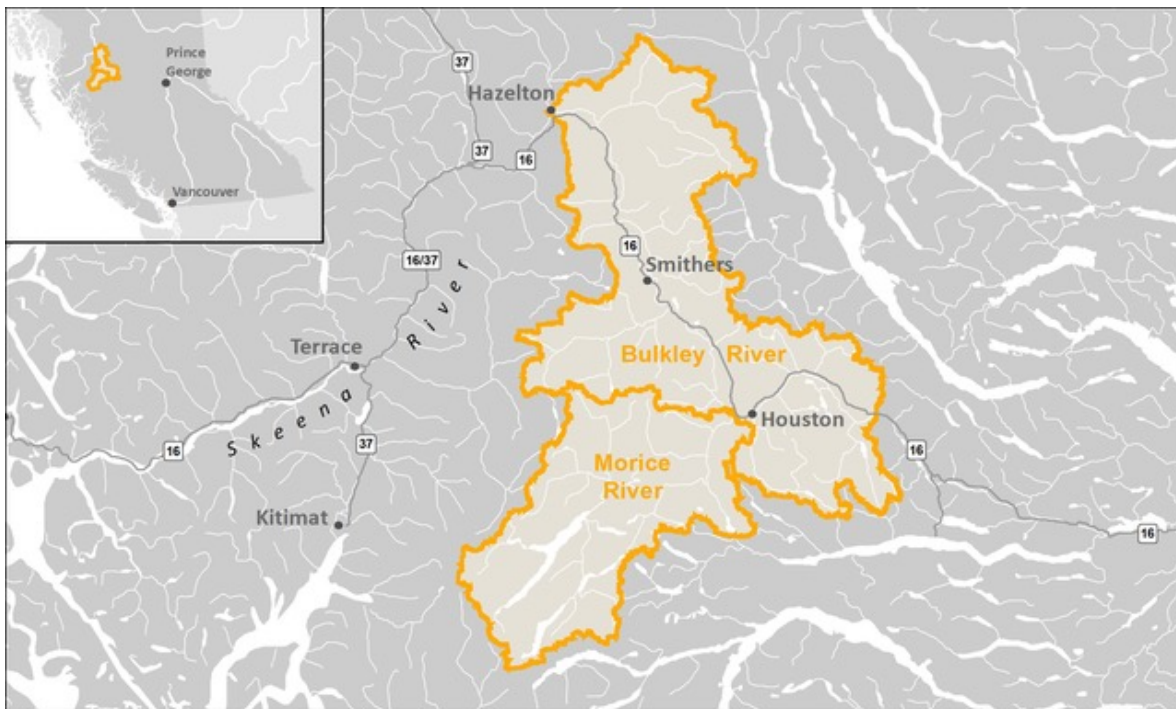


Figure 2.1: Overview map of Study Areas

### 2.3.1 Bulkley River

The Bulkley River is an 8th order stream that drains an area of 7,762 km<sup>2</sup> in a generally northerly direction from Bulkley Lake on the Nechako Plateau to its confluence with the Skeena River at Hazelton. It has a mean annual discharge of 139.1 m<sup>3</sup>/s at station 08EE004 located near Quick (~27km south of Telkwa) and 19.5 m<sup>3</sup>/s at station 08EE003 located upstream near Houston. Flow patterns at Quick are heavily influenced by inflows from the Morice River (enters just downstream of Houston) resulting in flow patterns typical of high elevation watersheds which receive large amounts of precipitation as snow leading to peak levels of discharge during snowmelt, typically from May to July (Figures [2.2](#) - [2.3](#)). The hydrograph peaks faster and generally earlier (May - June) for the Bulkley River upstream of Houston where the topography is of lower lower elevation (Figures [2.2](#) and [2.4](#)).

Changes to the climate systems are causing impacts to natural and human systems on all continents with alterations to hydrological systems caused by changing precipitation or melting snow and ice increasing the frequency and magnitude of extreme events such as floods and droughts (IPCC 2014; ECCC 2016). These changes are resulting in modifications to the quantity and quality of water resources throughout British Columbia and are likely to compound issues

## 2.3 Project Location

related to drought and flooding in the Bulkley River watershed where numerous water licenses are held with a potential over-allocation of flows identified during low flow periods (ILMB 2007).

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

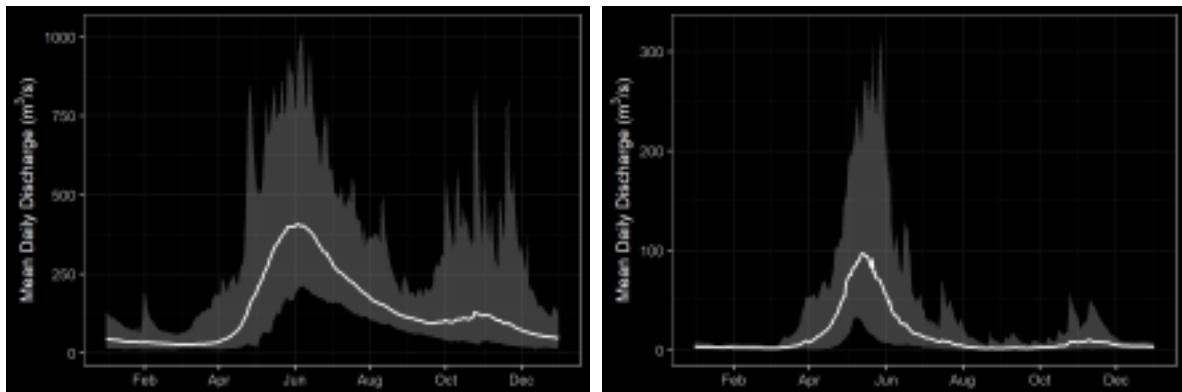


Figure 2.2: Hydrograph for Bulkley River at Quick (Station #08EE004) and near Houston (Station #08EE003).

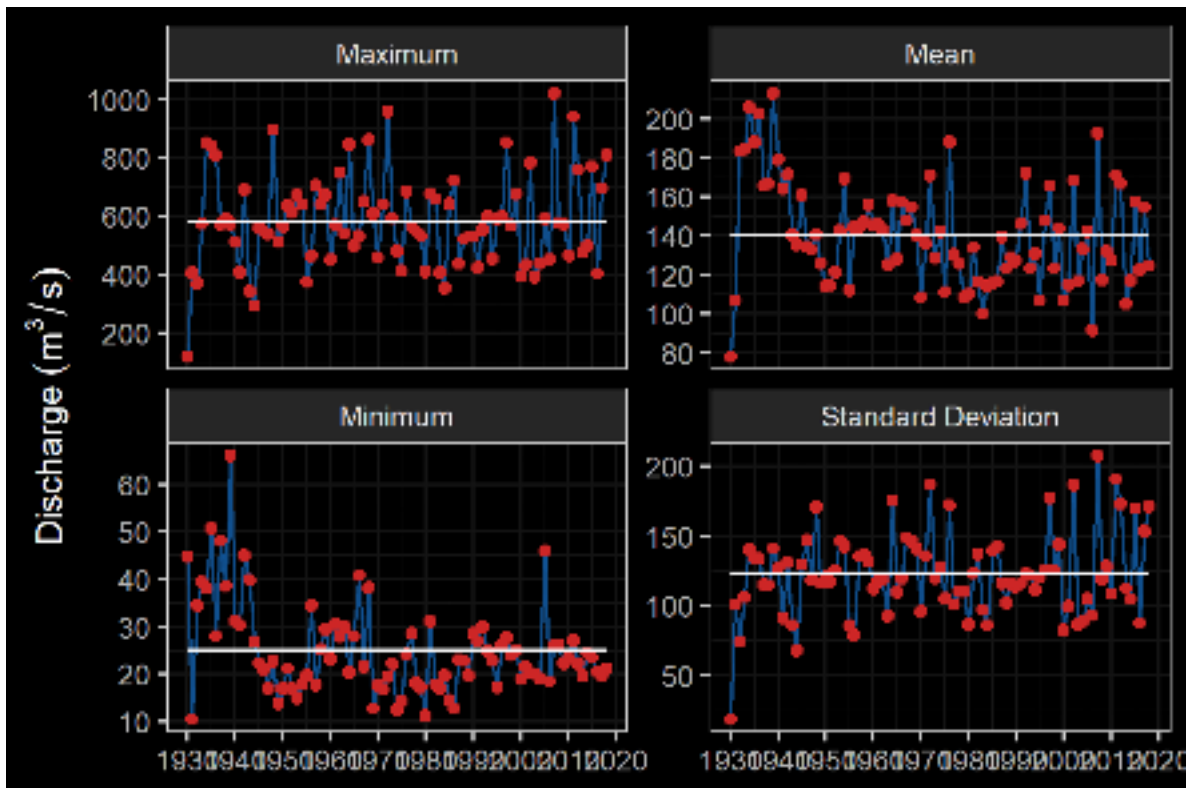


Figure 2.3: Summary of hydrology statistics for Bulkeley River at Quick (Station #08EE004 - daily discharge data from 1930 to 2018).

## 2.3 Project Location

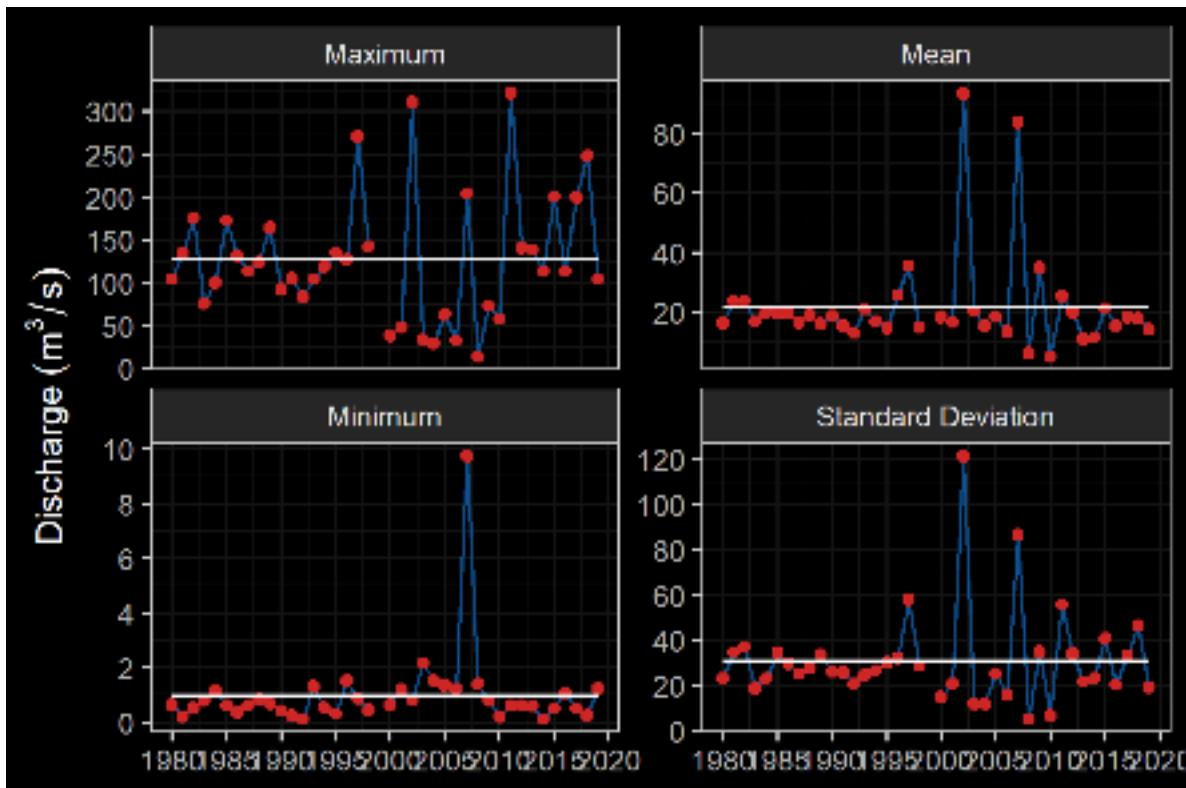


Figure 2.4: Summary of hydrology statistics for Bulkley River near Houston (Station #08EE003 - daily discharge data from 1980 to 2018).

### 2.3.2 Morice River

The Morice River watershed drains 4,379 km<sup>2</sup> of Coast Mountains and Interior Plateau in a generally south-eastern direction. The Morice River is an 8th order stream that flows approximately 80km from Morice Lake to the confluence with the upper Bulkley River just north of Houston. Major tributaries include the Nanika River, the Atna River, Gosnell Creek and the Thautil River. There are numerous large lakes situated on the south side of the watershed including Morice Lake, McBride Lake, Stepp Lake, Nanika Lake, Kid Price Lake, Owen Lake and others. There is one active hydrometric station on the mainstem of the Morice River near the outlet of Morice Lake and one historic station that was located at the mouth of the river near Houston that gathered data in 1971 only (Environment and Climate Change Canada 2021). An estimate of mean annual discharge for the one year of data available for the Morice near its confluence with the Bulkley River is 113.3 m<sup>3</sup>/s. Mean annual discharge is estimated at 75.3 m<sup>3</sup>/s at station 08ED002 located near the outlet of Morice Lake. Flow patterns are typical of high elevation watersheds influenced by coastal weather patterns which receive large amounts of winter precipitation as snow in the winter and large precipitation events in the fall. This leads to peak levels of discharge during snowmelt, typically from May to July with isolated high flows related to rain and rain on snow events common in the fall (Figures 2.5 - 2.6).

## 2 Background

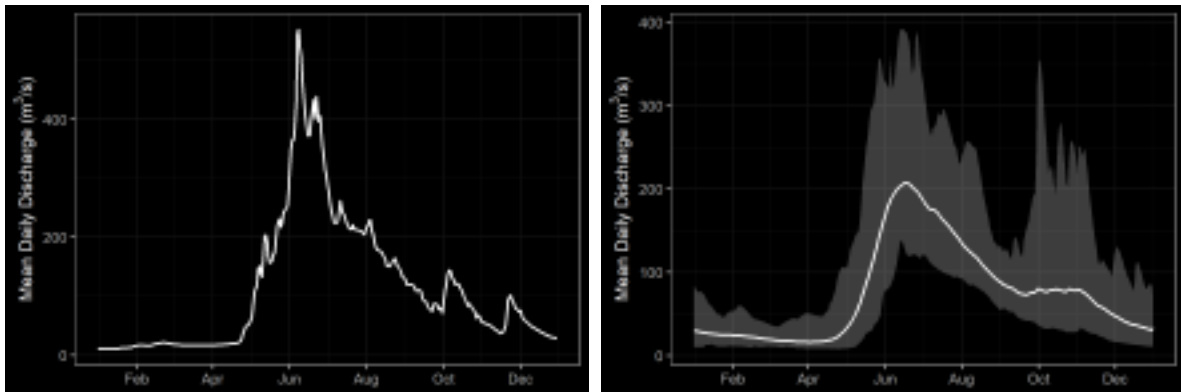


Figure 2.5: Left: Hydrograph for Morice River near Houston (Station #08ED003 - 1971 data only). Right: Hydrograph for Morice River near outlet of Morice Lake (Station #08ED002).

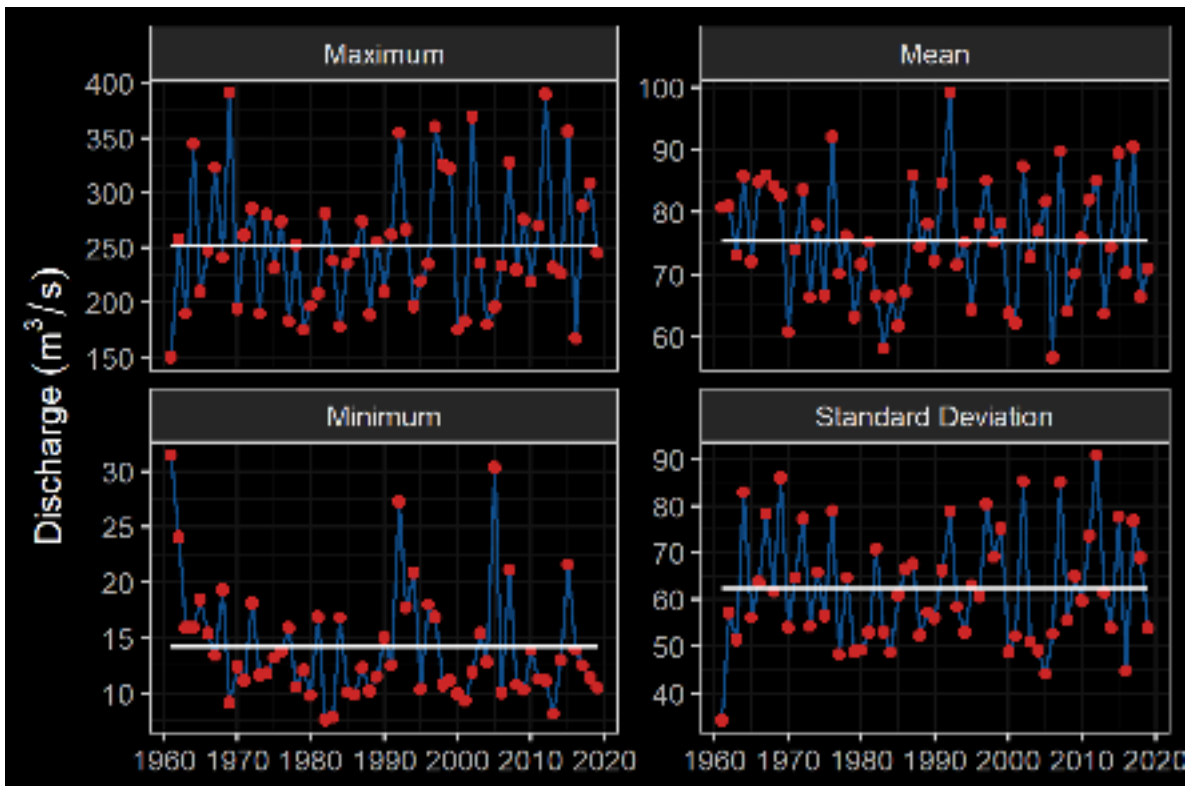


Figure 2.6: Summary of hydrology statistics for Morice River near outlet of Morice Lake (Station #08ED002 - Lat 54.116829 Lon -127.426582). Available daily discharge data from 1961 to 2018.

## 2.4 Fisheries

### 2.4 Fisheries

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

#### 2.4.1 Bulkley River

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

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

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

#### 2.4.2 Morice River

Detailed reviews of Morice River watershed fisheries can be found in Bustard and Schell (2002), Allen Gottesfeld, Rabnett, and Hall (2002), Schell (2003), A. Gottesfeld and Rabnett (2007), and

## 2 Background

ILMB (2007) with a comprehensive review of water quality by Oliver (2018). Overall, the Morice watershed contains high fisheries values as a major producer of chinook, pink, sockeye, coho and steelhead.

### 2.4.2.1 Fish Species

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

Some key areas of high fisheries values for chinook, sockeye and coho are noted in Bustard and Schell (2002) as McBride Lake, Nanika Lake, and Morice Lake watersheds. A draft gantt chart for select species in the Morice River and Bulkley River watersheds was derived from reviews of the aforementioned references and is included as Figure [2.7](#). The data is considered in draft form and will be refined over the spring and summer of 2021 with local fisheries technicians and knowledge holders during the collaborative assessment planning and fieldwork activities planned.

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

Summaries of historical fish observations in the Bulkley River and Morice River watershed groups (n=4033), graphed by remotely sensed average gradient as well as measured or modelled channel width categories for their associated stream segments where calculated with `bcfishpass` and `bcfishobs` and are provided in Figures [2.8](#) - [2.9](#).



## 2.4 Fisheries

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

| Scientific Name                     | Species Name                                   | Species Code | BC List   | Provincial FRPA | COSEWIC        | SARA | Bulkley | Morice |
|-------------------------------------|--|--------------|-----------|-----------------|----------------|------|---------|--------|
| <i>Catostomus catostomus</i>        | Longnose Sucker                                | LSU          | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Catostomus commersonii</i>       | White Sucker                                   | WSU          | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Catostomus macrocheilus</i>      | Largescale Sucker                              | CSU          | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Chrosomus eos</i>                | Northern Redbelly Dace                         | RDC          | Yellow    | –               | –              | –    | Yes     | –      |
| <i>Coregonus clupeaformis</i>       | Lake Whitefish                                 | LW           | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Cottus aleuticus</i>             | Coastrange Sculpin (formerly Aleutian Sculpin) | CAL          | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Cottus asper</i>                 | Prickly Sculpin                                | CAS          | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Couesius plumbeus</i>            | Lake Chub                                      | LKC          | Yellow    | –               | DD             | –    | Yes     | Yes    |
| <i>Entosphenus tridentatus</i>      | Pacific Lamprey                                | PL           | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Hybognathus hankinsoni</i>       | Brassy Minnow                                  | BMC          | No Status | –               | –              | –    | Yes     | –      |
| <i>Lota lota</i>                    | Burbot   | BB           | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Mylocheilus caurinus</i>         | Peamouth Chub                                  | PCC          | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Oncorhynchus clarkii</i>         | Cutthroat Trout                                | CT           | No Status | –               | –              | –    | Yes     | Yes    |
| <i>Oncorhynchus clarkii</i>         | Cutthroat Trout (Anadromous)                   | ACT          | No Status | –               | –              | –    | Yes     | –      |
| <i>Oncorhynchus clarkii clarkii</i> | Coastal Cutthroat Trout                        | CCT          | Blue      | –               | –              | –    | Yes     | Yes    |
| <i>Oncorhynchus gorbuscha</i>       | Pink Salmon                                    | PK           | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Oncorhynchus keta</i>            | Chum Salmon                                    | CM           | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Oncorhynchus kisutch</i>         | Coho Salmon                                    | CO           | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Oncorhynchus mykiss</i>          | Rainbow Trout                                  | RB           | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Oncorhynchus mykiss</i>          | Steelhead                                      | ST           | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Oncorhynchus mykiss</i>          | Steelhead (Summer-run)                         | SST          | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Oncorhynchus nerka</i>           | Kokanee  | KO           | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Oncorhynchus nerka</i>           | Sockeye Salmon                                 | SK           | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Oncorhynchus tshawytscha</i>     | Chinook Salmon                                 | CH           | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Prosopium coulterii</i>          | Pygmy Whitefish                                | PW           | Yellow    | –               | NAR (Nov 2016) | –    | Yes     | Yes    |
| <i>Prosopium coulterii</i> pop. 3   | Giant Pygmy Whitefish                          | GPW          | Yellow    | –               | –              | –    | Yes     | –      |
| <i>Prosopium williamsoni</i>        | Mountain Whitefish                             | MW           | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Ptychocheilus oregonensis</i>    | Northern Pikeminnow                            | NSC          | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Pungitius pungitius</i>          | Ninespine Stickleback                          | NSB          | Unknown   | –               | –              | –    | Yes     | –      |
| <i>Rhinichthys cataractae</i>       | Longnose Dace                                  | LNC          | Yellow    | –               | –              | –    | Yes     | Yes    |
| <i>Rhinichthys falcatus</i>         | Leopard Dace                                   | LDC          | Yellow    | –               | NAR (May       |      |         |        |

## 2 Background

| Scientific Name                       | Species Name            | Species Code | BC List | Provincial FRPA | COSEWIC | SARA | Bulkley | Morice |
|---------------------------------------|-------------------------|--------------|---------|-----------------|---------|------|---------|--------|
| 1990)                                 | -                       | -            | Yes     |                 |         |      |         |        |
| <i>Richardsonius balteatus</i>        | Redside Shiner          | RSC          | Yellow  | -               | -       | -    | Yes     | Yes    |
| <i>Salvelinus confluentus</i> pop. 26 | Bull Trout              | BT           | Blue    | -               | -       | -    | Yes     | Yes    |
| <i>Salvelinus fontinalis</i>          | Brook Trout             | EB           | Exotic  | -               | -       | -    | Yes     | Yes    |
| <i>Salvelinus malma</i>               | Dolly Varden            | DV           | Yellow  | -               | -       | -    | Yes     | Yes    |
| <i>Salvelinus namaycush</i>           | Lake Trout              | LT           | Yellow  | -               | -       | -    | Yes     | Yes    |
| -                                     | Arctic Char             | AC           | -       | -               | -       | -    | -       | Yes    |
| -                                     | Cutthroat/Rainbow cross | CRS          | -       | -               | -       | -    | Yes     | -      |
| -                                     | Dace (General)          | DC           | -       | -               | -       | -    | -       | Yes    |
| -                                     | Lamprey (General)       | L            | -       | -               | -       | -    | Yes     | Yes    |
| -                                     | Minnow (General)        | C            | -       | -               | -       | -    | Yes     | Yes    |
| -                                     | Salmon (General)        | SA           | -       | -               | -       | -    | Yes     | Yes    |
| -                                     | Sculpin (General)       | CC           | -       | -               | -       | -    | Yes     | Yes    |
| -                                     | Sucker (General)        | SU           | -       | -               | -       | -    | Yes     | Yes    |
| -                                     | Whitefish (General)     | WF           | -       | -               | -       | -    | Yes     | Yes    |

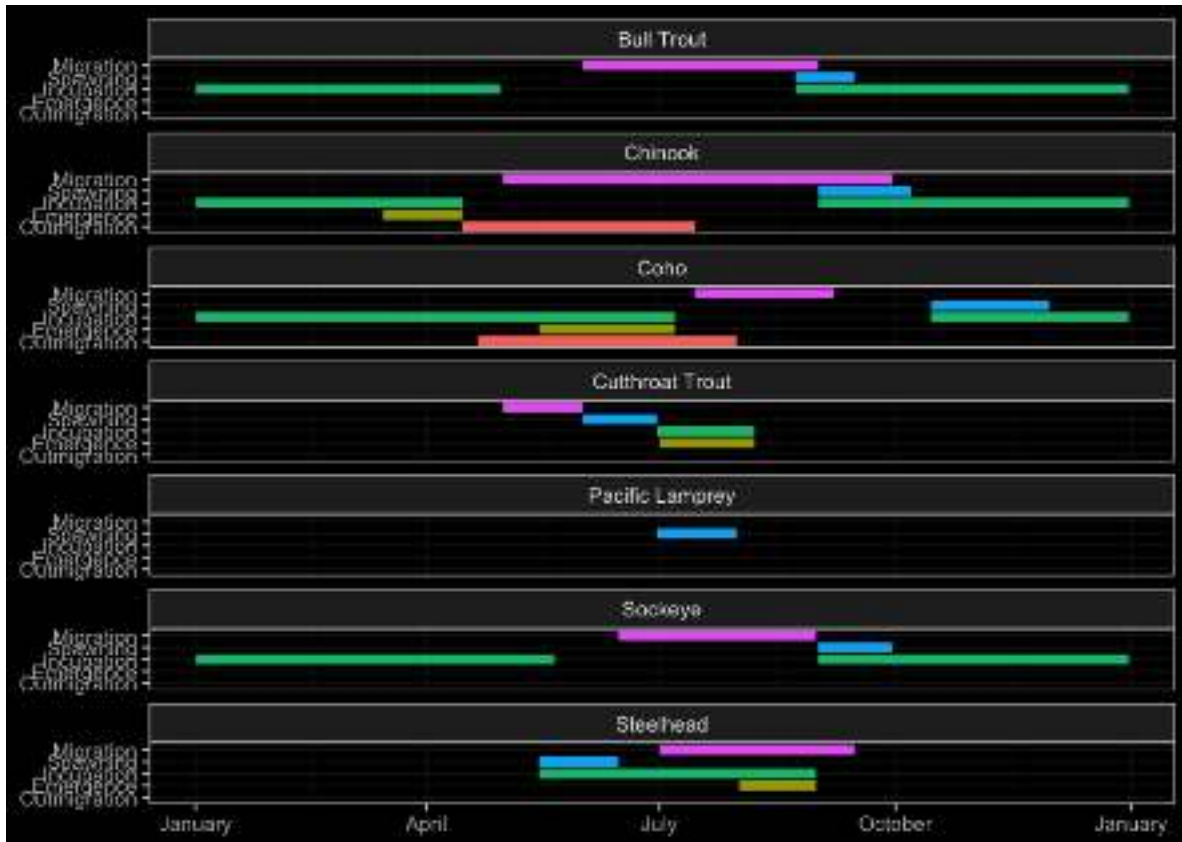


Figure 2.7: Gantt chart for select species in the Morice River and Bulkley River watersheds. To be updated in consultation with local fisheries technicians and knowledge holders.

## 2.4 Fisheries

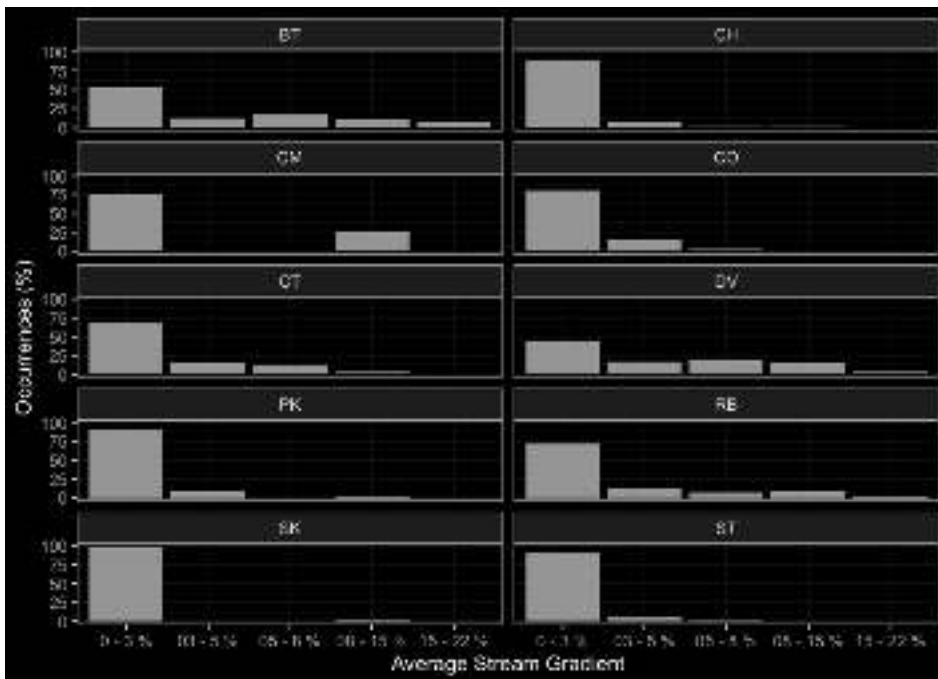


Figure 2.8: Summary of historic salmonid observations vs. stream gradient category for the Bulkley River watershed group.

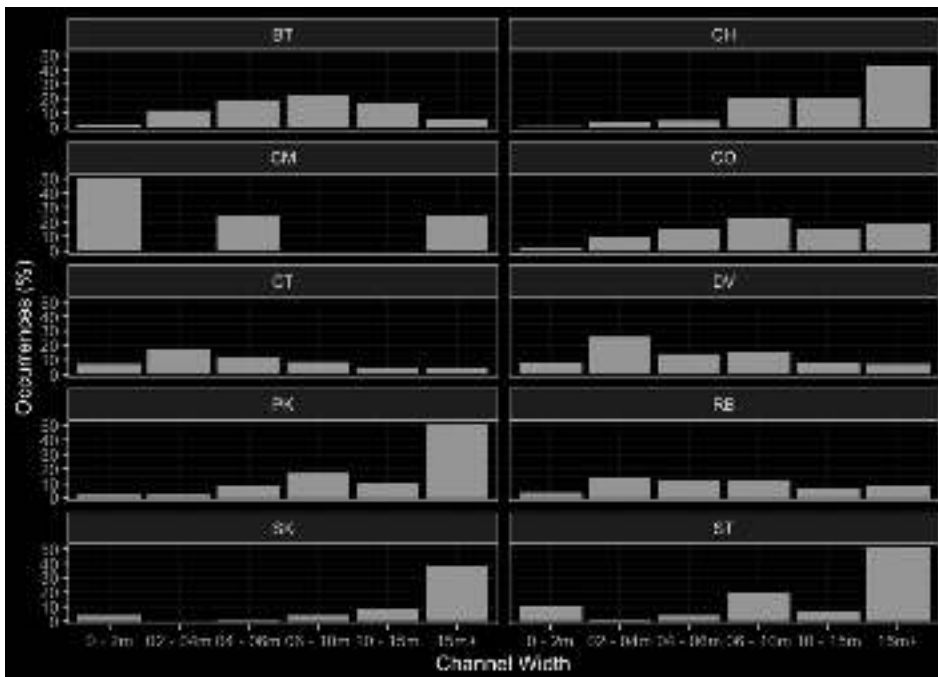


Figure 2.9: Summary of historic salmonid observations vs. channel width category for the Bulkley River watershed group.

### 2.5 Fish Passage Restoration Planning and Implementation

As a result of high-level direction from the provincial government, a Fish Passage Strategic Approach protocol has been developed for British Columbia to ensure that the greatest opportunities for restoration of fish passage are pursued. A Fish Passage Technical Working Group has been formed to coordinate the protocol and data is continuously amalgamated within the Provincial Stream Crossing Inventory System (PSCIS). The strategic approach protocol involves a four-phase process as described in Fish Passage Technical Working Group (2014) :

- Phase 1: Fish Passage Assessment – Fish stream crossings within watersheds with high fish values are assessed to determine barrier status of structures and document a general assessment of adjacent habitat quality and quantity.
- Phase 2: Habitat Confirmation – Assessments of crossings prioritized for follow up in Phase 1 studies are conducted to confirm quality and quantity of habitat upstream and down as well as to scope for other potential nearby barriers that could affect the practicality of remediation.
- Phase 3: Design – Site plans and designs are drawn for priority crossings where high value fish habitat has been confirmed.
- Phase 4: Remediation – Re-connection of isolated habitats through replacement, rehabilitation or removal of prioritized crossing structure barriers.

#### 2.5.1 Bulkley River

There is a rich history of fish passage restoration planning in the Bulkley River watershed group with not all the work documented in the PSCIS system. A non-exhaustive list of historic fish passage reports for the watershed includes Wilson and Rabnett (2007), McCarthy and Fernando (2015), Smith (2018) Casselman and Stanley (2010) and Irvine (2018).

Review of the PSCIS database indicated that prior to 2021, 1665 assessments for fish passage (Phase 1) at crossing structures within the Bulkley River watershed group have been recorded in the PSCIS database (MoE 2021a). No habitat confirmations are recorded in the PSCIS database (MoE 2021b). Within the Bulkley River watershed group, a number of remediation projects have been completed over the years with backwatering works conducted on Toboggan Creek, Coffin Creek, Moan Creek, Johnny David Creek and potentially others. Three culvert replacements (with open bottom structures) in the watershed group have been tracked in PSCIS and include works on Barren Creek as well as two tributaries to Harold Prince Creek (MoE 2021c). McDowell Creek at Highway 16 was replaced with a horizontally drilled baffled structure in 2017 and a design is currently being drafted for the Highway 16 crossing over Taman Creek (pers. comm. Kathryn Graham, Regional Manager Environmental Services - Ministry of Transportation and Infrastructure).

## 2.6 Morice river

### **2.6 Morice river**

Within the Morice River watershed group prior to 2021, 21 fish passage assessments (Phase 1) had been recorded in the PSCIS database (MoE 2021a). At the time of reporting, no habitat confirmations had been recorded (MoE 2021b). Two culvert replacements (with open bottom structures) in the watershed group have been tracked in PSCIS in the and include works on a tributary to the Morice River located at km 39.2 of the Morice River FSR and on bridge installation at km 4 of McBride Road on a tributary to McBride Lake (MoE 2021c).



## 3 Methods

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

### 3.1 Planning

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

#### 3.1.1 Habitat Modelling

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

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

### 3 Methods

annual precipitation weighted to upstream watershed area and channel width can be collated using `bcfishpass`, `fwapg` and `bcfishobs`. This information can be used to provide an indication of the potential quantity and quality of habitat potentially gained should fish passage be restored by comparing to user defined thresholds for the aforementioned parameters. A discussion of the methodology to derive channel width is below.

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

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



### 3.1 Planning

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

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

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

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

Table 3.3: bcfishpass outputs and associated definitions

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

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

### 3.1.2 PSCIS and Modelled Stream Crossing Review

To prepare for Phase 1 and 2 assessments in the study area, past fish passage assessment reports for the Bulkley River and Morice River watershed groups were first reviewed to identify crossing structures not yet assessed or previously ranked as priorities for rehabilitation (Casselman and Stanley 2010; Irvine 2018; McCarthy and Fernando 2015; Smith 2018; Wilson and Rabnett 2007). To determine which of those crossings had not yet been assessed with Phase 1 and Phase 2 assessments we cross-referenced these reports with the PSCIS database, available background info and viewed sites within the output of `bcfishpass`. Outputs for modelled and PSCIS crossings (barriers and potential barriers) that met the following criteria underwent a detailed review to facilitate prioritization for Phase 1 - Fish Passage Assessments and Phase 2 - Habitat Confirmations.

- Confirmed fish presence upstream of the structure.
- Stream width documented as > 2.0m in PSCIS.
- Linear lengths of modelled upstream habitat <8% gradient for ≥1km.
- Crossings located on streams classified as 3rd order or higher.
- Crossings located on streams with >5 ha of modeled wetland and/or lake habitat upstream.
- Habitat value rated as “medium” or “high” in PSCIS.

Additionally, `bcfishpass` outputs and working group discussions were utilized as described in Mazany-Wright et al. (2021) to provide candidate crossings for field review in the Bulkley River watershed group.

### 3.2 Fish Passage Assessments

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

### 3.2 Fish Passage Assessments

potential barriers or barriers based on the data (see [Barrier Scoring \(page 22\)](#)), a culvert fix and recommended diameter/span was proposed.

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

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

### 3.2.1 Barrier Scoring

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

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

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

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

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

### 3.2.2 Cost Benefit Analysis

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

## 3.2 Fish Passage Assessments

### 3.2.2.1 Habitat Gain Index

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

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

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

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

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

### 3 Methods

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.

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 \$12500/linear m and assumed that the road could be closed during construction and a minimum bridge span of 10m. For streams with channel widths <2m, embedded culverts were reported as an effective solution with total installation costs estimated at \$25k/crossing (pers. comm. Phil MacDonald, Steve Page). For larger streams (>6m), span width increased proportionally to the size of the stream (ex. for an 8m wide stream a 12m wide span was prescribed). For crossings with large amounts of fill (>3m), the replacement bridge span was increased by an additional 3m for each 1m of fill >3m to account for cut-slopes to the stream at a 1.5:1 ratio. To account for road type, a multiplier table was also generated to estimate incremental cost increases with costs estimated for structure replacement on paved surfaces, railways and arterial/highways costing up to 20 times more than forest service roads due to expenses associated with design/engineering requirements, traffic control and paving. The cost multiplier table (Table 3.7) should be considered very approximate with refinement recommended for future projects.

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

| Class               | Surface | Class Multiplier | Surface Multiplier | Bridge \$K/10m | Streambed Simulation \$K |
|---------------------|---------|------------------|--------------------|----------------|--------------------------|
| Forest Service Road | Loose   | 1                | 1                  | 200            | 40                       |
| Resource            | Loose   | 1                | 1                  | 200            | 40                       |
| Road Permit         | Loose   | 1                | 1                  | 200            | 40                       |
| Unclassified        | Loose   | 1                | 1                  | 200            | 40                       |
| Unclassified        | Rough   | 1                | 1                  | 200            | 40                       |
| Unclassified        | Paved   | 1                | 2                  | 400            | 80                       |
| Unclassified        | Unknown | 1                | 2                  | 400            | 80                       |
| Local               | Loose   | 4                | 1                  | 800            | 160                      |
| Local               | Paved   | 4                | 2                  | 1600           | 320                      |
| Arterial            | Paved   | 15               | 2                  | 6000           | 1200                     |
| Highway             | Paved   | 15               | 2                  | 6000           | 1200                     |
| Rail                | Rail    | 15               | 2                  | 6000           | 1200                     |

#### 3.3 Habitat Confirmation Assessments

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

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

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

## 3 Methods

### 3.4 Reporting

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

- Populated [Fish Data Submission Spreadsheet Template - V 2.0, January 20, 2020](#)
- Populated [pscis\\_assessment\\_template\\_v24.xls](#)
- [bcfishpass](#) outputs.
- [Custom CSV file](#) detailing Phase 2 site:
  - priority level for proceeding to design for replacement
  - length of survey upstream and downstream
  - a conservative estimate of the linear length of mainstem habitat potentially available upstream of the crossing
  - fish species confirmed as present upstream of the crossing
- [GPS tracks](#) from field surveys.
- [Photos](#) and photo metadata

Version changes are tracked [here](#) and issues/planned enhancements tracked [here](#).

### 3.5 Mapping

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



## 4 Results and Discussion

### 4.1 Phase 1

Field assessments were conducted between August 09 2021 and September 16 2021 by Allan Irvine, R.P.Bio. and Kyle Prince, P.Biol., Teasha Pierre, Vern Joseph, Dallas Nikal, Alexandria Nikal, Chad Lewis, Tim Wilson, Adam Wrench, Lars Reese-Hanson and Don Morgan. A total of 191 Phase 1 assessments were conducted with 77 crossings considered “passable”, 10 crossings considered “potential” barriers and 84 crossings considered “barriers” according to threshold values based on culvert embedment, outlet drop, slope, diameter (relative to channel size) and length (MoE 2011a). Additionally, although all were considered fully passable, 20 crossings assessed were fords and ranked as “unknown” according to the provincial protocol. Georeferenced field maps are presented in [Attachment 1](#). A summary of crossings assessed, a cost benefit analysis and priority ranking for follow up for Phase 1 sites presented in Table [4.1](#). Detailed data with photos are presented in [Attachment 2](#).

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

4 Results and Discussion

benefit analysis for Phase 1 assessments. Steelhead network model (total length stream network <20% gradient).

| PSCIS ID | External ID | Stream                      | Road                  | Result    | Habitat value | Stream Width (m) | Priority | Fix    | Cost Est (\$K) | Habitat Upstream (km) | Cost Benefit (m / \$K) | Cost Benefit (m2 / \$K) |
|----------|-------------|-----------------------------|-----------------------|-----------|---------------|------------------|----------|--------|----------------|-----------------------|------------------------|-------------------------|
| 198048   | 1800048     | Cesford Creek               | Highway 16            | Barrier   | High          | 5.48             | high     | OBS    | 6000           | 54.43                 | 9.1                    | 24.9                    |
| 197967   | 1800050     | Taman Creek                 | Highway 16            | Barrier   | Medium        | 5.30             | mod      | OBS    | 18600          | 142.42                | 7.7                    | 20.3                    |
| 197903   | 1800180     | Tributary to Bulkley River  | Rose Lake Cutoff Road | Barrier   | Low           | 1.50             | low      | SS-CBS | 160            | 3.67                  | 22.9                   | 17.2                    |
| 198065   | 1800191     | Watson Creek                | Montgomery Road       | Barrier   | Medium        | 3.00             | mod      | OBS    | 800            | 18.77                 | 23.5                   | 35.2                    |
| 198049   | 1800193     | Cesford Creek               | Highway 118           | Barrier   | High          | 4.90             | high     | OBS    | 6000           | 50.46                 | 8.4                    | 20.6                    |
| 197976   | 1800355     | Ailport Creek               | Highway 16            | Barrier   | High          | 7.50             | high     | OBS    | 7500           | 53.15                 | 7.1                    | 26.6                    |
| 197974   | 1800356     | Watson Creek                | Highway 16            | Barrier   | Low           | 2.20             | low      | OBS    | 6000           | 21.24                 | 3.5                    | 3.9                     |
| 197902   | 1800360     | Tributary to Bulkley River  | Rose Lake Cutoff Road | Barrier   | Low           | 1.50             | low      | SS-CBS | 160            | 4.75                  | 29.7                   | 22.3                    |
| 197904   | 1800372     | Tributary to Bulkley River  | Crow Creek Road       | Barrier   | Low           | 2.00             | low      | OBS    | 200            | 3.03                  | 15.2                   | 15.2                    |
| 197975   | 1801122     | Ailport Creek               | Private Driveway      | Barrier   | Medium        | 6.50             | mod      | OBS    | 230            | 52.76                 | 229.4                  | 745.5                   |
| 197972   | 1802040     | Tributary to Broman Lake    | Powerline             | Barrier   | Low           | 0.80             | low      | SS-CBS | 40             | 7.78                  | 194.5                  | 77.8                    |
| 198066   | 1802488     | Thompson Creek              | Private Road          | Potential | High          | 2.77             | mod      | OBS    | 200            | 35.88                 | 179.4                  | 248.5                   |
| 197907   | 1802611     | Tributary to Maxan Creek    | Maxan Creek FSR       | Barrier   | Low           | 1.30             | low      | SS-CBS | 40             | 8.97                  | 224.2                  | 145.8                   |
| 197908   | 1803697     | Tributary to Maxan Creek    | Maxan Creek FSR       | Barrier   | Low           | 1.00             | low      | SS-CBS | 40             | 4.03                  | 100.8                  | 50.4                    |
| 197906   | 1803706     | Tributary to Maxan Creek    | Maxan Creek FSR       | Barrier   | Low           | 1.20             | low      | SS-CBS | 40             | 7.84                  | 196.0                  | 117.6                   |
| 197970   | 1803813     | Tributary to Broman Lake    | Broman Lake FSR       | Barrier   | Low           | 0.70             | low      | SS-CBS | 40             | 2.84                  | 71.0                   | 24.8                    |
| 197909   | 1804693     | Tributary to Maxan Creek    | Maxan Creek FSR       | Barrier   | Medium        | 0.90             | mod      | SS-CBS | 40             | 0.68                  | 17.0                   | 7.7                     |
| 197964   | 1805529     | Bulkley River               | Railway               | Potential | High          | 9.00             | mod      | OBS    | 8400           | 144.22                | 17.2                   | 77.3                    |
| 197963   | 1805531     | Tributary to Bulkley River  | Railway               | Barrier   | Low           | 4.00             | low      | OBS    | 6000           | 1.52                  | 0.3                    | 0.5                     |
| 198044   | 1805573     | Tributary to Toboggan Creek | Railway               | Barrier   | Low           | 2.00             | low      | SS-CBS | 1200           | 10.09                 | 8.4                    | 8.4                     |
| 198071   | 14000022    | Tributary to Collins Lake   | spur Morice Nado      | Barrier   | Medium        | 2.00             | mod      | SS-CBS | 40             | 4.63                  | 115.8                  | 115.8                   |
| 198069   | 14000256    | Tributary to Collins Lake   | Morice Nado           | Barrier   | Medium        | 2.50             | mod      | OBS    | 200            | 6.08                  | 30.4                   | 38.0                    |
| 198037   | 14000375    | Tributary to Thautil River  | Thautil FSR           | Potential | Low           | 0.65             | low      | SS-CBS | 40             | 1.14                  | 28.5                   | 9.3                     |
| 198036   | 14000377    | Tributary to Thautil River  | Thautil FSR           | Barrier   | Medium        | 1.90             | mod      | SS-CBS | 40             | 2.39                  | 59.8                   | 56.8                    |
| 198039   | 14000379    | Tributary to Thautil River  | Thautil FSR           | Barrier   | Low           | 1.10             | low      | SS-CBS | 40             | 6.01                  | 150.2                  | 82.6                    |
| 198055   | 14000381    | Tributary to Thautil River  | Thautil FSR           | Barrier   | Low           | 1.10             | low      | SS-CBS | 40             | 0.09                  | 2.2                    | 1.2                     |
| 198038   | 14000382    | Tributary to Thautil River  | Thautil FSR           | Barrier   | Low           | 0.70             | low      | SS-CBS | 40             | 1.27                  | 31.8                   | 11.1                    |
| 198057   | 14000383    | Tributary to Gabriel Creek  | Thautil FSR           | Barrier   | Medium        | 3.00             | mod      | OBS    | 200            | 1.69                  | 8.4                    | 12.7                    |
| 198056   | 14000389    | Tributary to                |                       |           |               |                  |          |        |                |                       |                        |                         |

## 4.1 Phase 1

| PSCIS ID      | External ID | Stream                     | Road            | Result    | Habitat value | Stream Width (m) | Priority | Fix    | Cost Est (\$K) | Habitat Upstream (km) | Cost Benefit (m / \$K) | Cost Benefit (m2 / \$K) |
|---------------|-------------|----------------------------|-----------------|-----------|---------------|------------------|----------|--------|----------------|-----------------------|------------------------|-------------------------|
| Thautil River | Thautil FSR | Barrier                    | Low             | 1.80      | low           | SS-CBS           | 40       | 2.09   | 52.2           | 47.0                  |                        |                         |
| 198058        | 14000390    | Tributary to Gabriel Creek | Thautil FSR     | Barrier   | Low           | 1.50             | low      | SS-CBS | 40             | 1.13                  | 28.2                   | 21.2                    |
| 198059        | 14000392    | Tributary to Gabriel Creek | Thautil FSR     | Barrier   | Medium        | 1.50             | mod      | SS-CBS | 40             | 2.85                  | 71.2                   | 53.4                    |
| 198050        | 14000394    | Tributary to Thautil River | Thautil FSR     | Barrier   | Low           | 0.90             | low      | SS-CBS | 40             | 1.79                  | 44.8                   | 20.1                    |
| 198033        | 14000395    | Tributary to Gabriel Creek | Thautil FSR     | Barrier   | Low           | 0.67             | low      | SS-CBS | 40             | 1.11                  | 27.8                   | 9.3                     |
| 198035        | 14000398    | Tributary to Gabriel Creek | Thautil FSR     | Barrier   | Low           | 1.17             | low      | SS-CBS | 40             | 1.21                  | 30.2                   | 17.7                    |
| 198011        | 14000443    | Tributary to Nanika River  | 4 Road          | Barrier   | Low           | 2.20             | low      | OBS    | 200            | 0.42                  | 2.1                    | 2.3                     |
| 198087        | 14000453    | Tributary to Nanika River  | Cutthroat 1     | Barrier   | Low           | 1.90             | low      | SS-CBS | 1200           | 3.96                  | 3.3                    | 3.1                     |
| 197994        | 14000481    | Tributary to Gosnell Creek | 6 Road          | Barrier   | Medium        | 1.10             | mod      | SS-CBS | 40             | 0.94                  | 23.5                   | 12.9                    |
| 197991        | 14000506    | Tributary to Gosnell Creek | 6 Road          | Barrier   | Medium        | 0.80             | mod      | SS-CBS | 40             | 0.00                  | 0.0                    | 0.0                     |
| 197998        | 14000507    | Tributary to Gosnell Creek | 6 Road          | Barrier   | Medium        | 1.80             | mod      | SS-CBS | 40             | 1.15                  | 28.8                   | 25.9                    |
| 198009        | 14000535    | Tributary to Nanika River  | 1 Road          | Barrier   | Low           | 1.00             | low      | SS-CBS | 40             | 0.49                  | 12.2                   | 6.1                     |
| 197937        | 14000536    | Tributary to Nanika River  | Spur            | Barrier   | Low           | 0.80             | low      | SS-CBS | 40             | 1.49                  | 37.2                   | 14.9                    |
| 198016        | 14000562    | Tributary to Thautil River | Chisholm FSR    | Barrier   | Medium        | 1.30             | mod      | SS-CBS | 40             | 0.74                  | 18.5                   | 12.0                    |
| 198003        | 14000582    | Tributary to Nanika River  | Nanika FSR      | Barrier   | Low           | 0.50             | low      | SS-CBS | 40             | 1.14                  | 28.5                   | 7.1                     |
| 198081        | 14000592    | Tributary to Lamprey Creek | 07 Road         | Barrier   | Low           | 1.60             | low      | SS-CBS | 40             | 3.65                  | 91.2                   | 73.0                    |
| 198019        | 14000669    | Tributary to Thautil River | Chisholm FSR    | Barrier   | Medium        | 1.60             | mod      | SS-CBS | 40             | 5.40                  | 135.0                  | 108.0                   |
| 198028        | 14000683    | Tributary to Thautil River | Chisholm FSR    | Barrier   | Low           | 1.10             | low      | SS-CBS | 40             | 5.12                  | 128.0                  | 70.4                    |
| 197945        | 14000684    | Tributary to Thautil River | Chisholm FSR    | Barrier   | Low           | 1.00             | low      | SS-CBS | 40             | 2.34                  | 58.5                   | 29.2                    |
| 198020        | 14000688    | Tributary to Thautil River | Chisholm FSR    | Barrier   | Low           | 0.00             | low      | SS-CBS | 40             | 5.70                  | 142.5                  | 0.0                     |
| 197952        | 14000690    | Tributary to Morice River  | Chisholm FSR    | Barrier   | Low           | 2.10             | low      | OBS    | 200            | 6.19                  | 31.0                   | 32.5                    |
| 198029        | 14000694    | Tributary to Thautil River | Chisholm FSR    | Barrier   | Low           | 0.90             | low      | SS-CBS | 40             | 4.94                  | 123.5                  | 55.6                    |
| 197944        | 14000695    | Tributary to Thautil River | Chisholm FSR    | Barrier   | Medium        | 2.20             | mod      | OBS    | 200            | 0.00                  | 0.0                    | 0.0                     |
| 197954        | 14000696    | Tributary to Morice River  | Chisholm FSR    | Barrier   | Medium        | 1.70             | mod      | OBS    | 200            | 7.86                  | 39.3                   | 33.4                    |
| 198026        | 14000697    | Tributary to Thautil River | Chisholm FSR    | Barrier   | Low           | 0.70             | low      | SS-CBS | 40             | 1.97                  | 49.2                   | 17.2                    |
| 198060        | 14000718    | Tributary to Owen Creek    | Morice-Owen FSR | Potential | Medium        | 2.00             | low      | OBS    | 200            | 7.01                  | 35.0                   | 35.0                    |
| 197962        | 14000798    | Peacock Creek              | Morice FSR      | Barrier   | High          | 9.30             | high     | OBS    | 316            | 6.14                  | 19.4                   | 90.4                    |
| 198085        | 14000799    | Tributary to Lamprey Creek | Morice FSR      | Barrier   | Medium        | 1.40             | mod      | SS-CBS | 40             | 0.68                  | 17.0                   | 11.9                    |
| 197989        | 14000801    | Tributary to Morice River  | Morice FSR      | Barrier   | Medium        | 2.20             | mod      | OBS    | 200            | 2.68                  | 13.4                   | 14.7                    |

## 4 Results and Discussion

| PSCIS ID | External ID | Stream                     | Road              | Result    | Habitat value | Stream Width (m) | Priority | Fix    | Cost Est (\$K) | Habitat Upstream (km) | Cost Benefit (m / \$K) | Cost Benefit (m2 / \$K) |
|----------|-------------|----------------------------|-------------------|-----------|---------------|------------------|----------|--------|----------------|-----------------------|------------------------|-------------------------|
| 198067   | 14000804    | Tributary to Lamprey Creek | Morice R FSR      | Barrier   | Low           | 2.20             | low      | OBS    | 200            | 6.77                  | 33.9                   | 37.2                    |
| 198068   | 14000815    | Tributary to Lamprey Creek | Morice R FSR      | Barrier   | Low           | 0.80             | low      | SS-CBS | 40             | 1.03                  | 25.8                   | 10.3                    |
| 197965   | 14000820    | Tributary to Collins Lake  | Morice R FSR      | Barrier   | Medium        | 0.35             | mod      | SS-CBS | 40             | 7.77                  | 194.2                  | 34.0                    |
| 198030   | 14000823    | Tributary to Lamprey Creek | Morice FSR        | Barrier   | Low           | 1.00             | low      | SS-CBS | 40             | 0.90                  | 22.5                   | 11.2                    |
| 198008   | 14000865    | Tributary to Nanika River  | Spur              | Barrier   | Medium        | 1.80             | mod      | SS-CBS | 40             | 0.60                  | 15.0                   | 13.5                    |
| 198040   | 14000882    | Tributary to Morice River  | Spur              | Potential | Medium        | 0.90             | low      | SS-CBS | 40             | 0.34                  | 8.5                    | 3.8                     |
| 198079   | 14000890    | Tributary to Lamprey Creek | Spur              | Barrier   | Medium        | 0.90             | mod      | SS-CBS | 40             | 1.23                  | 30.8                   | 13.8                    |
| 198072   | 14000892    | Tributary to Lamprey Creek | Spur              | Potential | Low           | 1.00             | low      | SS-CBS | 40             | 3.61                  | 90.2                   | 45.1                    |
| 198080   | 14000894    | Tributary to Lamprey Creek | Spur              | Barrier   | Medium        | 0.60             | mod      | SS-CBS | 40             | 1.01                  | 25.2                   | 7.6                     |
| 197931   | 14000932    | Tributary to Nanika River  | Spur              | Barrier   | Low           | 0.40             | low      | SS-CBS | 40             | 1.19                  | 29.8                   | 6.0                     |
| 197982   | 14000941    | Tributary to Gosnell Creek | Crystal Creek FSR | Barrier   | Medium        | 2.20             | mod      | OBS    | 200            | 5.75                  | 28.8                   | 31.6                    |
| 197923   | 14000949    | Tributary to Gosnell Creek | Crystal Creek FSR | Barrier   | Low           | 0.90             | low      | SS-CBS | 40             | 0.28                  | 7.0                    | 3.1                     |
| 197924   | 14000954    | Tributary to Gosnell Creek | Crystal Creek FSR | Barrier   | Low           | 1.30             | low      | SS-CBS | 40             | 1.46                  | 36.5                   | 23.7                    |
| 198084   | 14000968    | Tributary to Lamprey Creek | Spur              | Barrier   | Medium        | 0.90             | mod      | SS-CBS | 40             | 1.48                  | 37.0                   | 16.6                    |
| 198062   | 14000991    | Tributary to Morice River  | Morice-West FSR   | Barrier   | Medium        | 10.00            | mod      | OBS    | 300            | 2.61                  | 8.7                    | 43.5                    |
| 198034   | 14000994    | Tributary to Thautil River | Thautil FSR       | Barrier   | Medium        | 0.60             | mod      | SS-CBS | 40             | 3.15                  | 78.8                   | 23.6                    |
| 197928   | 14000997    | Tributary to Morice River  | Morice West FSR   | Barrier   | Low           | 1.20             | low      | SS-CBS | 40             | 0.63                  | 15.8                   | 9.4                     |
| 197926   | 14001002    | Tributary to Morice River  | Morice West FSR   | Barrier   | Medium        | 2.00             | mod      | OBS    | 200            | 8.98                  | 44.9                   | 44.9                    |
| 198002   | 14001009    | Tributary to Nanika River  | 9 Road            | Barrier   | Low           | 0.50             | low      | SS-CBS | 40             | 1.37                  | 34.2                   | 8.6                     |
| 198082   | 14001062    | Tributary to Lamprey Creek | Bill Nye          | Barrier   | Medium        | 0.60             | mod      | SS-CBS | 40             | 1.81                  | 45.2                   | 13.6                    |
| 198007   | 14001077    | Tributary to Nanika River  | Spur              | Barrier   | Low           | 1.00             | low      | SS-CBS | 40             | 2.13                  | 53.2                   | 26.6                    |
| 198005   | 14001078    | Tributary to Nanika River  | Spur              | Barrier   | Low           | 0.80             | low      | SS-CBS | 40             | 2.09                  | 52.2                   | 20.9                    |
| 198064   | 14001094    | Tributary to Lamprey Creek | Spur              | Barrier   | Medium        | 2.56             | mod      | OBS    | 200            | 5.05                  | 25.2                   | 32.3                    |
| 198000   | 14001161    | McBride Creek              | Nanika FSR        | Potential | High          | 9.00             | mod      | OBS    | 280            | 84.07                 | 300.2                  | 1351.1                  |
| 198086   | 14001170    | Tributary to Lamprey Creek | spur (overgrown)  | Barrier   | Low           | 2.00             | low      | OBS    | 200            | 6.12                  | 30.6                   | 30.6                    |
| 197951   | 14001177    | Tributary to Morice River  | False Tagit FSR   | Barrier   | Medium        | 3.00             | mod      | OBS    | 200            | 11.06                 | 55.3                   | 83.0                    |
| 198051   | 14001409    | Tributary to Thautil River | Spur              | Barrier   | Low           | 1.30             | low      | SS-CBS | 40             | 2.07                  | 51.8                   | 33.6                    |
| 197934   | 14001414    | Tributary to Nanika River  | Spur              | Potential | Low           | 1.00             | low      | SS-CBS | 40             | 3.10                  | 77.5                   | 38.8                    |
| 198052   | 14001468    | Tributary to Thautil River | Spur              | Barrier   | Low           | 0.50             | low      | SS-CBS | 80             | 1.60                  | 20.0                   | 5.0                     |
| 198075   | 14001624    | Tributary to               |                   |           |               |                  |          |        |                |                       |                        |                         |

## 4.2 Bulkley Falls Assessment

| PSCIS ID     | External ID | Stream                     | Road    | Result    | Habitat value | Stream Width (m) | Priority | Fix    | Cost Est (\$K) | Habitat Upstream (km) | Cost Benefit (m / \$K) | Cost Benefit (m2 / \$K) |
|--------------|-------------|----------------------------|---------|-----------|---------------|------------------|----------|--------|----------------|-----------------------|------------------------|-------------------------|
| Collins Lake | Spur        | Potential                  | Low     | 0.65      | low           | SS-CBS           | 40       | 0.70   | 17.5           | 5.7                   |                        |                         |
| 198022       | 14001769    | Tributary to Tagit Creek   | 5 Road  | Barrier   | Medium        | 1.40             | mod      | SS-CBS | 40             | 6.67                  | 166.8                  | 116.7                   |
| 197960       | 24704566    | Corya Creek                | Railway | Barrier   | High          | 18.00            | high     | OBS    | 1800           | 27.01                 | 15.0                   | 135.1                   |
| 197938       | 2021083150  | Bulkley River Side Channel | Railway | Potential | Medium        | 3.00             | low      | SS-CBS | 1200           | 1.01                  | 0.8                    | 1.3                     |
| 197992       | 2021090161  | Tributary to Gosnell Creek | 6 Road  | Barrier   | Low           | 0.50             | low      | SS-CBS | 40             | -                     | -                      | -                       |
| 197936       | 2021090299  | -                          | Spur    | Barrier   | Low           | 0.90             | low      | SS-CBS | 40             | 1.62                  | 40.5                   | 18.2                    |
| 197949       | 2021090303  | Tributary to Tagit Creek   | 11 Rd   | Barrier   | Medium        | 2.00             | mod      | OBS    | 200            | 6.16                  | 30.8                   | 30.8                    |
| 198090       | 2021090551  | Cesford Creek              | Railway | Barrier   | High          | 5.00             | high     | OBS    | 200            | 0.00                  | 0.0                    | 0.0                     |

## 4.2 Bulkley Falls Assessment

Bulkley Falls is located near Topley, BC on the mainstem of the Bulkley River. Information on the crossing was scarce so an assessment was prioritized by Canadian Wildlife Federation. The site was assessed on October 28, 2021 by Nallas Nikal, B.i.T, and Chad Lewis, Environmental Technician. The top of the falls is located at 11U.678269.6038266 at an elevation of 697m approximatley 11.3km downstream of Bulkley Lake and upstream of Ailport Creek (Figure ??).. Water temperature was 3.0°C, pH was 7.75 and conductivity was 159uS/cm. Within the Bulkley River immediately below the 12 - 15m high bedrock falls, channel width was 17.4m and the wetted width was 15.6m. Two channels comprised the falls. The primary channel was 20m long, had a channel/wetted width of 8.5m, a 16% grade and water depths ranging from 35 - 63cm. The secondary channel was 25m long, with channel/wetted widths of 7.5m, a grade of 12% and water depths ranging from 3 - 13cm.

Dyson (1949) and Stokes (1956) report substantial use of habitat above Bulkley Falls by steelhead, chinook, coho and sockeye utilization in the past (pre-1950) based on spawning reports. Both authors concluded that the Bulkley Falls pose a partial obstruction to migrating fish based on flow levels. Chinook, which migrate early in the summer when water levels are high, have been noted as able to ascend the falls in normal to high water years and in high water years it was thought that coho and steelhead could ascend. A. Gottesfeld and Rabnett (2007) report that the falls are almost completely impassable to all salmon during low water flows. Stokes (1956) reports that there was high value spawning habitat located within the first 3km of the Bulkley River from the outlet of Bulkley Lake.



Figure 4.1: Left: Bulkley Falls main channel. Right: Bulkley Falls side channel.

### 4.3 Phase 2

During 2021 field assessments, habitat confirmation assessments were conducted at 29 sites in the Bulkley River and Morice River watershed groups. A total of approximately 22km of stream was assessed, fish sampling utilizing electrofishing was conducted at five sites, and five sites were mapped using remotely piloted aircraft. Georeferenced field maps are presented in [Attachment 1](#).

As collaborative decision making was ongoing at the time of reporting, site prioritization can be considered preliminary. In total, Twelve crossings were rated as high priorities for proceeding to design for replacement, 11 crossings were rated as moderate priorities, and 6 crossings were rated as low priorities. Results are summarized in Tables [4.2](#) - [4.4](#) with raw habitat and fish sampling data included in digital format as [Attachment 3](#). A summary of preliminary modelling results illustrating the quantity of chinook, coho and steelhead spawning and rearing habitat potentially available upstream of each crossing as estimated by measured/modelled channel width and upstream accessible stream length are presented in Figure [4.2](#). Detailed information for each site assessed with Phase 2 assessments (including maps) are presented within site specific appendices to this document.

4.3 Phase 2

rearing model used for habitat estimates (total length of stream segments <7.5% gradient)

| PSCIS ID | Stream                       | Road            | UTM (11U)         | Fish Species                             | Habitat Gain (km) | Habitat Value | Priority | Comments  |
|----------|------------------------------|-----------------|-------------------|--|-------------------|---------------|----------|---|
| 57944    | Toboggan Creek               | Highway 16      | 607729<br>6089383 | CC,CH,CO,CT,DV,KO,L,LS,SW,TR,PK,RB,SK,ST | 5.2               | High          | High     | Water quite turbid due to rain event. Armoured banks due to adjacent properties. Not very complex in area surveyed from highway up. Hatchery located upstream. Extremely high value spawning and rearing habitat upstream of Owen Creek bridge with spawning salmon noted throughout.   |
| 58151    | McDowell Creek               | Woodmere Road   | 629753<br>6061126 | RB                                       | 4.3               | Medium        | low      | Channel dry. Close to house so very short dry survey. Lots of fines and sediment likely from cleared yard, roads, and agriculture use. Channel well defined.  |
| 123375   | Tributary to Thompson Creek  | Highway 16      | 642497<br>6048191 | CT,DV,RB                                 | 10.6              | Low           | low      | Heavily impacted by cattle. Fine substrates, low flow, very small stream. Main flow comes from stream to north that is mapped as a tributary.   |
| 123377   | Thompson Creek               | Walcott Road    | 641633<br>6049398 | CT,DV,RB                                 | 12.3              | High          | high     | High value habitat, frequent deep pools to 80cm and abundant large woody debris and gravels. Narrow but meaningful mature cottonwood riparian. Majority of flow comes from open bottom structure under highway (PSCIS 123376) vs channel mapped as mainstem.  |
| 123544   | McDowell Creek               | Private Road    | 628287<br>6060648 | RB                                       | 6.1               | Medium        | low      | Dry at time of survey. Culvert inlet is perched approx. 5m above channel. Road appears to be historic pipeline or powerline. Creates impassably steep gradients immediately downstream of crossing due to fill placement.   |
| 123770   | John Brown                   | Highway 16      | 606627<br>6097185 | BT,CH,CT,DV,RB                           | 11.7              | Medium        | high     | Frequent sections of gravels suitable for spawning salmon. Occasional very deep pools formed by large woody debris. Large eroding bank near mill. Healthy mature mixed riparian vegetation. Six electrofishing sites.   |
| 123775   | Witset Creek                 | Highway 16      | 606445<br>6099726 | -  | -                 | Low           | low      | No flow. Beaver activity present. Stream channel overgrown. Witset Lake outflow disconnected from stream. Witset maintenance actively traps beavers to prevent flood events as of 2017.   |
| 124420   | Station Creek                | Highway 16      | 586632<br>6122395 | BT,CO,CT,DV,PK,RB,SP                     | 9.3               | Medium        | high     | Frequent pockets of gravels suitable for spawning throughout. High value spawning habitat in upper end of survey area. Refer to DFO report for habitat details.   |
| 124421   | Tributary to Waterfall Creek | 11th Ave        | 589467<br>6123042 | CO,DV                                    | 1.3               | Medium        | moderate | Slow moving wetland type stream. Deep glides throughout with instream vegetation, overhanging vegetation, and undercut banks. Near top of survey, gradient increased slightly and substrate goes from fines/organics to small gravel.   |
| 124422   | Tributary to Waterfall Creek | Highway 16      | 589500<br>6123162 | CO,DV                                    | 1.2               | Medium        | low      | Appears to be restoration site with logs embedded in stream and gravels added. Upstream of footbridge stream flows from wetland type habitat. Low priority as 100% backwatered and likely passable for parr and adult salmon.   |
| 197370   | Owen Creek                   | Morice West FSR | 639980<br>6008557 | -  | 1.9               | High          | high     | Aerial survey conducted. Wetland and glide type habitat. Bii Wenii C'eeek historic fishing site located near confluence of this stream and Morice River. Office of Wet'suwet'en contact (Mike Risdale) reports that this stream historically carrier flows from mainstem of Owen Creek which has now been redirected to Morice River at bridge site |

## 4 Results and Discussion

| PSCIS ID   | Stream                   | Road             | UTM (11U)         | Fish Species                   | Habitat Gain (km) | Habitat Value | Priority | Comments   |
|--|--------------------------|------------------|-------------------|--------------------------------|-------------------|---------------|----------|--|
| upstream. Mesohabitat mapping conducted in this area in the fall of 2021 by Jeff Anderson. |                          |                  |                   |                                |                   |               |          |  |
| 197378   | Tributary to Owen Creek  | Klate Lake       | 645085<br>5998822 | DV,LNC,MW,RB                   | 0.6               | Medium        | moderate | Several pockets of gravel suitable for resident rainbow spawning. Good flow with run habitat.  |
| 197379   | Tributary to Owen Creek  | Morice-Owen FSR  | 640961<br>6005930 | CO,RB                          | 0.1               | High          | high     | Abundant undercut banks with some pools. Healthy riparian vegetation providing cover and woody debris to habitat. Good flow.   |
| 197662   | Richfield Creek          | Highway 16       | 672405<br>6044146 | CH,CO,LKC,LNC,LSU,RB,S32.8     | 32.8              | High          | high     | Three closed multipass electrofishing sites upstream and downstream. Habitat confirmation conducted in 2020 with results in 2021 report. Mesohabitat mapping conducted with Office of Wet'suwet'en field crew and Jeff Anderson in 2021.   |
| 197909   | Tributary to Maxan Creek | Maxan Creek FSR  | 687557<br>6020572 | -                              | 0.2               | Medium        | low      | Small stream with beaver pond upstream. Downstream channel confined.   |
| 197912   | Robert Hatch Creek       | Private          | 670963<br>6046221 | LSU,RB                         | 27.7              | -             | moderate | High value habitat. Abundant gravels, deep pools, undercut banks, and small woody debris. Areas of algal growth. Cattle impacts extreme throughout.  |
| 197960   | Corya Creek              | CN Railway       | 605786<br>6099884 | DV,RB                          | 10.0              | High          | high     | High energy glaciated system. Substrate quite embedded. Three electrofishing sites upstream and three sites downstream.  |
| 197962   | Peacock Creek            | Morice FSR       | 643460<br>6025890 | -                              | 4.8               | Medium        | high     | Culvert has been replaced with a bridge. Complex habitat with undercut banks, large and small woody debris and some nice pools. Three closed site multi-pass electrofishing sites upstream and three downstream.   |
| 197967   | Taman Creek              | Highway 16       | 692435<br>6032331 | BMC,CSU,LKC,LNC,LSU,NSC,RLB,SC | 16.50             | Medium        | moderate | First 250m above crossing was beaver influenced area with dry channel. Frequent pockets of gravels and small cobbles suitable for rainbow trout and coho salmon spawning further upstream. Canyon section has deep bedrock pools with small fish present.  |
| 197975   | Ailport Creek            | Private Driveway | 680832<br>6040045 | CO,CT,RB                       | 24.7              | Medium        | high     | Cattle and dredging damage in first sections of survey with dredges in first 80m removing all habitat. Heavy grazing continuous for another few hundred meters. Deep pools, undercut banks, and overhanging vegetation occurs throughout. Fence across stream halfway up. Some areas have large piles of substrate deposited within extent of channel (perhaps from flooding). Two electrofishing sites upstream and two sites downstream. |
| 197976   | Ailport Creek            | Highway 16       | 680645<br>6039756 | CO,CT,RB                       | 25.1              | High          | moderate | Fish sighted throughout. E-  |



4.3 Phase 2

| PSCIS ID   | Stream                     | Road         | UTM (11U)         | Fish Species                                     | Habitat Gain (km) | Habitat Value | Priority | Comments  |
|--|----------------------------|--------------|-------------------|--|-------------------|---------------|----------|---|
| <p>extensive algae growth seen during entire survey. Fences accrosss creek near highway including electric fence. Riparian / bank damage from livestock quite minimal and only seen in a few places as trails, perhaps watering sites. 150mm long fish observed swimming upstream through culvert during survey.</p> |                            |              |                   |  |                   |               |          |   |
| 198000   | McBride Creek              | Nanika FSR   | 605511<br>5992667 | BB,CAS,CO,CSU,CT,DV,LD2,LS,LT,ML,MR,OR,PS,RS,WSU | 2.0               | High          | moderate | Abundant instream vegetation including vascular plants. Large woody debris accumulated at outflow of McBride Lake.  |
| 198008   | Tributary to Nanika River  | Spur         | 606426<br>5986782 | -  | 0.0               | Medium        | moderate | Multiple channels. Surveyed non-dominant channel. Site should be reassessed to confirm habitat upstream of 100m. Bottom 100m before split is low gradient gravels with good flow for time of year.  |
| 198016   | Tributary to Thautil River | Chisholm FSR | 608138<br>6020911 | -  | 0.0               | Medium        | moderate | Sporadic pools and abundant deeply undercut banks. Abundant gravels present suitable for spawning. Very occasional large and small woody debris steps to 70cm. Good flow with mature spruce riparian.   |
| 198048   | Cesford Creek              | Highway 16   | 674397<br>6043433 | -  | 10.7              | High          | moderate | Stream appears to have been dredged for near entire length between highways. Left side of stream is powerline and highway for first 200m. Riparian area is very sparse below due to agricultural land clearing. Fish are concentrated in pool habitat which is sporadic. Frequent pockets of gravel throughout. Good flow. Eroded bank at near highway 118. |
| 198049   | Cesford Creek              | Highway 118  | 674875<br>6043782 | -  | 10.0              | High          | moderate | Good flow and decent complexity due to mature cottonwood riparian / large woody debris. Occossional pools and frequent gravel sections.   |
| 198064   | Tributary to Lamprey Creek | Spur         | 623369<br>6000283 | DV   | 0.0               | Medium        | moderate | Comparitively good flow for the greater Lamprey Creek watershed. Abundant gravel suitable for coho spawning at higher flows. Abundant undercut banks for cover but pools observed as shallow.   |
| 198066   | Thompson Creek             | Private Road | 640244<br>6048061 | CO,CRS,CT,DV,RB,SP                               | 14.7              | High          | high     | Important migration corridor. Fully channelized through agricultural area. Fine sediments, pool and glide habitat up to 80 cm deep. Canary reed grass riparian. Landowner reports stream was redirected in 60s and used to flow from the valley to the Bulkeley in a low lying area in a north west direction.  |
| 198090   | Cesford Creek              | CN Railway   | 673235<br>6043218 | RB   | 11.7              | High          | high     | No connection to Bulkeley   |

## 4 Results and Discussion

| PSCIS ID | Stream | Road | UTM (11U) | Fish Species | Habitat Gain (km) | Habitat Value | Priority | Comments |
|----------|--------|------|-----------|--------------|-------------------|---------------|----------|----------|
|----------|--------|------|-----------|--------------|-------------------|---------------|----------|----------|

River under railway found and landowner reports there is not one present. Large ditch runs north-south and may be impacting water level in oxbow type habitat comprising lower end of stream. Primarily dry to just before Highway 16. Important migration corridor. Coho would likely be present upstream if connected to the Bulkley River.

**Table 4.3: Summary of Phase 2 fish passage reassessments.**

| PSCIS ID | Embedded | Outlet Drop (m) | Diameter (m) | SWR  | Slope (%) | Length (m) | Final score | Barrier Result |
|----------|----------|-----------------|--------------|------|-----------|------------|-------------|----------------|
| 57944    | No       | 0.00            | 7.00         | 1.2  | 3.0       | 30         | 29          | Barrier        |
| 58151    | No       | 0.25            | 1.00         | 1.8  | 5.0       | 14         | 31          | Barrier        |
| 123375   | No       | 0.00            | 0.50         | 2.0  | 2.0       | 29         | 24          | Barrier        |
| 123377   | No       | 0.25            | 1.05         | 4.6  | 3.0       | 29         | 34          | Barrier        |
| 123544   | No       | 0.00            | 1.50         | 1.8  | 18.5      | 14         | 26          | Barrier        |
| 123770   | No       | 0.64            | 4.00         | 3.1  | 2.0       | 36         | 37          | Barrier        |
| 123775   | No       | 0.00            | 1.22         | 0.4  | 0.5       | 32         | 16          | Potential      |
| 124420   | No       | 0.80            | 1.60         | 3.5  | 3.5       | 90         | 42          | Barrier        |
| 124421   | No       | 0.30            | 1.00         | 2.6  | 1.0       | 15         | 34          | Barrier        |
| 124422   | No       | 0.00            | 1.20         | 4.3  | 1.5       | 45         | 27          | Barrier        |
| 197370   | No       | 0.00            | 0.90         | 7.6  | 1.0       | 18         | 24          | Barrier        |
| 197378   | No       | 0.10            | 1.00         | 2.4  | 1.0       | 15         | 24          | Barrier        |
| 197379   | No       | 0.47            | 1.50         | 4.3  | 1.5       | 26         | 34          | Barrier        |
| 197662   | No       | 0.20            | 4.20         | 3.0  | 2.0       | 24         | 29          | Barrier        |
| 197909   | No       | 0.00            | 0.60         | 1.5  | 3.0       | 16         | 29          | Barrier        |
| 197912   | –        | –               | 12.00        | 0.0  | –         | 7          | 0           | Passable       |
| 197960   | No       | 0.65            | 3.40         | 5.3  | 2.5       | 24         | 34          | Barrier        |
| 197962   | No       | 0.50            | 3.60         | 2.6  | 3.5       | 15         | 39          | Barrier        |
| 197967   | No       | 0.00            | 3.00         | 1.8  | 2.5       | 30         | 27          | Barrier        |
| 197975   | No       | 0.30            | 3.00         | 2.2  | 4.0       | 10         | 36          | Barrier        |
| 197976   | No       | –               | 3.50         | 2.1  | 2.0       | 23         | 24          | Barrier        |
| 198000   | No       | 0.05            | 3.90         | 2.3  | 0.5       | 16         | 19          | Potential      |
| 198008   | No       | 0.18            | 0.90         | 2.0  | 6.0       | 11         | 31          | Barrier        |
| 198016   | No       | 0.19            | 1.20         | 1.1  | 5.0       | 25         | 31          | Barrier        |
| 198048   | No       | 0.00            | 2.50         | 2.2  | 1.5       | 25         | 24          | Barrier        |
| 198049   | No       | 0.50            | 3.70         | 1.3  | 1.5       | 21         | 34          | Barrier        |
| 198064   | No       | 0.54            | 1.60         | 1.6  | 5.0       | 14         | 36          | Barrier        |
| 198066   | No       | 0.00            | 1.30         | 2.1  | 0.4       | 6          | 16          | Potential      |
| 198090   | No       | 0.00            | 0.10         | 50.0 | 3.0       | 15         | 29          | Barrier        |

4.3 Phase 2

Table 4.4: Cost benefit analysis for Phase 2 assessments. Coho rearing model used (total length of stream segments <7.5% gradient)

| PSCIS ID | Stream                       | Road             | Result    | Habitat value | Stream Width (m) | Fix    | Cost Est (in \$K) | Habitat Upstream (m) | Cost Benefit (m / \$K) | Cost Benefit (m2 / \$K) |
|----------|------------------------------|------------------|-----------|---------------|------------------|--------|-------------------|----------------------|------------------------|-------------------------|
| 57944    | Toboggan Creek               | Highway 16       | Barrier   | High          | 8.5              | OBS    | 8100              | 52355                | 6.5                    | 54.9                    |
| 58151    | McDowell Creek               | Woodmere Road    | Barrier   | Medium        | 1.7              | SS-CBS | 160               | 4300                 | 26.9                   | 45.7                    |
| 123377   | Thompson Creek               | Walcott Road     | Barrier   | High          | 4.8              | OBS    | 1600              | 12315                | 7.7                    | 36.9                    |
| 123544   | McDowell Creek               | Private Road     | Barrier   | Medium        | 2.7              | OBS    | 200               | 6070                 | 30.4                   | 81.9                    |
| 123770   | John Brown                   | Highway 16       | Barrier   | Medium        | 12.2             | OBS    | 11400             | 11710                | 1.0                    | 12.5                    |
| 123775   | Witset Creek                 | Highway 16       | Potential | Low           | 2.4              | SS-CBS | 1200              | –                    | –                      | –                       |
| 124420   | Mission Creek                | Highway 16       | Barrier   | Medium        | 5.7              | OBS    | 18000             | 9255                 | 0.5                    | 2.9                     |
| 124421   | Tributary to Waterfall Creek | 11th Ave         | Barrier   | Medium        | 2.6              | OBS    | 800               | 1340                 | 1.7                    | 4.4                     |
| 124422   | Tributary to Waterfall Creek | Highway 16       | Barrier   | Medium        | 6.7              | OBS    | 11400             | 1210                 | 0.1                    | 0.7                     |
| 197370   | Owen Creek                   | Morice West FSR  | Barrier   | High          | –                | OBS    | 240               | 1870                 | 7.8                    | –                       |
| 197378   | Tributary to Owen Creek      | Klate Lake       | Barrier   | Medium        | 1.8              | OBS    | 200               | 560                  | 2.8                    | 5.0                     |
| 197379   | Tributary to Owen Creek      | Morice-Owen FSR  | Barrier   | High          | 6.4              | OBS    | 320               | 120                  | 0.4                    | 2.4                     |
| 197662   | Richfield Creek              | Highway 16       | Barrier   | High          | 13.2             | OBS    | 9900              | 32780                | 3.3                    | 43.7                    |
| 197909   | Tributary to Maxan Creek     | Maxan Creek FSR  | Barrier   | Medium        | 1.3              | SS-CBS | 40                | 225                  | 5.6                    | 7.3                     |
| 197912   | Robert Hatch Creek           | Private          | Passable  | –             | 4.3              | –      | 30                | 27720                | 924.0                  | 3973.2                  |
| 197960   | Corya Creek                  | Railway          | Barrier   | High          | 18.0             | OBS    | 13800             | 9960                 | 0.7                    | 13.0                    |
| 197962   | Peacock Creek                | Morice FSR       | Barrier   | Medium        | 6.9              | OBS    | 320               | 4810                 | 15.0                   | 103.7                   |
| 197967   | Taman Creek                  | Highway 16       | Barrier   | Medium        | 5.3              | OBS    | 18600             | 51905                | 2.8                    | 14.8                    |
| 197975   | Ailport Creek                | Private Driveway | Barrier   | Medium        | 7.7              | OBS    | 230               | 24690                | 107.3                  | 826.6                   |
| 197976   | Ailport Creek                | Highway 16       | Barrier   | High          | 8.1              | OBS    | 7500              | 25090                | 3.3                    | 27.1                    |
| 198000   | McBride Creek                | Nanika FSR       | Potential | High          | 5.5              | OBS    | 280               | 20095                | 71.8                   | 394.7                   |
| 198008   | Tributary to Nanika River    | Spur             | Barrier   | Medium        | 2.0              | SS-CBS | 40                | 0                    | 0.0                    | 0.0                     |
| 198016   | Tributary to Thautil River   | Chisholm FSR     | Barrier   | Medium        | 1.9              | SS-CBS | 40                | 0                    | 0.0                    | 0.0                     |
| 198048   | Cesford Creek                | Highway 16       | Barrier   | High          | 5.1              | OBS    | 6000              | 10700                | 1.8                    | 9.1                     |
| 198049   | Cesford Creek                | Highway 118      | Barrier   | High          | 5.0              | OBS    | 6000              | 10030                | 1.7                    | 8.4                     |
| 198064   | Tributary to Lamprey Creek   | Spur             | Barrier   | Medium        | 2.8              | OBS    | 200               | 0                    | 0.0                    | 0.0                     |
| 198066   | Thompson Creek               | Private Road     | Potential | High          | 2.8              | OBS    | 200               | 14705                | 73.5                   | 205.9                   |
| 198090   | Cesford Creek                | Railway          | Barrier   | High          | 5.5              | OBS    | 200               | 11700                | 58.5                   | 321.8                   |

#### 4 Results and Discussion

Table 4.5: Summary of Phase 2 habitat confirmation details.

| PSCIS ID | Length surveyed upstream (m) | Channel Width (m) | Wetted Width (m) | Pool Depth (m) | Gradient (%) | Total Cover | Habitat Value |
|----------|------------------------------|-------------------|------------------|----------------|--------------|-------------|---------------|
| 57944    | 880                          | 8.5               | 6.7              | 0.5            | 2.1          | moderate    | high          |
| 57944    | 150                          | 12.6              | 10.5             | 2.0            | 0.5          | abundant    | high          |
| 58151    | 70                           | 1.7               | –                | –              | 0.8          | abundant    | low           |
| 123375   | 100                          | 1.7               | 1.9              | –              | 0.7          | –           | low           |
| 123377   | 450                          | 4.8               | 3.4              | 0.7            | 2.7          | abundant    | high          |
| 123544   | 25                           | 2.7               | –                | –              | –            | –           | low           |
| 123770   | 1000                         | 12.2              | 8.3              | 0.8            | 2.9          | moderate    | high          |
| 123770   | 350                          | 11.2              | 9.1              | 0.3            | 3.0          | moderate    | high          |
| 123775   | 200                          | 2.4               | 0.9              | –              | 1.2          | moderate    | low           |
| 124420   | 370                          | 5.7               | 4.7              | 0.5            | 2.0          | abundant    | high          |
| 124420   | 430                          | 6.2               | 5.5              | –              | 0.5          | abundant    | high          |
| 124421   | 120                          | 2.6               | 2.5              | 0.3            | 1.0          | abundant    | moderate      |
| 124422   | 350                          | 6.7               | 6.6              | –              | 1.0          | abundant    | moderate      |
| 197370   | 1500                         | –                 | –                | –              | –            | –           | high          |
| 197378   | –                            | 1.8               | 1.5              | –              | 3.0          | abundant    | medium        |
| 197379   | 800                          | 6.4               | 3.1              | 0.7            | 4.8          | moderate    | high          |
| 197662   | 100                          | 13.2              | –                | –              | 2.1          | –           | high          |
| 197909   | 100                          | 1.3               | 1.3              | –              | 1.5          | moderate    | moderate      |
| 197912   | 340                          | 4.3               | 2.5              | 0.6            | 1.5          | abundant    | high          |
| 197960   | 1000                         | 18.0              | 8.9              | 0.7            | 2.8          | moderate    | medium        |
| 197962   | 750                          | 6.9               | 3.6              | 0.4            | 2.8          | moderate    | high          |
| 197967   | 800                          | 5.3               | 2.3              | 0.7            | 1.7          | moderate    | medium        |
| 197967   | 400                          | 3.8               | 2.2              | 0.5            | 1.5          | moderate    | medium        |
| 197975   | 550                          | 7.7               | 3.5              | 0.3            | 3.0          | moderate    | medium        |
| 197976   | 345                          | 8.1               | 4.2              | 0.3            | 2.2          | moderate    | medium        |
| 198000   | 135                          | 5.5               | 4.4              | –              | 1.0          | moderate    | high          |
| 198008   | –                            | 2.0               | 0.9              | 0.2            | 7.5          | –           | medium        |
| 198016   | 625                          | 1.9               | 1.5              | 0.3            | 7.0          | moderate    | medium        |
| 198042   | –                            | 11.5              | 11.0             | –              | 0.2          | moderate    | –             |
| 198048   | 675                          | 5.1               | 3.3              | 0.3            | 2.8          | moderate    | medium        |
| 198049   | 600                          | 5.0               | 2.8              | 0.5            | 2.1          | moderate    | medium        |
| 198049   | 500                          | 4.3               | 1.9              | 0.5            | 4.2          | moderate    | medium        |
| 198064   | 500                          | 2.8               | 1.9              | –              | 4.2          | moderate    | medium        |
| 198066   | 350                          | 2.8               | 2.1              | –              | 0.5          | –           | medium        |
| 198090   | –                            | 5.5               | 1.5              | –              | –            | –           | moderate      |

**Table 4.6: Summary of watershed area statistics upstream of Phase 2 crossings.**

| Site   | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|--------|---------|-----------|----------|----------|-------------|----------|--------|
| 57944  | 119.9   | 413       | 412      | 2586     | 629         | 547      | SE     |
| 58151  | 15.9    | 610       | 576      | 1038     | 850         | 810      | SSW    |
| 123377 | 43.1    | 613       | 596      | 1623     | 832         | 802      | WSW    |
| 123544 | 15.9    | 553       | 576      | 1038     | 850         | 810      | SSW    |
| 123770 | 80.6    | 385       | 375      | 2050     | 1201        | 1087     | SE     |
| 123775 | 4.1     | 406       | 478      | 1248     | 762         | 697      | E      |
| 124420 | 28.6    | 301       | 211      | 2171     | 521         | 425      | NNE    |
| 124422 | 3.3     | 320       | 224      | 430      | 331         | 326      | SSW    |
| 197370 | 3.9     | 650       | 644      | 953      | 739         | 717      | WSW    |
| 197378 | 7.9     | 758       | 743      | 2073     | 920         | 885      | ENE    |
| 197379 | 32.9    | 676       | 688      | 1418     | 931         | 909      | SSW    |
| 197662 | 161.3   | 676       | 650      | 1753     | 1096        | 1039     | SSW    |
| 197909 | 2.1     | 835       | 788      | 956      | 851         | 847      | E      |
| 197912 | 31.5    | 720       | 715      | 1070     | 1004        | 983      | S      |
| 197960 | 65.7    | 415       | 410      | 2502     | 1260        | 1106     | ESE    |
| 197962 | 36.3    | 631       | 654      | 1822     | 1166        | 1119     | E      |
| 197967 | 93.8    | 736       | 699      | 1373     | 900         | 870      | S      |
| 197975 | 66.9    | 735       | 736      | 1445     | 1186        | 1093     | SSW    |
| 197976 | 66.9    | 729       | 736      | 1445     | 1186        | 1093     | SSW    |
| 198000 | 83.5    | 799       | -1270    | 1597     | 908         | 887      | SSW    |
| 198008 | 1.6     | 912       | -1114    | 1605     | 1221        | 1150     | NW     |
| 198016 | 0.1     | 917       | 889      | 1019     | 953         | 944      | W      |
| 198048 | 36.6    | 679       | 659      | 1543     | 935         | 914      | SSW    |
| 198049 | 34.0    | 698       | 675      | 1543     | 951         | 929      | SSW    |
| 198064 | 4.8     | 740       | 763      | 1221     | 1061        | 967      | WSW    |
| 198066 | 43.1    | 548       | 596      | 1623     | 832         | 802      | WSW    |

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

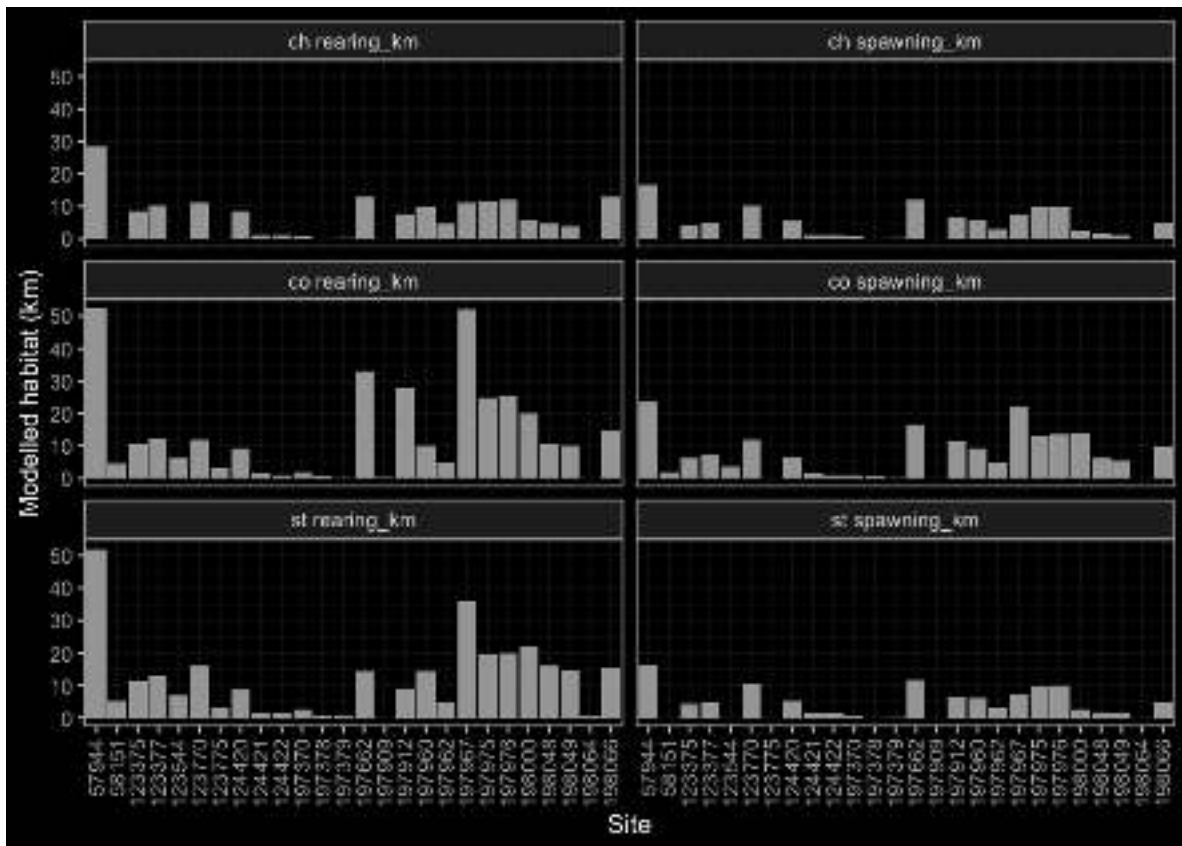


Figure 4.2: Summary of potential habitat upstream of habitat confirmation assessment sites estimated based on modelled channel width and upstream channel length.

### 4.3.1 Fish Sampling

Fish sampling was conducted at 31 sites with a total of 663 fish captured. Of these, 400 were rainbow trout, 147 coho, 69 were dolly varden and 19 were lamprey. Fork length data was used to delineate salmonids based on life stages: fry (0 to 65mm), parr (>65 to 110mm), juvenile (>110mm to 140mm) and adult (>140mm) by visually assessing the histograms presented in Figure 4.3. A summary of sites assessed are included in Table 4.7 and raw data is provided in Attachment 3. A summary of density results for all life stages combined of select species is also presented in Figure 4.4. Results are presented in greater detail within individual habitat confirmation site appendices.

4.3 Phase 2

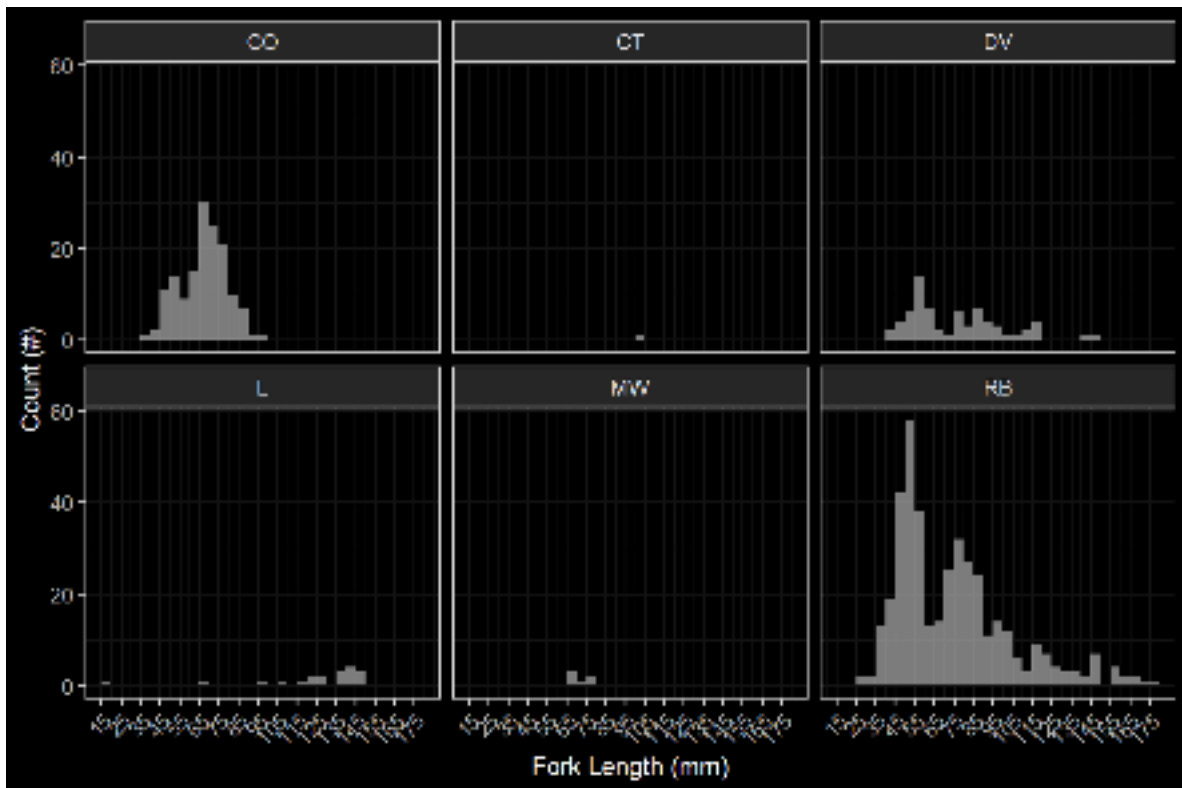


Figure 4.3: Histograms of fish lengths by species. Fish captured by electrofishing during habitat confirmation assessments.

#### 4 Results and Discussion

**Table 4.7: Summary of electrofishing sites.**

| site          | passes | ef_length_m | ef_width_m | area_m2 | enclosure |
|---------------|--------|-------------|------------|---------|-----------|
| 123770_us_ef1 | 1      | 15.7        | 1.65       | 25.9    | Open      |
| 123770_us_ef2 | 1      | 3.3         | 3.23       | 10.7    | Open      |
| 123770_us_ef3 | 1      | 1.8         | 2.83       | 5.1     | Open      |
| 123770_us_ef4 | 1      | 6.4         | 3.57       | 22.8    | Open      |
| 123770_us_ef5 | 1      | 4.8         | 3.03       | 14.5    | Open      |
| 123770_us_ef6 | 1      | 2.9         | 2.00       | 5.8     | Open      |
| 197662_ds_ef1 | 6      | 21.4        | 6.10       | 130.5   | Closed    |
| 197662_ds_ef2 | 4      | 5.8         | 5.60       | 32.5    | Closed    |
| 197662_ds_ef3 | 3      | 4.2         | 6.05       | 25.4    | Closed    |
| 197662_us_ef1 | 4      | 6.4         | 7.00       | 44.8    | Closed    |
| 197662_us_ef2 | 3      | 5.1         | 4.83       | 24.6    | Closed    |
| 197662_us_ef3 | 3      | 5.6         | 2.73       | 15.3    | Closed    |
| 197912_ds_ef1 | 3      | 8.6         | 4.80       | 41.3    | Closed    |
| 197912_ds_ef2 | 1      | 28.0        | 1.96       | 54.9    | Open      |
| 197912_ds_ef3 | 1      | 14.0        | 2.87       | 40.2    | Open      |
| 197960_ds_ef1 | 1      | 9.6         | 1.28       | 12.3    | Open      |
| 197960_ds_ef2 | 1      | 5.0         | 1.83       | 9.2     | Open      |
| 197960_ds_ef3 | 1      | 10.1        | 1.67       | 16.9    | Open      |
| 197960_us_ef1 | 1      | 4.7         | 1.65       | 7.8     | Open      |
| 197960_us_ef2 | 1      | 19.0        | 1.86       | 35.3    | Open      |
| 197960_us_ef3 | 1      | 3.3         | 3.27       | 10.8    | Open      |
| 197962_ds_ef1 | 3      | 14.2        | 4.83       | 68.6    | Closed    |
| 197962_ds_ef2 | 3      | 6.8         | 4.63       | 31.5    | Closed    |
| 197962_ds_ef3 | 3      | 7.1         | 2.90       | 20.6    | Closed    |
| 197962_us_ef1 | 3      | 7.2         | 3.87       | 27.9    | Closed    |
| 197962_us_ef2 | 3      | 5.7         | 4.97       | 28.3    | Closed    |
| 197962_us_ef3 | 3      | 7.0         | 5.27       | 36.9    | Closed    |
| 197975_ds_ef1 | 1      | 3.8         | 4.27       | 16.2    | Open      |
| 197975 ds_ef2 | 1      | 3.9         | 3.60       | 14.0    | Open      |



#### 4.4 Phase 3

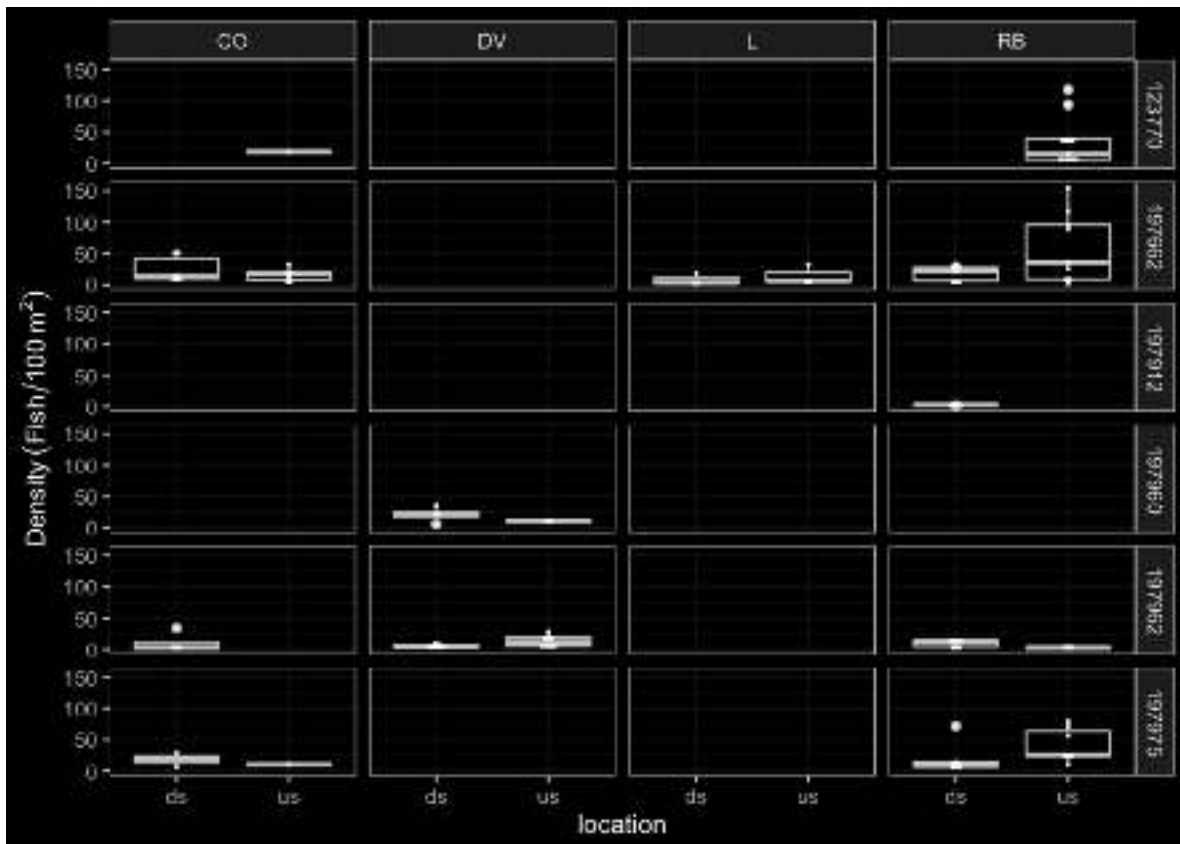


Figure 4.4: Boxplots of densities (fish/100m<sup>2</sup>) of fish captured by electrofishing during habitat confirmation assessments.

#### 4.4 Phase 3

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

#### 4.5 Phase 4

Ministry of Forest engineers collaborated with Canfor and Coastal Gaslink to replace crossing 197962 on Peacock Creek located on the Morice FSR within the Morice River watershed group. As detailed in the associated attachment within this report, baseline effectiveness monitoring including

#### 4 Results and Discussion

multipass electrofishing at three closed sites both upstream and downstream of the FSR in the fall of 2021 before the bridge install occurred.

## 5 Recommendations

Recommendations for potential incorporation into collaborative watershed connectivity planning include:

- Continue to acquire background information and leverage ongoing research initiatives in the region to collaboratively clarify current conditions and identify limiting factors to inform prioritization and effectiveness monitoring programs.
- Develop strategies to explore cost and fisheries production benefits of stream crossing structure upgrades alongside alternative/additional restoration and enhancement investments such as land conservation/procurement/covenant, cattle exclusion, riparian restoration, habitat complexing, water conservation, commercial/recreational fishing management, water treatment and research. Identify and pursue opportunities to collaborate and leverage initiatives together in study area watersheds (ex. fish passage rehabilitation, riparian restoration and cattle exclusion) for maximum likely restoration benefits.
- Refine barrier thresholds for road-stream crossing structures to explore metrics specific to life stage and life history types of species of interest. This will further focus efforts of potential remediation actions based on biological attributes (ex. timing of migration, size/direction of fish migrating, population dynamics, etc.) and could result in the consideration of interim “stop-gap” physical works to alter crossing characteristics that can address key connectivity issues yet be significantly less costly than structure replacements (ex. building up of downstream area with rock riffles to decrease the outlet drop size and/or increasing water depth within pipe with baffles and substrate additions).
- Model fish densities (fish/m<sup>2</sup>) vs. habitat/water quality characteristics (i.e. gradient, discharge, alkalinity, elevation, riparian health, distance from high order streams, etc.) using historically gathered electrofishing and remotely sensed geodata to inform crossing prioritization, future data acquisition needs and the monitoring of restoration actions.
- Continue to develop `bcfishpass`, `bcfishobs`, `fwapg`, `bcdata` and `fpr` as well as to share open source data analysis and presentation tools that are scaleable and facilitate continual improvement. Tools should continue to be flexible and well documented to allow the future incorporation of alternative fragmentation indicators, habitat gain/value metrics and watershed sensitivity indicators.
- Continue to collaborate with potential partners to build relationships, explore perspectives and develop “road maps” for aquatic restoration in different situations (MoT roads, rail lines, permit roads of different usages, FSRs, etc.) – documenting the people involved, discussions and processes that are undertaken, funding options, synergies, measures of success, etc.



## Toboggan Creek - 57944 - Appendix

### Site Location

PSCIS crossing 57944 is located on Toboggan Creek within the Coryatsaqua 2 (Moricetown) Indian Reserve at Moricetown, BC. PSCIS crossing 57944 is located on Highway 16. Crossing 57944 was located 0.2km upstream from the confluence with the Bulkley River. Crossing 57944 is the responsibility of the Ministry of Transportation and Infrastructure.

### Background

At crossing 57944, Toboggan Creek is a fifth order stream with a watershed area upstream of the crossing of approximately 119.9km<sup>2</sup>. The elevation of the watershed ranges from a maximum of 2586m to 412m near the crossing (Table 5.1). Upstream of crossing 57944, longnose sucker, cutthroat trout, pink salmon, coho salmon, rainbow trout, steelhead, kokanee, sockeye salmon, chinook salmon, mountain whitefish, dolly varden, sculpin (general), and lamprey (general) have previously been recorded (MoE 2020b; Norris 2020). There is a wealth of information available for Toboggan Creek with numerous references available through the [Skeena Salmon Data Centre](#).

Table 5.1: Summary of derived upstream watershed statistics for PSCIS crossing 57944.

| Site  | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|-------|---------|-----------|----------|----------|-------------|----------|--------|
| 57944 | 119.9   | 413       | 412      | 2586     | 629         | 547      | SE     |

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

The Toboggan Creek Hatchery facility is located on the stream approximately 8.7km upstream of Highway 16. The hatchery has been operated by the Toboggan Creek Salmon & Steelhead Enhancement Society since 1985. The hatchery serves to enhance coho and chinook stocks in the watershed as well as help assess coho stock with coded wire tag hatchery releases (Smithers District Chamber of Commerce 2022; Wilson and Rabnett 2007). Office of Wet'suwet'en (2016) report that Toboggan hatchery fish have been used to enhance the Bulkley mainstem, Maxan Creek and Buck Creek with chinook fry and smolt.

Office of Wet'suwet'en (2016) note that Wet'suwet'en Knowledge documents Toboggan Lake as a sockeye nursery lake. Additionally, as cited in Office of Wet'suwet'en (2016), K. Rabnett, Holland, and Gottesfeld (2017) report a historic fishery at the outlet of Toboggan Lake where an extirpated stock of sockeye stock existed.

Toboggan Lake is 25ha in size and modelling indicates an additional 256ha of wetland upstream of the highway. Significantly sized lakes within watersheds can throttle high freshet and storm flows often resulting in increased stability downstream and conditions conducive to egg incubation and juvenile rearing.

Works to remediate fish passage issues at PSCIS stream crossing 57944 were conducted in 2015 with backwatering completed through installation of boulders downstream of the crossing (McCarthy and Fernando 2015). Comparison of historic PSCIS photos and data between 2021 and 2012 indicate that the historical recorded outlet drop of 90cm has been reduced to 0cm as a result of the works. Sandra Devcic, DFO Restoration Engineer (pers. comm.) has noted that developing a design to replace the crossing with an open bottom structure presents challenges due to the stream crossing location at the bottom of a hill and on a corner of the highway.

In 2021 at the time of the assessment, pink salmon spawners were noted as present at the enumeration fences near the hatchery indicating that the highway structure was passable to these relatively weak swimmers in 2021.

PSCIS stream crossing 57944 was ranked as a high priority for follow up by Wilson and Rabnett (2007), Irvine (2018), Irvine (2021) and Mazany-Wright et al. (2021) because of significant amounts of habitat modelled as upstream of the crossing. A summary of habitat modelling outputs is presented in Table 5.2. A map of the watershed is provided in map attachment [093L.122](#).

Table 5.2: Summary of fish habitat modelling for PSCIS crossing 57944.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 96.3      | 33.0             | 34                   |
| ST Lake Reservoir (ha)           | 16.9      | 15.7             | 93                   |
| ST Wetland (ha)                  | 256.1     | 93.5             | 37                   |
| ST Slopeclass03 Waterbodies (km) | 13.6      | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 38.5      | 18.1             | 47                   |
| ST Slopeclass05 (km)             | 18.1      | 2.8              | 15                   |
| ST Slopeclass08 (km)             | 11.3      | 1.1              | 10                   |
| ST Spawning (km)                 | 16.6      | 13.8             | 83                   |
| ST Rearing (km)                  | 51.7      | 19.7             | 38                   |
| CH Spawning (km)                 | 16.6      | 13.8             | 83                   |
| CH Rearing (km)                  | 28.2      | 15.9             | 56                   |
| CO Spawning (km)                 | 23.5      | 16.2             | 69                   |
| CO Rearing (km)                  | 52.4      | 25.6             | 49                   |
| CO Rearing (ha)                  | 122.8     | 0.0              | 0                    |
| SK Spawning (km)                 | 0.0       | 0.0              | –                    |
| SK Rearing (km)                  | 0.0       | 0.0              | –                    |

## Stream Characteristics at Crossing

| Habitat                   | Potential | Remediation Gain | Remediation Gain (%) |
|---------------------------|-----------|------------------|----------------------|
| SK Rearing (ha)           | –         | 0.0              | –                    |
| All Spawning (km)         | 23.5      | 16.2             | 69                   |
| All Rearing (km)          | 63.5      | 26.6             | 42                   |
| All Spawning Rearing (km) | 63.5      | 26.6             | 42                   |

\* Model data is preliminary and subject to adjustments.

## Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 57944 was un-embedded, non-backwatered and ranked as a barrier barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table [5.3](#)). Water temperature was 8°C, pH was 8.2 and conductivity was 74uS/cm.

Table 5.3: Summary of fish passage assessment for PSCIS crossing 57944.

| Location and Stream Data  |  | Crossing Characteristics |              |
|---|--|--------------------------|--------------|
| Date  | 2021-09-15                             | Crossing Sub Type        | Oval Culvert |
| PSCIS ID  | 57944                                  | Diameter (m)             | 7            |
| External ID   | –                                      | Length (m)               | 30           |
| Crew  | AI                                     | Embedded                 | No           |
| UTM Zone  | 9                                      | Depth Embedded (m)       | –            |
| Easting   | 607729                                 | Resemble Channel         | No           |
| Northing  | 6089383                                | Backwatered              | No           |
| Stream  | Toboggan Creek                         | Percent Backwatered      | –            |
| Road  | Highway 16                             | Fill Depth (m)           | 2            |
| Road Tenure   | Highway                                | Outlet Drop (m)          | 0            |
| Channel Width (m)   | 8.5                                    | Outlet Pool Depth (m)    | 2            |
| Stream Slope (%)  | 2.1                                    | Inlet Drop               | No           |
| Beaver Activity   | No                                     | Slope (%)                | 3            |
| Habitat Value   | High                                   | Valley Fill              | Deep Fill    |
| Final score   | 29                                     | Barrier Result           | Barrier      |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 13.5         |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |              |



## Stream Characteristics Downstream



### Stream Characteristics Downstream

The stream was surveyed downstream from crossing 57944 for 140m to the confluence with the Bulkley River (Figure 5.1). Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, boulders, and

overhanging vegetation. The average channel width was 13.9m, the average wetted width was 6.7m and the average gradient was 5.5%. The dominant substrate was cobbles with boulders subdominant. Although rated as an important migration corridor, the habitat was rated as medium value for salmonid rearing and spawning.

### **Stream Characteristics Upstream**

The stream was surveyed upstream from crossing 57944 for 880m (Figure 5.2). Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as small woody debris and boulders. 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 8.5m, the average wetted width was 6.7m and the average gradient was 2.1%. The dominant substrate was cobbles with gravels subdominant. The first 50 - 100m upstream of crossing channel and banks were noted as armoured with riprap. Abundant gravels suitable for resident and anadromous salmonids were noted throughout. The habitat was rated as high value as an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

The stream was also surveyed at a second location upstream of the hatchery adjacent to the Owen Road bridge for 150m (Figure 5.3). Total cover amount was rated as abundant with deep pools dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation. The average channel width was 12.6m, the average wetted width was 10.5m and the average gradient was 0.5%. The dominant substrate was gravels with fines subdominant. The habitat was rated as high value for salmon rearing and spawning.

### **Structure Remediation and Cost Estimate**

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 57944 with a bridge (13.5m span) is recommended. The cost of the work is estimated at \$8,100,000 for a cost benefit of 6.5 linear m/\$1000 and 54.9 m<sup>2</sup>/\$1000.

### **Conclusion**

There was 52.4km of habitat modelled upstream of crossing 57944 with areas surveyed rated as high value for salmonid rearing and spawning. Crossing 57944 was ranked as a high priority for proceeding to design for replacement. Toboggan Creek represents an extremely important system for the Bulkley River system in terms of fisheries values, its function for outreach within the community as well as its contribution to stock enhancement and assessment. Development of a plan to replace the crossing with a bridge may be considered as a prudent step to mitigating risks of a blow out of the backwatering works currently in place downstream and a return to conditions similar to those observed historically when a significant outlet drop was present (Figure 5.4).



## Conclusion

Table 5.4: Summary of habitat details for PSCIS crossing 57944.

| Site  | Location   | Length Surveyed (m) | Channel Width (m) | Wetted Width (m) | Pool Depth (m) | Gradient (%) | Total Cover | Habitat Value |
|-------|------------|---------------------|-------------------|------------------|----------------|--------------|-------------|---------------|
| 57944 | Downstream | 140                 | 13.9              | 10.1             | 0.3            | 5.5          | moderate    | medium        |
| 57944 | Upstream   | 880                 | 8.5               | 6.7              | 0.5            | 2.1          | moderate    | high          |
| 57944 | Upstream2  | 150                 | 12.6              | 10.5             | 2.0            | 0.5          | abundant    | high          |



Figure 5.1: Left: Typical habitat downstream of PSCIS crossing 57944. Right: Typical habitat downstream of PSCIS crossing 57944.



Figure 5.2: Left: Typical habitat upstream of PSCIS crossing 57944. Right: Typical habitat upstream of PSCIS crossing 57944.



Figure 5.3: Left: Typical habitat upstream of PSCIS crossing 57944. Right: Typical habitat upstream of PSCIS crossing 57944.



Figure 5.4: Left: Outlet of PSCIS crossing 57944 in 2012. Photo from PSCIS. Right: Inlet of PSCIS crossing 57944 in 2012. Photo from PSCIS.

## McDowell Creek - 123544 & 58151 - Appendix

### Site Location

PSCIS crossing 123544 and 58151 are located on McDowell Creek approximately 3.5km south-east of Telkwa, BC. PSCIS crossing 123544 is located on a private road and 58151 is located on Woodmere Road. Crossing 123544 was located 0.9km upstream from the confluence with the Bulkley River and crossing 58151 was located a further 1773m upstream. Crossing 123544 is located on private land so likely the responsibility of the landowner. Crossing 58151 is the responsibility of the Ministry of Transportation and Infrastructure.

### Background

McDowell Creek drains McDowell Lake (35ha), Dorsay Lake (4ha) and one other unnamed lake (9ha) flowing from McDowell Lake in a south then west direction for approximately 9km to the confluence with the Bulkley River adjacent to the Woodmere Nursery. At crossing 123544, McDowell Creek is a third order stream with a watershed area upstream of the crossing of approximately 15.9km<sup>2</sup>. The elevation of the watershed ranges from a maximum of 1038m to 576m near the crossing (Table [5.5](#)).

Upstream of crossing 123544, rainbow trout have previously been recorded (MoE 2020b; Norris 2020). An adjacent landowner reports that historic high flow events in the watershed were likely related to beaver dam failures in the upper reaches of the stream network.

A habitat confirmation assessment downstream of 123544 PSCIS stream crossing 58159 (Woodmere Nursery private road) was assessed with by Irvine (2021) in 2020 and the reader is directed there for detailed background, habitat assessment and fish sampling information from 2020 surveys. 58151 was ranked as a moderate priority for follow up by Irvine (2018) due to significant quantities of upstream habitat suitable for salmonid rearing. A total of 54ha of lake and 18ha of wetland is modelled upstream with a summary of additional habitat modelling outputs presented in Table [5.6](#). A map of the watershed is provided in map attachment [093L.118](#).

crossing 123544.

| Site   | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|--------|---------|-----------|----------|----------|-------------|----------|--------|
| 123544 | 15.9    | 553       | 576      | 1038     | 850         | 810      | SSW    |

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

Table 5.6: Summary of fish habitat modelling for PSCIS crossing 123544.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 9.6       | 1.8              | 19                   |
| ST Lake Reservoir (ha)           | 4.4       | 0.0              | 0                    |
| ST Wetland (ha)                  | 0.0       | 0.0              | –                    |
| ST Slopeclass03 Waterbodies (km) | 0.3       | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 3.1       | 0.0              | 0                    |
| ST Slopeclass05 (km)             | 3.0       | 1.8              | 60                   |
| ST Slopeclass08 (km)             | 1.7       | 0.0              | 0                    |
| ST Spawning (km)                 | 0.0       | 0.0              | –                    |
| ST Rearing (km)                  | 7.0       | 1.8              | 26                   |
| CH Spawning (km)                 | 0.0       | 0.0              | –                    |
| CH Rearing (km)                  | 0.0       | 0.0              | –                    |
| CO Spawning (km)                 | 3.5       | 1.8              | 51                   |
| CO Rearing (km)                  | 6.1       | 1.8              | 30                   |
| CO Rearing (ha)                  | –         | 0.0              | –                    |
| SK Spawning (km)                 | 0.0       | 0.0              | –                    |
| SK Rearing (km)                  | 0.0       | 0.0              | –                    |
| SK Rearing (ha)                  | –         | 0.0              | –                    |
| All Spawning (km)                | 3.5       | 1.8              | 51                   |
| All Rearing (km)                 | 7.4       | 1.8              | 24                   |
| All Spawning Rearing (km)        | 7.4       | 1.8              | 24                   |

\* Model data is preliminary and subject to adjustments.

Table 5.7: Summary of fish habitat modelling for PSCIS crossing 58151.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 7.8       | 2.2              | 28                   |
| ST Lake Reservoir (ha)           | 4.4       | 0.0              | 0                    |
| ST Wetland (ha)                  | 0.0       | 0.0              | –                    |
| ST Slopeclass03 Waterbodies (km) | 0.3       | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 3.1       | 2.2              | 71                   |
| ST Slopeclass05 (km)             | 1.2       | 0.0              | 0                    |
| ST Slopeclass08 (km)             | 1.7       | 0.0              | 0                    |
| ST Spawning (km)                 | 0.0       | 0.0              | –                    |
| ST Rearing (km)                  | 5.3       | 2.2              | 42                   |
| CH Spawning (km)                 | 0.0       | 0.0              | –                    |
| CH Rearing (km)                  | 0.0       | 0.0              | –                    |
| CO Spawning (km)                 | 1.8       | 0.6              | 33                   |
| CO Rearing (km)                  | 4.3       | 2.2              | 51                   |
| CO Rearing (ha)                  | –         | 0.0              | –                    |
| SK Spawning (km)                 | 0.0       | 0.0              | –                    |
| SK Rearing (km)                  | 0.0       | 0.0              | –                    |
| SK Rearing (ha)                  | –         | 0.0              | –                    |



| Habitat                   | Potential | Remediation Gain | Remediation Gain (%) |
|---------------------------|-----------|------------------|----------------------|
| All Spawning (km)         | 1.8       | 0.6              | 33                   |
| All Rearing (km)          | 5.6       | 2.2              | 39                   |
| All Spawning Rearing (km) | 5.6       | 2.2              | 39                   |

\* Model data is preliminary and subject to adjustments.

### Stream Characteristics at Crossing

McDowell Creek was dewatered at both culverts at the time of the surveys. Additionally, the stream was dry at Highway 16 and the Woodmere Nursery private road. PSCIS crossing 123544 was not backwatered, un-embedded and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.8). The culvert was perched above the stream at the inlet approximately 2m and road fill had caused a steep slope (>25%) just below the culvert for 5 - 10m.

PSCIS crossing 58151 was not backwatered, not embedded and ranked as a barrier to upstream fish passage according to the provincial protocol (Table 5.9).

Table 5.8: Summary of fish passage assessment for PSCIS crossing 123544.

| Location and Stream Data |  | Crossing Characteristics |               |
|--------------------------|--|--------------------------|---------------|
| Date                     | 2021-09-13                             | Crossing Sub Type        | Round Culvert |
| PSCIS ID                 | 123544                                 | Diameter (m)             | 1.5           |
| External ID              | –                                      | Length (m)               | 14            |
| Crew                     | AI                                     | Embedded                 | No            |
| UTM Zone                 | 9                                      | Depth Embedded (m)       | –             |
| Easting                  | 628286.7                               | Resemble Channel         | No            |
| Northing                 | 6060648                                | Backwatered              | No            |
| Stream                   | McDowell Creek                         | Percent Backwatered      | –             |
| Road                     | Private Road                           | Fill Depth (m)           | 1.5           |
| Road Tenure              | Unclassified                           | Outlet Drop (m)          | 0             |
| Channel Width (m)        | 2.7                                    | Outlet Pool Depth (m)    | 0             |
| Stream Slope (%)         | 1                                      | Inlet Drop               | No            |
| Beaver Activity          | No                                     | Slope (%)                | 18.5          |
| Habitat Value            | Medium                                 | Valley Fill              | Deep Fill     |
| Final score              | 26                                     | Barrier Result           | Barrier       |
| Fix type                 | Replace with New Open Bottom Structure | Fix Span / Diameter      | 10            |

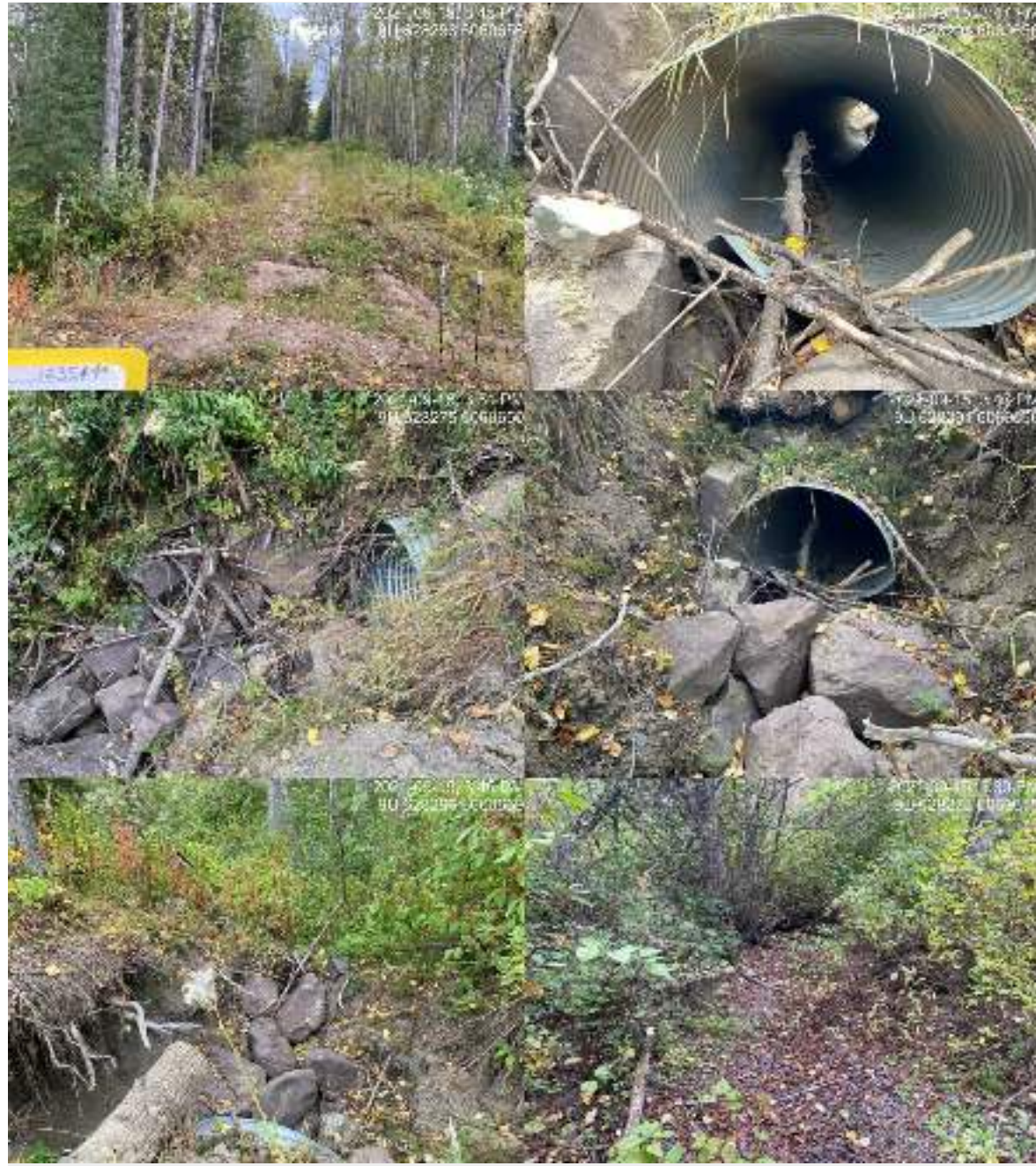
Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet.



# Stream Characteristics at Crossing

| Location and Stream Data | • | Crossing Characteristics | - |
|--------------------------|---|--------------------------|---|
|--------------------------|---|--------------------------|---|

Comments: Inlet of culvert is ~5m elevation more than upstream channel. Road has filled in the creek. 15:44



| Location and Stream Data | .   | Crossing Characteristics | -             |
|--------------------------|---|--------------------------|---------------|
| Date                     | 2021-09-15                                      | Crossing Sub Type        | Round Culvert |
| PSCIS ID                 | 58151   | Diameter (m)             | 1             |
| External ID              | -   | Length (m)               | 14            |
| Crew                     | KP  | Embedded                 | No            |
| UTM Zone                 | 9   | Depth Embedded (m)       | -             |
| Easting                  | 629753.3  | Resemble Channel         | No            |
| Northing                 | 6061126   | Backwatered              | No            |
| Stream                   | McDowell Creek                                  | Percent Backwatered      | -             |
| Road                     | Woodmere Road                                   | Fill Depth (m)           | 0.5           |
| Road Tenure              | MoTi Local                                      | Outlet Drop (m)          | 0.25          |
| Channel Width (m)        | 1.8   | Outlet Pool Depth (m)    | 0.64          |
| Stream Slope (%)         | 1.5   | Inlet Drop               | No            |
| Beaver Activity          | No  | Slope (%)                | 5             |
| Habitat Value            | Medium  | Valley Fill              | Deep Fill     |
| Final score              | 31  | Barrier Result           | Barrier       |
| Fix type                 | Replace Structure with Streambed Simulation CBS | Fix Span / Diameter      | 3             |

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



## Stream Characteristics Downstream o...

| Location and Stream Data   | Crossing Characteristics |
|--|--------------------------|
| Comments: Channel dry. Current pool water depth is 0.31, outlet drop measured using long tape to simulate riffle crest height. 14:48 |                          |
|   |                          |

### Stream Characteristics Downstream of 123544

The stream was surveyed downstream from crossing 123544 for 300m (Figure 5.5). Total cover amount was rated as abundant with undercut banks dominant. Cover was also present as small

woody debris, large woody debris, boulders, deep pools, and overhanging vegetation. The dominant substrate was gravels with fines sub-dominant. The average channel width was 2.6m, and the average gradient was 2%. Although dry, the channel was well defined with frequent gravels throughout. The undercut banks were deeply cut and riparian vegetation was comprised of thick red-osier dogwood understory and open mature cottonwood forest. Habitat was rated as low value for salmonid rearing and spawning.

At the time of the survey, PSCIS culvert 58158 on Highway 16 located approximately had been recently replaced with a baffled structure embedded with a natural cobble and gravel substrates. Although ranked as a barrier to upstream fish passage using the provincial metric the crossing is likely not a barrier during most flows for adult anadromous salmon and fluvial salmonids migrating upstream from the Bulkley River.

### **Stream Characteristics Upstream of 123544 and downstream of 58151**

The stream was surveyed upstream of crossing 123544 for 25m and downstream from crossing 58151 for 120m (Figure 5.6). The average channel width was 1.7m, and the average gradient was 2%. The dominant substrate was fines with gravels sub-dominant. Total cover amount was rated as abundant with overhanging vegetation dominant. Cover was also present as small woody debris and undercut banks. With the exception of the culvert outlet pool, the channel was dry throughout the area surveyed. Riparian vegetation was primarily grass. Habitat value was rated as low as the surveyed area was dry with extensive agricultural development adjacent.

### **Stream Characteristics Upstream of 58151**

The stream was surveyed upstream from crossing 58151 for 70m (Figure 5.7). The average channel width was 1.7m, and the average gradient was 2%. Total cover amount was rated as abundant with overhanging vegetation dominant. Cover was also present as small woody debris and undercut banks. The dominant substrate was fines with gravels sub-dominant. Survey notes indicate the well defined channel bed was dry and contained fines and sediment likely from the high amount of development of yards, roads, and agriculture adjacent to the stream. Habitat value was rated as low.

### **Structure Remediation and Cost Estimate**

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 123544 with a bridge (10m span) is recommended. The cost of the work is estimated at \$200,000 for a cost benefit of 30.4 linear m/\$1000 and 81.9 m<sup>2</sup>/\$1000.

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 58151 with a bridge (3m span) is recommended. The cost of the work is estimated at \$160,000 for a cost benefit of 26.9 linear m/\$1000 and 45.7 m<sup>2</sup>/\$1000. Relocation of the driveway accessing the private land from the other side of the stream and removal of the crossing could also be considered.

## Conclusion

### **Conclusion**

There was 6.1km of habitat modelled upstream of crossing 58151 with areas surveyed rated as low value for salmonid rearing and spawning. Crossing 123544 was ranked as a low priority for proceeding to design due to low flows and highly impacted habitats upstream. Crossing 58151 was ranked as a low priority for proceeding to design for replacement. In the upper reaches of McDowell Creek, impacts are apparent due to adjacent land use (cattle trampled banks and grazed/removed riparian vegetation). It is recommended that a plan be developed to work with adjacent landowners and tenure holders to exclude cattle from the riparian area, implement stream restoration actions and explore possibilities related to progressive beaver management in the watershed.



Table 5.10: Summary of habitat details for PSCIS crossing 123544.

| Site   | Location   | Length Surveyed (m) | Channel Width (m) | Wetted Width (m) | Pool Depth (m) | Gradient (%) | Total Cover  | Habitat Value |
|--------|------------|---------------------|-------------------|------------------|----------------|--------------|--------------|---------------|
| 58151  | Downstream | 120                 | 1.8               | 0.1              | –              | –            | 1.2 abundant | low           |
| 58151  | Upstream   | 70                  | 1.7               | –                | –              | –            | 0.8 abundant | low           |
| 123544 | Downstream | 300                 | 2.6               | –                | –              | –            | 2.0 abundant | low           |
| 123544 | Upstream   | 25                  | 2.7               | –                | –              | –            | –            | low           |



Figure 5.5: Left: Habitat downstream of PSCIS crossing 123544. Right: Habitat downstream of PSCIS crossing 123544.

Conclusion



Figure 5.6: Left: Habitat downstream of PSCIS crossing 58151. Right: Typical habitat upstream of PSCIS crossing 123544.



Figure 5.7: Left: Typical habitat upstream of PSCIS crossing 58151. Right: Typical habitat upstream of PSCIS crossing 58151.





## John Brown - 123770 - Appendix

### Site Location

PSCIS crossing 123770 is located on John Brown approximately 650m south of the Moricetown canyon at Moricetown, BC. PSCIS crossing 123770 is located on Highway 16. Crossing 123770 was located 0.3km upstream from the confluence with the Bulkley River and is the responsibility of the Ministry of Transportation and Infrastructure.

### Background

At crossing 123770, John Brown is a fifth order stream with a watershed area upstream of the crossing of approximately 80.6km<sup>2</sup>. The elevation of the watershed ranges from a maximum of 2050m to 375m near the crossing (Table 5.11). Upstream of crossing 123770, coho salmon, cutthroat trout, rainbow trout, chinook salmon, bull trout, and dolly varden have previously been recorded (MoE 2020b; Norris 2020). A. Gottesfeld and Rabnett (2007) report that although spawner abundance and location are unknown, chinook have been observed with John Brown Creek at 0.4km.

Table 5.11: Summary of derived upstream watershed statistics for PSCIS crossing 123770.

| Site   | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|--------|---------|-----------|----------|----------|-------------|----------|--------|
| 123770 | 80.6    | 385       | 375      | 2050     | 1201        | 1087     | SE     |

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

Wilson and Rabnett (2007) and McCarthy and Fernando (2015) report that the culvert on John Brown at Highway 16 has received efforts to facilitate backwatering including rock lines to establish backwater pools downstream of the culvert.

PSCIS stream crossing 123770 was ranked as a high priority for follow up by Irvine (2018), Irvine (2021) and Mazany-Wright et al. (2021) because of significant amounts of habitat modelled as upstream of the crossing. A summary of habitat modelling outputs is presented in Table 5.12. A map of the watershed is provided in map attachment [093M.102](#).

Table 5.12: Summary of fish habitat modelling for PSCIS crossing 123770.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 39.6      | 39.3             | 99                   |
| ST Lake Reservoir (ha)           | 0.0       | 0.0              | –                    |
| ST Wetland (ha)                  | 11.4      | 11.4             | 100                  |
| ST Slopeclass03 Waterbodies (km) | 0.7       | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 5.0       | 5.0              | 100                  |
| ST Slopeclass05 (km)             | 8.1       | 8.0              | 99                   |
| ST Slopeclass08 (km)             | 8.2       | 7.9              | 96                   |
| ST Spawning (km)                 | 10.3      | 10.3             | 100                  |
| ST Rearing (km)                  | 15.9      | 15.9             | 100                  |
| CH Spawning (km)                 | 10.3      | 10.3             | 100                  |
| CH Rearing (km)                  | 11.2      | 11.2             | 100                  |
| CO Spawning (km)                 | 11.7      | 11.7             | 100                  |
| CO Rearing (km)                  | 11.7      | 11.7             | 100                  |
| CO Rearing (ha)                  | 0.0       | 0.0              | –                    |
| SK Spawning (km)                 | 0.0       | 0.0              | –                    |
| SK Rearing (km)                  | 0.0       | 0.0              | –                    |
| SK Rearing (ha)                  | –         | 0.0              | –                    |
| All Spawning (km)                | 11.7      | 11.7             | 100                  |
| All Rearing (km)                 | 15.9      | 15.9             | 100                  |
| All Spawning Rearing (km)        | 15.9      | 15.9             | 100                  |

\* Model data is preliminary and subject to adjustments.

### Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 123770 was non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.13). The crossing consisted on two pipes with baffles installed within the lower elevation pipe. There was a significant outlet drop and the baffled pipe was not embedded for its entire length. Water temperature was 10° C, pH was 7.2 and conductivity was 94uS/cm. The stream was also assessed at the location of a modelled crossing 1418m upstream from the confluence with the Bulkley River (PSCIS 198043) where a ford was located.

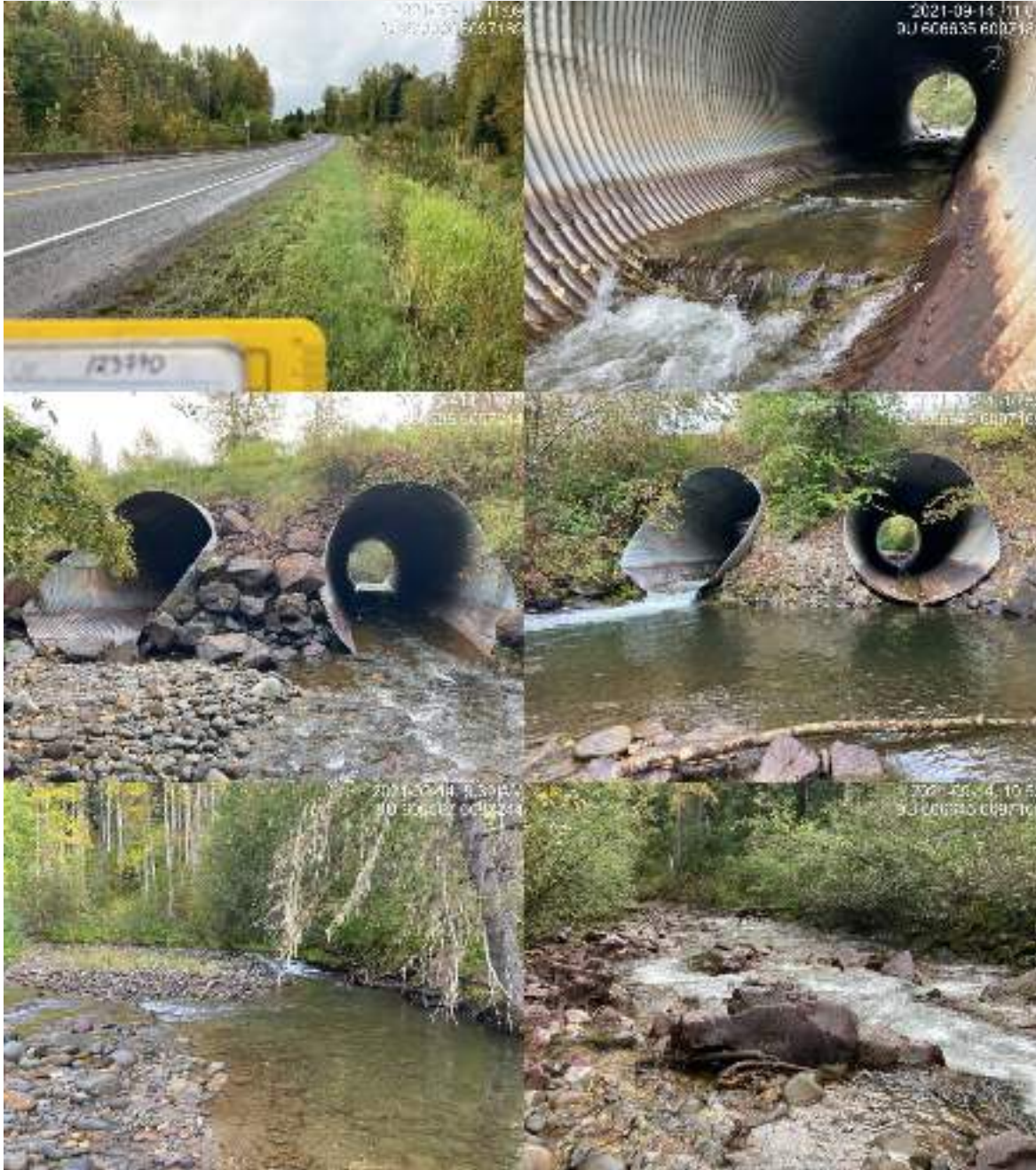
Stream Characteristics at Crossing

crossing 123770.

| Location and Stream Data  | •                                      | Crossing Characteristics | –             |
|---|--|--------------------------|---------------|
| Date  | 2021-09-07                             | Crossing Sub Type        | Round Culvert |
| PSCIS ID  | 123770                                 | Diameter (m)             | 4             |
| External ID   | –                                      | Length (m)               | 36            |
| Crew  | KP AN                                  | Embedded                 | No            |
| UTM Zone  | 9                                      | Depth Embedded (m)       | –             |
| Easting   | 606626.5                               | Resemble Channel         | No            |
| Northing  | 6097185                                | Backwatered              | No            |
| Stream  | John Brown                             | Percent Backwatered      | –             |
| Road  | Highway 16                             | Fill Depth (m)           | 3.5           |
| Road Tenure   | MoTi Arterial                          | Outlet Drop (m)          | 0.64          |
| Channel Width (m)   | 12.3                                   | Outlet Pool Depth (m)    | 1.5           |
| Stream Slope (%)  | 2.9                                    | Inlet Drop               | Yes           |
| Beaver Activity   | No                                     | Slope (%)                | 2             |
| Habitat Value   | Medium                                 | Valley Fill              | Deep Fill     |
| Final score   | 37                                     | Barrier Result           | Barrier       |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 19            |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |               |

| Location and Stream Data | • | Crossing Characteristics | - |
|--------------------------|---|--------------------------|---|
|--------------------------|---|--------------------------|---|

Comments: Both pipes have outlet drop and water flowing through. Water depth in left pipe is 0.01m, left pipe no embedment. Inlet drop only on right one. Also has baffling with substrate but baffling not in place for downstream ~3m, so not continuous. Estimated pool depth. 10:52



### **Stream Characteristics Downstream**

The stream was surveyed downstream from crossing 123770 for 230m to the confluence with the Bulkley River (Figure [5.9](#)). Total cover amount was rated as moderate with boulders dominant. Cover was also present as deep pools and overhanging vegetation. The average channel width was 13.6m, the average wetted width was 8.3m and the average gradient was 4.1%. The dominant substrate was large rock/bedrock with cobbles subdominant. Although rated as an important migration corridor, the habitat was rated as medium value for salmonid rearing and spawning with high flows and limited complexity. Several dead pink salmon were noted on the fan at the confluence with the Bulkley River.

### **Stream Characteristics Upstream**

The stream was surveyed upstream from crossing 123770 for 1000m (Figure [5.10](#)). Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, boulders, deep pools, and overhanging vegetation. The average channel width was 12.2m, the average wetted width was 8.3m and the average gradient was 2.9%. The dominant substrate was cobbles with gravels subdominant. The first 50 - 100m upstream of crossing channel and banks were noted as armoured with riprap. Abundant gravels suitable for resident and anadromous salmonids were noted throughout. The habitat was rated as high value as an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

The stream was also surveyed immediately upstream of PSCIS ford 198043 for 350m (Figure [5.11](#)). Total cover amount was rated as moderate with boulders dominant. Cover was also present as small woody debris and overhanging vegetation.. The average channel width was 11.2m, the average wetted width was 9.1m and the average gradient was 3%. The dominant substrate was cobbles with boulders subdominant. The habitat was rated as high value for salmon rearing and spawning.

### **Fish Sampling**

Electrofishing was conducted with results summarised in Tables [5.15](#) - [5.16](#) and Figure [5.8](#).

### **Structure Remediation and Cost Estimate**

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 123770 with a bridge (19m span) is recommended. The cost of the work is estimated at \$11,400,000 for a cost benefit of 1 linear m/\$1000 and 12.5 m<sup>2</sup>/\$1000.

## **Conclusion**

There was 11.7km of habitat modelled upstream of crossing 123770 with areas surveyed rated as high value for salmonid rearing and spawning. Crossing 123770 was ranked as a high priority for proceeding to design for replacement. John Brown Creek is a large system with habitat suitable for numerous species including coho, steelhead and chinook salmon. Development of a plan to replace the crossing with a bridge may be considered as a prudent step to eliminating an outlet drop, reducing flow velocities at the highway crossing and mitigating risks of a blow out to the baffle induced partial embedding currently in place in the south pipe of the crossing.

## Conclusion

Table 5.14: Summary of habitat details for PSCIS crossing 123770.

| Site   | Location   | Length Surveyed (m) | Channel Width (m) | Wetted Width (m) | Pool Depth (m) | Gradient (%) | Total Cover | Habitat Value |
|--------|------------|---------------------|-------------------|------------------|----------------|--------------|-------------|---------------|
| 123770 | Downstream | 230                 | 13.6              | 7.4              | 1.0            | 4.1          | moderate    | medium        |
| 123770 | Upstream   | 1000                | 12.2              | 8.3              | 0.8            | 2.9          | moderate    | high          |
| 123770 | Upstream2  | 350                 | 11.2              | 9.1              | 0.3            | 3.0          | moderate    | high          |

Table 5.15: Fish sampling site summary for 123770.

| site          | passes | ef_length_m | ef_width_m | area_m2 | enclosure |
|---------------|--------|-------------|------------|---------|-----------|
| 123770_us_ef1 | 1      | 15.7        | 1.65       | 25.9    | Open      |
| 123770_us_ef2 | 1      | 3.3         | 3.23       | 10.7    | Open      |
| 123770_us_ef3 | 1      | 1.8         | 2.83       | 5.1     | Open      |
| 123770_us_ef4 | 1      | 6.4         | 3.57       | 22.8    | Open      |
| 123770_us_ef5 | 1      | 4.8         | 3.03       | 14.5    | Open      |
| 123770_us_ef6 | 1      | 2.9         | 2.00       | 5.8     | Open      |

Table 5.16: Fish sampling density results summary for 123770.

| local_name    | species_code | life_stage | catch | density_100m2 | nfc_pass |
|---------------|--------------|------------|-------|---------------|----------|
| 123770_us_ef1 | RB           | fry        | 2     | 7.7           | FALSE    |
| 123770_us_ef1 | RB           | parr       | 4     | 15.4          | FALSE    |
| 123770_us_ef2 | CO           | fry        | 2     | 18.7          | FALSE    |
| 123770_us_ef2 | RB           | fry        | 10    | 93.5          | FALSE    |
| 123770_us_ef2 | RB           | parr       | 4     | 37.4          | FALSE    |
| 123770_us_ef3 | RB           | fry        | 6     | 117.6         | FALSE    |
| 123770_us_ef3 | RB           | parr       | 2     | 39.2          | FALSE    |
| 123770_us_ef3 | RB           | juvenile   | 2     | 39.2          | FALSE    |
| 123770_us_ef4 | RB           | fry        | 1     | 4.4           | FALSE    |
| 123770_us_ef4 | RB           | parr       | 8     | 35.1          | FALSE    |
| 123770_us_ef4 | RB           | juvenile   | 2     | 8.8           | FALSE    |
| 123770_us_ef4 | RB           | adult      | 1     | 4.4           | FALSE    |
| 123770_us_ef5 | RB           | fry        | 1     | 6.9           | FALSE    |
| 123770_us_ef5 | RB           | parr       | 1     | 6.9           | FALSE    |
| 123770_us_ef6 | NFC          | –          | 0     | 0.0           | TRUE     |

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

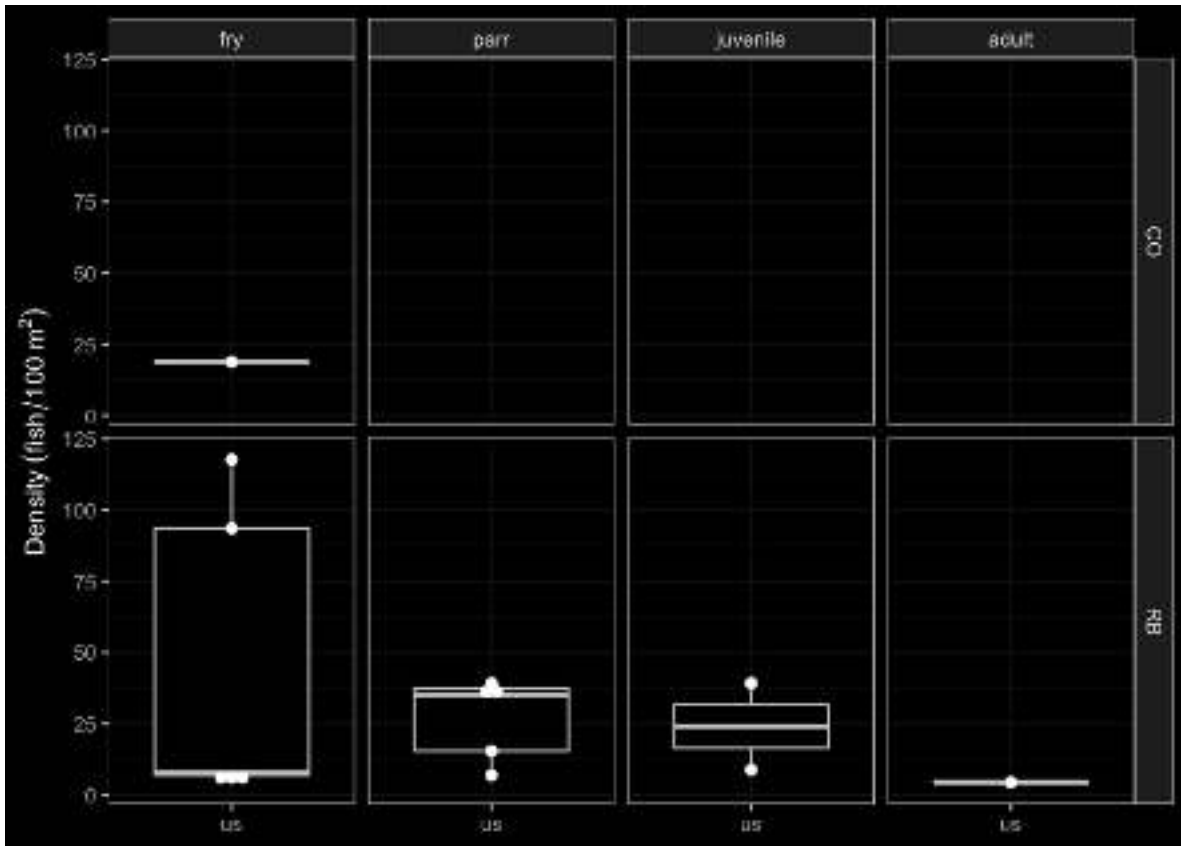


Figure 5.8: Densities of fish (fish/100m<sup>2</sup>) captured upstream of PSCIS crossing 123770.



Conclusion



Figure 5.9: Left: Typical habitat downstream of PSCIS crossing 123770. Right: Typical habitat downstream of PSCIS crossing 123770.



Figure 5.10: Left: Typical habitat upstream of PSCIS crossing 123770. Right: Typical habitat upstream of PSCIS crossing 123770.



Figure 5.11: Left: Typical habitat upstream of PSCIS crossing 123770. Right: Typical habitat upstream of PSCIS crossing 123770.

## Station Creek - 124420 & 124421 & 124422 - Appendix

### Site Location

PSCIS crossing 124420 was located on Station Creek at Hazelton, BC. Station Creek is also known locally as Mission Creek. PSCIS crossing 124420 is located on Highway 16. Crossing 124420 was located 1.8km upstream from the confluence with the Bulkley River. Crossing 124420 is the responsibility of the Ministry of Transportation and Infrastructure.

### Background

At crossing 124420, Station Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 28.6km<sup>2</sup>. The elevation of the watershed ranges from a maximum of 2171m to 211m near the crossing (Table 5.17). Upstream of crossing 124420, cutthroat trout, pink salmon, coho salmon, rainbow trout, bull trout, and dolly varden have previously been recorded (MoE 2020b; Norris 2020).

Wilson and Rabnett (2007) report that the crossing structure located on Highway 16 and Station Creek has been the subject of numerous assessments and designs with respect to the rehabilitation of fish passage, and they rated this crossing as the highest priority for rehabilitation in the Bulkley River watershed. Gitksan Watershed Authority reports that Xsan Xsagiibil was a fishing site located at the mouth of Station Creek (Xsi Gwin SagiiblaX) (Wilson and Rabnett 2007). Identified as a high priority for additional assessments by K. Rabnett and Williams (2004), SKR Consultants Ltd. (2006) conducted a detailed inspection, offered rehabilitation design options and identified the natural limits of potential fish distribution to support rehabilitation efforts. At the time of reporting, a design for remediation utilizing a retrofit of the existing structure to backwater the pipe was being drafted (Sean Wong, Environmental Programs Manager - Ministry of Transportation and Infrastructure pers. comm.).

A trap and truck operation led by the Chicago Creek Community Environmental Enhancement Society moves coho from a fence set up near the confluence with the Bulkley River to upstream of Highway 16 on Waterfall Creek annually. Houlden, Houlden, and Donas (2001) report that the coho stocks in the system were wiped out in the late 1970s by the improper installation of PSCIS crossing 124420. The Waterfall Creek Stream Rehabilitation Project began in 1990 to reintroduce coho to the stream with surplus stocks transplanted from Toboggan Creek near Smithers. In 1993 the Hazelton Elementary Streamkeepers program was developed to assist with the project and in 1995 the Chicago Creek Community Environmental Enhancement Society was incorporated to develop a hatchery nearby. The hatchery no longer operates but operations were considered successful with coho runs between 65 - 297 fish documented between 1998 - 2001 Watershed restoration and enhancement efforts were coordinated with other groups working in the system (Houlden, Houlden, and Donas 2001; Houlden and Donas 2002).

Following stream morphology changes which occurred during a fall 2017 flood event causing the release and distribution of sediment loads, Newman and England (2018) conducted a fish habitat assessment from the confluence of Station Creek with the Bulkley River upstream to the Mile 48 Canadian National railway crossing to determine stream diversity, spawning gravel catchment areas, beaver dam activity and negative impacts present in or along the stream. Beaver control activities on Station and Waterfall Creeks by CN Rail upstream of crossing 124420 may have been the cause of the 2017 flood event (pers comm. Brenda Donas, Chicago Creek Restoration Society).

Table 5.17: Summary of derived upstream watershed statistics for PSCIS crossing 124420.

| Site   | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|--------|---------|-----------|----------|----------|-------------|----------|--------|
| 124420 | 28.6    | 301       | 211      | 2171     | 521         | 425      | NNE    |

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

PSCIS stream crossing 124420 was ranked as a high priority for follow up by Wilson and Rabnett (2007), McCarthy and Fernando (2015), Irvine (2018) and Mazany-Wright et al. (2021) because of known high value spawning and rearing habitat upstream of the crossing. A summary of habitat modelling outputs is presented in Table 5.18. A map of the watershed is provided in map attachment 093M.106. There are numerous stream crossings located on tributaries to Station Creek with crossing 124421 and 124422 also assessed in 2021.

Table 5.18: Summary of fish habitat modelling for PSCIS crossing 124420.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 26.3      | 14.2             | 54                   |
| ST Lake Reservoir (ha)           | 6.5       | 2.0              | 31                   |
| ST Wetland (ha)                  | 73.9      | 56.5             | 76                   |
| ST Slopeclass03 Waterbodies (km) | 3.4       | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 11.1      | 6.5              | 59                   |
| ST Slopeclass05 (km)             | 5.2       | 1.0              | 19                   |
| ST Slopeclass08 (km)             | 4.1       | 3.0              | 73                   |
| ST Spawning (km)                 | 5.3       | 3.0              | 57                   |
| ST Rearing (km)                  | 8.5       | 5.0              | 59                   |
| CH Spawning (km)                 | 5.3       | 3.0              | 57                   |
| CH Rearing (km)                  | 8.4       | 5.0              | 60                   |
| CO Spawning (km)                 | 6.5       | 4.2              | 65                   |
| CO Rearing (km)                  | 9.3       | 5.8              | 62                   |
| CO Rearing (ha)                  | 28.3      | 0.0              | 0                    |
| SK Spawning (km)                 | 0.0       | 0.0              | –                    |
| SK Rearing (km)                  | 0.0       | 0.0              | –                    |
| SK Rearing (ha)                  | –         | 0.0              | –                    |
| All Spawning (km)                | 6.5       | 4.2              | 65                   |
| All Rearing (km)                 | 9.3       | 5.8              | 62                   |
| All Spawning Rearing (km)        | 9.3       | 5.8              | 62                   |

\* Model data is preliminary and subject to adjustments.

## Stream Characteristics at Crossings

At the time of the survey, PSCIS crossing 124420 was un-embedded, non-backwatered and ranked as a barrier barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table [5.19](#)). Water temperature was 8°C, pH was 7.9 and conductivity was 89uS/cm.

PSCIS crossing 124421 on Waterfall Creek was un-embedded, non-backwatered and ranked as a barrier barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table [5.20](#)).

PSCIS crossing 124422 on Waterfall Creek was un-embedded, 100% backwatered and ranked as a barrier barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table [5.21](#)).



Surveys were conducted with a remotely piloted aircraft upstream of the crossing with resulting images stitched into an orthomosaic and 3-dimensional model presented [here](#) and [here](#).

Table 5.19: Summary of fish passage assessment for PSCIS crossing 124420.

| Location and Stream Data  |  | Crossing Characteristics |               |
|---|--|--------------------------|---------------|
| Date  | 2021-09-16                             | Crossing Sub Type        | Round Culvert |
| PSCIS ID  | 124420                                 | Diameter (m)             | 1.6           |
| External ID   | –                                      | Length (m)               | 90            |
| Crew  | KP DN                                  | Embedded                 | No            |
| UTM Zone  | 9                                      | Depth Embedded (m)       | –             |
| Easting   | 586632.3                               | Resemble Channel         | No            |
| Northing  | 6122395                                | Backwatered              | No            |
| Stream  | Station Creek                          | Percent Backwatered      | –             |
| Road  | Highway 16                             | Fill Depth (m)           | 9.99          |
| Road Tenure   | New Hazelton Highway                   | Outlet Drop (m)          | 0.8           |
| Channel Width (m)   | 5.6                                    | Outlet Pool Depth (m)    | 1.6           |
| Stream Slope (%)  | 2                                      | Inlet Drop               | Yes           |
| Beaver Activity   | No                                     | Slope (%)                | 3.5           |
| Habitat Value   | Medium                                 | Valley Fill              | Deep Fill     |
| Final score   | 42                                     | Barrier Result           | Barrier       |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 30            |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |               |

# Stream Characteristics at Crossings

| Location and Stream Data | • | Crossing Characteristics | - |
|--------------------------|---|--------------------------|---|
|--------------------------|---|--------------------------|---|

Comments: Majority of culvert is ~3% however last 5 m steepens to 6-7%, appears to be because exposed section is bending from weight of water. Fill depth ~24m. Huge pool appears it would require a lot of material to backwater and build up. 10:30



Station Creek - 124420 & 124421 & 1...

| Location and Stream Data  | .                                      | Crossing Characteristics | -             |
|---|--|--------------------------|---------------|
| Date  | 2021-09-16                             | Crossing Sub Type        | Round Culvert |
| PSCIS ID  | 124421                                 | Diameter (m)             | 1             |
| External ID   | -                                      | Length (m)               | 15            |
| Crew  | KP                                     | Embedded                 | No            |
| UTM Zone  | 9                                      | Depth Embedded (m)       | -             |
| Easting   | 589466.5                               | Resemble Channel         | No            |
| Northing  | 6123042                                | Backwatered              | No            |
| Stream  | Tributary to Waterfall Creek           | Percent Backwatered      | -             |
| Road  | 11th Ave                               | Fill Depth (m)           | 1.5           |
| Road Tenure   | New Hazelton Local                     | Outlet Drop (m)          | 0.3           |
| Channel Width (m)   | 2.6                                    | Outlet Pool Depth (m)    | 0.27          |
| Stream Slope (%)  | 1                                      | Inlet Drop               | Yes           |
| Beaver Activity   | No                                     | Slope (%)                | 1             |
| Habitat Value   | Medium                                 | Valley Fill              | Deep Fill     |
| Final score   | 34                                     | Barrier Result           | Barrier       |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 10            |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |               |



# Stream Characteristics at Crossings

| Location and Stream Data | • | Crossing Characteristics | - |
|--------------------------|---|--------------------------|---|
|--------------------------|---|--------------------------|---|

Comments: Bent in middle from road weight. Inlet drop of 0.10 for both pipes. Slow steady flow almost wetland habitat above and below. Water is high. 12:54




Station Creek - 124420 & 124421 & 1...

| Location and Stream Data  | .                                      | Crossing Characteristics | -             |
|---|--|--------------------------|---------------|
| Date  | 2021-09-16                             | Crossing Sub Type        | Round Culvert |
| PSCIS ID  | 124422                                 | Diameter (m)             | 1.2           |
| External ID   | -                                      | Length (m)               | 45            |
| Crew  | KP                                     | Embedded                 | No            |
| UTM Zone  | 9                                      | Depth Embedded (m)       | -             |
| Easting   | 589499.9                               | Resemble Channel         | No            |
| Northing  | 6123162                                | Backwatered              | Yes           |
| Stream  | Tributary to Waterfall Creek           | Percent Backwatered      | 25            |
| Road  | Highway 16                             | Fill Depth (m)           | 6             |
| Road Tenure   | New Hazelton Arterial                  | Outlet Drop (m)          | 0             |
| Channel Width (m)   | 5.2                                    | Outlet Pool Depth (m)    | 0             |
| Stream Slope (%)  | 5.2                                    | Inlet Drop               | Yes           |
| Beaver Activity   | Yes                                    | Slope (%)                | 1.5           |
| Habitat Value   | Medium                                 | Valley Fill              | Deep Fill     |
| Final score   | 27                                     | Barrier Result           | Barrier       |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 19            |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |               |



# Stream Characteristics at Crossings

| Location and Stream Data  | Crossing Characteristics |
|---|--------------------------|
| <p>Comments: 2 pipes. Both have water, left bank one is flowing. Assessment comments indicate right bank pipe is backwatered 100% but changed to 25% based on photos and past PSCIS data and photos which also indicated not backwatered. Suspect blockage due to debris. Outlet water depth, fish sighted in outlet of right barrel. 13:42</p> |                          |
|    |                          |

### **Stream Characteristics Downstream of 124420**

The stream was surveyed downstream from the culvert for 375m (Figure [5.12](#)). Total cover amount was rated as with large woody debris dominant. Cover was also present as small woody debris, boulders, and overhanging vegetation (Table [5.22](#)). The average channel width was 6.1m, the average wetted width was 4.6m and the average gradient was 2.1%. The dominant substrate was gravels with cobbles subdominant. Survey notes indicate a complex system with deeply undercut banks with steep sections and confined areas. Segments of stream showed signs of erosion and deposition of fine sediments. Multiple areas with braided channels around woody debris and evidence of large fluctuations in flow were noted. The habitat was rated as high value for salmonid rearing and spawning. The reader is referred to Newman and England (2018) for additional information on habitat containing more detail.

### **Stream Characteristics Upstream of 124420 and downstream of 124421**

The stream was surveyed immediately upstream from 124420 for approximately 370m (Figure [5.13](#)). Within the area surveyed, total cover amount was rated as with large woody debris dominant. Cover was also present as small woody debris, undercut banks, deep pools, and overhanging vegetation (Table [5.22](#)). The average channel width was 5.7m, the average wetted width was 4.7m and the average gradient was 2%. The dominant substrate was cobbles with gravels subdominant. There were frequent pockets of gravels suitable for spawning throughout with high value spawning habitat in upper end of the survey area. Habitat value was rated as high value for resident salmonid rearing and spawning. The reader is referred to Newman and England (2018) for additional information on habitat in this area.

A small bridge (modelled crossing 24704553 - a.k.a Mile 48) is located under the CN Railway approximately 875m upstream of the highway.

At approximately 1200m upstream of Highway 16, Waterfall Creek enters into station Creek. In addition to the survey via drone, Waterfall Creek was assessed immediately upstream of the confluence with Station Creek for 430m (Figure [5.14](#)) Total cover amount was rated as abundant with instream vegetation dominant. Cover was also present as undercut banks, deep pools, and overhanging vegetation., The average channel width was 6.2m, the average wetted width was 5.5m, and the average gradient was 2.1%., The dominant substrate was fines with gravels subdominant. The area assessed included slow flowing wetland type habitat with generally shallow glide type habitat and significant quantities of instream vascular vegetation. Habitat value for areas surveyed was rated as high value as the area could provide significant amounts of rearing habitat for juvenile rainbow and coho.

Crossing 1803294 is modeled on Waterfall Creek at a location approximately 2.6km upstream of Highway 16 crossing 124420 and approximately 965m downstream of PSCIS crossing 124421.

## Stream Characteristics Upstream of 1...

This site was not assessed in the field and data regarding this crossing has not previously been loaded to PSCIS. Access to this location should be possible by wading across Waterfall Creek from access on the railway line. At the time of assessment, the road leading to the crossing from the north was behind a gated area on private land.

PSCIS crossing 124424 is located under the railway line approximately 55m downstream of 11th avenue where PSCIS crossing 124421 is located. PSCIS records indicate this crossing was non-embedded and 100% backwatered. Although ranking as a barrier according to the provincial protocol, 100% backwatered crossings are seldom an issue for fish passage for any life stage or species. Upstream of 124424 the stream was assessed to PSCIS crossing 124421. The dominant substrate was fines with gravels sub-dominant., Total cover amount was rated as moderate with instream vegetation dominant. Cover was also present as deep pools and overhanging vegetation., The average channel width was 6.7m, the average wetted width was 11.9m, and the average gradient was 2.1%. Survey notes indicate that below the crossing the water enters a wetland type complex dense in grasses and shrubs. Deep water and dense instream vegetation were present with the wetland/stream running relatively straight and parallel to the railway. Water depth was estimated at ~1.5m near the stream edge. Habitat value was rated as moderate with surveyor notes indicating a defined channel that widens into a small wetland complex dominated by tall grasses and significant instream vegetation.

### **Stream Characteristics Upstream of 124421 and downstream of 124422**

The stream was surveyed upstream from crossing 124421 for 120m to 124422 (Figure [5.15](#)). The dominant substrate was fines with gravels sub-dominant., Total cover amount was rated as abundant with instream vegetation 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 2.5m, and the average gradient was 2.1%. Survey notes indicate a slow moving wetland like stream with deep glides throughout. Instream vegetation was abundant with somewhat stagnant water often smelling of sulfur. Near top of the survey, the gradient increased slightly and the substrate transitioned from primarily fines to small gravel. Within the riparian area shrubs and sedges were thick and vigorous. Habitat value was rated as moderate as the this section of stream was considered an important migration corridor.

### **Stream Characteristics Upstream of 124422**

The stream was surveyed upstream from crossing 124422 for 350m (Figure [5.16](#)). Total cover amount was rated as abundant with instream vegetation dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation., The average channel width was 6.7m, the average wetted width was 6.6m, and the average gradient was 2.1%., The dominant substrate was fines with gravels sub-dominant. Within this section of stream there appears to have been restorative efforts involving the placement of logs to provide riffle pool breaks and retain gravel suitable for coho spawning. Gravels were abundant in this area and it's location within a residential area of New Hazelton provides an important connection between the stream and the surrounding community. Habitat value was rated as moderate as the this section of stream was considered critical for coho spawning.

### **Structure Remediation and Cost Estimate**

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 124420 with a bridge (30m span) is recommended. The cost of the work is estimated at \$18,000,000 for a cost benefit of 0.5 linear m/\$1000 and 2.9 m<sup>2</sup>/\$1000. These cost benefit estimates assume that adult coho spawner passage through 124420 will result in passage through upstream crossings which rank as barriers according to the provincial metric but are likely to be passable to adult coho.

### **Conclusion**

There was 124420 is 9.3km of habitat modelled upstream of the crossing with areas surveyed rated as high value for salmonid rearing and spawning. Crossing 124420 was ranked as a high priority for proceeding to design for replacement. At the time of reporting, the Ministry of Transportation and Infrastructure was in the process of developing a design to retrofit the existing structure at 124420 with some sort of backwatering mechanism so that it could pass adult coho spawners. Although, backwatering can be considered an interim solution, replacement of this crossing with an open bottom structure is recommended in the long term.

Station and Waterfall Creeks are located directly within the community of New Hazelton and there is a rich history of community efforts to help restore coho stocks and enhance the habitat in the system. This location and history provide importing context for the connection between the community, the Gitsxan, the salmon and the watershed. Station Creek is a unique opportunity for CP Rail, the Ministry of Transportation and Infrastructure, DFO, the Chicago Creek Community Environmental Enhancement Society, the community of New Hazelton, the Gitsxan and other to work together for meaningful restorative actions.



## Conclusion

Table 5.22: Summary of habitat details for PSCIS crossing 124420, 124421 and 124422.

| Site   | Location   | Length Surveyed (m) | Channel Width (m) | Wetted Width (m) | Pool Depth (m) | Gradient (%) | Total Cover | Habitat Value |
|--------|------------|---------------------|-------------------|------------------|----------------|--------------|-------------|---------------|
| 124420 | Downstream | 375                 | 6.1               | 4.6              | 0.5            | 2.1          | abundant    | high          |
| 124420 | Upstream   | 370                 | 5.7               | 4.7              | 0.5            | 2.0          | abundant    | high          |
| 124420 | Upstream2  | 430                 | 6.2               | 5.5              | –              | 0.5          | abundant    | high          |
| 124421 | Downstream | 50                  | 1.6               | 1.5              | –              | 1.0          | –           | moderate      |
| 124421 | Upstream   | 120                 | 2.6               | 2.5              | 0.3            | 1.0          | abundant    | moderate      |
| 124422 | Upstream   | 350                 | 6.7               | 6.6              | –              | 1.0          | abundant    | moderate      |



Figure 5.12: Left: Typical habitat downstream of PSCIS crossing 124420. Right: Typical habitat downstream of PSCIS crossing 124420.



Figure 5.13: Left: Habitat upstream of PSCIS crossing 124420. Right: Habitat upstream of PSCIS crossing 124420.



Figure 5.14: Left: Habitat upstream of PSCIS crossing 124420. Right: Habitat upstream of PSCIS crossing 124420 within Waterfall Creek.



Conclusion



Figure 5.15: Left: Typical habitat upstream of PSCIS crossing 124420. Right: Typical habitat upstream of PSCIS crossing 124420.



Figure 5.16: Left: Typical habitat upstream of PSCIS crossing 124420. Right: Typical habitat upstream of PSCIS crossing 124420.



## **Owen Creek - 197370 - Appendix**

Bii Wenii C'eeek - Owen Creek / Morice River Confluence



## Richfield Creek - 197662 - Appendix

### Site Location

PSCIS crossing 197662 is located on Richfield Creek approximately 30km east of Houston, BC with the highway located approximately 1.2km upstream from the confluence with the Bulkley River. Highway 16 is the responsibility of the Ministry of Transportation and Infrastructure.

### Background

At crossing 197662, Richfield Creek is a fifth order stream with a watershed area upstream of the crossing of approximately 161.3km<sup>2</sup>. The elevation of the watershed ranges from a maximum of 1753m to 650m near the crossing (Table 5.23). Upstream of crossing 197662, longnose sucker, lake chub, longnose dace, coho salmon, rainbow trout, steelhead, and chinook salmon have previously been recorded upstream (MoE 2020b; Norris 2020). Habitat modelling outputs are presented in Table 5.24. A map of the watershed is provided in map attachment 093L.115.

Table 5.23: Summary of derived upstream watershed statistics for PSCIS crossing 197662.

| Site   | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|--------|---------|-----------|----------|----------|-------------|----------|--------|
| 197662 | 161.3   | 676       | 650      | 1753     | 1096        | 1039     | SSW    |

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

A habitat confirmation assessment was conducted by Irvine (2021) in 2020 and the reader is directed there for detailed background, habitat assessment and fish sampling information from 2020 surveys. Acquisition of high resolution aerial imagery and fish sampling was conducted at the site in 2021 to provide context for crossing prioritization. Additionally, Society for Ecosystem Restoration BC, Fisheries and Oceans Canada and the Morice Watershed Monitoring Trust were able to collaborate in 2021 to provide funding for the installation of barbed wire fencing adjacent to a buffer on the west bank of Richfield Creek below the highway as a restorative action to exclude cattle from the riparian area. Details of these three activities are provided below.

Table 5.24: Summary of fish habitat modelling for PSCIS crossing 197662.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 70.8      | 50.9             | 72                   |
| ST Lake Reservoir (ha)           | 2.5       | 2.0              | 80                   |
| ST Wetland (ha)                  | 198.5     | 65.8             | 33                   |
| ST Slopeclass03 Waterbodies (km) | 8.7       | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 31.9      | 23.8             | 75                   |
| ST Slopeclass05 (km)             | 20.6      | 16.4             | 80                   |
| ST Slopeclass08 (km)             | 7.2       | 3.3              | 46                   |
| ST Spawning (km)                 | 11.8      | 11.8             | 100                  |
| ST Rearing (km)                  | 14.4      | 14.4             | 100                  |
| CH Spawning (km)                 | 11.8      | 11.8             | 100                  |
| CH Rearing (km)                  | 12.8      | 12.8             | 100                  |
| CO Spawning (km)                 | 16.4      | 16.4             | 100                  |
| CO Rearing (km)                  | 32.8      | 26.0             | 79                   |
| CO Rearing (ha)                  | 104.4     | 0.0              | 0                    |
| SK Spawning (km)                 | 0.0       | 0.0              | –                    |
| SK Rearing (km)                  | 0.0       | 0.0              | –                    |
| SK Rearing (ha)                  | –         | 0.0              | –                    |
| All Spawning (km)                | 16.4      | 16.4             | 100                  |
| All Rearing (km)                 | 33.2      | 26.5             | 80                   |
| All Spawning Rearing (km)        | 33.2      | 26.5             | 80                   |

\* Model data is preliminary and subject to adjustments.

### Stream Characteristics at Crossing

Although, culvert measurement data was recycled from 2020, crossing photos were retaken (Table [5.25](#)).

Table 5.25: Summary of fish passage assessment for PSCIS crossing 197662.

| Location and Stream Data | •               | Crossing Characteristics | –             |
|--------------------------|-----------------|--------------------------|---------------|
| Date                     | 2021-09-10      | Crossing Sub Type        | Round Culvert |
| PSCIS ID                 | 197662          | Diameter (m)             | 4.2           |
| External ID              | –               | Length (m)               | 24            |
| Crew                     | AI              | Embedded                 | No            |
| UTM Zone                 | 9               | Depth Embedded (m)       | –             |
| Easting                  | 672404.7        | Resemble Channel         | No            |
| Northing                 | 6044146         | Backwatered              | No            |
| Stream                   | Richfield Creek | Percent Backwatered      | –             |

## Stream Characteristics at Crossing

| Location and Stream Data  |  | Crossing Characteristics |           |
|---|--|--------------------------|-----------|
| Road  | Highway 16                             | Fill Depth (m)           | 1         |
| Road Tenure   | MoTi highway                           | Outlet Drop (m)          | 0.2       |
| Channel Width (m)   | 12.5                                   | Outlet Pool Depth (m)    | 1         |
| Stream Slope (%)  | 1.5                                    | Inlet Drop               | No        |
| Beaver Activity   | No                                     | Slope (%)                | 2         |
| Habitat Value   | High                                   | Valley Fill              | Deep Fill |
| Final score   | 29                                     | Barrier Result           | Barrier   |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 16.5      |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |           |



| Location and Stream Data | • | Crossing Characteristics | - |
|--------------------------|---|--------------------------|---|
|--------------------------|---|--------------------------|---|

Comments: Culvert and habitat measurements taken in 2020. Multipass closed site electrofishing conducted in 2021 upstream and downstream of highway. 17:25





## 5.1 Aerial Imagery

### **5.1 Aerial Imagery**

Surveys were conducted with a remotely piloted aircraft upstream of the crossing with resulting images stitched into an orthomosaic and 3-dimensional model presented [here](#) and [here](#).

## 5.2 Fish Sampling

Multipass electrofishing was conducted at three sites upstream of the highway and three sites downstream. Water temperature was 10°C, pH was 8.1 and conductivity was 234µS/cm. results are summarised in Tables [5.26](#) - [5.27](#) and Figure [5.17](#). Photos are provided in (Figures [5.18](#)) - [5.19](#)).

Table 5.26: Fish sampling site summary for 197662.

| site          | passes | ef_length_m | ef_width_m | area_m2 | enclosure |
|---------------|--------|-------------|------------|---------|-----------|
| 197662_ds_ef1 | 6      | 21.4        | 6.10       | 130.5   | Closed    |
| 197662_ds_ef2 | 4      | 5.8         | 5.60       | 32.5    | Closed    |
| 197662_ds_ef3 | 3      | 4.2         | 6.05       | 25.4    | Closed    |
| 197662_us_ef1 | 4      | 6.4         | 7.00       | 44.8    | Closed    |
| 197662_us_ef2 | 3      | 5.1         | 4.83       | 24.6    | Closed    |
| 197662_us_ef3 | 3      | 5.6         | 2.73       | 15.3    | Closed    |

Table 5.27: Fish sampling density results summary for 197662.

| local_name    | species_code | life_stage | catch | density_100m2 | nfc_pass |
|---------------|--------------|------------|-------|---------------|----------|
| 197662_ds_ef1 | CO           | fry        | 12    | 9.2           | TRUE     |
| 197662_ds_ef1 | CO           | parr       | 65    | 49.8          | FALSE    |
| 197662_ds_ef1 | L            | –          | 3     | 2.3           | FALSE    |
| 197662_ds_ef1 | LSU          | –          | 1     | 0.8           | TRUE     |
| 197662_ds_ef1 | MW           | parr       | 6     | 4.6           | TRUE     |
| 197662_ds_ef1 | RB           | fry        | 29    | 22.2          | FALSE    |
| 197662_ds_ef1 | RB           | parr       | 42    | 32.2          | FALSE    |
| 197662_ds_ef1 | RB           | juvenile   | 9     | 6.9           | TRUE     |
| 197662_ds_ef1 | RB           | adult      | 4     | 3.1           | TRUE     |
| 197662_ds_ef1 | SU           | –          | 14    | 10.7          | FALSE    |
| 197662_ds_ef2 | CO           | fry        | 17    | 52.3          | FALSE    |
| 197662_ds_ef2 | CO           | parr       | 5     | 15.4          | TRUE     |
| 197662_ds_ef2 | L            | –          | 6     | 18.5          | FALSE    |
| 197662_ds_ef2 | RB           | fry        | 11    | 33.8          | FALSE    |
| 197662_ds_ef2 | RB           | parr       | 7     | 21.5          | TRUE     |
| 197662_ds_ef2 | RB           | adult      | 2     | 6.2           | TRUE     |
| 197662_ds_ef2 | SU           | –          | 3     | 9.2           | TRUE     |
| 197662_ds_ef3 | CO           | fry        | 2     | 7.9           | TRUE     |
| 197662_ds_ef3 | CO           | parr       | 3     | 11.8          | FALSE    |
| 197662_ds_ef3 | L            | –          | 1     | 3.9           | TRUE     |
| 197662_ds_ef3 | RB           | fry        | 7     | 27.6          | FALSE    |
| 197662_ds_ef3 | RB           | parr       | 7     | 27.6          | TRUE     |
| 197662_ds_ef3 | SU           | –          | 3     | 11.8          | TRUE     |
| 197662_us_ef1 | CO           | fry        | 6     | 13.4          | FALSE    |
| 197662_us_ef1 | CO           | parr       | 2     | 4.5           | TRUE     |
| 197662_us_ef1 | L            | –          | 3     | 6.7           | TRUE     |

## 5.2 Fish Sampling

| local_name    | species_code | life_stage | catch | density_100m2 | nfc_pass |
|---------------|--------------|------------|-------|---------------|----------|
| 197662_us_ef1 | RB           | fry        | 43    | 96.0          | FALSE    |
| 197662_us_ef1 | RB           | parr       | 16    | 35.7          | TRUE     |
| 197662_us_ef1 | RB           | juvenile   | 4     | 8.9           | TRUE     |
| 197662_us_ef1 | RB           | adult      | 1     | 2.2           | FALSE    |
| 197662_us_ef2 | CO           | fry        | 5     | 20.3          | TRUE     |
| 197662_us_ef2 | CO           | parr       | 5     | 20.3          | FALSE    |
| 197662_us_ef2 | L            | –          | 1     | 4.1           | FALSE    |
| 197662_us_ef2 | RB           | fry        | 38    | 154.5         | FALSE    |
| 197662_us_ef2 | RB           | parr       | 22    | 89.4          | FALSE    |
| 197662_us_ef2 | RB           | juvenile   | 2     | 8.1           | TRUE     |
| 197662_us_ef3 | CO           | fry        | 5     | 32.7          | FALSE    |
| 197662_us_ef3 | CO           | parr       | 1     | 6.5           | TRUE     |
| 197662_us_ef3 | L            | –          | 5     | 32.7          | FALSE    |
| 197662_us_ef3 | RB           | fry        | 18    | 117.6         | TRUE     |
| 197662_us_ef3 | RB           | parr       | 4     | 26.1          | FALSE    |

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

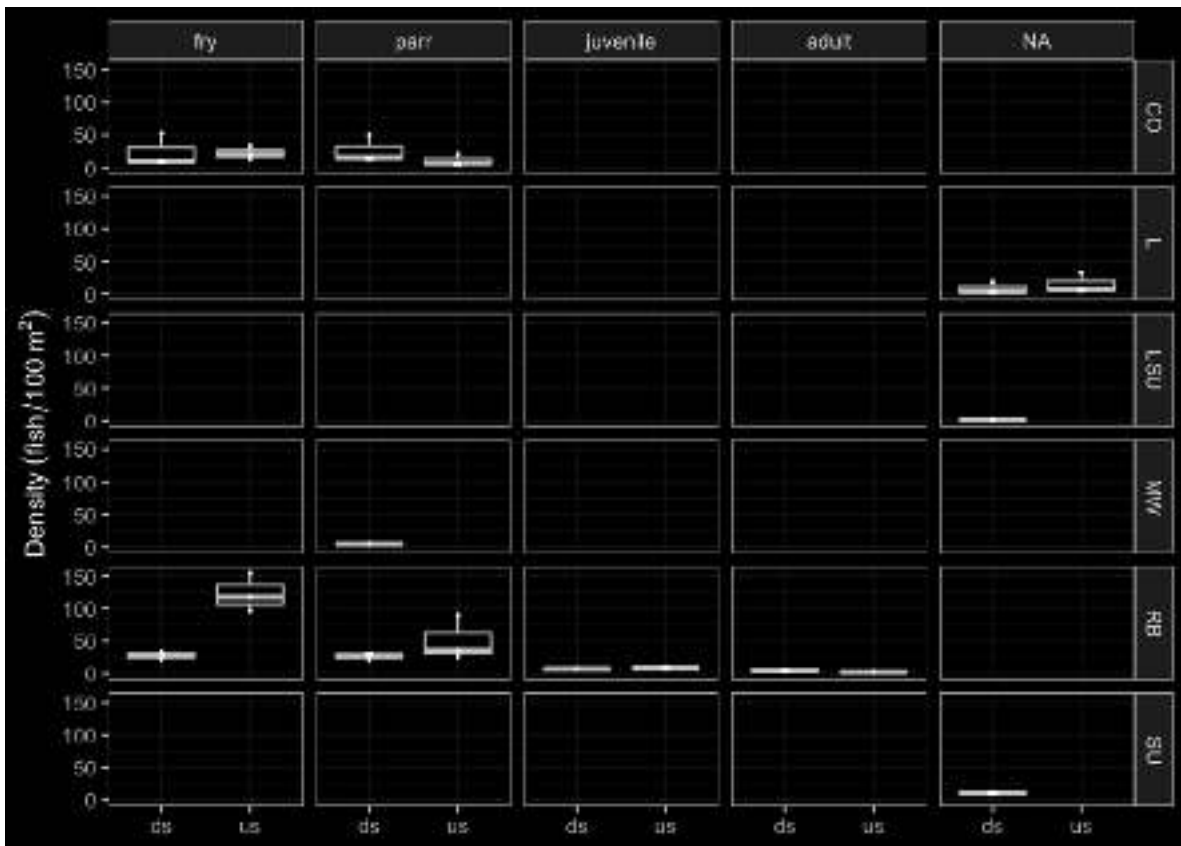


Figure 5.17: Densities of fish (fish/100m<sup>2</sup>) captured upstream and downstream of PSCIS crossing 197662.

### 5.3 Riparian Fencing



Figure 5.18: Left: Habitat downstream of PSCIS crossing 197662. Right: Lamprey captured downstream of PSCIS crossing 197662.



Figure 5.19: Left: Habitat upstream of PSCIS crossing 197662. Right: Habitat upstream of PSCIS crossing 197662.

### 5.3 Riparian Fencing

Approximately 1100 m of new four strand barbed wire fencing was installed to the west of Richfield Creek between November 26 and December 14, 2021. Fencing of the area complemented significant restoration work completed in by the Morice Watershed Monitoring Trust project which included bank stabilization, installation of vertical posts for bank stability, live stakeing of willow/cottonwood and planting of rooted willow plugs. Details of the work conducted is documented in Wrench (2022) and included as [Attachment 4](#).

## **Conclusion**

There was 197662 is 32.8km of habitat modelled upstream of the crossing with areas surveyed in 2020 rated as high value for salmonid rearing and spawning (Irvine 2021). There is extensive background information on this system summarized in Irvine (2021) and in development at the time of reporting. Crossing 197662 was ranked as a high priority for proceeding to design for replacement. As Richfield Creek is a high value fish stream with cold water inputs and significant historic and ongoing impacts due to adjacent land use (linear development, residential development, cattle trampled banks and grazed/removed riparian vegetation) it is recommended that individuals, organizations and regulators continue to work with adjacent landowners and tenure holders to implement stream restoration actions, exclude cattle from the riparian area, and explore possibilities related to progressive beaver management in the watershed.

## Tributary to Maxan Creek - 197909 - Appendix

### Site Location

PSCIS crossing 197909 is located on Tributary to Maxan Creek adjacent to the west side of Maxan Lake located south of Topley, BC. PSCIS crossing 197909 is located on Maxan Creek FSR. Crossing 197909 was located 1.8km upstream from the confluence with Maxan Lake. Crossing 198043 is the responsibility of the Ministry of Forests.

### Background

At crossing 197909, Tributary to Maxan Creek is a first order stream with a watershed area upstream of the crossing of approximately 2.1km<sup>2</sup>. The elevation of the watershed ranges from a maximum of 956m to 788m near the crossing (Table 5.28). No fish have previously been recorded at the site (MoE 2020b; Norris 2020).

Table 5.28: Summary of derived upstream watershed statistics for PSCIS crossing 197909.

| Site   | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|--------|---------|-----------|----------|----------|-------------|----------|--------|
| 197909 | 2.1     | 835       | 788      | 956      | 851         | 847      | E      |

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

Although the associated reporting could not be located, fisheries assessments were conducted on the stream approximately 170m downstream of the crossing and 50m upstream of the crossing by FINS Consulting Ltd. in 1999 (MoE 2020e). Although information regarding sampling effort is not present, site card notes indicate the site was classified as S6 (non-fish bearing) due to a lack of significant fish habitat.

PSCIS stream crossing 198043 was ranked as a moderate priority for follow up during field assessments because of the presence of modelled habitat upstream and relatively good flows in the stream when compared to the rest of the culverted streams surveyed in the greater Maxan Creek watershed (Table 5.29). A map of the watershed is provided in map attachment 093L.110.

Table 5.29: Summary of fish habitat modelling for PSCIS crossing 197909.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 0.7       | 0.7              | 100                  |
| ST Lake Reservoir (ha)           | 5.7       | 5.7              | 100                  |
| ST Wetland (ha)                  | 27.7      | 27.7             | 100                  |
| ST Slopeclass03 Waterbodies (km) | 0.6       | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 0.0       | 0.0              | –                    |
| ST Slopeclass05 (km)             | 0.1       | 0.1              | 100                  |
| 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)                 | 0.0       | 0.0              | –                    |
| CO Rearing (km)                  | 0.2       | 0.2              | 100                  |
| CO Rearing (ha)                  | 13.8      | 0.0              | 0                    |
| SK Spawning (km)                 | 0.0       | 0.0              | –                    |
| SK Rearing (km)                  | 0.0       | 0.0              | –                    |
| SK Rearing (ha)                  | –         | 0.0              | –                    |
| All Spawning (km)                | 0.0       | 0.0              | –                    |
| All Rearing (km)                 | 0.2       | 0.2              | 100                  |
| All Spawning Rearing (km)        | 0.2       | 0.2              | 100                  |

\* Model data is preliminary and subject to adjustments.

### Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 197909 was comprised of an un-embedded and non-backwatered round culvert (Table 5.30). Water temperature was 12°C, pH was 7.2 and conductivity was 106µS/cm.



Stream Characteristics at Crossing

Table 5.30: Summary of fish passage assessment for PSCIS crossing 197909.

| Location and Stream Data | .   | Crossing Characteristics | –             |
|--------------------------|---|--------------------------|---------------|
| Date                     | 2021-08-30                                      | Crossing Sub Type        | Round Culvert |
| PSCIS ID                 | 197909  | Diameter (m)             | 0.6           |
| External ID              | –   | Length (m)               | 16            |
| Crew                     | AI KP   | Embedded                 | No            |
| UTM Zone                 | 9   | Depth Embedded (m)       | –             |
| Easting                  | 687557  | Resemble Channel         | No            |
| Northing                 | 6020572   | Backwatered              | No            |
| Stream                   | Tributary to Maxan Creek                        | Percent Backwatered      | –             |
| Road                     | Maxan Creek FSR                                 | Fill Depth (m)           | 2.5           |
| Road Tenure              | FLNR DND 7735                                   | Outlet Drop (m)          | 0             |
| Channel Width (m)        | 0.9   | Outlet Pool Depth (m)    | 0.65          |
| Stream Slope (%)         | 4   | Inlet Drop               | Yes           |
| Beaver Activity          | Yes   | Slope (%)                | 3             |
| Habitat Value            | Medium  | Valley Fill              | Deep Fill     |
| Final score              | 29  | Barrier Result           | Barrier       |
| Fix type                 | Replace Structure with Streambed Simulation CBS | Fix Span / Diameter      | 3             |

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

| Location and Stream Data | • | Crossing Characteristics | - |
|--------------------------|---|--------------------------|---|
|--------------------------|---|--------------------------|---|

Comments: Habitat value is low to medium. Large beaver influenced lake upstream with two dams ~1.5m high at 10m and 30m upstream. Inlet blocked. Water at inlet is level with the top of the culvert. At 4m downstream is a 1m high beaver dam. 13:23



### **Stream Characteristics Downstream**

The stream was surveyed downstream from crossing 197909 for 400m (Figure [5.20](#)). Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as undercut banks. The average channel width was 1.3m, the average wetted width was 1.3m, and the average gradient was 3.2%. Substrate was composed of fines. At approximately 300m downstream of the culvert the stream became wider with glide habitat to ~50cm in depth resulting from sediments deposited by a failure on the steep north canyon wall. Habitat was rated as low value for salmonid rearing and spawning due to the small size of the stream, low flows and fine substrate.

### **Stream Characteristics Upstream**

The stream was surveyed upstream from crossing 197909 for 100m to the location of a series of large beaver dams (Figure [5.21](#)). Substrate was composed of fines. Cover was present as overhanging vegetation and as deep pool due to beaver influenced water impoundment. Habitat value was rated as moderate value as the area could provide significant amounts of rearing habitat for rainbow and coho if access from downstream was possible.

### **Structure Remediation and Cost Estimate**

Should restoration/maintenance activities proceed at the site, replacement of PSCIS crossing 197909 with a clear span bridge is recommended. The cost of the work is estimated at \$40,000 for a cost benefit of 5.6 linear m/\$1000 and 7.3 m<sup>2</sup>/\$1000.

### **Conclusion**

Although past assessment work in the watershed indicates stream is likely non-fish bearing (MoE 2020e), there was 0.2km of habitat and 27.7ha of wetland type habitat modelled upstream of crossing 197909 with areas surveyed rated as moderate value for rainbow trout and coho rearing. Crossing 197909 was ranked as a low priority for proceeding to design for removal however this ranking could be revisited in the future should fish presence or potential for fish presence be confirmed through subsequent survey activities.



Table 5.31: Summary of habitat details for PSCIS crossing 197909.

| Site   | Location   | Length Surveyed (m) | Channel Width (m) | Wetted Width (m) | Pool Depth (m) | Gradient (%) | Total Cover | Habitat Value |
|--------|------------|---------------------|-------------------|------------------|----------------|--------------|-------------|---------------|
| 197909 | Downstream | 400                 | 1.3               | 1.3              | 0.5            | 3.2          | abundant    | low           |
| 197909 | Upstream   | 100                 | 1.3               | 1.3              | -              | 1.5          | moderate    | moderate      |



Figure 5.20: Left: Habitat downstream of PSCIS crossing 197909. Right: Habitat downstream of PSCIS crossing 197909.



Figure 5.21: Left: Habitat upstream of PSCIS crossing 197909. Right: Habitat upstream of PSCIS crossing 197909.

## Robert Hatch Creek - 197912 - Appendix

### Site Location

PSCIS crossing 197912 is located on Robert Hatch Creek near Topley, BC. PSCIS crossing 197912 is located on a small private road and the Hatch Creek Ranch. Crossing 197912 was located 2.6km upstream from the confluence with Richfield Creek. Crossing 198043 is the responsibility of the range tenure holder (Hatch Creek Ranch Ltd. - forest file id RAN074136 and Groot Bros. Contracting Ltd. - forest file id RANM01180) where the road is located.

### Background

At crossing 197912, Robert Hatch Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 31.5km<sup>2</sup>. The elevation of the watershed ranges from a maximum of 1070m to 715m near the crossing (Table 5.32). No fish have previously been recorded at the site (MoE 2020b; Norris 2020).

Table 5.32: Summary of derived upstream watershed statistics for PSCIS crossing 197912.

| Site   | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|--------|---------|-----------|----------|----------|-------------|----------|--------|
| 197912 | 31.5    | 720       | 715      | 1070     | 1004        | 983      | S      |

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

Extensive background on Richfield Creek is presented in Irvine (2021) with fish sampling and orthoimagery available within the “Richfield Creek - 197662 - Appendix” within this document.

PSCIS stream crossing 198043 was ranked as a high priority for follow up by Canadian Wildlife Federation because of the relatively large size of the stream and habitat rated as high value in PSCIS (Table 5.33). A map of the watershed is provided in map attachment 093L.115.

Table 5.33: Summary of fish habitat modelling for PSCIS crossing 197912.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 63.7      | 55.6             | 87                   |
| ST Lake Reservoir (ha)           | 2.5       | 2.4              | 96                   |
| ST Wetland (ha)                  | 198.5     | 198.5            | 100                  |
| ST Slopeclass03 Waterbodies (km) | 8.7       | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 26.8      | 26.8             | 100                  |
| ST Slopeclass05 (km)             | 18.8      | 15.1             | 80                   |
| ST Slopeclass08 (km)             | 7.0       | 3.1              | 44                   |
| ST Spawning (km)                 | 6.7       | 6.7              | 100                  |
| ST Rearing (km)                  | 9.3       | 9.3              | 100                  |
| CH Spawning (km)                 | 6.7       | 6.7              | 100                  |
| CH Rearing (km)                  | 7.8       | 7.8              | 100                  |
| CO Spawning (km)                 | 11.3      | 11.3             | 100                  |
| CO Rearing (km)                  | 27.7      | 27.7             | 100                  |
| CO Rearing (ha)                  | 104.4     | 104.4            | 100                  |
| SK Spawning (km)                 | 0.0       | 0.0              | –                    |
| SK Rearing (km)                  | 0.0       | 0.0              | –                    |
| SK Rearing (ha)                  | –         | 0.0              | –                    |
| All Spawning (km)                | 11.3      | 11.3             | 100                  |
| All Rearing (km)                 | 28.2      | 28.2             | 100                  |
| All Spawning Rearing (km)        | 28.2      | 28.2             | 100                  |

\* Model data is preliminary and subject to adjustments.

### Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 197912 was comprised of a collapsing bridge (Table [5.34](#)). The structure may have been presenting an impediment to upstream fish passage for adult fish and the bridge debris in the channel was resulting in erosion of the banks adjacent to the historic structure. Water temperature was 12°C, pH was 8 and conductivity was 283uS/cm. Surveys were conducted with a remotely piloted aircraft immediately upstream and downstream of the crossing with resulting images stitched into an orthomosaic and 3-dimensional model presented [here](#) and [here](#).

Table 5.34: Summary of fish passage assessment for PSCIS crossing 197912.

| Location and Stream Data | •                  | Crossing Characteristics | –        |
|--------------------------|--------------------|--------------------------|----------|
| Date                     | 2021-08-31         | Crossing Sub Type        | Bridge   |
| PSCIS ID                 | 197912             | Diameter (m)             | 12       |
| External ID              | –                  | Length (m)               | 7        |
| Crew                     | AI                 | Embedded                 | –        |
| UTM Zone                 | 9                  | Depth Embedded (m)       | –        |
| Easting                  | 670963             | Resemble Channel         | –        |
| Northing                 | 6046221            | Backwatered              | –        |
| Stream                   | Robert Hatch Creek | Percent Backwatered      | –        |
| Road                     | Private            | Fill Depth (m)           | –        |
| Road Tenure              | Unclassified       | Outlet Drop (m)          | –        |
| Channel Width (m)        | –                  | Outlet Pool Depth (m)    | –        |
| Stream Slope (%)         | –                  | Inlet Drop               | –        |
| Beaver Activity          | –                  | Slope (%)                | –        |
| Habitat Value            | –                  | Valley Fill              | –        |
| Final score              | 0                  | Barrier Result           | Passable |
| Fix type                 | –                  | Fix Span / Diameter      | –        |

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



| Location and Stream Data  | • Crossing Characteristics |
|---|----------------------------|
| Comments: Bridge has collapsed and is impediment to upstream fish passage. Habitat confirmation conducted. 16:56  |                            |
|  <p>The image consists of six photographs arranged in a 3x2 grid. The top-left photo shows a wide view of a stream with a collapsed wooden bridge structure in the foreground and a yellow survey marker with the number '1802106' in the lower-left corner. The top-right photo is a close-up of the collapsed bridge structure, showing logs and debris in the water. The middle-left photo shows a close-up of the collapsed bridge structure, with a timestamp '2021-09-31 4:56 PM' and '011 570964 6048228' overlaid. The middle-right photo shows a close-up of the collapsed bridge structure, with a timestamp '2021-09-31 4:59 PM' and '011 570964 6048228' overlaid. The bottom-left photo shows a close-up of the collapsed bridge structure, with a timestamp '2021-09-31 4:59 PM' and '011 570964 6048228' overlaid. The bottom-right photo shows a wide view of the stream with a collapsed bridge structure in the foreground and surrounding vegetation.</p> |                            |

### **Stream Characteristics Downstream**

The stream was surveyed downstream from the culvert for 300m (Figure [5.24](#)). Total cover amount was rated as with deep pools dominant. Cover was also present as small woody debris, large woody debris, undercut banks, and overhanging vegetation (Table [5.35](#)). The average channel width was 4.7m, the average wetted width was 3.2m and the average gradient was 1.2%. The dominant substrate was gravels with fines subdominant. The habitat was rated as medium value for salmonid rearing and spawning.

### **Stream Characteristics Upstream of 197912**

The stream was surveyed immediately upstream from 197912 for approximately 340m to the location of a large beaver dam (Figure [5.25](#)). Within the area surveyed, total cover amount was rated as with deep pools dominant. Cover was also present as small woody debris, large woody debris, undercut banks, and overhanging vegetation (Table [5.35](#)). The average channel width was 4.3m, the average wetted width was 2.5m and the average gradient was 1.5%. The dominant substrate was gravels with fines subdominant. Habitat value was rated as high value for resident salmonid rearing and spawning.

### **Fish Sampling**

Electrofishing was conducted downstream of the collapsed bridge with results summarised in Tables [5.36](#) - [5.37](#) and Figure [5.23](#).

### **Structure Remediation and Cost Estimate**

Should restoration/maintenance activities proceed at the site, removal of PSCIS crossing 197912 is recommended. In addition to removal of the collapsed bridge, resloping of banks and the installation of live cuttings/pegboarding is recommended in three areas downstream where cattle trampling is resulting in significant erosion. A map of the erosion areas and associated prescriptions for rehabilitation of the downstream corners is provided as Figure [5.22](#). The cost of the work is estimated at \$30,000 for a cost benefit of 924 linear m/\$1000 and 3973.2 m<sup>2</sup>/\$1000.





Figure 5.22: Restoration plan for Robert Hatch Creek including removal of collapsed bridge, resloping of banks and the installation of live cuttings/pegboarding

### Conclusion

There was 197912 is 27.7km of habitat modelled upstream of crossing with areas surveyed rated as high value for salmonid rearing and spawning. Crossing 197912 was ranked as a moderate priority for proceeding to design for removal. As Robert Hatch Creek appears to be a high value fish stream with significant impacts due to adjacent land use (cattle trampled banks and grazed/removed riparian vegetation), it is recommended that a plan be developed to work with adjacent landowners and tenure holders to exclude cattle from the riparian area, implement stream restoration actions and explore possibilities related to progressive beaver management in the watershed.

## Conclusion

Table 5.35: Summary of habitat details for PSCIS crossing 197912.

| Site   | Location   | Length Surveyed (m) | Channel Width (m) | Wetted Width (m) | Pool Depth (m) | Gradient (%) | Total Cover | Habitat Value |
|--------|------------|---------------------|-------------------|------------------|----------------|--------------|-------------|---------------|
| 197912 | Downstream | 300                 | 4.7               | 3.2              | 0.5            | 1.2          | –           | medium        |
| 197912 | Upstream   | 340                 | 4.3               | 2.5              | 0.6            | 1.5          | abundant    | high          |

Table 5.36: Fish sampling site summary for 197912.

| site          | passes | ef_length_m | ef_width_m | area_m2 | enclosure |
|---------------|--------|-------------|------------|---------|-----------|
| 197912_ds_ef1 | 3      | 8.6         | 4.80       | 41.3    | Closed    |
| 197912_ds_ef2 | 1      | 28.0        | 1.96       | 54.9    | Open      |
| 197912_ds_ef3 | 1      | 14.0        | 2.87       | 40.2    | Open      |

Table 5.37: Fish sampling density results summary for 197912.

| local_name    | species_code | life_stage | catch | density_100m2 | nfc_pass |
|---------------|--------------|------------|-------|---------------|----------|
| 197912_ds_ef1 | NFC          | –          | 0     | 0.0           | TRUE     |
| 197912_ds_ef1 | RB           | adult      | 1     | 2.4           | TRUE     |
| 197912_ds_ef2 | RB           | fry        | 1     | 1.8           | FALSE    |
| 197912_ds_ef3 | RB           | fry        | 1     | 2.5           | FALSE    |
| 197912_ds_ef3 | RB           | adult      | 1     | 2.5           | FALSE    |

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

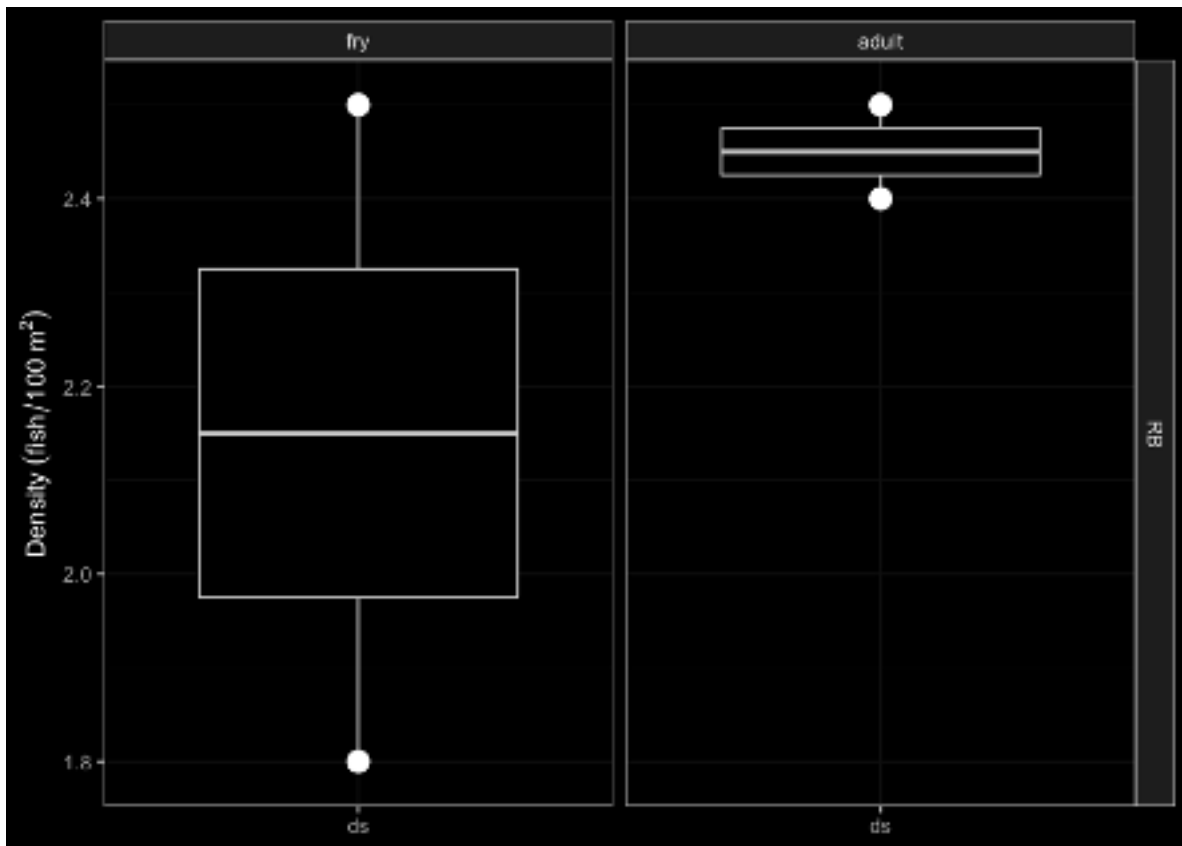


Figure 5.23: Densities of fish (fish/100m<sup>2</sup>) captured downstream of PSCIS crossing 197912.

## Conclusion



Figure 5.24: Left: Typical habitat downstream of PSCIS crossing 197912. Right: Typical habitat downstream of PSCIS crossing 197912.



Figure 5.25: Left: Typical habitat upstream of PSCIS crossing 197912. Right: Typical habitat upstream of PSCIS crossing 197912.





## **Corya Creek - 197960 - Appendix**

### **Site Location**

PSCIS crossing 197960 is located on Corya Creek within the Coryatsaqua 2 (Moricetown) Indian Reserve at Moricetown, BC. PSCIS crossing 197960 is located on CN Railway. Crossing 197960 was located 2.7km upstream from the confluence with the Bulkley River. Crossing 197960 is the responsibility of the Canadian National Railway.

### **Background**

At crossing 197960, Corya Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 65.7km<sup>2</sup>. The elevation of the watershed ranges from a maximum of 2502m to 410m near the crossing (Table [5.38](#)). Upstream of crossing 197960, rainbow trout and dolly varden have previously been recorded (MoE 2020b; Norris 2020). PSCIS crossing 124612 is a bridge located 800m upstream at the powerline crossing and PSCIS crossing 123776 is a newly installed bridge downstream on Highway 16. Witset Creek drains Witset Lake and is a tributary to Corya Creek that flows in immediately downstream of the Highway 16 bridge. Witset Lake is 41ha in size with an associated 12ha of wetland. The upper Corya Creek watershed is glaciated and may provide habitat conditions most suitable for bull trout and cutthroat due to cold water and turbid conditions due to glacial flour. Although only rainbow trout and dolly varden have previously been recorded upstream of the railway, the historic culvert under Highway 16 and the current culvert under the railway may have hindered passage by other species including anadromous salmon.

In spring of 2017 a flood event caused by beaver dam failure forced the evacuation of homes in the Two Mile subdivision of Moricetown (Smithers Interior News 2017). Since this time beaver control activities have taken place in both the Corya and Witset watersheds to reduce the risk of flooding (pers comm. Dallas Nikal, Nico Ridge Consulting).

Table 5.38: Summary of derived upstream watershed statistics for PSCIS crossing 197960 and PSCIS crossing 123775.

| Site   | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|--------|---------|-----------|----------|----------|-------------|----------|--------|
| 123775 | 4.1     | 406       | 478      | 1248     | 762         | 697      | E      |
| 197960 | 65.7    | 415       | 410      | 2502     | 1260        | 1106     | ESE    |

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

Corya Creek was ranked as a high priority for follow up by Irvine (2018) and Mazany-Wright et al. (2021) because of significant amounts of habitat modelled as upstream of the crossing. A summary of habitat modelling outputs is presented in Table 5.39. In the field, PSCIS stream crossing 123775 was also assessed as Witset Lake is located upstream. A map of the watershed is provided in map attachment [093M.102](#).

Table 5.39: Summary of fish habitat modelling for PSCIS crossing 197960.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 27.0      | 24.4             | 90                   |
| ST Lake Reservoir (ha)           | 0.0       | 0.0              | –                    |
| ST Wetland (ha)                  | 0.0       | 0.0              | –                    |
| ST Slopeclass03 Waterbodies (km) | 1.4       | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 4.7       | 3.8              | 81                   |
| ST Slopeclass05 (km)             | 6.8       | 6.6              | 97                   |
| ST Slopeclass08 (km)             | 7.6       | 6.6              | 87                   |
| ST Spawning (km)                 | 6.1       | 6.1              | 100                  |
| ST Rearing (km)                  | 14.1      | 13.9             | 99                   |
| CH Spawning (km)                 | 6.1       | 6.1              | 100                  |
| CH Rearing (km)                  | 10.0      | 9.8              | 98                   |
| CO Spawning (km)                 | 9.1       | 9.1              | 100                  |
| CO Rearing (km)                  | 10.0      | 9.8              | 98                   |
| 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              | –                    |
| All Spawning (km)                | 9.1       | 9.1              | 100                  |
| All Rearing (km)                 | 14.1      | 13.9             | 99                   |
| All Spawning Rearing (km)        | 14.1      | 13.9             | 99                   |

\* Model data is preliminary and subject to adjustments.

### Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 197960 was un-embedded, non-backwatered and ranked as a barrier barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.40). Water temperature was 8°C, pH was 8.6 and conductivity was 138uS/cm.

At the time of the survey, PSCIS crossing 123775 was un-embedded, non-backwatered and ranked as a potential barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table ??).

Table 5.40: Summary of fish passage assessment for PSCIS crossing 197960.

| Location and Stream Data  |  | Crossing Characteristics |               |
|---|--|--------------------------|---------------|
| Date  | 2021-09-13                             | Crossing Sub Type        | Round Culvert |
| PSCIS ID  | 197960                                 | Diameter (m)             | 3.4           |
| External ID   | –                                      | Length (m)               | 24            |
| Crew  | AI KP                                  | Embedded                 | No            |
| UTM Zone  | 9                                      | Depth Embedded (m)       | –             |
| Easting   | 605785.6                               | Resemble Channel         | No            |
| Northing  | 6099884                                | Backwatered              | No            |
| Stream  | Corya Creek                            | Percent Backwatered      | –             |
| Road  | CN Railway                             | Fill Depth (m)           | 1.5           |
| Road Tenure   | Canadian National                      | Outlet Drop (m)          | 0.65          |
| Channel Width (m)   | 18                                     | Outlet Pool Depth (m)    | 3             |
| Stream Slope (%)  | 2.8                                    | Inlet Drop               | No            |
| Beaver Activity   | Yes                                    | Slope (%)                | 2.5           |
| Habitat Value   | High                                   | Valley Fill              | Deep Fill     |
| Final score   | 34                                     | Barrier Result           | Barrier       |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 23            |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |               |

# Stream Characteristics at Crossing

| Location and Stream Data | • | Crossing Characteristics | - |
|--------------------------|---|--------------------------|---|
|--------------------------|---|--------------------------|---|

Comments: Outlet is cracked and drops. Inlet embedded to 2/3 way. 10:33



Corya Creek - 197960 - Appendix

| Location and Stream Data | .   | Crossing Characteristics | -             |
|--------------------------|---|--------------------------|---------------|
| Date                     | 2021-09-15                                      | Crossing Sub Type        | Round Culvert |
| PSCIS ID                 | 123775  | Diameter (m)             | 1.22          |
| External ID              | -   | Length (m)               | 32            |
| Crew                     | DN AN   | Embedded                 | No            |
| UTM Zone                 | 9   | Depth Embedded (m)       | -             |
| Easting                  | 606445.5  | Resemble Channel         | No            |
| Northing                 | 6099726   | Backwatered              | No            |
| Stream                   | Witset Creek                                    | Percent Backwatered      | -             |
| Road                     | Highway 16                                      | Fill Depth (m)           | 0.3           |
| Road Tenure              | MoTi Arterial                                   | Outlet Drop (m)          | 0             |
| Channel Width (m)        | 0.5   | Outlet Pool Depth (m)    | 0             |
| Stream Slope (%)         | 1   | Inlet Drop               | No            |
| Beaver Activity          | No  | Slope (%)                | 0.5           |
| Habitat Value            | Low   | Valley Fill              | Deep Fill     |
| Final score              | 16  | Barrier Result           | Potential     |
| Fix type                 | Replace Structure with Streambed Simulation CBS | Fix Span / Diameter      | 3             |

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





### Stream Characteristics Downstream of 197960

The stream was surveyed downstream from crossing 197960 for 450m (Figure 5.27). Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris, large woody debris, undercut banks, and deep pools. The average channel



width was 25.4m, the average wetted width was 8.9m and the average gradient was 1.7%. The dominant substrate was cobbles with gravels subdominant. The stream was moderately turbid due to glacial flour with abundant quantities of gravels suitably sized for trout and salmon species present. The stream channel was noted as riffle dominated with a lack of complexity due to adjacent riparian clearing and dyke installation. The habitat was rated as medium value for salmonid rearing and spawning.

### **Stream Characteristics Upstream of 197960**

The stream was surveyed upstream from crossing 197960 for 1000m (Figure [5.28](#)). Total cover amount was rated as moderate with overhanging vegetation dominant. Cover was also present as small woody debris, large woody debris, boulders, and undercut banks. The average channel width was 18m, the average wetted width was 8.9m and the average gradient was 2.8%. The dominant substrate was cobbles with gravels subdominant. The first 50 - 100m upstream of crossing channel and banks were noted as armoured with riprap. Abundant gravels suitable for resident and anadromous salmonids were noted throughout. The habitat was rated as medium value as an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

### **Fish Sampling**

To assess potential impacts of the culvert on fisheries values in the stream, electrofishing was conducted with results summarised in Tables [5.43](#) - [5.44](#) and Figure [5.26](#).

### **Structure Remediation and Cost Estimate**

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 197960 with a bridge (23m span) is recommended. The cost of the work is estimated at \$13,800,000 for a cost benefit of 0.7 linear m/\$1000 and 13 m<sup>2</sup>/\$1000.

### **Conclusion**

There was 10km of habitat upstream of crossing 197960 rated as medium value for salmonid rearing and spawning. Crossing 197960 was ranked as a high priority for proceeding to design for replacement. The stream is a cold water glaciated system and may currently provide habitat conditions most suitable for dolly varden and cutthroat trout.

Crossing 197960 was ranked as a low priority for remediation at the time of reporting due to low habitat value within the channel connecting Witset Lake to Corya Creek. Beaver control activities within the watershed to reduce the risk of flooding in the Moricetown likely impacts flow patterns (shorter freshet and flashier flows following precipitation) and the subsequent habitat quality in Witset Creek. A watershed level plan to hold more water on the landscape upstream of the highway and increase the capacity of PSCIS crossing 197960 to pass higher flow events could be considered in the long term to increase the overall health of the watershed and improve the potential for connectivity between Corya Creek and Witset Lake.

## Conclusion

Table 5.42: Summary of habitat details for PSCIS crossing 197960 and 123775.

| Site   | Location   | Length Surveyed (m) | Channel Width (m) | Wetted Width (m) | Pool Depth (m) | Gradient (%) | Total Cover | Habitat Value |
|--------|------------|---------------------|-------------------|------------------|----------------|--------------|-------------|---------------|
| 123775 | Downstream | 100                 | 0.5               | –                | –              | 1.0          | abundant    | low           |
| 123775 | Upstream   | 200                 | 2.4               | 0.9              | –              | 1.2          | moderate    | low           |
| 197960 | Downstream | 450                 | 25.4              | 10.8             | 0.5            | 1.7          | moderate    | medium        |
| 197960 | Upstream   | 1000                | 18.0              | 8.9              | 0.7            | 2.8          | moderate    | medium        |

Table 5.43: Fish sampling site summary for 197960.

| site          | passes | ef_length_m | ef_width_m | area_m2 | enclosure |
|---------------|--------|-------------|------------|---------|-----------|
| 197960_ds_ef1 | 1      | 9.6         | 1.28       | 12.3    | Open      |
| 197960_ds_ef2 | 1      | 5.0         | 1.83       | 9.2     | Open      |
| 197960_ds_ef3 | 1      | 10.1        | 1.67       | 16.9    | Open      |
| 197960_us_ef1 | 1      | 4.7         | 1.65       | 7.8     | Open      |
| 197960_us_ef2 | 1      | 19.0        | 1.86       | 35.3    | Open      |
| 197960_us_ef3 | 1      | 3.3         | 3.27       | 10.8    | Open      |

Table 5.44: Fish sampling density results summary for 197960.

| local_name    | species_code | life_stage | catch | density_100m2 | nfc_pass |
|---------------|--------------|------------|-------|---------------|----------|
| 197960_ds_ef1 | NFC          | –          | 0     | 0.0           | TRUE     |
| 197960_ds_ef2 | DV           | fry        | 2     | 21.7          | FALSE    |
| 197960_ds_ef2 | DV           | parr       | 2     | 21.7          | FALSE    |
| 197960_ds_ef3 | DV           | fry        | 6     | 35.5          | FALSE    |
| 197960_ds_ef3 | DV           | parr       | 1     | 5.9           | FALSE    |
| 197960_us_ef1 | DV           | parr       | 1     | 12.8          | FALSE    |
| 197960_us_ef2 | NFC          | –          | 0     | 0.0           | TRUE     |
| 197960_us_ef3 | DV           | parr       | 1     | 9.3           | FALSE    |

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

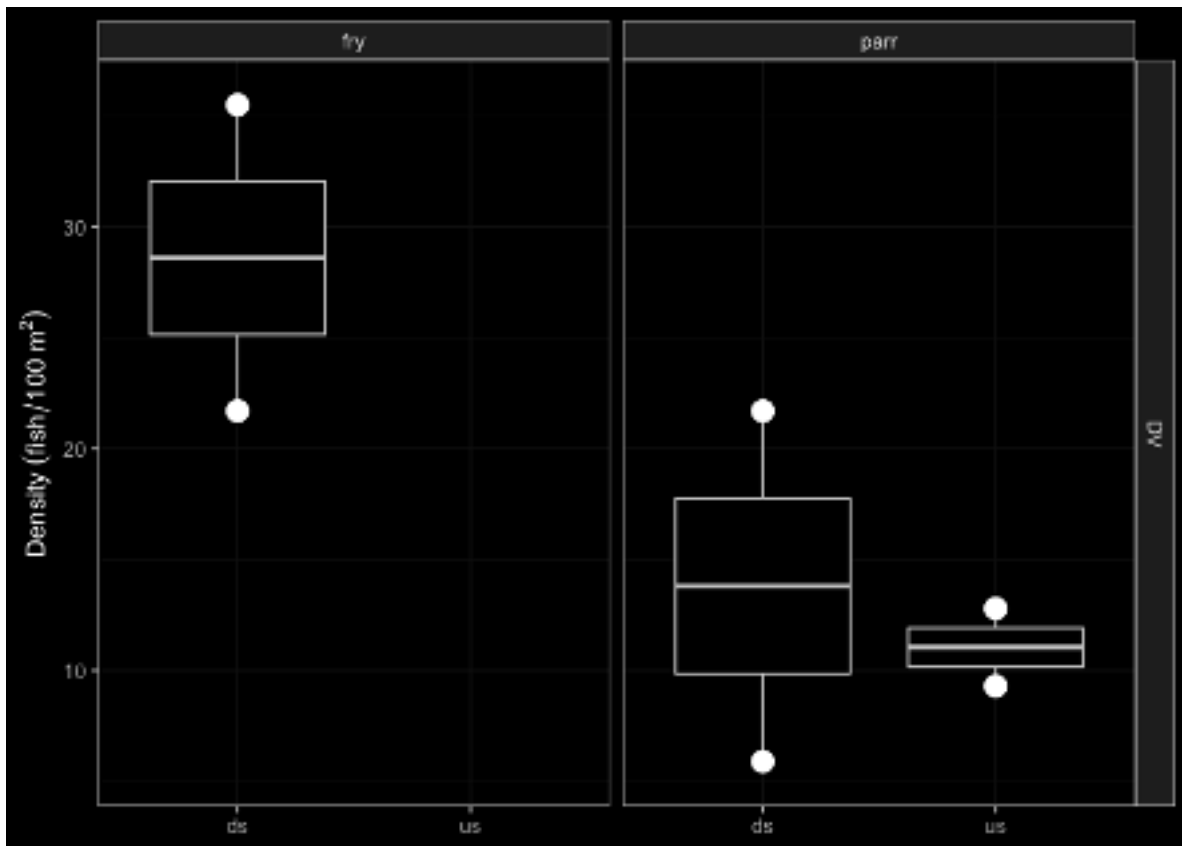


Figure 5.26: Densities of fish (fish/100m<sup>2</sup>) capture upstream and downstream of PSCIS crossing 197960.

## Conclusion



Figure 5.27: Left: Typical habitat downstream of PSCIS crossing 197960. Right: Typical habitat downstream of PSCIS crossing 197960.



Figure 5.28: Left: Typical habitat upstream of PSCIS crossing 197960. Right: Typical habitat upstream of PSCIS crossing 197960.



## Peacock Creek - 197962 - Appendix

### Site Location

PSCIS crossing 197962 was located on Peacock Creek approximately 9km west of Houston, BC. Crossing 197962 was located on Morice FSR approximately 1.2km upstream from the confluence with the Morice River. Crossing 197962 is the responsibility of the Ministry of Forests.

### Background

At crossing 197962, Peacock Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 36.3km<sup>2</sup>. The elevation of the watershed ranges from a maximum of 1822m to 654m near the crossing (Table [5.45](#)).

Upstream of crossing 197962, no fish species have previously been recorded within provincial databases (MoE 2020b; Norris 2020).

McCarthy and Fernando (2015) and Smith (2018) reported that a large concrete weir and spillway that were built in the 1990s were not functioning correctly and that the crossing was a high priority fish barrier. Gaboury and Smith (2016) conducted a site survey in 2015 and produced design options to remediate passage. There were no records of crossing 197962 within PSCIS before the 2021 assessment data was loaded in. The site was prioritized for follow up because of significant amounts of habitat modelled as upstream of the crossing (Table [5.46](#)). A map of the watershed is provided in map attachment [093L.109](#).

Table 5.45: Summary of derived upstream watershed statistics for PSCIS crossing 197962.

| Site   | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|--------|---------|-----------|----------|----------|-------------|----------|--------|
| 197962 | 36.3    | 631       | 654      | 1822     | 1166        | 1119     | E      |

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

Table 5.46: Summary of fish habitat modelling for PSCIS crossing 197962.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 6.1       | 6.1              | 100                  |
| ST Lake Reservoir (ha)           | –         | 0.0              | –                    |
| ST Wetland (ha)                  | –         | 0.0              | –                    |
| ST Slopeclass03 Waterbodies (km) | 0.0       | 0.0              | –                    |
| ST Slopeclass03 (km)             | 0.4       | 0.4              | 100                  |
| ST Slopeclass05 (km)             | 4.5       | 4.5              | 100                  |
| ST Slopeclass08 (km)             | 0.1       | 0.1              | 100                  |
| ST Spawning (km)                 | 3.0       | 3.0              | 100                  |
| ST Rearing (km)                  | 4.9       | 4.9              | 100                  |
| CH Spawning (km)                 | 3.0       | 3.0              | 100                  |
| CH Rearing (km)                  | 4.8       | 4.8              | 100                  |
| CO Spawning (km)                 | 4.8       | 4.8              | 100                  |
| CO Rearing (km)                  | 4.8       | 4.8              | 100                  |
| CO Rearing (ha)                  | –         | 0.0              | –                    |
| SK Spawning (km)                 | 0.0       | 0.0              | –                    |
| SK Rearing (km)                  | 0.0       | 0.0              | –                    |
| SK Rearing (ha)                  | –         | 0.0              | –                    |
| All Spawning (km)                | 4.8       | 4.8              | 100                  |
| All Rearing (km)                 | 4.9       | 4.9              | 100                  |
| All Spawning Rearing (km)        | 4.9       | 4.9              | 100                  |

\* Model data is preliminary and subject to adjustments.

### Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 197962 was un-backwatered, un-embedded and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.47). Water temperature was 8°C, pH was 8.2 and conductivity was 222uS/cm.

Table 5.47: Summary of fish passage assessment for PSCIS crossing 197962.

| Location and Stream Data | •          | Crossing Characteristics | –            |
|--------------------------|------------|--------------------------|--------------|
| Date                     | 2021-09-07 | Crossing Sub Type        | Oval Culvert |
| PSCIS ID                 | 197962     | Diameter (m)             | 3.6          |
| External ID              | –          | Length (m)               | 15           |
| Crew                     | KP         | Embedded                 | No           |
| UTM Zone                 | 9          | Depth Embedded (m)       | –            |
| Easting                  | 643460.3   | Resemble Channel         | No           |
| Northing                 | 6025890    | Backwatered              | No           |



## Stream Characteristics at Crossing

| Location and Stream Data  |  | Crossing Characteristics |           |
|---|--|--------------------------|-----------|
| Stream  | Peacock Creek                          | Percent Backwatered      | –         |
| Road  | Morice FSR                             | Fill Depth (m)           | 3.5       |
| Road Tenure   | FLNR DND 4656                          | Outlet Drop (m)          | 0.5       |
| Channel Width (m)   | 9.3                                    | Outlet Pool Depth (m)    | 1.05      |
| Stream Slope (%)  | 4                                      | Inlet Drop               | Yes       |
| Beaver Activity   | No                                     | Slope (%)                | 3.5       |
| Habitat Value   | Medium                                 | Valley Fill              | Deep Fill |
| Final score   | 39                                     | Barrier Result           | Barrier   |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 16        |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |           |

| Location and Stream Data   | Crossing Characteristics |
|--|--------------------------|
| <p>Comments: Partial inlet drop of varying height due to large woody debris and boulders. Side channel dry, must be seasonal use only. 17:47</p> |                          |
|  |                          |

**Stream Characteristics Downstream**

The stream was surveyed downstream from crossing 197962 for 600m (Figure 5.30). The dominant substrate was cobbles with boulders sub-dominant., The average channel width was 8.1m, the

## Stream Characteristics Upstream

average wetted width was 4.2m, and the average gradient was 2.6%. Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, boulders, deep pools, and overhanging vegetation. Multiple areas of side channels and small braided sections were noted with intermittent sections of aggraded cobbles / gravels moved in high flows. There were pockets of gravel present suitable for spawning resident and anadromous salmonids.

The complex habitat was rated as high value for salmonid rearing and spawning.

## Stream Characteristics Upstream

The stream was surveyed upstream from crossing 197962 for 750m (Figure [5.31](#)). Total cover amount was rated as moderate with boulders dominant. Cover was also present as small woody debris, large woody debris, undercut banks, and deep pools. The average channel width was 6.9m, the average wetted width was 3.6m, and the average gradient was 2.6%. The dominant substrate was cobbles with boulders sub-dominant. Survey notes indicate signs of high powerful flows, including clumped large woody debris. Patches of gravels suitable for spawning were present. Habitat value was rated as high as the surveyed area was considered an important migration corridor containing suitable spawning habitat and having high rearing potential.

## Fish Sampling

Electrofishing was conducted with results summarised in Tables [5.49](#) - [5.50](#) and Figure [5.29](#).

## Structure Remediation and Cost

Through a collaboration between FLNR, Canfor and Coastal Gaslink, PSCIS crossing 197962 was remediated in the fall of 2021 shortly after habitat confirmation field assessments were completed.

## Conclusion

Access was restored to an estimated 4.8km of habitat modelled upstream of crossing 197962 due to the replacement of the culvert with a clear span bridge. Although numerous dolly varden and several rainbow trout were captured upstream, coho salmon were captured downstream only before the site restoration indicating that 197962 was a complete barrier to upstream fish passage. The completion of three multi-pass closed electrofishing sites both upstream and downstream of the crossing can provide baseline data for future effectiveness monitoring at the site to track changes in fish population structure resulting from the works.

Table 5.48: Summary of habitat details for PSCIS crossing 197962.

| Site   | Location   | Length Surveyed (m) | Channel Width (m) | Wetted Width (m) | Pool Depth (m) | Gradient (%) | Total Cover | Habitat Value |
|--------|------------|---------------------|-------------------|------------------|----------------|--------------|-------------|---------------|
| 197962 | Downstream | 600                 | 8.1               | 4.2              | 0.4            | 2.6          | moderate    | high          |
| 197962 | Upstream   | 750                 | 6.9               | 3.6              | 0.4            | 2.8          | moderate    | high          |

Table 5.49: Fish sampling site summary for 197962.

| site          | passes | ef_length_m | ef_width_m | area_m2 | enclosure |
|---------------|--------|-------------|------------|---------|-----------|
| 197962_ds_ef1 | 3      | 14.2        | 4.83       | 68.6    | Closed    |
| 197962_ds_ef2 | 3      | 6.8         | 4.63       | 31.5    | Closed    |
| 197962_ds_ef3 | 3      | 7.1         | 2.90       | 20.6    | Closed    |
| 197962_us_ef1 | 3      | 7.2         | 3.87       | 27.9    | Closed    |
| 197962_us_ef2 | 3      | 5.7         | 4.97       | 28.3    | Closed    |
| 197962_us_ef3 | 3      | 7.0         | 5.27       | 36.9    | Closed    |

Table 5.50: Fish sampling density results summary for 197962.

| local_name    | species_code | life_stage | catch | density_100m2 | nfc_pass |
|---------------|--------------|------------|-------|---------------|----------|
| 197962_ds_ef1 | CO           | fry        | 1     | 1.5           | TRUE     |
| 197962_ds_ef1 | CO           | parr       | 1     | 1.5           | TRUE     |
| 197962_ds_ef1 | CT           | parr       | 1     | 1.5           | TRUE     |
| 197962_ds_ef1 | DV           | fry        | 3     | 4.4           | FALSE    |
| 197962_ds_ef1 | DV           | parr       | 5     | 7.3           | FALSE    |
| 197962_ds_ef1 | DV           | adult      | 1     | 1.5           | TRUE     |
| 197962_ds_ef1 | RB           | fry        | 3     | 4.4           | FALSE    |
| 197962_ds_ef1 | RB           | parr       | 9     | 13.1          | TRUE     |
| 197962_ds_ef1 | RB           | juvenile   | 1     | 1.5           | FALSE    |
| 197962_ds_ef2 | DV           | fry        | 2     | 6.3           | TRUE     |
| 197962_ds_ef2 | DV           | parr       | 3     | 9.5           | TRUE     |
| 197962_ds_ef2 | DV           | juvenile   | 1     | 3.2           | TRUE     |
| 197962_ds_ef2 | NFC          | -          | 0     | 0.0           | TRUE     |
| 197962_ds_ef2 | RB           | fry        | 5     | 15.9          | TRUE     |
| 197962_ds_ef2 | RB           | parr       | 4     | 12.7          | TRUE     |
| 197962_ds_ef3 | CO           | fry        | 1     | 4.9           | TRUE     |
| 197962_ds_ef3 | CO           | parr       | 7     | 34.0          | TRUE     |
| 197962_ds_ef3 | DV           | fry        | 1     | 4.9           | TRUE     |
| 197962_ds_ef3 | NFC          | -          | 0     | 0.0           | TRUE     |
| 197962_ds_ef3 | RB           | fry        | 1     | 4.9           | TRUE     |
| 197962_ds_ef3 | RB           | parr       | 3     | 14.6          | TRUE     |
| 197962_us_ef1 | DV           | fry        | 8     | 28.7          | TRUE     |
| 197962_us_ef1 | DV           | parr       | 6     | 21.5          | FALSE    |
| 197962_us_ef1 | DV           | juvenile   | 2     | 7.2           | TRUE     |
| 197962_us_ef1 | RB           | juvenile   | 1     | 3.6           | TRUE     |

## Conclusion

| local_name    | species_code | life_stage | catch | density_100m2 | nfc_pass |
|---------------|--------------|------------|-------|---------------|----------|
| 197962_us_ef2 | DV           | fry        | 5     | 17.7          | TRUE     |
| 197962_us_ef2 | DV           | parr       | 2     | 7.1           | TRUE     |
| 197962_us_ef2 | DV           | juvenile   | 1     | 3.5           | FALSE    |
| 197962_us_ef2 | DV           | adult      | 1     | 3.5           | TRUE     |
| 197962_us_ef3 | DV           | fry        | 6     | 16.3          | TRUE     |
| 197962_us_ef3 | DV           | parr       | 7     | 19.0          | FALSE    |
| 197962_us_ef3 | DV           | juvenile   | 2     | 5.4           | TRUE     |
| 197962_us_ef3 | RB           | juvenile   | 1     | 2.7           | TRUE     |
| 197962_us_ef3 | RB           | adult      | 1     | 2.7           | TRUE     |

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

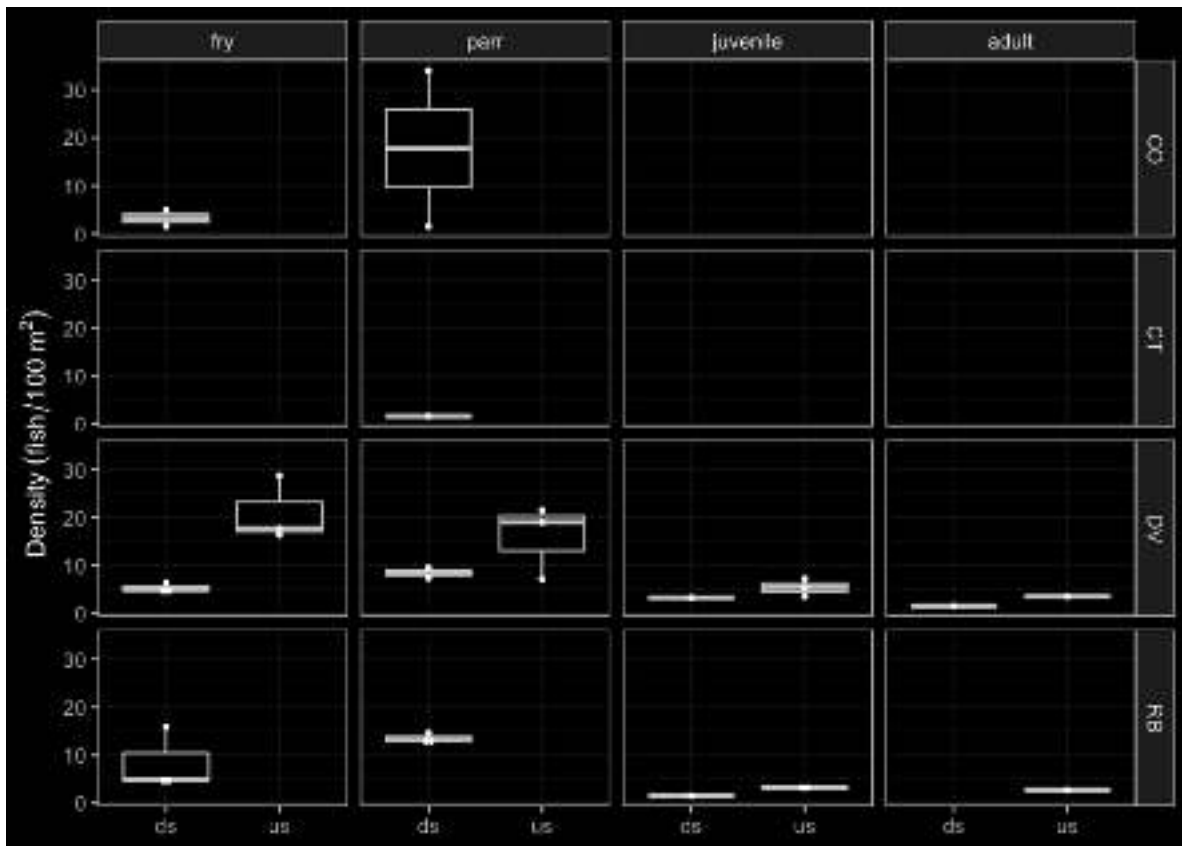


Figure 5.29: Densities of fish (fish/100m2) capture upstream and downstream of PSCIS crossing 197962.



Conclusion



Figure 5.30: Left: Habitat downstream of PSCIS crossing 197962. Right: Habitat downstream of PSCIS crossing 197962.



Figure 5.31: Left: Habitat upstream of PSCIS crossing 197962. Right: Habitat upstream of PSCIS crossing 197962.





## Taman Creek - 197967 - Appendix

### Site Location

PSCIS crossing 197967 is located on the Upper Bulkley River approximately 22.5km east of Topley, BC. PSCIS crossing 197967 is located on Highway 16, approximately 2.5km upstream from Bulkley Lake. Although Taman Creek flows into this stream approximately 750m upstream of the highway, the stream at the highway is commonly referred to as Taman Creek including on highway signage. The culvert is the responsibility of the Ministry of Transportation and Infrastructure.

### Background

At crossing 197967, the Upper Bulkley River is a fifth order stream with a watershed area upstream of the crossing of approximately 93.8km<sup>2</sup>. The elevation of the watershed ranges from a maximum of 1373m to 375m near the crossing (Table 5.51). Upstream of crossing 197967, longnose sucker, largescale sucker, lake chub, brassy minnow, northern pikeminnow, longnose dace, redbside shiner, and rainbow trout have previously been recorded upstream (MoE 2020b; Norris 2020).

Table 5.51: Summary of derived upstream watershed statistics for PSCIS crossing 197967.

| Site   | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|--------|---------|-----------|----------|----------|-------------|----------|--------|
| 197967 | 93.8    | 736       | 699      | 1373     | 900         | 870      | S      |

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

although no records of the falls have yet been recorded in MoE (2020d), Redden and Jedrzejczyk (1997) report that a 15m high rock falls is located at 7.8km upstream from the confluence with the upper Bulkley River and represents the upstream limit of fish distribution in the watershed. They also report excellent and good rearing potential in upper reaches of the stream located from 5.1km to 7.8km upstream of the confluence.

McCarthy and Fernando (2015) report that the culvert has received past efforts to facilitate backwatering including rock lines to establish backwater pools downstream of the culvert. They also report that the works were not functioning correctly. Smith (2018) visited the site in 2017, subjectively rated the crossing as a potential barrier and ranked the crossing as a low priority for follow up. Irvine (2021) noted that a design was being drafted for the Highway 16 crossing by Ministry of Transportation and Infrastructure in 2021.

PSCIS stream crossing 197967 was ranked as a high priority for follow up by Mazany-Wright et al. (2021) because of significant amounts of habitat modelled as upstream of the crossing and because gathering of habitat confirmation information was considered as potentially beneficial for informing prioritization of the site should remediation plans stall. A total of 172ha of lake and 695ha of wetland is modelled upstream and a summary of habitat modelling outputs is presented in Table [5.52](#). A map of the watershed is provided in map attachment [093L.115](#).

Table 5.52: Summary of fish habitat modelling for PSCIS crossing 197967.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 142.4     | 20.0             | 14                   |
| ST Lake Reservoir (ha)           | 172.4     | 98.7             | 57                   |
| ST Wetland (ha)                  | 631.7     | 208.8            | 33                   |
| ST Slopeclass03 Waterbodies (km) | 34.5      | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 30.7      | 7.2              | 23                   |
| ST Slopeclass05 (km)             | 36.9      | 2.1              | 6                    |
| ST Slopeclass08 (km)             | 26.2      | 0.0              | 0                    |
| ST Spawning (km)                 | 7.2       | 6.0              | 83                   |
| ST Rearing (km)                  | 35.8      | 7.9              | 22                   |
| CH Spawning (km)                 | 7.2       | 6.0              | 83                   |
| CH Rearing (km)                  | 10.9      | 6.0              | 55                   |
| CO Spawning (km)                 | 22.2      | 7.4              | 33                   |
| CO Rearing (km)                  | 51.9      | 14.6             | 28                   |
| CO Rearing (ha)                  | 285.7     | 0.0              | 0                    |
| SK Spawning (km)                 | 0.0       | 0.0              | –                    |
| SK Rearing (km)                  | 0.0       | 0.0              | –                    |
| SK Rearing (ha)                  | –         | 0.0              | –                    |
| All Spawning (km)                | 22.2      | 7.4              | 33                   |
| All Rearing (km)                 | 58.0      | 14.6             | 25                   |
| All Spawning Rearing (km)        | 58.0      | 14.6             | 25                   |

\* Model data is preliminary and subject to adjustments.

### Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 197967 was non-backwatered and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.53). Water temperature was 12°C, pH was 7.2 and conductivity was 359uS/cm. A beaver dam was noted just upstream of the culvert inlet (~1.5m high).

Table 5.53: Summary of fish passage assessment for PSCIS crossing 197967.

| Location and Stream Data  |  | Crossing Characteristics |               |
|---|--|--------------------------|---------------|
| Date  | 2021-08-31                             | Crossing Sub Type        | Round Culvert |
| PSCIS ID  | 197967                                 | Diameter (m)             | 3             |
| External ID   | –                                      | Length (m)               | 30            |
| Crew  | KP AI                                  | Embedded                 | No            |
| UTM Zone  | 9                                      | Depth Embedded (m)       | –             |
| Easting   | 692434.6                               | Resemble Channel         | No            |
| Northing  | 6032331                                | Backwatered              | No            |
| Stream  | Taman Creek                            | Percent Backwatered      | –             |
| Road  | Highway 16                             | Fill Depth (m)           | 9.99          |
| Road Tenure   | Highway                                | Outlet Drop (m)          | 0             |
| Channel Width (m)   | 5.3                                    | Outlet Pool Depth (m)    | 0.4           |
| Stream Slope (%)  | 1.7                                    | Inlet Drop               | Yes           |
| Beaver Activity   | Yes                                    | Slope (%)                | 2.5           |
| Habitat Value   | Medium                                 | Valley Fill              | Deep Fill     |
| Final score   | 27                                     | Barrier Result           | Barrier       |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 31            |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |               |

## Stream Characteristics Downstream

| Location and Stream Data  | Crossing Characteristics |
|---|--------------------------|
| <p>Comments: Beaver dam at inlet ~1.5m high. Rocks placed at outlet reducing drop to 0, rocks about long, and have staged drop of 0.7m. 12:20</p> |                          |
|   |                          |

## Stream Characteristics Downstream

The stream was surveyed downstream from crossing 197967 for 375m to the bridge (PSCIS 197966) located on Ross Lake Cutoff Rd (Figure 5.32). The average channel width was 5.7m, the

average wetted width was 3.1m, and the average gradient was 2.5%. The dominant substrate was cobbles with fines sub-dominant. Total cover amount was rated as trace with overhanging vegetation dominant. Cover was also present as deep pools and instream vegetation. The site was noted as having significant amounts of thick red colored algae for the majority of survey. Flow was very low with uncommon pools. Fence material was noted in or across channel in two locations and riparian vegetation had been removed where an agricultural field and fence line were close. Although considered an important migration corridor, the habitat was rated as medium value for salmonid rearing and spawning due to limited complexity resulting from adjacent agricultural activities.

PSCIS crossing 197964 is located on the CN Railway approximately 1.7km downstream of the highway. Although the crossing was assessed as a potential barrier according to the provincial protocol it was 100% backwatered at the time of the assessment and appeared passable to all species and life stages at the time of assessment (Table 5.54).

Table 5.54: Summary of fish passage assessment for PSCIS crossing 1805529.

| Location and Stream Data  |  | Crossing Characteristics |               |
|---|--|--------------------------|---------------|
| Date  | 2021-08-31                             | Crossing Sub Type        | Round Culvert |
| PSCIS ID  | –                                      | Diameter (m)             | 1.5           |
| External ID   | 1805529                                | Length (m)               | 21            |
| Crew  | KP AI                                  | Embedded                 | No            |
| UTM Zone  | 9                                      | Depth Embedded (m)       | –             |
| Easting   | 691218.3                               | Resemble Channel         | No            |
| Northing  | 6031478                                | Backwatered              | Yes           |
| Stream  | Bulkley River                          | Percent Backwatered      | 100           |
| Road  | Railway                                | Fill Depth (m)           | 3             |
| Road Tenure   | Canadian National                      | Outlet Drop (m)          | 0             |
| Channel Width (m)   | 9                                      | Outlet Pool Depth (m)    | 0.8           |
| Stream Slope (%)  | 0                                      | Inlet Drop               | No            |
| Beaver Activity   | No                                     | Slope (%)                | 0.7           |
| Habitat Value   | High                                   | Valley Fill              | Deep Fill     |
| Final score   | 19                                     | Barrier Result           | Potential     |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 14            |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |               |



## Stream Characteristics Upstream

| Location and Stream Data   | Crossing Characteristics |
|--|--------------------------|
| Comments: Backwatered fully, appears fully passable. Fish sighted at outlet. Distance from water surface to top of culvert is 70cm. 9:58 |                          |
|   |                          |

## Stream Characteristics Upstream

The stream was surveyed upstream from crossing 197967 for 800m (Figure 5.33). The average channel width was 5.3m, the average wetted width was 2.3m, and the average gradient was 2.5%.,

Total cover amount was rated as moderate with deep pools dominant. Cover was also present as large woody debris and overhanging vegetation., The dominant substrate was gravels with cobbles sub-dominant. The first ~250m of channel upstream of the highway were noted as beaver influenced wetland with extensive dry sections at the time of the survey. Frequent pockets of gravels and small cobbles suitable for rainbow trout and coho salmon spawning were noted throughout the area surveyed. A canyon section of stream was located upstream of the crossing approximately 300m contained deep bedrock pools with small fish present and no large woody debris. One deep pool upstream of the canyon section contained likely 2-3 year old juveniles (coloring indicated rainbow trout, unverified). The habitat was rated as medium value as an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

Taman Creek was surveyed for 400m above where it joins the Bulkley River mainstem upstream of PSCIS crossing 197967 (Figure [5.34](#)). 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., The average channel width was 3.8m, the average wetted width was 2.2m, and the average gradient was 2.5%., The dominant substrate was gravels with cobbles sub-dominant. The water in Taman Creek during the survey was noted as turbid with numerous salmonid fry present at the downstream end of the site. Algae was abundant throughout the system and eroding banks were common. Abundant gravels suitable for resident rainbow trout and coho salmon spawning were present and habitat was rated as medium value for salmon rearing and spawning.

The upper Bulkley River was surveyed at numerous crossings upstream of the highway with bridges noted at PSCIS crossings 197968, 197969, 197973 and 197971. Survey crews were not able to access crossing 1802047 from Highway 16 due to a gate and private land postings. This crossing is located between Broman Lake and Old Woman Lake with public access potentially possible by ATV from the powerline to the north. Modelled crossing 1802663 is located on the mainstem of Taman Creek 1.8km upstream of the confluence with the upper Bulkley River. Although this site was not assessed it was considered likely to be a ford due to its location on the powerline. Numerous other unassessed crossings are modelled as located upstream within the system on Taman Creek as well as the upper Bulkley River and their tributaries. As the effort required to assess all these crossings was likely significant with the majority of higher value gains most likely present in the lower reaches, field time was allocated elsewhere in the greater Bulkley River watershed.

### **Structure Remediation and Cost Estimate**

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 197967 with a bridge (31m span) is recommended. The cost of the work is estimated at \$18,600,000 for a cost benefit of 2.8 linear m/\$1000 and 14.8 m<sup>2</sup>/\$1000.

## Conclusion

### **Conclusion**

There was 51.9km of habitat modelled upstream of crossing 197967 rated as medium value for salmonid rearing and spawning. Crossing 197967 was ranked as a moderate priority for proceeding to design for replacement. At the time of reporting, the Ministry of transportation and Infrastructure were in the process of planning for crossing replacement. Of note, due to budgetary constraints, survey plans for the site call for horizontal drilling of a closed bottom structure under the highway with costs likely lower than those estimated for replacement with a clear span bridge. Should structure replacement proceed follow up monitoring is recommended to assess passability and utilization of the crossing by downstream fish populations including coho who have been recorded in the upper Bulkley River within 100m downstream of crossing 197967.

Table 5.55: Summary of habitat details for PSCIS crossing 197967.

| Site   | Location   | Length Surveyed (m) | Channel Width (m) | Wetted Width (m) | Pool Depth (m) | Gradient (%) | Total Cover | Habitat Value |
|--------|------------|---------------------|-------------------|------------------|----------------|--------------|-------------|---------------|
| 197967 | Downstream | 375                 | 5.7               | 3.1              | 0.5            | 2.5          | trace       | medium        |
| 197967 | Upstream   | 800                 | 5.3               | 2.3              | 0.7            | 1.7          | moderate    | medium        |
| 197967 | Upstream2  | 400                 | 3.8               | 2.2              | 0.5            | 1.5          | moderate    | medium        |



Figure 5.32: Left: Habitat downstream of PSCIS crossing 197967. Right: Habitat downstream of PSCIS crossing 197967.



Conclusion



Figure 5.33: Left: Habitat upstream of PSCIS crossing 197967. Right: Habitat upstream of PSCIS crossing 197967.



Figure 5.34: Left: Habitat upstream of PSCIS crossing 197967. Right: Habitat upstream of PSCIS crossing 197967.



## **Ailport Creek - 197976 & 197975 - Appendix**

### **Site Location**

PSCIS crossing 197976 and 197975 are located on Ailport Creek approximately 7km south-west of Topley, BC. PSCIS crossing 197976 is located on Highway 16 and 197975 is located on a private driveway. Crossing 197976 was located 4.2km upstream from the confluence with the Bulkley River and crossing 197975 was located 393m upstream fo Highway 16. Crossing 197976 is the responsibility of the Ministry of Transportation and Infrastructure and crossing 197976 is the responsibility of the private land owner.

### **Background**

At crossing 197976, Ailport Creek is a fifth order stream with a watershed area upstream of the crossing of approximately 66.9km<sup>2</sup>. The elevation of the watershed ranges from a maximum of 1445m to 375m near the crossing (Table [5.56](#)).

Upstream of crossing 197976, cutthroat trout, coho salmon, and rainbow trout have previously been recorded (MoE 2020b; Norris 2020). A. Gottesfeld and Rabnett (2007) report that upper Bulkley coho and steelhead spawn and rear in Ailport Creek. An adjacent landowner noted that in the past, during a high flow event, an adult steelhead was stranded in a pond at the side of the field adjacent to the stream upstream of crossing 197975. Another adjacent landowner reports that historic high flow events in the watershed were likely related to beaver dam failures in the upper reaches of the stream network.

DFO (1998), (as cited in McCarthy and Fernando (2015)) reported that crossing 197976 was a barrier at low flows. Following site visits in 2007 and 2017, Wilson and Rabnett (2007) and Smith (2018) reported that the culvert was not an issue for passage. There were no records found of crossing 197975 being assessed for fish passage in the past.

Government of British Columbia (2022) records indicate that downstream of 197976 a range tenure is held by 102039220 Saskatchewan Ltd. and that tenure for the first 210m of stream immediately upstream of the highway is registered to Danny Staudt. Additionally, there are multiple other range tenures overlapping Ailport Creek and tributaries further up in the watershed.

There are numerous modelled stream crossing locations upstream of 197975 however all crossings on the mainstem appear to be bridges in aerial imagery.



PSCIS stream crossings on Ailport Creek were ranked as high priorities for follow up by Irvine (2021) and Mazany-Wright et al. (2021) because of significant amounts of habitat modelled as upstream of the crossing. A total of 42ha of lake and 374ha of wetland is modelled upstream with a summary of additional habitat modelling outputs presented in Tables [5.57](#) - [5.58](#). A map of the watershed is provided in map attachment [093L.115](#).

Table 5.56: Summary of derived upstream watershed statistics for PSCIS crossing 197976.

| Site   | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|--------|---------|-----------|----------|----------|-------------|----------|--------|
| 197976 | 66.9    | 729       | 736      | 1445     | 1186        | 1093     | SSW    |

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

Table 5.57: Summary of fish habitat modelling for PSCIS crossing 197976.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 53.1      | 0.4              | 1                    |
| ST Lake Reservoir (ha)           | 29.8      | 0.0              | 0                    |
| ST Wetland (ha)                  | 211.0     | 0.0              | 0                    |
| ST Slopeclass03 Waterbodies (km) | 10.7      | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 17.6      | 0.4              | 2                    |
| ST Slopeclass05 (km)             | 9.8       | 0.0              | 0                    |
| ST Slopeclass08 (km)             | 7.6       | 0.0              | 0                    |
| ST Spawning (km)                 | 9.9       | 0.4              | 4                    |
| ST Rearing (km)                  | 19.8      | 0.4              | 2                    |
| CH Spawning (km)                 | 9.9       | 0.4              | 4                    |
| CH Rearing (km)                  | 11.9      | 0.4              | 3                    |
| CO Spawning (km)                 | 13.5      | 0.4              | 3                    |
| CO Rearing (km)                  | 25.1      | 0.4              | 2                    |
| CO Rearing (ha)                  | 96.1      | 0.0              | 0                    |
| SK Spawning (km)                 | 0.0       | 0.0              | –                    |
| SK Rearing (km)                  | 0.0       | 0.0              | –                    |
| SK Rearing (ha)                  | –         | 0.0              | –                    |
| All Spawning (km)                | 13.5      | 0.4              | 3                    |
| All Rearing (km)                 | 28.2      | 0.4              | 1                    |
| All Spawning Rearing (km)        | 28.2      | 0.4              | 1                    |

\* Model data is preliminary and subject to adjustments.

Table 5.58: Summary of fish habitat modelling for PSCIS crossing 197975.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 52.8      | 38.4             | 73                   |
| ST Lake Reservoir (ha)           | 29.8      | 28.9             | 97                   |
| ST Wetland (ha)                  | 211.0     | 149.7            | 71                   |
| ST Slopeclass03 Waterbodies (km) | 10.7      | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 17.2      | 14.5             | 84                   |
| ST Slopeclass05 (km)             | 9.8       | 5.6              | 57                   |
| ST Slopeclass08 (km)             | 7.6       | 6.6              | 87                   |
| ST Spawning (km)                 | 9.6       | 9.3              | 97                   |
| ST Rearing (km)                  | 19.4      | 16.7             | 86                   |
| CH Spawning (km)                 | 9.6       | 9.3              | 97                   |
| CH Rearing (km)                  | 11.5      | 10.8             | 94                   |
| CO Spawning (km)                 | 13.1      | 11.4             | 87                   |
| CO Rearing (km)                  | 24.7      | 21.8             | 88                   |
| CO Rearing (ha)                  | 96.1      | 0.0              | 0                    |
| SK Spawning (km)                 | 0.0       | 0.0              | –                    |
| SK Rearing (km)                  | 0.0       | 0.0              | –                    |
| SK Rearing (ha)                  | –         | 0.0              | –                    |

| Habitat                   | Potential | Remediation Gain | Remediation Gain (%) |
|---------------------------|-----------|------------------|----------------------|
| All Spawning (km)         | 13.1      | 11.4             | 87                   |
| All Rearing (km)          | 27.8      | 24.5             | 88                   |
| All Spawning Rearing (km) | 27.8      | 24.5             | 88                   |

\* Model data is preliminary and subject to adjustments.

### Stream Characteristics at Crossing


At the time of the survey, PSCIS crossing 197976 was 50% backwatered, un-embedded and ranked as a barrier to upstream fish passage according to the provincial protocol (MoE 2011b) (Table 5.59). A juvenile fish (~140 cm) was noted as easily swimming upstream through the culvert during the survey. PSCIS crossing 197976 was not backwatered, not embedded and ranked as a barrier to upstream fish passage according to the provincial protocol (Table 5.60). Water temperature was 11°C, pH was 7 and conductivity was 248µS/cm.

Table 5.59: Summary of fish passage assessment for PSCIS crossing 197976.

| Location and Stream Data |  | Crossing Characteristics |              |
|--------------------------|--|--------------------------|--------------|
| Date                     | 2021-08-31                             | Crossing Sub Type        | Oval Culvert |
| PSCIS ID                 | 197976                                 | Diameter (m)             | 3.5          |
| External ID              | –                                      | Length (m)               | 23           |
| Crew                     | KP                                     | Embedded                 | No           |
| UTM Zone                 | 9                                      | Depth Embedded (m)       | –            |
| Easting                  | 680644.8                               | Resemble Channel         | No           |
| Northing                 | 6039756                                | Backwatered              | Yes          |
| Stream                   | Ailport Creek                          | Percent Backwatered      | 50           |
| Road                     | Highway 16                             | Fill Depth (m)           | 3            |
| Road Tenure              | Highway                                | Outlet Drop (m)          | –            |
| Channel Width (m)        | 7.5                                    | Outlet Pool Depth (m)    | 0.55         |
| Stream Slope (%)         | 4                                      | Inlet Drop               | No           |
| Beaver Activity          | No                                     | Slope (%)                | 2            |
| Habitat Value            | High                                   | Valley Fill              | Deep Fill    |
| Final score              | 24                                     | Barrier Result           | Barrier      |
| Fix type                 | Replace with New Open Bottom Structure | Fix Span / Diameter      | 12.5         |

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

# Stream Characteristics at Crossing

| Location and Stream Data  | Crossing Characteristics |
|---|--------------------------|
| <p>Comments: Fish sighted upstream, not aligned with stream, channel runs into rip rap berm of highway then over closed bottom structure. Pool (40cn) on upstream inlet. Fish sighted in downstream pool. 18:16</p> |                          |
|    |                          |

| Location and Stream Data  | .                                      | Crossing Characteristics | -             |
|---|--|--------------------------|---------------|
| Date  | 2021-08-31                             | Crossing Sub Type        | Round Culvert |
| PSCIS ID  | 197975                                 | Diameter (m)             | 3             |
| External ID   | -                                      | Length (m)               | 10            |
| Crew  | KP                                     | Embedded                 | No            |
| UTM Zone  | 9                                      | Depth Embedded (m)       | -             |
| Easting   | 680832                                 | Resemble Channel         | No            |
| Northing  | 6040045                                | Backwatered              | No            |
| Stream  | Ailport Creek                          | Percent Backwatered      | -             |
| Road  | Private Driveway                       | Fill Depth (m)           | 0.5           |
| Road Tenure   | Unclassified                           | Outlet Drop (m)          | 0.3           |
| Channel Width (m)   | 6.5                                    | Outlet Pool Depth (m)    | 1.45          |
| Stream Slope (%)  | 3                                      | Inlet Drop               | No            |
| Beaver Activity   | No                                     | Slope (%)                | 4             |
| Habitat Value   | Medium                                 | Valley Fill              | Deep Fill     |
| Final score   | 36                                     | Barrier Result           | Barrier       |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 11.5          |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |               |



# Stream Characteristics at Crossing

| Location and Stream Data | • Crossing Characteristics | - |
|--------------------------|----------------------------|---|
|--------------------------|----------------------------|---|

Comments: Dredging upstream, channel width not natural. Signs of major flooding including wear on upstream sides of culvert. No riparian zone on river left upstream. Culvert 4% but has bend at last 2m outlet drop and outlet pool depth are estimates. This stream could use some restoration. 17:46



### **Stream Characteristics Downstream of 197976**

The stream was surveyed downstream from crossing 197976 for 575m (Figure [5.36](#)). The dominant substrate was cobbles with gravels sub-dominant., Total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, undercut banks, overhanging vegetation, and instream vegetation., The average channel width was 7.7m, the average wetted width was 3.5m, and the average gradient was 1%. Although side channels continued to flow throughout the area surveyed, approximately 160m downstream of the crossing the main channel was dewatered below the location of a beaver dam. Areas of riparian and bank degradation from cattle trampling were noted throughout the area surveyed and there was fencing spanning the channel. Large deposits of substrate and clumped large woody debris piles were observed within widened channel areas indicating disturbance and high flow events. There were abundant gravels present suitable for spawning resident and anadromous salmonids. Habitat was rated as high value for salmonid rearing and spawning with numerous fish observed and numerous deep pools to 0.95m deep.

### **Stream Characteristics Upstream of 197976 and downstream of 197975**

The stream was surveyed upstream from crossing 197976 for 345m (Figure [5.37](#)). The dominant substrate was cobbles with gravels sub-dominant., Total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, undercut banks, and overhanging vegetation., The average channel width was 8.1m, the average wetted width was 4.2m, and the average gradient was 1%. Fish were observed throughout the area surveyed and extensive algae growth was present on stream substrates. Large woody debris was rare and riparian/bank damage due to livestock was minimal and located at what appeared to be watering sites. Fencing was located across the stream in multiple locations. Patches of gravels suitable for spawning were present. Habitat value was rated as medium as the surveyed area was considered an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

### **5.4 Stream Characteristics Upstream of 197975**

The stream was surveyed upstream from crossing 197975 for 550m (Figure [5.38](#)). Total cover amount was rated as moderate with deep pools dominant. Cover was also present as small woody debris, boulders, undercut banks, and overhanging vegetation., The average channel width was 7.7m, the average wetted width was 3.5m, and the average gradient was 1%., The dominant substrate was cobbles with gravels sub-dominant. Immediately upstream of the crossing for ~80m, extensive anthropogenic damage was noted due to dredging of the channel. Heavy cattle grazing was also observed on the left bank. Juvenile salmonids were observed occasionally throughout the area surveyed. Fencing was located across the stream approximately 250m upstream of the culvert. Patches of gravels suitable for spawning were present. Habitat value was rated as medium as the surveyed area was considered an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

### **Fish Sampling**

Electrofishing was conducted with results summarised in Tables [5.62](#) - [5.63](#) and Figure [5.35](#).



### **Structure Remediation and Cost Estimate**

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 197976 with a bridge (12.5m span) is recommended. The cost of the work is estimated at \$7,500,000 for a cost benefit of 3.3 linear m/\$1000 and 27.1 m<sup>2</sup>/\$1000. As the crossing partially backwaters naturally, a plan to backwater the crossing could also be of consideration in the short term with a rough cost estimate to complete of \$25,000.

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 197975 with a bridge (11.5m span) is recommended. The cost of the work is estimated at \$230,000 for a cost benefit of 107.3 linear m/\$1000 and 826.6 m<sup>2</sup>/\$1000. Relocation of the driveway accessing the private land from the other side of the stream and removal of the crossing could also be considered.

### **Conclusion**

There was 24.7km of habitat modelled upstream of crossing 197975 rated as medium value for salmonid rearing and spawning. Crossing 197976 was ranked as a moderate priority for proceeding to design for replacement as it appears to pass fish during most flows. Crossing 197975 was ranked as a moderate priority for proceeding to design for replacement as it appears to likely present a more serious impediment to upstream passage and because implementation of the works can be considered cost effective and logistically less complicated than works on a major highway. As Ailport Creek appears to be a high value fish stream with significant impacts due to culvert maintenance (dredging), adjacent land use (cattle trampled banks and grazed/removed riparian vegetation) and high flow events (potentially beaver dam failure related), it is recommended that a plan be developed to work with adjacent landowners and tenure holders to exclude cattle from the riparian area, implement stream restoration actions and explore possibilities related to progressive beaver management in the watershed.

Table 5.61: Summary of habitat details for PSCIS crossing 197976.

| Site   | Location   | Length Surveyed (m) | Channel Width (m) | Wetted Width (m) | Pool Depth (m) | Gradient (%) | Total Cover | Habitat Value |
|--------|------------|---------------------|-------------------|------------------|----------------|--------------|-------------|---------------|
| 197975 | Upstream   | 550                 | 7.7               | 3.5              | 0.3            | 3.0          | moderate    | medium        |
| 197976 | Downstream | 575                 | 7.7               | 3.5              | 0.5            | 1.0          | moderate    | high          |
| 197976 | Upstream   | 345                 | 8.1               | 4.2              | 0.3            | 2.2          | moderate    | medium        |

Table 5.62: Fish sampling site summary for 197975.

| site          | passes | ef_length_m | ef_width_m | area_m2 | enclosure |
|---------------|--------|-------------|------------|---------|-----------|
| 197975_ds_ef1 | 1      | 3.8         | 4.27       | 16.2    | Open      |
| 197975_ds_ef2 | 1      | 3.9         | 3.60       | 14.0    | Open      |
| 197975_us_ef1 | 1      | 6.0         | 3.30       | 19.8    | Open      |
| 197975_us_ef2 | 1      | 3.0         | 2.97       | 8.9     | Open      |

Table 5.63: Fish sampling density results summary for 197975.

| local_name    | species_code | life_stage | catch | density_100m2 | nfc_pass |
|---------------|--------------|------------|-------|---------------|----------|
| 197975_ds_ef1 | RB           | fry        | 2     | 12.3          | FALSE    |
| 197975_ds_ef1 | RB           | parr       | 1     | 6.2           | FALSE    |
| 197975_ds_ef2 | CO           | fry        | 1     | 7.1           | FALSE    |
| 197975_ds_ef2 | CO           | parr       | 4     | 28.6          | FALSE    |
| 197975_ds_ef2 | RB           | fry        | 1     | 7.1           | FALSE    |
| 197975_ds_ef2 | RB           | parr       | 10    | 71.4          | FALSE    |
| 197975_ds_ef2 | RB           | juvenile   | 2     | 14.3          | FALSE    |
| 197975_ds_ef2 | RB           | adult      | 1     | 7.1           | FALSE    |
| 197975_us_ef1 | CO           | parr       | 2     | 10.1          | FALSE    |
| 197975_us_ef1 | RB           | fry        | 2     | 10.1          | FALSE    |
| 197975_us_ef1 | RB           | parr       | 14    | 70.7          | FALSE    |
| 197975_us_ef1 | RB           | juvenile   | 5     | 25.3          | FALSE    |
| 197975_us_ef1 | RB           | adult      | 5     | 25.3          | FALSE    |
| 197975_us_ef2 | RB           | fry        | 5     | 56.2          | FALSE    |
| 197975_us_ef2 | RB           | parr       | 7     | 78.7          | FALSE    |
| 197975_us_ef2 | RB           | adult      | 2     | 22.5          | FALSE    |

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

Conclusion

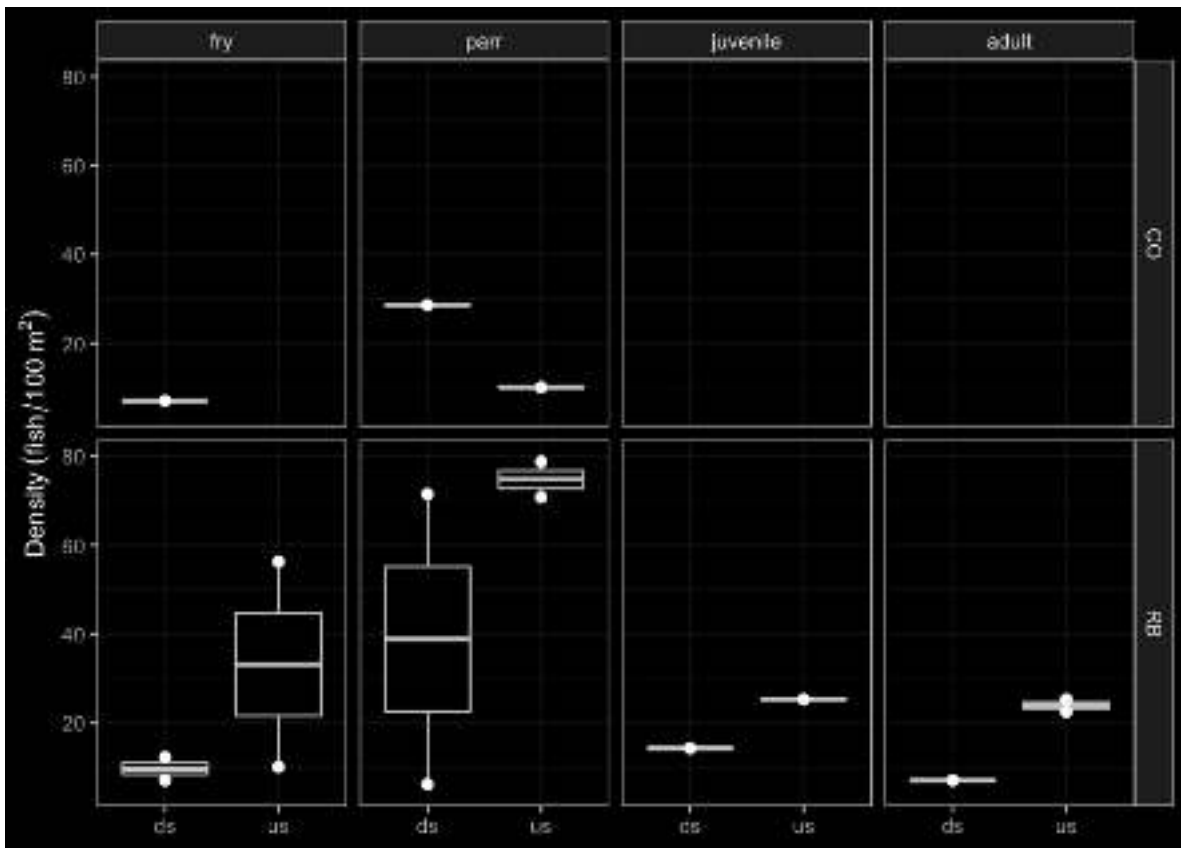


Figure 5.35: Densities of fish (fish/100m2) capture upstream and downstream of PSCIS crossing 197975.



Figure 5.36: Left: Typical habitat downstream of PSCIS crossing 197976. Right: Typical habitat downstream of PSCIS crossing 197976.



Figure 5.37: Left: Typical habitat upstream of PSCIS crossing 197976. Right: Typical habitat upstream of PSCIS crossing 197976.

## Conclusion



Figure 5.38: Left: Typical habitat upstream of PSCIS crossing 197975. Right: Typical habitat upstream of PSCIS crossing 197975.





## McBride Creek - 198000 - Appendix

### Site Location

PSCIS crossing 198000 is located on McBride Creek approximately 75km west of Houston, BC. PSCIS crossing 198000 is located on Nanika FSR. Crossing 198000 was located 10.1km upstream from the confluence with Morice Lake and approximately 200m downstream from the outlet of McBride Lake. Crossing 197975 is the responsibility of the Ministry of Forests and is identified as crossing R5-049 in the Coastal Bridge Registry.

### Background

At crossing 198000, McBride Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 83.5km<sup>2</sup>. The elevation of the watershed ranges from a maximum of 1597m to -1270m near the crossing (Table 5.64). Upstream of crossing 198000, longnose sucker, white sucker, largescale sucker, peamouth chub, leopard dace, redbside shiner, burbot, lake whitefish, cutthroat trout, coho salmon, rainbow trout, mountain whitefish, dolly varden, lake trout, and prickly sculpin have previously been recorded (MoE 2020b; Norris 2020).

Table 5.64: Summary of derived upstream watershed statistics for PSCIS crossing 198000.

| Site   | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|--------|---------|-----------|----------|----------|-------------|----------|--------|
| 198000 | 83.5    | 799       | -1270    | 1597     | 908         | 887      | SSW    |

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

PSCIS stream crossing 198000 was ranked as a high priority for follow up by Irvine (2021) because of the large amount of potential habitat upstream of the crossing. A summary of habitat modelling outputs is presented in Table 5.65. A map of the watershed is provided in map attachment [093L.102](#).

Table 5.65: Summary of fish habitat modelling for PSCIS crossing 198000.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 84.1      | 31.8             | 38                   |
| ST Lake Reservoir (ha)           | 845.9     | 782.1            | 92                   |
| ST Wetland (ha)                  | 61.8      | 26.0             | 42                   |
| ST Slopeclass03 Waterbodies (km) | 26.4      | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 21.0      | 4.2              | 20                   |
| ST Slopeclass05 (km)             | 16.2      | 3.7              | 23                   |
| ST Slopeclass08 (km)             | 13.8      | 3.5              | 25                   |
| ST Spawning (km)                 | 2.5       | 2.5              | 100                  |
| ST Rearing (km)                  | 21.9      | 9.4              | 43                   |
| CH Spawning (km)                 | 2.5       | 2.5              | 100                  |
| CH Rearing (km)                  | 5.9       | 5.0              | 85                   |
| CO Spawning (km)                 | 14.0      | 5.7              | 41                   |
| CO Rearing (km)                  | 20.1      | 7.3              | 36                   |
| CO Rearing (ha)                  | 35.9      | 0.0              | 0                    |
| SK Spawning (km)                 | 0.7       | 0.7              | 100                  |
| SK Rearing (km)                  | 27.8      | 27.8             | 100                  |
| SK Rearing (ha)                  | 782.1     | 0.0              | 0                    |
| All Spawning (km)                | 14.0      | 5.7              | 41                   |
| All Rearing (km)                 | 51.6      | 38.2             | 74                   |
| All Spawning Rearing (km)        | 51.6      | 38.2             | 74                   |

\* Model data is preliminary and subject to adjustments.

### Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 198000 was un-embedded, non-backwatered and ranked as a potential barrier to upstream fish passage according to the provincial protocol [5.66](#)>MoE (2011b). Water temperature was 12°C, pH was 7.3 and conductivity was 366uS/cm. Surveys were conducted with a remotely piloted aircraft immediately upstream and downstream of the crossing with resulting images stitched into an orthomosaic and 3-dimensional model presented [here](#) and [here](#).

Stream Characteristics at Crossing

crossing 198000.

| Location and Stream Data  | •                                      | Crossing Characteristics | –            |
|---|--|--------------------------|--------------|
| Date  | 2021-09-02                             | Crossing Sub Type        | Oval Culvert |
| PSCIS ID  | 198000                                 | Diameter (m)             | 3.9          |
| External ID   | –                                      | Length (m)               | 16           |
| Crew  | KP AI                                  | Embedded                 | No           |
| UTM Zone  | 9                                      | Depth Embedded (m)       | –            |
| Easting   | 605511                                 | Resemble Channel         | No           |
| Northing  | 5992667                                | Backwatered              | No           |
| Stream  | McBride Creek                          | Percent Backwatered      | –            |
| Road  | Nanika FSR                             | Fill Depth (m)           | 0.8          |
| Road Tenure   | FLNR DND 4656                          | Outlet Drop (m)          | 0.05         |
| Channel Width (m)   | 9                                      | Outlet Pool Depth (m)    | 0.8          |
| Stream Slope (%)  | 2                                      | Inlet Drop               | No           |
| Beaver Activity   | No                                     | Slope (%)                | 0.5          |
| Habitat Value   | High                                   | Valley Fill              | Deep Fill    |
| Final score   | 19                                     | Barrier Result           | Potential    |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 14           |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |              |



### **Stream Characteristics Downstream**

The stream was surveyed downstream from the culvert for 300m (Figure [5.39](#)). Total cover amount was rated as with instream vegetation dominant. Cover was also present as small woody debris, large woody debris, and overhanging vegetation (Table [5.67](#)). The average channel width was 6.2m, the average wetted width was 5.1m and the average gradient was 1.2%. The dominant substrate was gravels with cobbles subdominant. The habitat was rated as high value for salmonid rearing and spawning.

### **Stream Characteristics Upstream of 198000 and downstream of 197975**

The stream was surveyed immediately upstream from 198000 for approximately 135m (Figure [5.40](#)). Within the area surveyed, total cover amount was rated as with large woody debris dominant. Cover was also present as small woody debris, overhanging vegetation, and instream vegetation (Table [5.67](#)). The average channel width was 5.5m, the average wetted width was 4.4m and the average gradient was 1%. The dominant substrate was gravels with fines subdominant. Habitat value was rated as high value for resident salmonid rearing and spawning.

### **Structure Remediation and Cost Estimate**

Should restoration/maintenance activities proceed at the site, replacement of PSCIS crossing 198000 with a bridge (14m span) is recommended.

### **Conclusion**

There was 198000 is 20.1km of habitat upstream of crossing rated as high value for salmonid rearing and spawning. Crossing 198000 was ranked as a moderate priority for proceeding to design for replacement.



Table 5.67: Summary of habitat details for PSCIS crossing 198000.

| Site   | Location   | Length Surveyed (m) | Channel Width (m) | Wetted Width (m) | Pool Depth (m) | Gradient (%) | Total Cover | Habitat Value |
|--------|------------|---------------------|-------------------|------------------|----------------|--------------|-------------|---------------|
| 198000 | Downstream | 300                 | 6.2               | 5.1              | –              | 1.2          | moderate    | high          |
| 198000 | Upstream   | 135                 | 5.5               | 4.4              | –              | 1.0          | moderate    | high          |



Figure 5.39: Left: Typical habitat downstream of PSCIS crossing 198000. Right: Typical habitat downstream of PSCIS crossing 198000.



Figure 5.40: Left: Typical habitat upstream of PSCIS crossing 198000. Right: Typical habitat upstream of PSCIS crossing 198000.



## Cesford Creek - 198048 & 198049 - Appendix

### Site Location

PSCIS crossing 198048 and 198049 are located on Cesford Creek near Topley, BC. PSCIS crossing 198048 is located on Highway 16 and 198049 is located on Highway 118. Crossing 198048 was located 0.6km upstream from the confluence with the Bulkley River and 198049 was located 1.3km upstream of the confluence. Crossings 198048 and 198049 are the responsibility of the Ministry of Transportation and Infrastructure. PSCIS crossing 198090 makes reference to a potential crossing location under the CN Railway. The survey team was not able to locate a crossing in the field which coincides with personal communications with the adjacent landowner (Figure [5.41](#)).

### Background

At crossing 198048, Cesford Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 36.6km<sup>2</sup>. The elevation of the watershed ranges from a maximum of 1543m to 659m near the crossing (Table [5.68](#)). Upstream of crossing 198048, rainbow trout have previously been recorded (MoE 2020b; Norris 2020).



Figure 5.41: Location of potential location of crossing 198090 which was not present in the field.

Table 5.68: Summary of derived upstream watershed statistics for PSCIS crossing 198048.

| Site   | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|--------|---------|-----------|----------|----------|-------------|----------|--------|
| 198048 | 36.6    | 679       | 659      | 1543     | 935         | 914      | SSW    |

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

PSCIS stream crossing 198048 was ranked as a priority for follow up by Irvine (2021) because of the relatively large size of the stream and the potential for large amounts of habitat gains through fish passage remediation (Table 5.69). Although Wilson and Rabnett (2007) recommended establishing a downstream weir and excavating adequate outfall drop pools to facilitate fish passage at crossing 198048, they ranked the site as a moderate priority for remediation due to dewatering below Highway 16. Smith (2018) assessed the site in 2017 and noted that a comparison of photos taken in 2006 and 2017 indicates that a significant amount of gravel has been deposited in the channel below the culvert outlets.

## Background

Upon review of aerial imagery, it appears that a large portion of the historical paths of Cesford Creek are located with the floodplain of the Bulkley River with extensive impacts apparent due to land clearing and the installation of the railway. The railway in this section of the upper Bulkley River bisects numerous historical meanders blocking access to extensive areas of likely very high value low velocity salmon rearing habitat. In addition there also appears to be ditching within these lands used for agriculture that although unconfirmed, may function to lower the water table in the floodplain, reducing productivity exacerbating seasonal dewatering. A map of the watershed is provided in map attachment [093L.115](#).

Table 5.69: Summary of fish habitat modelling for PSCIS crossing 198048.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 54.4      | 1.0              | 2                    |
| ST Lake Reservoir (ha)           | 26.4      | 0.0              | 0                    |
| ST Wetland (ha)                  | 24.0      | 0.0              | 0                    |
| ST Slopeclass03 Waterbodies (km) | 3.4       | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 4.9       | 0.7              | 14                   |
| ST Slopeclass05 (km)             | 20.8      | 0.0              | 0                    |
| ST Slopeclass08 (km)             | 14.0      | 0.3              | 2                    |
| ST Spawning (km)                 | 1.8       | 0.7              | 39                   |
| ST Rearing (km)                  | 15.9      | 1.0              | 6                    |
| CH Spawning (km)                 | 1.7       | 0.7              | 41                   |
| CH Rearing (km)                  | 4.5       | 0.7              | 16                   |
| CO Spawning (km)                 | 6.1       | 0.7              | 11                   |
| CO Rearing (km)                  | 10.7      | 0.7              | 7                    |
| CO Rearing (ha)                  | –         | 0.0              | –                    |
| SK Spawning (km)                 | 0.0       | 0.0              | –                    |
| SK Rearing (km)                  | 0.0       | 0.0              | –                    |
| SK Rearing (ha)                  | –         | 0.0              | –                    |
| All Spawning (km)                | 6.2       | 0.7              | 11                   |
| All Rearing (km)                 | 15.9      | 1.0              | 6                    |
| All Spawning Rearing (km)        | 15.9      | 1.0              | 6                    |

\* Model data is preliminary and subject to adjustments.

### Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 198048 was un-embedded, non-backwatered and ranked as a barrier barrier to upstream fish passage according to the provincial protocol [5.70](#)>MoE (2011b). Water temperature was 11°C, pH was 8.2 and conductivity was 263uS/cm.

Table 5.70: Summary of fish passage assessment for PSCIS crossing 198048.

| Location and Stream Data | •          | Crossing Characteristics | –             |
|--------------------------|------------|--------------------------|---------------|
| Date                     | 2021-09-05 | Crossing Sub Type        | Round Culvert |
| PSCIS ID                 | 198048     | Diameter (m)             | 2.5           |
| External ID              | –          | Length (m)               | 25            |
| Crew                     | AI         | Embedded                 | No            |
| UTM Zone                 | 9          | Depth Embedded (m)       | –             |
| Easting                  | 674397.1   | Resemble Channel         | No            |
| Northing                 | 6043433    | Backwatered              | Yes           |

## Stream Characteristics at Crossing

| Location and Stream Data  |  | Crossing Characteristics |           |
|---|--|--------------------------|-----------|
| Stream  | Cesford Creek                          | Percent Backwatered      | 30        |
| Road  | Highway 16                             | Fill Depth (m)           | 1         |
| Road Tenure   | MoTi Arterial                          | Outlet Drop (m)          | 0         |
| Channel Width (m)   | 5.48                                   | Outlet Pool Depth (m)    | 0.09      |
| Stream Slope (%)  | 3.5                                    | Inlet Drop               | Yes       |
| Beaver Activity   | No                                     | Slope (%)                | 1.5       |
| Habitat Value   | High                                   | Valley Fill              | Deep Fill |
| Final score   | 24                                     | Barrier Result           | Barrier   |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 10        |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |           |

| Location and Stream Data | • | Crossing Characteristics | - |
|--------------------------|---|--------------------------|---|
|--------------------------|---|--------------------------|---|

Comments: Habitat confirmation conducted. Two pipes (2.5m x 2.5m). Culvert slope measured with lazel level. Fish observed. Could not locate downstream crossing on railway. Garmin backroads mapbook shows stream connecting with side channel of the Bulkley. 9:17

NO IMAGE AVAILABLE





## Stream Characteristics at Crossing

| Location and Stream Data  |  | Crossing Characteristics |               |
|---|--|--------------------------|---------------|
| Date  | 2021-09-05                             | Crossing Sub Type        | Round Culvert |
| PSCIS ID  | 198049                                 | Diameter (m)             | 3.7           |
| External ID   | –                                      | Length (m)               | 21            |
| Crew  | AI                                     | Embedded                 | No            |
| UTM Zone  | 9                                      | Depth Embedded (m)       | –             |
| Easting   | 674875.4                               | Resemble Channel         | No            |
| Northing  | 6043782                                | Backwatered              | No            |
| Stream  | Cesford Creek                          | Percent Backwatered      | –             |
| Road  | Highway 118                            | Fill Depth (m)           | 1             |
| Road Tenure   | MoTi Arterial                          | Outlet Drop (m)          | 0.5           |
| Channel Width (m)   | 4.9                                    | Outlet Pool Depth (m)    | 0.25          |
| Stream Slope (%)  | 2.83                                   | Inlet Drop               | No            |
| Beaver Activity   | No                                     | Slope (%)                | 1.5           |
| Habitat Value   | High                                   | Valley Fill              | Deep Fill     |
| Final score   | 34                                     | Barrier Result           | Barrier       |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 10            |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |               |

| Location and Stream Data   | Crossing Characteristics |
|--|--------------------------|
| Comments: Habitat confirmation conducted. ~110mm fish observed in outlet pool. Culvert slope surveyed with lazer level. 8:37 |                          |
|   |                          |

## Stream Characteristics at Crossing

| Location and Stream Data  |  | Crossing Characteristics |               |
|---|--|--------------------------|---------------|
| Date  | 2021-09-05                             | Crossing Sub Type        | Round Culvert |
| PSCIS ID  | 198090                                 | Diameter (m)             | 0.1           |
| External ID   | –                                      | Length (m)               | 15            |
| Crew  | KP                                     | Embedded                 | No            |
| UTM Zone  | 9                                      | Depth Embedded (m)       | –             |
| Easting   | 673235                                 | Resemble Channel         | No            |
| Northing  | 6043218                                | Backwatered              | No            |
| Stream  | Cesford Creek                          | Percent Backwatered      | –             |
| Road  | CN Railway                             | Fill Depth (m)           | 2             |
| Road Tenure   | Canadian National                      | Outlet Drop (m)          | 0             |
| Channel Width (m)   | 5                                      | Outlet Pool Depth (m)    | 0             |
| Stream Slope (%)  | 1                                      | Inlet Drop               | No            |
| Beaver Activity   | No                                     | Slope (%)                | 3             |
| Habitat Value   | High                                   | Valley Fill              | Deep Fill     |
| Final score   | 29                                     | Barrier Result           | Barrier       |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 10            |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |               |

| Location and Stream Data | • | Crossing Characteristics | - |
|--------------------------|---|--------------------------|---|
|--------------------------|---|--------------------------|---|

Comments: No crossing actually exists in the field however site entered as a placeholder because there should be connection between Bulkley and Cesford at this location. Survey found no culvert and landowner reported none present. Large man-made ditch through adjacent field may be draining some water. Lower section of stream dry at time of survey. 11:22



**NO IMAGE AVAILABLE**

**NO IMAGE AVAILABLE**

**NO IMAGE AVAILABLE**





### **Stream Characteristics Downstream**

The stream was surveyed downstream from crossing 198048 at Highway 16 for 1400m to the mainstem of the Bulkley River (Figure [5.42](#)). Total cover amount was rated as with overhanging vegetation dominant. Cover was also present as small woody debris and undercut banks (Table [5.73](#)). The average channel width was 5.5m, the average wetted width was 1.5m and the average gradient was 3.5%. The dominant substrate was cobbles with gravels subdominant. The habitat was rated as medium value for salmonid rearing and spawning.

### **Stream Characteristics Upstream of 198048 and downstream of 198049**

The stream was surveyed immediately upstream from 198048 for approximately 675m (Figure [5.43](#)). Within the area surveyed, total cover amount was rated as with deep pools dominant. Cover was also present as small woody debris, large woody debris, and overhanging vegetation (Table [5.73](#)). The average channel width was 5.1m, the average wetted width was 3.3m and the average gradient was 2.8%. The dominant substrate was cobbles with gravels subdominant. Habitat value was rated as medium value for resident salmonid rearing and spawning.

### **Stream Characteristics Upstream of 198048**

The stream was surveyed upstream from crossing 198049 for 600m (Figure [5.44](#)). Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as deep pools and overhanging vegetation., The dominant substrate was cobbles with boulders sub-dominant., The average channel width was 5m, the average wetted width was 2.8m, and the average gradient was 3.5%. The stream had good flow and moderate complexity due to mature cottonwood riparian and frequent large woody debris. Occasional pool and frequent gravel sections were also noted. Habitat value was rated as medium as the surveyed area was considered an important migration corridor containing suitable spawning habitat and having moderate rearing potential.

Cesford Creek was also surveyed approximately 950m upstream from 198049 for a distance of approximately 500m. The average channel width was 4.3m, the average wetted width was 1.9m, and the average gradient was 3.5%., Total cover amount was rated as moderate with large woody debris dominant. Cover was also present as deep pools and overhanging vegetation., The dominant substrate was cobbles with boulders sub-dominant. Habitat value was rated as medium with moderate value habitat for salmonid rearing and occasional pockets of gravel suitable for salmonid spawning.

### **Structure Remediation and Cost Estimate**

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 198048 with a bridge (10m span) is recommended. The cost of the work is estimated at \$6,000,000 for a cost benefit of 1.8 linear m/\$1000 and 9.1 m<sup>2</sup>/\$1000.

Should restoration/maintenance activities proceed, replacement of PSCIS crossing 198049 with a bridge (10m span) is recommended. The cost of the work is estimated at \$6,000,000 for a cost benefit of 1.7 linear m/\$1000 and 8.4 m<sup>2</sup>/\$1000. Relocation of the driveway accessing the private land from the other side of the stream and removal of the crossing could also be considered.

For PSCIS crossing 198090 it is recommended some sort of fish passable structure be installed under the railway to reconnect Cesford Creek with the Bulkley River. The cost of the work is roughly estimated at \$6,000,000.

## **Conclusion**

Management of connectivity within Cesford Creek would be most appropriately managed on the watershed level beginning with re-connection of the stream under the railway in the vicinity of the location of PSCIS 198090. Without re-connection at the railway, the stream cannot provide habitat for species other than the rainbow trout documented as resident. A large portion of the historical paths of Cesford Creek are located with the floodplain of the Bulkley River with extensive impacts apparent due to land clearing and the installation of the railway which bisects numerous historical upper Bulkley River meanders. In addition there also appears to be ditching within these lands used for agriculture that although unconfirmed, may function to lower the water table in the floodplain. It is recommended that a plan be developed in conjunction with CN Rail, adjacent landowners, First Nations regulators and local stewardship groups to reconnect the channel at the railway, exclude cattle from the riparian area, implement stream restoration actions and explore possibilities related to progressive beaver management in the watershed.

There was 10.7km of habitat modelled upstream of crossing 198048 rated as medium value for salmonid rearing and spawning. Crossing 198048 was ranked as a moderate priority for proceeding to design for replacement.

There was 10km of habitat modelled upstream of crossing 198049 rated as medium value for salmonid rearing and spawning. Crossing 198049 was ranked as a moderate priority for proceeding to design for replacement.

There was 198049 is 10km of habitat upstream of crossing rated as medium value for salmonid rearing and spawning. Crossing 198049 was ranked as a moderate priority for proceeding to design for replacement.



## Conclusion

Table 5.73: Summary of habitat details for PSCIS crossing 198048 and 198049.

| Site   | Location   | Length Surveyed (m) | Channel Width (m) | Wetted Width (m) | Pool Depth (m) | Gradient (%) | Total Cover | Habitat Value |
|--------|------------|---------------------|-------------------|------------------|----------------|--------------|-------------|---------------|
| 198048 | Downstream | 1400                | 5.5               | 1.5              | 0.3            | 3.5          | moderate    | medium        |
| 198048 | Upstream   | 675                 | 5.1               | 3.3              | 0.3            | 2.8          | moderate    | medium        |
| 198049 | Upstream   | 600                 | 5.0               | 2.8              | 0.5            | 2.1          | moderate    | medium        |
| 198049 | Upstream2  | 500                 | 4.3               | 1.9              | 0.5            | 4.2          | moderate    | medium        |



Figure 5.42: Left: Typical habitat downstream of PSCIS crossing 198048. Right: Typical habitat downstream of PSCIS crossing 198048.



Figure 5.43: Left: Typical habitat upstream of PSCIS crossing 198048. Right: Typical habitat upstream of PSCIS crossing 198048.



Figure 5.44: Left: Habitat upstream of PSCIS crossing 198049. Right: Habitat upstream of PSCIS crossing 198049.

## Thompson Creek - 198066 & 123377 - Appendix

### Site Location

PSCIS crossing 198066 and 123377 are located on Thompson Creek midway between Telkwa and Houston. PSCIS crossing 198066 is located on a small private road and 123377 is located on Walcott Road. Crossing 198066 was located 0.1km upstream from the confluence with a side channel of the Bulkley River and 123377 was located 2.4km upstream of the confluence. Crossing 198066 was on private land owned by Jeremy Rouw and hay fields as well as other infrastructure that was part of Udder View Dairy were located upstream of the crossing. Crossing 123377 is the responsibility of the Ministry of Transportation and Infrastructure.

### Background

At crossing 198066, Thompson Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 43.1km<sup>2</sup>. The elevation of the watershed ranges from a maximum of 1623m to 596m near the crossing (Table 5.74). Upstream of crossing 198066, cutthroat trout, coastal cutthroat trout, coho salmon, rainbow trout, and dolly varden have previously been recorded (MoE 2020b; Norris 2020).

Landowners adjacent to the stream at both crossings as well as regional DFO staff report that Thompson Creek was historically redirected from its original channel on the height of land near the Bulkley River in the 1960s. The historic channel is visible in aerial imagery and would have directed flows in a north-eastern direction from where the agricultural fields meet the Thompson creek valley. The redirection diverts the channel into two separate channels that flow south-east. The main flow of the channel was flowing in an excavated trench through the hay field at the time of the survey. The distance from the current confluence with the Bulkley River side channel to the historic valley is approximately 370m. The distance the stream would have traveled historically in a north-eastern direction is estimated at 1300m. The landowner reported that conceptually they would like to see the stream redirected to its historic channel. They noted that stranding has been observed within the excavated channel and a realignment would help prevent the loss of hay production caused by the high water table adjacent to the excavated channel. A map of the current man made channels and the historic channel is provided in Figure 5.45. Adjacent landowners also report that the crossing at Walcott Road had nearly washed out at the road due to high flows related to beaver dam failures. Crossing 123378 has been recorded as a bridge on Thompson Creek on the BC Hydro powerline between 198066 and 123377 (Gollner and Cain 2014). Landowners report this bridge washed out at the time of the beaver dam failure and was replaced in 2020.



upstream watershed statistics for PSCIS  
crossing 198066.

| Site   | Area Km | Elev Site | Elev Min | Elev Max | Elev Median | Elev P60 | Aspect |
|--------|---------|-----------|----------|----------|-------------|----------|--------|
| 198066 | 43.1    | 548       | 596      | 1623     | 832         | 802      | WSW    |

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



Figure 5.45: Map of the current man made channels and the historic channel on Thompson Creek adjacent to the Bulkley River.

G. Tamblyn and Jessop (2000) have documented detailed fish habitat, riparian and channel assessment data for Reach 1 and 2 of the stream surveying 12.6km along with an impact synopsis and restoration suggestions.

PSCIS stream crossing 123377 was ranked as a high priority for follow up by Irvine (2018) and Smith (2018) because of the relatively large size of the stream and habitat rated as high value in PSCIS (Table [5.75](#). A map of the watershed is provided in map attachment [093L.113](#).

## Stream Characteristics at Crossing

Table 5.75: Summary of fish habitat modelling for PSCIS crossing 198066.

| Habitat                          | Potential | Remediation Gain | Remediation Gain (%) |
|----------------------------------|-----------|------------------|----------------------|
| ST Network (km)                  | 35.9      | 2.4              | 7                    |
| ST Lake Reservoir (ha)           | 12.6      | 0.0              | 0                    |
| ST Wetland (ha)                  | 24.6      | 0.0              | 0                    |
| ST Slopeclass03 Waterbodies (km) | 1.9       | 0.0              | 0                    |
| ST Slopeclass03 (km)             | 12.1      | 1.6              | 13                   |
| ST Slopeclass05 (km)             | 4.8       | 0.8              | 17                   |
| ST Slopeclass08 (km)             | 7.6       | 0.0              | 0                    |
| ST Spawning (km)                 | 4.9       | 0.0              | 0                    |
| ST Rearing (km)                  | 15.4      | 2.4              | 16                   |
| CH Spawning (km)                 | 4.9       | 0.0              | 0                    |
| CH Rearing (km)                  | 12.7      | 2.4              | 19                   |
| CO Spawning (km)                 | 9.7       | 2.4              | 25                   |
| CO Rearing (km)                  | 14.7      | 2.4              | 16                   |
| CO Rearing (ha)                  | 12.3      | 0.0              | 0                    |
| SK Spawning (km)                 | 0.0       | 0.0              | –                    |
| SK Rearing (km)                  | 0.0       | 0.0              | –                    |
| SK Rearing (ha)                  | –         | 0.0              | –                    |
| All Spawning (km)                | 9.7       | 2.4              | 25                   |
| All Rearing (km)                 | 16.7      | 2.4              | 14                   |
| All Spawning Rearing (km)        | 16.7      | 2.4              | 14                   |

\* Model data is preliminary and subject to adjustments.

## Stream Characteristics at Crossing

At the time of the survey, PSCIS crossing 198066 was un-embedded, non-backwatered and ranked as a potential barrier to upstream fish passage according to the provincial protocol (MoE 2011b). There was rip rap placed around the culvert inlets and outlets (Table 5.76). Water temperature was 13°C, pH was 8.2 and conductivity was 294µS/cm.

Table 5.76: Summary of fish passage assessment for PSCIS crossing 198066.

| Location and Stream Data | •          | Crossing Characteristics | –             |
|--------------------------|------------|--------------------------|---------------|
| Date                     | 2021-09-12 | Crossing Sub Type        | Round Culvert |
| PSCIS ID                 | 198066     | Diameter (m)             | 1.3           |
| External ID              | –          | Length (m)               | 6             |
| Crew                     | AI         | Embedded                 | No            |
| UTM Zone                 | 9          | Depth Embedded (m)       | –             |
| Easting                  | 640243.9   | Resemble Channel         | No            |

Thompson Creek - 198066 & 123377 ...

| Location and Stream Data  | •                                      | Crossing Characteristics | –         |
|---|--|--------------------------|-----------|
| Northing  | 6048061                                | Backwatered              | Yes       |
| Stream  | Thompson Creek                         | Percent Backwatered      | 95        |
| Road  | Private Road                           | Fill Depth (m)           | 0.2       |
| Road Tenure   | Unclassified                           | Outlet Drop (m)          | 0         |
| Channel Width (m)   | 2.77                                   | Outlet Pool Depth (m)    | 0.1       |
| Stream Slope (%)  | 0.5                                    | Inlet Drop               | No        |
| Beaver Activity   | No                                     | Slope (%)                | 0.4       |
| Habitat Value   | High                                   | Valley Fill              | Deep Fill |
| Final score   | 16                                     | Barrier Result           | Potential |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 10        |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |           |



## Stream Characteristics at Crossing

| Location and Stream Data  | • | Crossing Characteristics | - |
|---|---|--------------------------|---|
| <p>Comments: Udder View Farm. Curently appears passable for all life stages and species but may present slight barrier at time of year when flow are high. Large outlet pool indicates that culvert is undersized. Landowners adjacent to the stream report that the channel was historically relocated through the fields near the river and they would like to work together to relocate. 16:48</p> |   |                          |   |
|    |   |                          |   |

Table 5.77: Summary of fish passage assessment for PSCIS crossing 123377.

| Location and Stream Data  | •                                      | Crossing Characteristics | –             |
|---|--|--------------------------|---------------|
| Date  | 2021-09-05                             | Crossing Sub Type        | Round Culvert |
| PSCIS ID  | 123377                                 | Diameter (m)             | 1.05          |
| External ID   | –                                      | Length (m)               | 29            |
| Crew  | AI                                     | Embedded                 | No            |
| UTM Zone  | 9                                      | Depth Embedded (m)       | –             |
| Easting   | 641632.6                               | Resemble Channel         | No            |
| Northing  | 6049398                                | Backwatered              | No            |
| Stream  | Thompson Creek                         | Percent Backwatered      | –             |
| Road  | Walcott Road                           | Fill Depth (m)           | 1.5           |
| Road Tenure   | MoTi Local                             | Outlet Drop (m)          | 0.25          |
| Channel Width (m)   | 4.8                                    | Outlet Pool Depth (m)    | 0.3           |
| Stream Slope (%)  | 2.7                                    | Inlet Drop               | No            |
| Beaver Activity   | No                                     | Slope (%)                | 3             |
| Habitat Value   | High                                   | Valley Fill              | Deep Fill     |
| Final score   | 34                                     | Barrier Result           | Barrier       |
| Fix type  | Replace with New Open Bottom Structure | Fix Span / Diameter      | 10            |
| Photos: From top left clockwise: Road/Site Card, Barrel, Outlet, Downstream, Upstream, Inlet. |  |                          |               |



## Stream Characteristics Downstream

| Location and Stream Data  | • | Crossing Characteristics | - |
|---|---|--------------------------|---|
| Comments: Debris is partially blocking one of the two pipes. Historic washouts on road at this site. Landowner reports stream diverted downstream >50 years ago and crosses farmers field in ditched channel. 15:12 |   |                          |   |
|    |   |                          |   |

## Stream Characteristics Downstream

The stream was surveyed downstream from the culvert for 100m (Figure 5.46). Total cover amount was rated as with overhanging vegetation dominant. Cover was also present as (Table 5.78). The

average channel width was 3.4m, the average wetted width was 2.5m and the average gradient was 1.8%. The dominant substrate was gravels with fines subdominant. The habitat was rated as medium value for salmonid rearing and spawning.

### **Stream Characteristics Upstream of 198066 and downstream of 123377**

The stream was surveyed immediately upstream from 198066 for approximately 350m (Figure [5.47](#)). Within the area surveyed, total cover amount was rated as with undercut banks dominant. Cover was also present as deep pools and overhanging vegetation (Table [5.78](#)). The average channel width was 2.8m, the average wetted width was 2.1m and the average gradient was 0.5%. The dominant substrate was NA with NA subdominant. Habitat value was rated as medium value for resident salmonid rearing and spawning.

### **Structure Remediation and Cost Estimate**

Should restoration/maintenance activities proceed at the site, replacement of PSCIS crossing 198066 with a bridge (10m span) is recommended.

### **Conclusion**

There was 14.7km of habitat modelled upstream of crossing 198066 rated as medium value for salmonid rearing and spawning. Crossing 198066 was ranked as a high priority for proceeding to design for replacement.

There was 12.3km of habitat upstream of crossing 123377 rated as high value for salmonid rearing and spawning. Crossing 123377 was ranked as a high priority for proceeding to design for replacement.

Restoration suggestions by G. Tamblyn and Jessop (2000) can be considered still relevant for Thompson Creek and include working with landowners to limit cattle access to the riparian zone, re-establishing riparian vegetation, improving cattle crossings and fish passage at roads. Additionally, the redirection of the stream back into its historic channel on the north side of the agricultural field near the confluence with the Bulkley River provides an extraordinary opportunity for sizable fish habitat gains in a currently very severely impacted section of stream.

## Conclusion

Table 5.78: Summary of habitat details for PSCIS crossing 198066 and 123377.

| Site   | Location   | Length Surveyed (m) | Channel Width (m) | Wetted Width (m) | Pool Depth (m) | Gradient (%) | Total Cover | Habitat Value |
|--------|------------|---------------------|-------------------|------------------|----------------|--------------|-------------|---------------|
| 123377 | Downstream | 484                 | 4.3               | 2.7              | 0.3            | 2.9          | abundant    | high          |
| 123377 | Upstream   | 450                 | 4.8               | 3.4              | 0.7            | 2.7          | abundant    | high          |
| 198066 | Downstream | 100                 | 3.4               | 2.5              | –              | 1.8          | moderate    | medium        |
| 198066 | Upstream   | 350                 | 2.8               | 2.1              | –              | 0.5          | –           | medium        |



Figure 5.46: Left: Typical habitat downstream of PSCIS crossing 198066. Right: Habitat on side channel of Bulkley River downstream of crossing 198066.





Figure 5.47: Left: Small drop (50cm high) located ~20m upstream of PSCIS crossing 198066. Right: Habitat immediately upstream of PSCIS crossing 198066 that flows through a hay field within an excavated trench for approximately 350m.



## References

- Allaire, JJ, Yihui Xie, Jonathan McPherson, Javier Luraschi, Kevin Ushey, Aron Atkins, Hadley Wickham, Joe Cheng, Winston Chang, and Richard Iannone. 2022. *Rmarkdown: Dynamic Documents for r*. <https://CRAN.R-project.org/package=rmarkdown>.
- 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](https://www.fs.fed.us/biology/nsaec/fishxing/fplibrary/Bell_1991_Fisheries_handbook_of_engineering_requirements_and.pdf).
- 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>.
- Bramblett, Robert, Mason Bryant, Brenda Wright, and Robert 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: 498–506. [https://doi.org/10.1577/1548-8659\(2002\)131<0498:SUOSTA>2.0.CO;2](https://doi.org/10.1577/1548-8659(2002)131<0498:SUOSTA>2.0.CO;2).
- Busch, D.Shallin, Mindi Sheer, Kelly Burnett, Paul McElhany, and Tom Cooney. 2013. "Landscape-Level Model to Predict Spawning Habitat For Lower Columbia River Fall Chinook Salmon (*Oncorhynchus Tshawytscha*): Intrinsic Potential Model for Spawning Fall Chinook Salmon." *River Research and Applications* 29 (3): 297–312. <https://doi.org/10.1002/rra.1597>.
- Bustard, D, and C Schell. 2002. "Conserving Morice Watershed Fish Populations and Their Habitat." Community Futures Development Corporation of Nadina. <https://waves-vagues.dfo-mpo.gc.ca/Library/315091.pdf>.
- Casselman, J, and D Stanley. 2010. "Bulkley/Fulton Watershed Fish Passage Culvert Assessment Program." 2010. [http://a100.gov.bc.ca/appsdata/acat/documents/r24143/8094011\\_Final\\_Report\\_Part\\_1328571584158\\_0bd68c842ee1398fde7c7fe754a7643122e5cb4e7c79ddd8436406d529bd7151.pdf](http://a100.gov.bc.ca/appsdata/acat/documents/r24143/8094011_Final_Report_Part_1328571584158_0bd68c842ee1398fde7c7fe754a7643122e5cb4e7c79ddd8436406d529bd7151.pdf).
- 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 and Development Program. <https://www.fs.fed.us/biology/nsaec/fishxing/publications/PDFs/NIAP.pdf>.
- Cooney, Thomas, and Damon Holzer. 2006. "Appendix C: Interior Columbia Basin Stream Type Chinook Salmon and Steelhead Populations: Habitat Intrinsic Potential Analysis," 21.
- Cote, David, P Frampton, M Langdon, and R Collier. 2005. *Fish Passage and Stream Habitat Restoration in Terra Nova National Park Highway Culverts*.
- DFO. 1998. "Fish Value and Highway Culvert Inspection, August 1998." <https://data.skeenasalmon.info/dataset?q=Fish+Value+and+Highway+Culvert+Inspection%2C+August+1998>.
- 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>.
- Dyson, J. B. 1949. "Bulkley Falls Investigation Report." <https://data.skeenasalmon.info/dataset/0af0ecf8-0d55-4d48-9bde-d869db0fb71a/resource/b3360add-f7df-4906-8cb5-c2cb4a3e7fa9/download/bulkley-falls-investigation-dfo-1949.pdf>.
- ECCC. 2016. *Climate Data and Scenarios for Canada: Synthesis of Recent Observation and Modelling Results*. Environment and Climate Change Canada (ECCC). <http://proxy.library.carleton>

## References

- [.carleton.ca/loginurl=https://www.deslibris.ca/ID/10066004](https://www.carleton.ca/loginurl=https://www.deslibris.ca/ID/10066004).
- Environment, and Climate Change Canada. 2021. "National Water Data Archive: HYDAT." Service description. Environment and Climate Change Canada (ECCC). 2021. <https://www.canada.ca/en/environment-climate-change/services/water-overview/quantity/monitoring/survey/data-products-services/national-archive-hydat.html>.
- Fish Passage Technical Working Group. 2011. "A Checklist for Fish Habitat Confirmation Prior to the Rehabilitation of 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>.
- — —. 2014. "Fish Passage Strategic Approach: Protocol for Prioritizing Sites for Fish Passage Remediation." <https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/fish-passage/strategic20approach20july202014.pdf>.
- FLNRO. 2013a. "Bulkley River Angling Management Plan." Ministry of Forests, Lands and Natural Resource Operations (FLNRO). <http://www.env.gov.bc.ca/fw/fish/guide/docs/amp/skeena-amp-bulkley-river.pdf>.
- — —. 2013b. "Overview of Angling Management Plans for the Skeena Watershed." Ministry of Forests, Lands, Natural Resource Operations (FLNRO). <http://www.env.gov.bc.ca/skeena/fish/AMPs/Context AMP.pdf>.
- FLNRORD. 2017. "Natural Resource Stewardship Monitoring and Assessment Report for the Wet'suwet'en Hereditary Territory." <https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/integrated-monitoring/nrsmonitoringandassessmentreport-wetsuweten.pdf>.
- — —. 2019. "Freshwater Fishing Regulations Synopsis." Ministry of Forests, Lands, Natural Resource Operations & Rural Development (FLNRORD). [https://www2.gov.bc.ca/assets/gov/sports-recreation-arts-and-culture/outdoor-recreation/fishing-and-hunting/freshwater-fishing/region\\_6\\_skeena.pdf](https://www2.gov.bc.ca/assets/gov/sports-recreation-arts-and-culture/outdoor-recreation/fishing-and-hunting/freshwater-fishing/region_6_skeena.pdf).
- — —. 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>.
- Gaboury, M. N., and J. J. Smith. 2016. "Development Of Aquatic Restoration Designs And On-Farm Cattle Management Improvements Within the Wet'suwet'en First Nation Territory." Prepared by: Wet'suwet'en First Nation.
- "Gitxsan Huwilp Government." 2021. 2021. <http://gitxsan.ca/>.
- Gollner, M C, and Robijn Cain. 2014. "FISH PASSAGE CULVERT INVESTIGATIONS 2013," 112. <https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=43108>.
- Gottesfeld, Allen, Ken Rabnett, and Peter Hall. 2002. "Conserving Skeena Fish Populations and Their Habitat - Skeena Stage I Watershed-Based Fish Sustainability Plan." Skeena Fisheries Commission. <https://www.psf.ca/sites/default/files/Skeena%20WFSP%2012%20%28low%20res%29.pdf>.
- Gottesfeld, A, and K Rabnett. 2007. "Skeena Fish Populations and Their Habitat." Skeena Fisheries Commission.
- Government of British Columbia. 2022. "Range Tenure - Datasets - Data Catalogue." 2022. <https://catalogue.data.gov.bc.ca/dataset/range-tenure>.
- Houlden, G, and B Donas. 2002. "Chicago Creek Hatchery Operations 2001 - 2002." <https://data.skeenasalmon.info/dataset/388df1df-e0c4-45ce-9ae2-e8de23a0facf/resource/9cacb8b0-5d40-4a8a>

[-83dd-dcb2cac2029d/download/chicago\\_creek\\_hatchery\\_operations\\_2001-02.pdf](#).

Houlden, G, J Houlden, and B Donas. 2001. "Chicago Creek Hatchery Operations Project #00-06-01." [https://data.skeenasalmon.info/dataset/388df1df-e0c4-45ce-9ae2-e8de23a0facf/resource/1db8aa25-21cd-4004-9616-aac599692b51/download/chicago\\_creek\\_hatchery\\_operations\\_2000-01.pdf](https://data.skeenasalmon.info/dataset/388df1df-e0c4-45ce-9ae2-e8de23a0facf/resource/1db8aa25-21cd-4004-9616-aac599692b51/download/chicago_creek_hatchery_operations_2000-01.pdf).

IBM Business Consulting Services. 2006. "Valuation of the Wild Salmon Economy of the Skeena River Watershed." [https://www.psf.ca/sites/default/files/IBM\\_skeena\\_report\\_061.pdf](https://www.psf.ca/sites/default/files/IBM_skeena_report_061.pdf).

ILMB. 2007. "Morice Land and Resource Management Plan." Ministry of Agriculture and Lands - Integrated Land Management Bureau (ILMB). [https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/land-water-use/crown-land/land-use-plans-and-objectives/skeena-region/morice-lrmp/morice\\_lrmp\\_july2007.pdf](https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/land-water-use/crown-land/land-use-plans-and-objectives/skeena-region/morice-lrmp/morice_lrmp_july2007.pdf).

IPCC, ed. 2014. *Climate Change 2014: Synthesis Report*. Geneva, Switzerland: Intergovernmental Panel on Climate Change (IPCC). Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [[Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)].

Irvine. 2018. "Analysis And Priority Identification Of Existing Fish Passage Data: Bulkley River Watershed," 114. <http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=56648>.

— — —. 2021. "Bulkley River and Morice River Watershed Groups Fish Passage Restoration Planning." [https://newgraphenvironment.github.io/fish\\_passage\\_bulkley\\_2020\\_reporting/](https://newgraphenvironment.github.io/fish_passage_bulkley_2020_reporting/).

— — —. (2022) 2022. *NewGraphEnvironment/Fpr* (version 0.1.0.9000). <https://github.com/NewGraphEnvironment/fpr>.

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>.

Kirsch, J M, Joseph D Buckwalter, and Daniel J Reed. 2014. "Fish Inventory and Anadromous Cataloging in the Susitna River, Matanuska River, and Knik River Basins, 2003 and 2011." 149.

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>.

Mazany-Wright, Nick, Simon M Norris, Joshua Noseworthy, Betty Rebellato, Sarah Sra, and Nicolas W R Lapointe. 2021. "Bulkley River Watershed (Laxyip I Wedzin Kwah)," 46. [https://cwf-fcf.org/en/resources/research-papers/Bulkley\\_WCRP\\_10-08-2021.pdf](https://cwf-fcf.org/en/resources/research-papers/Bulkley_WCRP_10-08-2021.pdf).

McCarthy, M, and A Fernando. 2015. "2015 Inventory of High Priority Culverted Fish Passage Barriers in the Lower/Middle Skeena, Bulkley, Morice, and Babine River Watersheds."

MoE. 2011a. "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>.

— — —. 2011b. "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>.

— — —. 2020a. "Known BC Fish Observations and BC Fish Distributions." Ministry of Environment and Climate Change Strategy - Knowledge Management. 2020. <https://catalogue.data.gov.bc.ca/dataset/known-bc-fish-observations-and-bc-fish-distributions>.

## References

- . 2020b. “Known BC Fish Observations and BC Fish Distributions.” Ministry of Environment and Climate Change Strategy - Knowledge Management. 2020. <https://catalogue.data.gov.bc.ca/dataset/known-bc-fish-observations-and-bc-fish-distributions>.
- . 2020c. “Provincial Obstacles to Fish Passage - Data Catalogue.” 2020. <https://catalogue.data.gov.bc.ca/dataset/provincial-obstacles-to-fish-passage>.
- . 2020d. “Provincial Obstacles to Fish Passage - Data Catalogue.” 2020. <https://catalogue.data.gov.bc.ca/dataset/provincial-obstacles-to-fish-passage>.
- . 2020e. “Stream Inventory Sample Sites.” Ministry of Environment and Climate Change Strategy - Knowledge Management. 2020. <https://catalogue.data.gov.bc.ca/dataset/stream-inventory-sample-sites>.
- . 2021a. “PSCIS Assessments - Data Catalogue.” Ministry of Environment and Climate Change Strategy - Knowledge Management (MoE). 2021. <https://catalogue.data.gov.bc.ca/dataset/pscis-assessments>.
- . 2021b. “PSCIS Habitat Confirmations - Data Catalogue.” Ministry of Environment and Climate Change Strategy - Knowledge Management (MoE). 2021. <https://catalogue.data.gov.bc.ca/dataset/pscis-habitat-confirmations>.
- . 2021c. “PSCIS Remediation - Data Catalogue.” Ministry of Environment and Climate Change Strategy - Knowledge Management (MoE). 2021. <https://catalogue.data.gov.bc.ca/dataset/pscis-remediation>.
- Newman, Natalie, and Tasheena England. 2018. “Mission Creek Stream Survey Summer 2018.”
- Norris, Simon. 2020. *Bcfishobs*. Hillcrest Geographics. <https://github.com/smnorris/bcfishpass>.
- . 2021a. *Smnorris/Fwapg*. <https://github.com/smnorris/fwapg>.
- . 2021b. *Smnorris/Bcdata*. <https://github.com/smnorris/bcdata>.
- . 2021c. *Smnorris/Bcfishobs*. <https://github.com/smnorris/bcfishobs>.
- . 2021d. *Smnorris/Bcfishpass*. <https://github.com/smnorris/bcfishpass>.
- Norris, Simon, and Craig Mount. 2016. “Fish Passage GIS Analysis Version 2.2” Methodology and Output Data Specifications.” <https://data.skeenasalmon.info/dataset/bc-fish-passage-program>.
- Office of the Wet’suwet’en. 2013. “Wet’suwet’en Title and Rights Regarding Canada Department of Fisheries & Oceans And Pacific Trails Pipeline.” [http://www.wetsuweten.com/files/PTP\\_FHCP\\_Response\\_to\\_DFO-25Nov13-Final.pdf](http://www.wetsuweten.com/files/PTP_FHCP_Response_to_DFO-25Nov13-Final.pdf).
- “Office of the Wet’suwet’en.” 2021. 2021. <http://www.wetsuweten.com/>.
- Office of Wet’suwet’en. 2016. “Submission to: Canadian Environmental Assessment Agency for the Pacific NorthWest LNG Project.” 2016. [https://data.skeenasalmon.info/dataset/b2984c69-43a7-4957-aac9-dceb81e4feeb/resource/c571fff7-fe46-4b03-bf0a-d345a880f37d/download/wetsuweten\\_submission\\_canadian\\_environmental\\_assessment\\_agency.pdf](https://data.skeenasalmon.info/dataset/b2984c69-43a7-4957-aac9-dceb81e4feeb/resource/c571fff7-fe46-4b03-bf0a-d345a880f37d/download/wetsuweten_submission_canadian_environmental_assessment_agency.pdf).
- Oliver, Allison. 2018. “Analysis of Water Quality Monitoring in the Morice Water Management Area.” <http://moricetrust.ca/reports/MWMT%20Water%20Quality%20Analysis.pdf>.
- Porter, Marc, Darcy Pickard, Katherine Wieckowski, and Katy Bryan. 2008. “Developing Fish Habitat Models for Broad-Scale Forest Planning in the Southern Interior of B.C.” ESSA Technologies Ltd. and B.C. Ministry of the Environment (MOE) for B.C. Forest Science Program. [https://www.for.gov.bc.ca/hfd/library/FIA/2008/FSP\\_Y081231.pdf](https://www.for.gov.bc.ca/hfd/library/FIA/2008/FSP_Y081231.pdf).
- R Core Team. 2022. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. <https://www.R-project.org/>.
- Rabnett, K, K Holland, and A Gottesfeld. 2017. “Dispersed Traditional Fisheries in the Upper Skeena Watershed.”
- Rabnett, K., and L. Williams. 2004. “Highway #16 Fish Passage Assessment in Middle Skeena Watershed.” <https://data.skeenasalmon.info/lv/dataset/raabnett-williams-2004-middle-skeena-fish>

[-passage-pdf](#).

Redden, S, and M Jedrzejczyk. 1997. "Fish and Fish Habitat Inventory for Forest Licences A-16823 and A-16825." [https://a100.gov.bc.ca/pub/acat/documents/r2477/endako\\_1111018814827\\_dc139a317a2f4b3ab4fbf5f65ac33401.pdf](https://a100.gov.bc.ca/pub/acat/documents/r2477/endako_1111018814827_dc139a317a2f4b3ab4fbf5f65ac33401.pdf).

Roberge, M, J M B Hume, C K Minns, and T Slaney. 2002. "Life History Characteristics of Freshwater Fishes Occurring in British Columbia and the Yukon, with Major Emphasis on Stream Habitat Characteristics," 262.

Rosenfeld, Jordan, Marc Porter, and Eric Parkinson. 2000. "Habitat Factors Affecting the Abundance and Distribution of Juvenile Cutthroat Trout (*Oncorhynchus Clarki*) and Coho Salmon (*Oncorhynchus Kisutch*)" 57: 9.

Schell, Chris. 2003. "A Brief Overview of Fish, Fisheries and Aquatic Habitat Resources in the Morice TSA." Morice Land and Resource Management Plan. [https://www.for.gov.bc.ca/hfd/library/ffip/Schell\\_C2003.pdf](https://www.for.gov.bc.ca/hfd/library/ffip/Schell_C2003.pdf).

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>.

SKR Consultants Ltd. 2006. "Fish Passage Culvert Inspection Where Yellowhead Highway 16 Crosses Station (Alias Mission) Creek. Contract 356cs0561."

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](https://www.for.gov.bc.ca/hfd/library/FFIP/Slaney_PA1997_A.pdf).

Sloat, Matthew R., Gordon H. Reeves, and Kelly R. Christiansen. 2017. "Stream Network Geomorphology Mediates Predicted Vulnerability of Anadromous Fish Habitat to Hydrologic Change in Southeast Alaska." *Global Change Biology* 23 (2): 604–20. <https://doi.org/10.1111/gcb.13466>.

Smith, Jason J. 2018. "Assessing Barriers To Fish Passage Within The Wetsuweten First Nation Traditional Territory." LGL Limited environmental Research associates and Yinka Dene Economic Development Limited Partnership Inc.

Smithers District Chamber of Commerce. 2022. "Toboggan Creek Salmon & Steelhead Enhancement Society - Business Directory." Smithers District Chamber of Commerce. 2022. <https://smitherschamber.com/business-directory/toboggan-creek-salmon-steelhead-enhancement-society>.

Smithers Interior News. 2017. "Morice town Subdivision Evacuated." Smithers Interior News. 2017. <https://www.interior-news.com/news/morice-town-subdivision-evacuated/>.

Stokes, J. 1956. "Upper Bulkley River Survey 1956." <https://data.skeenasalmon.info/dataset/6d9cc7a6-683e-4de5-879e-77b592882a35/resource/9ff7c750-1a1d-40b3-9ee1-6bbb46bdf38e/download/dfo-ubulkley-hab-survey-1956.pdf>.

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>.

Tamblyn, Greg, and Matthew Jessop. 2000. "Detailed Fish Habitat, Riparian and Channel Assessment for Select Central Bulkley River Tributaries." [https://data.skeenasalmon.info/dataset/d7b0840a-382b-4f96-875a-a7db8ac2ad6c/resource/0ff53aa4-a6f8-45e2-bf78-dd55f60f3774/download/fish\\_habitat\\_riparian\\_channel\\_assessment\\_central\\_bulkley\\_tributaries.pdf](https://data.skeenasalmon.info/dataset/d7b0840a-382b-4f96-875a-a7db8ac2ad6c/resource/0ff53aa4-a6f8-45e2-bf78-dd55f60f3774/download/fish_habitat_riparian_channel_assessment_central_bulkley_tributaries.pdf).

Tamblyn, Gregory C. 2005. "A Plan to Conserve and Protect Morice Watershed Fish Populations," 78.



## References

- Thompson, Richard. 2013. "Assessing Fish Passage at Culverts – 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](https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/fish-passage/assessing_fish_passage_at_culverts.pdf).
- Wang, Tongli, Andreas Hamann, D. Spittlehouse, and Trevor Murdock. 2012. "ClimateWNA – High-Resolution Spatial Climate Data for Western North America." *Journal of Applied Meteorology and Climatology* 51 (January): 16–29. <https://doi.org/10.1175/JAMC-D-11-043.1>.
- Washington Department of Fish & Wildlife. 2009. "Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual." Washington Department of Fish and Wildlife. Olympia, Washington. <https://wdfw.wa.gov/sites/default/files/publications/00061/wdfw00061.pdf>.
- Wilson, Tim, and Ken Rabnett. 2007. "Fish Passage Assessment of Highway 16 and CN Rail in the Bulkley Watershed," 124. <https://data.skeenasalmon.info/dataset/fish-passage-assessment-highway-16-cn-rail-bulkley>.
- Woll, Christine, David Albert, and Diane Whited. 2017. "Salmon Ecological Systems." The Nature Conservancy.
- Wrench, A. 2022. "Richfield Creek Riparian Fencing Installation Report 2021."
- Xie, Yihui. 2016. *Bookdown: Authoring Books and Technical Documents with R Markdown*. Boca Raton, Florida: Chapman; Hall/CRC. <https://bookdown.org/yihui/bookdown>.



## Session Info

R version 4.2.0 (2022-04-22)  
Platform: aarch64-apple-darwin20 (64-bit)  
Running under: , RStudio 2022.2.2.485

Locale: en\_CA.UTF-8 / en\_CA.UTF-8 / en\_CA.UTF-8 / C / en\_CA.UTF-8 /  
en\_CA.UTF-8

### Package version:

|                       |                    |                    |
|-----------------------|--------------------|--------------------|
| AsioHeaders_1.16.1.1  | askpass_1.1        | assertthat_0.2.1   |
| backports_1.4.1       | base64enc_0.1-3    | bcdata_0.3.0       |
| BH_1.78.0.0           | bibtex_0.4.2.3     | bit_4.0.4          |
| bit64_4.0.5           | bitops_1.0-7       | blob_1.2.3         |
| bookdown_0.26         | boot_1.3.28        | brew_1.0-7         |
| broom_0.8.0           | bslib_0.3.1        | cachem_1.0.6       |
| callr_3.7.0           | cellranger_1.1.0   | chk_0.8.0.9000     |
| chron_2.3-56          | citr_0.3.2         | class_7.3-20       |
| classInt_0.4-3        | cli_3.3.0          | clipr_0.8.0        |
| codetools_0.2-18      | colorspace_2.0-3   | commonmark_1.8.0   |
| compiler_4.2.0        | cpp11_0.4.2        | crayon_1.5.1       |
| crosstalk_1.2.0       | crul_1.2.0         | curl_4.3.2         |
| data.table_1.14.2     | datapasta_3.1.0    | DBI_1.1.2          |
| dbplyr_2.1.1          | digest_0.6.29      | doParallel_1.0.17  |
| dplyr_1.0.9           | dtplyr_1.2.1       | e1071_1.7-9        |
| elevatr_0.4.2         | ellipsis_0.3.2     | english_1.2-6      |
| evaluate_0.15         | exifr_0.3.2        | fansi_1.0.3        |
| farver_2.1.0          | fasstr_0.4.1       | fastmap_1.1.0      |
| fishbc_0.2.1.9000     | fitdistrplus_1.1.8 | fontawesome_0.2.2  |
| forcats_0.5.1         | foreach_1.5.2      | foreign_0.8-82     |
| fpr_0.1.0.9003        | fs_1.5.2           | furrr_0.3.0        |
| future_1.25.0         | fwapgr_0.1.0.9011  | gargle_1.2.0       |
| generics_0.1.2        | geojson_0.3.4      | geojsonio_0.9.4    |
| geojsonsf_2.0.2       | geometries_0.2.0   | ggdark_0.2.1       |
| ggmap_3.0.0.903       | ggplot2_3.3.6      | globals_0.15.0     |
| glue_1.6.2            | googledrive_2.0.0  |                    |
| googlePolylines_0.8.2 |                    |                    |
| googlesheets4_1.0.0   | googleway_2.7.6    | graphics_4.2.0     |
| grDevices_4.2.0       | grid_4.2.0         | gridExtra_2.3      |
| gtable_0.3.0          | haven_2.5.0        | highr_0.9          |
| hms_1.1.1             | htmltools_0.5.2    | htmlwidgets_1.5.4  |
| httplibcode_0.3.0     | httpuv_1.6.5       | httr_1.4.3         |
| ids_1.0.1             | isoband_0.2.5      | iterators_1.0.14   |
| janitor_2.1.0         | jpeg_0.1-9         | jqr_1.2.3          |
| jquerylib_0.1.4       | jsonify_1.2.1      | jsonlite_1.8.0     |
| kableExtra_1.3.4      | Kendall_2.2.1      | KernSmooth_2.23-20 |

## Session Info

```
knitr_1.39
  lattice_0.20-45
leaflet_2.1.1
leaflet.providers_1.9.0
  leafpop_0.1.0
lubridate_1.8.0
  maptools_1.1-4
Matrix_1.4.1
  mgcv_1.8.40
modelr_0.1.8
  nlme_3.1.157
pacman_0.5.1
  parallelly_1.31.1
pgfeatureserv_0.0.0.9001
  plogr_0.2.0
poisspatial_0.1.0.9000
  processx_3.5.3
promises_1.2.0.1
  ps_1.7.0
R6_2.5.1
  raster_3.5-9
RColorBrewer_1.1.3
RcppArmadillo_0.11.0.0.0
  RcppEigen_0.3.3.9.2
readwritesqlite_0.1.2
  rematch_1.0.1
reprex_2.0.1
  rgl_0.108.3
rmarkdown_2.14
  RSQLite_2.2.14
s2_1.0.7
  selectr_0.4.2
sfheaders_0.4.0
  slippymath_0.3.1
sp_1.4-7
  stringi_1.7.6
svglite_2.1.0
  terra_1.4-22
tidyhydat_0.5.5
  tidyverse_1.3.1
triebeard_0.3.0
  urltools_1.7.3
uuid_1.1-0
  viridis_0.6.2
webshot_0.5.3
  wk_0.6.0
labeling_0.4.2
  lazyeval_0.2.2
leaflet.extras_1.0.0
  lifecycle_1.0.1
magick_2.7.3
  markdown_1.1
memoise_2.0.1
  mime_0.12
munsell_0.5.0
  openssl_2.0.0
pagedown_0.18.1
  pdftools_3.2.0
pillar_1.7.0
  plyr_1.8.7
poisutils_0.0.0.9010
  progress_1.2.2
protolite_2.1.1
  purrr_0.3.4
rapidjsonr_1.2.0
  rayimage_0.6.2
Rcpp_1.0.8.3
  RcppRoll_0.3.0
readxl_1.4.0
  rematch2_2.1.2
rgdal_1.5-32
  RgoogleMaps_1.4.5.3
RPostgres_1.4.4
  rstudioapi_0.13
sass_0.4.1
  servr_0.24
shiny_1.7.1
  snakecase_0.11.0
splines_4.2.0
  stringr_1.4.0
sys_3.4
  terrainmeshr_0.1.0
tidyr_1.2.0
  tinytex_0.38
tzdb_0.3.0
  utf8_1.2.2
V8_4.1.0
  viridisLite_0.4.0
websocket_1.4.1
  xfun_0.31
later_1.3.0
  leafem_0.2.0
  listenv_0.8.0
magrittr_2.0.3
  MASS_7.3.56
methods_4.2.0
  miniUI_0.1.1.1
nabor_0.5.0
  openxlsx_4.2.5
parallel_4.2.0
  PearsonDS_1.2.2
pkgconfig_2.0.3
  png_0.1-7
prettyunits_1.1.1
  progressr_0.10.0
proxy_0.4-26
  qpdf_1.1
rappdirs_0.3.3
  rayshader_0.24.10
  readr_2.1.2
RefManager_1.3.0
  remotes_2.4.2
rgeos_0.5-9
  rlang_1.0.2
RPostgreSQL_0.7-3
  rvest_1.0.2
scales_1.2.0
  sf_1.0-7
shinyjs_2.1.0
  sourcetools_0.1.7
stats_4.2.0
  survival_3.3.1
systemfonts_1.0.4
  tibble_3.1.7
tidyselect_1.1.2
  tools_4.2.0
units_0.8-0
  utils_4.2.0
vctrs_0.4.1
  vroom_1.5.7
withr_2.5.0
  XML_3.99.0.9
```

xml2\_1.3.3  
yesno\_0.1.2

xtable\_1.8-4  
zip\_2.2.0

yaml\_2.3.5  
zyp\_0.10.1.1



## **Attachment 1 - Maps**

All georeferenced field maps are presented at <https://hillcrestgeo.ca/outgoing/fishpassage/projects/bulkley/archive/2022-05-02/> and available for bulk download as [Attachment 1 - https://hillcrestgeo.ca/outgoing/fishpassage/projects/bulkley/archive/2022-05-02/bulkley\\_2022-05-02.zip](https://hillcrestgeo.ca/outgoing/fishpassage/projects/bulkley/archive/2022-05-02/bulkley_2022-05-02.zip).





## **Attachment 2 - Phase 1 Data and Photos**

Data and photos for all Phase 1 (fish passage assessments) are provided in [Attachment 2 - https://github.com/NewGraphEnvironment/fish\\_passage\\_elk\\_2021\\_reporting/raw/master/docs/Attachment\\_2.pdf](https://github.com/NewGraphEnvironment/fish_passage_elk_2021_reporting/raw/master/docs/Attachment_2.pdf)



### **Attachment 3 - Habitat Assessment Data**

Raw habitat assessment data included in digital format as [Attachment 3 - https://github.com/NewGraphEnvironment/fish\\_passage\\_skeena\\_2021\\_reporting/raw/master/data/habitat\\_confirmations](https://github.com/NewGraphEnvironment/fish_passage_skeena_2021_reporting/raw/master/data/habitat_confirmations)



## **Attachment 4 - Richfield Fencing Report**

Details of fencing installed along Richfield Creek riparian area is documented in Wrench (2022) and included as [Attachment 4](#)