Effectiveness Monitoring for Cross Creek, Bittner Creek and Five Mile Creek - 2022

Prepared for
Ministry of Transportation and Infrastructure

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Research & Consulting

Table of Contents

Acknowledgement

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

1 Introduction

New Graph Environment Ltd. was retained by the Ministry of Transportation and Infrastructure in the summer of 2022 to conduct effectivness monitoring at three sites in northern BC. Study areas for 2022 field work included Bittner Creek, within the Prince George city limits in the Tabor River watershed group, Cross Creek on the west shore of Babine Lake in the Babine Lake Watershed Group near Burns Lake BC, and Five Mile Creek located approximately 11km east of the town of Williams Lake within the San Jose River watershed group.

This report is available as pdf and as an online interactive report at https://newgraphenvironment.github.io/fish_passage_elk_2022_reporting/. Viewing online is recommended as the web-hosted version contains more features and is more easily navigable.

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). Replacing barrier structures with road stream crossings that better facilitate fish passage can help to restore natural fish migration patterns, improve the quality of the aquatic ecosystems, and enhance the overall health of fish populations. As the costs and effort required for works to remediate fish passage issues through the replacement of road/stream crossings can be significant, effectiveness monitoring is a prudent measure to help understanding conditions for target fish species and inform adjustments and modifications based on the results of the monitoring. Additionally, monitoring can facilitate adaptive management, where managers use feedback/lessons learned from monitoring to modify future projects to achieve greater success.

2 Background

Study areas for 2022 field work included Cross Creek on the west shore of Babine Lake in the Babine Lake Watershed Group, Bittner Creek, within the Prince George city limits in the Tabor River watershed group and Five Mile Creek located approximately 11km east of the town of Williams Lake within the San Jose River watershed group (Figure 2.1) . Road stream crossing structures at the three locations have been replaced in the last 10 years. The intention of the work was to provide information regarding the effectiveness of structure replacements in regards to facilitating upstream fish migration as well as to describe habitat conditions related to work areas potentially impacted by structure replacement works.

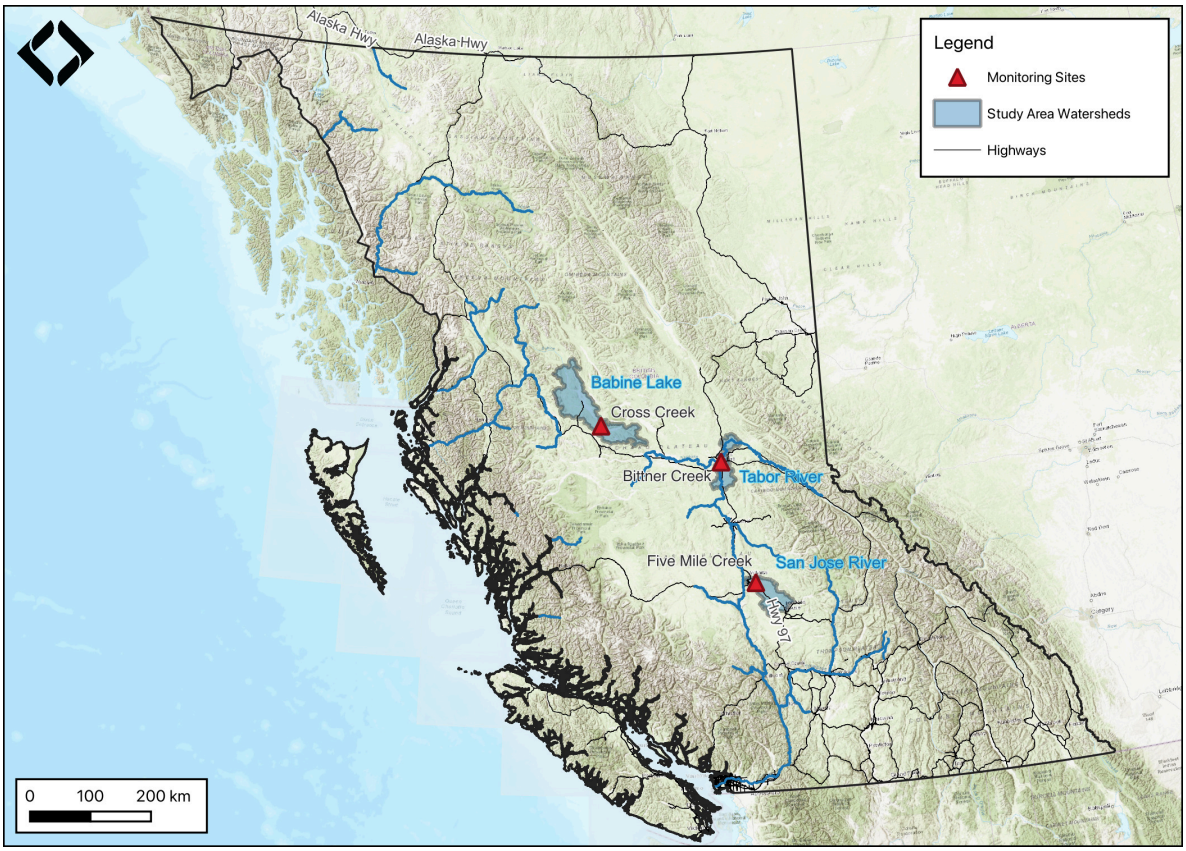

Figure 2.1: Map of monitoring site locations.

3 Methods

Assessment methods for monitoring are considered preliminary and subject to revision over time. Assessment methodologies included fish passage assessments (MoE 2011a), rapid habitat assessments (Resources Inventory Committee 2001) and data gathering related to a suite of custom monitoring metrics which include some paramaters adapted from Forest Investment Account (2003).

3.1 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 3.1). For crossings determined to be potential barriers or barriers based on the data (see Barrier Scoring (page 7)), a culvert fix and recommended diameter/span was proposed.

Table 3.1: Table 3.2: 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).

3.1.1 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 3.3, Table 3.4. 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 3.3: 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 3.4: Fish Barrier Scoring Results (MoE 2011).

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

3.2 Habitat Assessments

Habitat was assessed rapidly according to Resources Inventory Committee (2001) with characteristics documented included channel morphology, flow characteristics (perennial, intermittent, ephemeral), the presence/absence of deep pools, substrate, woody debris, undercut banks, aquatic vegetation and overhanging riparian vegetation. A key goal of the assessments was to gather stream width information upstream and downstream of the stream crossing structures to provide information regarding stream channel constriction through road/stream crossing structures as this can hinder upstream fish migration. To standardize data collected and facilitate submission of the data to provincial databases, information was collected on “Site Cards”. Additional 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.

3.3 Monitoring Metrics

Custom monitoring metrics were adapted from forestinvestmentaccount2003 (Table 4.2).

Table 3.5: Description of monitoring metrics used for effectiveness monitoring.

Parameter	Description
Dewatering	Have the remediation works led to dewatering of the channel due to substrate aggradation or other factors?
Velocity	Are flow velocities similar to those within the natural channel? Are they expected to exceed swim speeds of particular fish species/life stages of interest?
Constriction	Have the remediation works led to constriction of the channel. Compare channel width underneath structure and within construction footprint to average channel widths upstream and downstream?
Substrate	Is the substrate within/under and adjacent to the remediated structure generally equivalent to that found upstream and downstream where natural channel conditions exist?
Riparian	What is the condition of the riparian area within the construction footprint?
UAV Flight	Was a flight conducted with unmmanned aerial vehicle to document conditions at time of monitoring?
Flow_depth	What are the flow depths at the time of assessment within project footprint. Are depths expected to be sufficient to facilitat upstream passage for specific species/life stages of interest?
Stability	Does the structure appear to be stable or is there evidence of erosion/shifting?
Revegetation	How were riparian areas rehabillitated and are they improving fish habitat value?
Cover	Is cover available for fish within the construction footprint in the form of overhanging vegetation, large/small woody debris, boulders, undercut banks, etc?
Maintenance	If required, provide maintenance recommendations.
Recommendations	General recommendations for follow up. Could include revegetation, addition of substrate, fish sampling, etc.

3.4 Reporting

Reporting was generated with `bookdown` (Xie 2016) from `Rmarkdown` (Allaire et al. 2024) with primarily R (R Core Team 2022) and SQL scripts. The R package `fpr` contains many specialized custom functions related to the work (Irvine 2023). 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:
    - 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.

4 Results and Discussion

A summary of monitoring site locations and metrics are presented in Tables 4.1 and 4.2.

Table 4.1: Summary of monitoring site locations and replacement structure specifications.

Pscis Crossing Id	Stream Name	Road Name	Type	Zone	Easting	Northing	Diameter or Span (m)	Length or Width (m)
196200	Bittner Creek	Forman Road	Bridge	10	521567	5976182	21.0	5.5
198283	Cross Creek	Babine Lake Road	Pipe Arch	10	324806	60444069	6.0	14.0
198400	Five Mile Creek	Highway 97	Round Culvert	10	570699	5774416	2.3	55.0

Table 4.2: Summary of monitoring metric results.

Stream Name	Bittner Creek	Cross Creek	Five Mile Creek
Pscis Crossing Id	196200	198283	198400
Road Name	Forman Road	Babine Lake Road	Highway 97
Type	Bridge	Pipe Arch	Round Culvert
Dewatering	Wetted widths were very small in some locations due to low water levels however channel was still connected at the time of the survey.	Channel is watered all the way through at this point. Has filled in nicely since last year.	Channel flowing at bankfull channel width due to heavy rain in previous days.
Velocity	Similar to downstream and upstream at the time of survey as very little flow was present.	Similar to downstream and upstream although there are not defined stoneline riffle breaks yet.	Estimated to be slightly higher than upstream and downstream. Although pipe diameter is generally equivalent to average channel width. Addition of substrate within pipe structure would increase roughness and slow flows.
Constriction	Channel width under bridge was measured as an average of 4.6m between the riprap. Downstream average channel width was 8.2m and upstream was 6.4m.	Culvert does not appear to constricted channel.	Diameter of pipe is equivalent to the average of the upstream and downstream channel widths.
Substrate	Substrate equivalent to upstream and downstream and consists of primarily gravels and small cobbles.	Substrate is equivalent to upstream and downstream and consists of primarily gravels and small cobbles.	As the stream was turbed it was difficult to determine a subdominant substrate but by using a pole it appeared as though main channel was fines mixed in with boulders. Substrate within pipe was large cobbles.
Riparian	Downstream area adjacent to the bridge was lacking meaningful riparian vegetation due to a lack of shrub/tree installation into riprap areas during construction and the size of the channel in this location (due to infilling of historic large outlet pool).	Cuttings were installed on the upstream downstream sides of the gabion basket walls as well as immediately adjacent to the culvert. They appear to be growing at this point but year two and three will provide better indicators of survival/cover.	Riparian appears to have impacted by recent wildfire with widely spaced conifers dead. Vegetation within area of construction dominated by agronomic grasses. Upstream of construction area dominated by natural shrubs.
Uav Flight	no	yes	no
Flow Depth	Flow depths are shallow downstream of bridge where large deposit of gravel is located. Wondering if this gravel accumulated over the years when the culvert was in place and potentially restricting flows upstream resulting in deposition of gravels in this area. Channel restoration plan to maintain large outlet pool was not successful likley due to		

Stream Name	Bittner Creek	Cross Creek	Five Mile Creek
downstream transport of sediments that had accumulated upstream of the crossing.	Flow depths range from 4 - 7 cm at outlet and similar upstream. If there was a way to create more complexity in the substrate underneath the crossing there could be better holding areas for fish to move through. However that does not appear to be fish stacked up at the outlet and there are numerous spawning fish upstream.	Flow depths at outlet estimated as 30cm and deeper than rest of channel. At top of pipe depths were estimated at 10cm due to a lack of substrate. Similar depths to upstream throughout middle of pipe length.	
Stability	Stable	Stable	Stable
Revegetation	Large amount of riprap adjacent to bridge should have been planted with rooted cuttings to promote meaningful riparian cover. Future opportunities could be explored for riparian restoration on the downstream river right bank where agricultural field is directly adjacent to the creek.	Red osier dogwood cuttings planted with in soil arched structure. More riparian plantings could have been placed upstream on the left and right banks as there is notable erosion there. However, natural recruitment of cottonwood occuring and will likely provide stability and long-term cover.	Numerous invasive weeds present includeing mullen and Canada Thistle. Vegetation within area of construction dominated by agronomic grasses. Upstream of construction area riparian is dominated by natural shrubs. Silt fencing should be removed from site.
Cover	There does not appear to be any habitat enhancements creating cover in the vicinity of the bridge. Reports related to project planning indicate that the historic outlet pool was meant to provide cover however this area has infilled with gravels.	Large woody debris was placed upstream of the crossing however they are small pieces of wood from half a metre to 3 m long and will not likely remain in the channel. Some boulders were placed upstream which will likely provide habitat complexity in the long term.	Overhanging vegetation and large woody debrid minimal within construction footprint.
Maintenance	No maintenance issues. The wetted channel is extremely small immediately downstream of the bridge where gravels have accumulated. This may be causing connectivity issues during dry times of year however perhaps this is part of typical dewatering in this system.	None	Recommend addition of large cobble and boulder substrate to pipe to increase channel roughness and facilitate upstream passage for small species/lifestages. Remove silt fencing used during construction.
Recommendations	Fish sampling to determine use of habitat by chinook salmon for spawning and rearing. As site is located within Prince George city boundaries, potential collaboration could include University of Northern BC and local First Nations. To encourage year round flows, in collaboration with local landowners/stewardship groups/First Nations, wetland area in agricultural area to the north (connected to first upstream tributary) should be assessed to determine if water storage could be increased. Assess rail crossing on CN line (19703286) and scope for constriction, beaver management activitities that may be promoting flushing of water through the area, channel incision and lowering of the water table.	Follow up recommended to determine success of naturally regenerating riparian cottonwood and cuttings planted within soil arched structure.	Addition of large cobble and boulder substrate to pipe at upstream end to facilitate channel roughness. Removal of silt fencing with construction footprint.

4.1 Bittner Creek - 196200

PSCIS crossing 196200 on Bittner Creek is located on Foreman Road within the municiple boundaries of the City of Prince George approximately 0.7km upstream from the confluence with the Fraser River (Figures 2.1 - 4.2). In 2016, just downstream of the subject crossing, the banks of Bittner Creek were armoured to stabilize two areas of erosion (DWB Consulting Services Ltd. 2019). DWB Consulting Services Ltd. (2019) reported that to compensate for the net negative habitat balance of the project, the replacement of the culvert on Bittner Creek was included as a habitat enhancement in the habitat offsetting plan associated with permitting of the work. As part of

that the offsetting design intended to maintain the plunge pool habitat that had been created downstream of the culvert by installing a rock weir on the upstream end of the pool.

At crossing 196200, Bittner Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 40.1km^2. The elevation of the watershed ranges from a maximum of 768m to 574m at the crossing (Table 4.3).

The subject site is the first stream crossing structure upstream of the Fraser River with numerous modelled and previously assessed stream crossing structures upstream. Upstream of the site approximately 400m there is a crossing modelled (`modelled_crossing_id` 19703286) on the Canadian National railway line. Although data related to the assessment of this crossing was not provided and has not been uploaded to the Provincial Stream Crossing Inventory Summary System (PSCIS), DWB Consulting Services Ltd. (2019) report that the “CN crossing is considered passable to fish”. There are numerous other unassessed modelled crossings and previously assessed crossings on the stream with PSCIS crossing 196197 located approximately 5km upstream of the subject crossing on Highway 16. Review of PSCIS database information indicates this crossing was dry at the time of assessment (August 9, 2014) and ranked as a barrier to upstream migration (unembedded, with slope of 2% and outlet drop of 40cm). Numerous wetland and lakes are mapped as upstream of the crossing covering a total area estimated at approximatley 40ha.

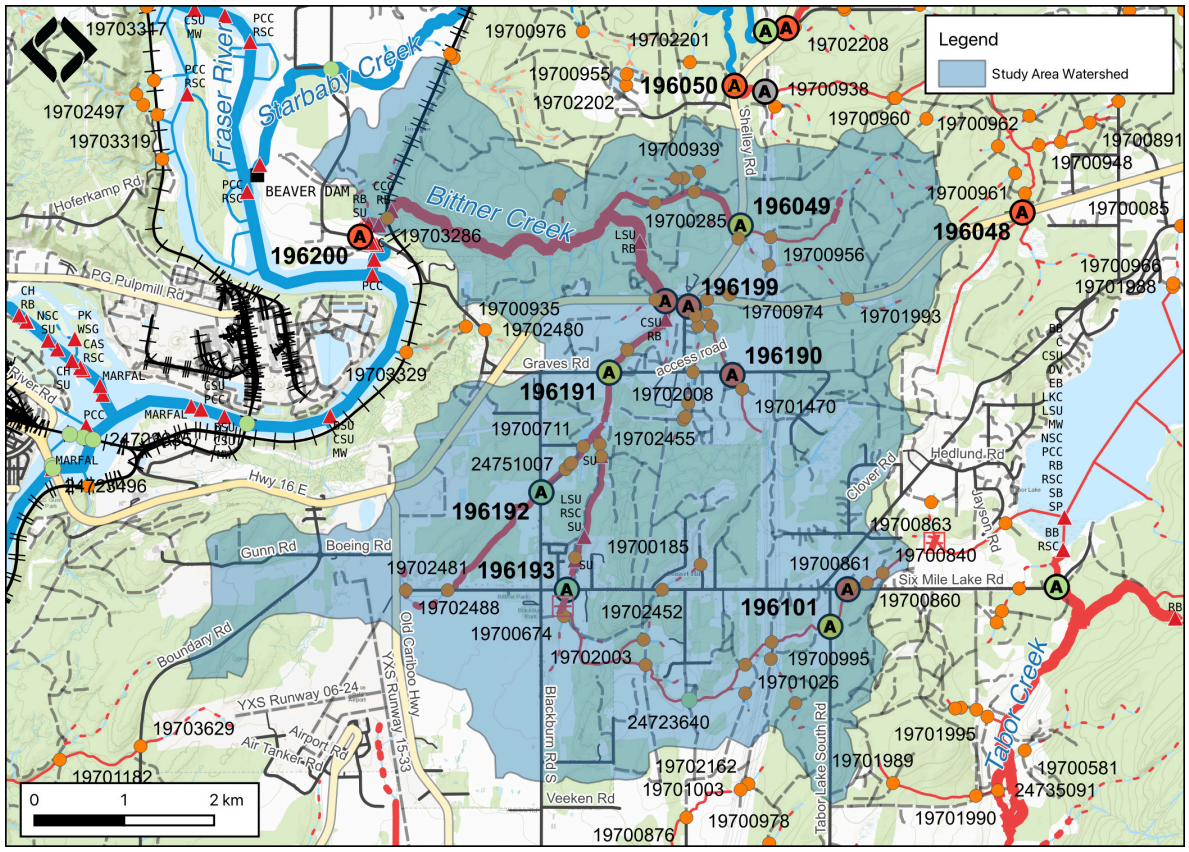

Figure 4.1: Map of Bittner Creek watershed.

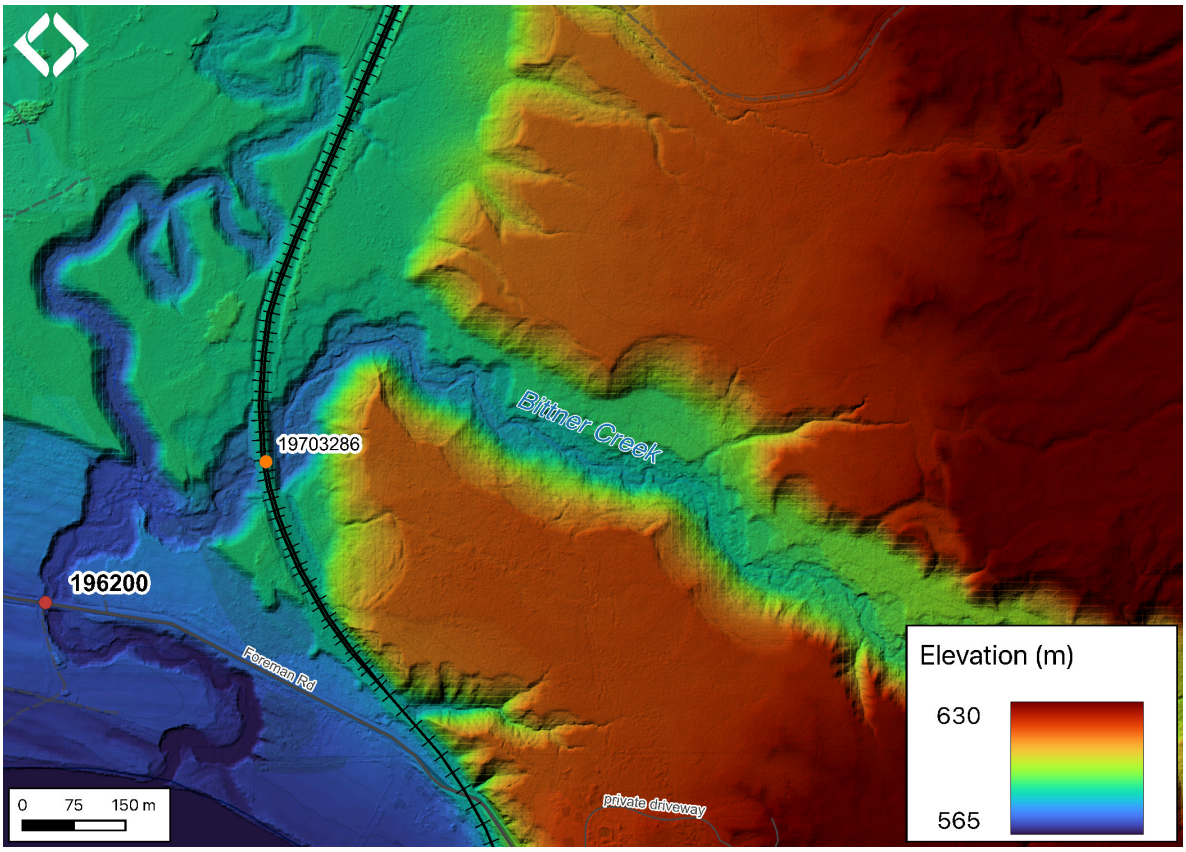

Figure 4.2: Lidar generated digital elevation model of Bittner Creek at Foreman Road.

Table 4.3: Summary of derived upstream watershed statistics for PSCIS crossing 196200.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
196200	40.1	574	565	768	682	676	SSW

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

4.1.1 Crossing Characteristics

Before remediation, the Bittner Creek culvert at PSCIS crossing 196200 was documented as a 1.9m wide round culvert of 20m in length, having an outlet drop of 0.7m and a culvert slope of 1% (MoE 2023c). The crossing ranked as a barrier to upstream migration according to the provincial protocol (MoE 2011b) . Photos taken in 2014 - before the remediation was completed are included as Figure 4.3.

In 2022, the site was reassessed. As PSCIS crossing 196200 was a bridge it ranked as passable to upstream fish passage according to the provincial protocol (Table 4.4).

Figure 4.3: Photos of culverts on Cross Creek taken in August 2014 before remediation of site.

Location and Stream Data	•	Crossing Characteristics	–
Date	2022-08-26	Crossing Sub Type	Bridge
PSCIS ID	196200	Diameter (m)	21
External ID	–	Length (m)	6
Crew	AI	Embedded	–
UTM Zone	10	Depth Embedded (m)	–
Easting	521567.2	Resemble Channel	–
Northing	5976182	Backwatered	–
Stream	Bittner Creek	Percent Backwatered	–
Road	Forman Road	Fill Depth (m)	–
Road Tenure	MoTi	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	–

Location and Stream Data	•	Crossing Characteristics	–

Comments: Effectiveness monitoring for MoTi. Adjacent landowner mentioned that in 30 years he has not seen salmon come to spawn and also indicated that the stream dewaters annually.

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

4.1.2 Stream Characteristics

Habitat characteristics were gathered upstream and downstream of the Foreman Road bridge over Bittner Creek (Figure 4.2 and Table 4.5. Flows at the time of the survey were low with near dewatering throughout sections of stream surveyed both upstream and downstream. Water temperature was 15°C, pH was 8.1 and conductivity was 432uS/cm. The landowner adjacent to the bridge (north-east side) was consulted to let them know that surveyors would be within the stream channel adjacent to their property. They reported that the stream dewatered completely on an annual basis and that they were not aware of use of the stream by Fraser River salmon.

Downstream of the bridge, the stream was surveyed for 100m. ґfpr_my_habitat_paragraph('ds')` The portion of creek immediately downstream of the bridge (20m) was lacking meaningful riparian vegetation due to a lack of shrub/tree installation into riprap areas during construction and the very wide channel width in this location. (due to infilling of historic large outlet pool).

Table 4.5: Summary of habitat details for sites adjacent to PSCIS crossing 196200 on Bittner Creek.

Site	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
196200_ds	100	8.2	4.9	–	1	moderate	medium
196200_us	130	6.3	2.5	–	1	moderate	medium

4.1.3 Discussion

Although DWB Consulting Services Ltd. (2019) noted that installation of a rock weir on the upstream end of the historic culvert outlet pool was planned to maintain this habitat feature, it is unclear if this occurred. Regardless, sediments have infilled the historic outlet pool and this area does not likely provide high or even moderate value habitat.

Flows in Bittner Creek were low at the time of assessment and the adjacent landowner reports seasonal dewatering of the stream. Nevetheless, numerous parr were observed within isolated pools upstream of the newly installed bridge and residual pools within intermittent systems can provide valuable habitat for juvenile salmon encouraging high growth rates and subsequent increased rates of overwinter survival (Ebersole et al. 2006; Wigington Jr et al. 2006; Maslin and McKinnev 1998). We recommend fish sampling to determine use of Bittner Creek habitats by chinook salmon for both spawning and rearing. As the site is located within Prince George city boundaries, potential collaborations could include programs involving University of Northern BC and local First Nations to understand not only fish health and movement but also overall watershed health including flow patterns and water temperatures. To encourage year round flows, in collaboration with local landowners/stewardship groups/First Nations, wetland area in the agricultural area to the north of the bridge (connected to first upstream tributary) should be assessed to determine if water storage could be increased by actions such as promoting beaver activity and infilling of historic drainage stuctures. The rail crossing located on the CN line

(19703286) approximately 400m upstream of Foreman Road should be assessed for fish passage with the data gathered loaded to the PSCIS database. At the same time this area could be scoped for evidence of channel constriction, beaver management activities and other railway/agricultural land practices that may be promoting flushing of water through the area, channel incision and lowering of the water table.

Figure 4.4: Left: Habitat downstream of PSCIS crossing 196200, on Bittner Creek. Right: Habitat downstream of PSCIS crossing 196200, on Bittner Creek

Figure 4.5: Left: Downstream view of location of historic outlet pool on Bittner Creek below Foreman Road which has filled with gravels due to culvert removal. Right: Salmonid parr observed upstream of bridge on Bittner Creek.

Figure 4.6: Left: Typical habitat upstream of Foreman Road bridge on Bittner Creek. Right: Typical habitat upstream of Foreman Road bridge on Bittner Creek.

4.2 Cross Creek - 198283

PSCIS crossing 198283 on Cross Creek is located on Babine Lake Road, approximately 30km north-east (45 minute drive) of the town of Burns Lake (Figure 2.1). A map of the watershed (see modelled crossing id 500059) is provided in map attachment 093K.111. At the time of reporting, the mapping for the stream was slightly incorrect with the site located approximately 100m to the north of where shown in the BC freshwater atlas and within Babine Lake Marine Provincial Park - Pendleton Bay Site boundaries. The road is the responsibility of the Ministry of Transportation and Infrastructure.

PSCIS crossing 198283 was identified by the Lake Babine Nation, Dustin Snyder (Spruce City Wildlife Association) as a barrier to fish passage blocking sockeye attempting to spawn annually and brought to the attention of the Ministry of Transportation and Infrastructure. The Ministry of Transportation and Infrastructure worked together with Fisheries and Oceans Canada and Canadian Wildlife Federation to plan and implement replacement of the existing culverts with an open bottomed geotextile soil arched reinforced structure designed by Terratech Consulting Ltd in the summer of 2021. A short video documents the story here.

An impassible 9m falls is located on the mainstem of the stream approximately 1km upstream of Babine Lake Road (FINS Consulting Ltd. 2000; MoE 2023b). There are no other stream crossings modelled between the road and the falls. Upstream of the crossing lake chub, coho salmon, rainbow trout, kokanee, and sockeye salmon have been recorded (MoE 2023a; Norris [2018] 2023).

At crossing 198283, Cross Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 34.8km^2. The elevation of the watershed ranges from a maximum of 1263m to 722m at the crossing (Table 4.6).

Table 4.6: Summary of derived upstream watershed statistics for PSCIS crossing 198283.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
198283	34.8	722	727	1263	1065	1047	SSE

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

4.2.1 Crossing Characteristics

Before remediation, the Cross Creek culverts at PSCIS crossing 198283 were documented as 1.8m wide ovals culverts of 12.4m in length, having an outlet drop of 0.45m and a culvert slope of 2% (MoE 2023c). The crossing ranked as a barrier to upstream migration according to the provincial protocol (MoE 2011b). Photos taken in 2017 - before the remediation was completed are included as Figure 4.7. In 2022, the site was reassessed. As PSCIS crossing 198283 was a newly installed open bottomed structure it ranked as a passable to upstream fish passage according to the provincial protocol (Table 4.7).

Figure 4.7: Photos of culverts on Cross Creek taken in November 2017 before remediation of site.

Table 4.7: Summary of fish passage assessment for PSCIS crossing 198283.

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

Location and Stream Data	•	Crossing Characteristics	–
PSCIS ID	198283	Diameter (m)	6
External ID	–	Length (m)	14
Crew	Ai MW	Embedded	–
UTM Zone	9	Depth Embedded (m)	–
Easting	324806	Resemble Channel	–
Northing	6044069	Backwatered	–
Stream	Cross Creek	Percent Backwatered	–
Road	Babine Lake Road	Fill Depth (m)	–
Road Tenure	MoTi	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	–

Location and Stream Data	•	Crossing Characteristics	–

Comments: Effectiveness monitoring for MoTi. Channel has filled in nicely since last year. Numerous sockeye holding upstream and downstream of the crossing. Multiple large dead spawn out sockeye present. Live cuttings installed within riparian area appear to be growing however year two and three will be better indicators of success for revegetation.

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

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.

Stream Characteristics

Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as small woody debris, large woody debris, and overhanging vegetation.The dominant substrate was gravels with cobbles sub-dominant.The average channel width was 6m, the average wetted width was 3m, and the average gradient was 1.2%. Water temperature was 13°C, pH was 8 and conductivity was 168uS/cm.

Table 4.8: Summary of habitat details for area surveyed downstream of PSCIS crossing 198283 on Cross Creek as well as within the replacement open bottomed structure (198283_x).

Site	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198283_ds	100	6	3	0.2	1.2	moderate	high

4.2.2 Discussion

Overall, the restoration of fish passage at Cross Creek appears to be successful demonstrating meaningful collaboration between numerous groups including Lake Babine Nation, Spruce City Wildlife Association, the Ministry of Transportation and Infrastructure, Fisheries and Oceans Canada and Canadian Wildlife Federation. The streambed appears to be filling in well following one year of flows since restoration and at the time of assessment in 2022, numerous sockeye and kokanee were observed spawning upstream of the crossing. Follow up is recommended in 2023 to determine success of naturally regenerating riparian cottonwood seedlings as well as cuttings planted within the soil arched structure.

Figure 4.8: Left: Typical habitat downstream of PSCIS crossing 198283in Cross Creek showing high value spawning gravels. Right: Typical habitat downstream of PSCIS crossing 198283 in Cross Creek.

Figure 4.9: Left: Habitat upstream of PSCIS crossing 198283 in Cross Creek. Right: Habitat immediately upstream of PSCIS crossing 198283 in Cross Creek.

4.3 Five Mile Creek - 198400

PSCIS crossing 198400 is located on Five Mile Creek under Highway 97 approximately 11km east of Williams Lake within the San Jose River watershed group (Figures 2.1 - 4.11. The structure is located within the boundaries of the Williams Lake 1 First Nation Reservation. The area around Five Mile Creek is home to T'exelcemc people of the T'exelc First Nation. The T'exelc First Nation (also known as the Williams Lake Indian Band) is part of the larger Secwepemc (Shuswap) Nation with traditional territory covering a vast area of central British Columbia. Secwepemctsin is the language of the Secwepem. It contains the cultural, ecological, and historical knowledge connecting the land and the people (T'exelcemc 2023; First Peoples' Cultural Council 2023). The Five Mile Creek

watershed upstream of the Highway encompasses three other First Nations reserve areas including Five Mile 3, James Louis 3A and Carpenter Mountain 15. Replacement of the historic structure (900mm round culvert) in 2016 was necessary to four-laneing Highway 97.

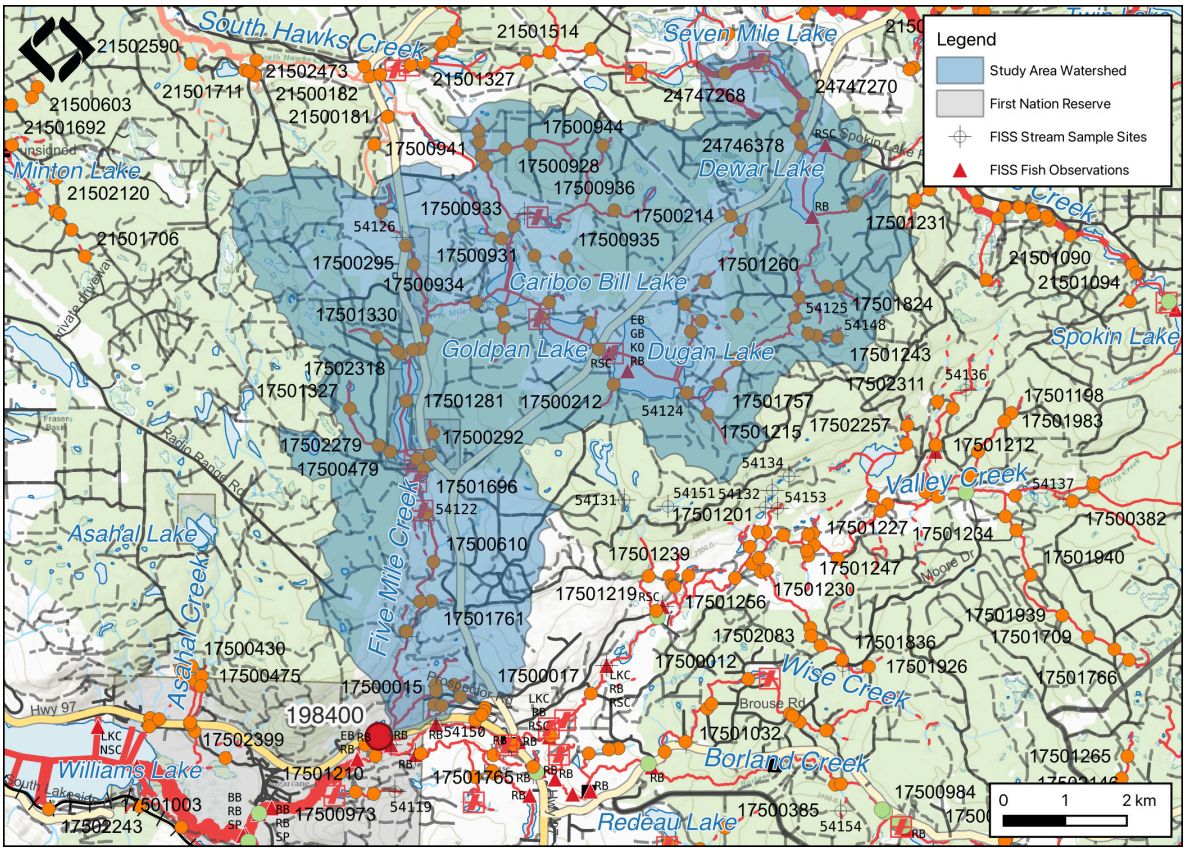

Figure 4.10: Map of Five Mile Creek watershed.

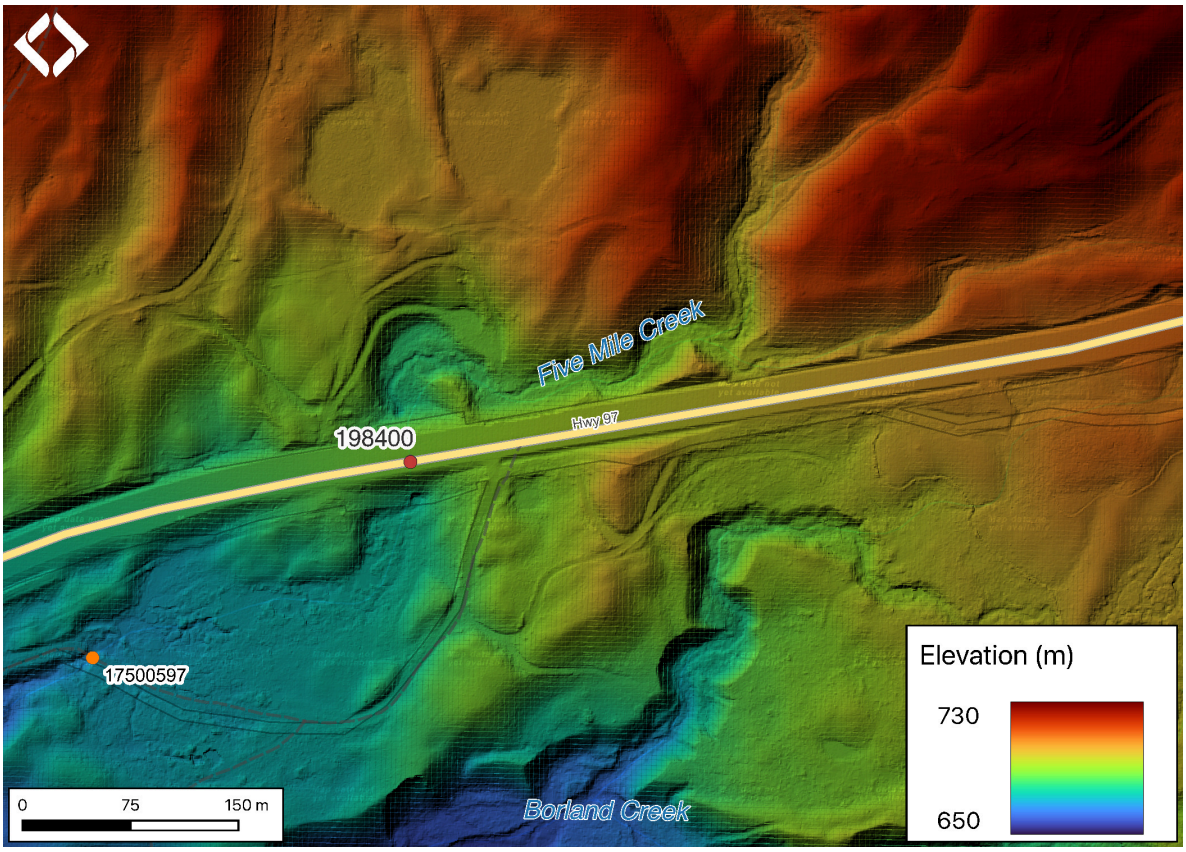

Figure 4.11: Lidar generated digital elevation model of Five Mile Creek at Highway 97.

Five Mile Creek flows into Borland Creek approximately 800m downstream of the highway then into the San Jose River a further 2.1km downstream. The San Jose River in turn empties into Williams Lake approximately 4.5km downstream of the highway. Although apparently a rare occurrence, due to impacts to Williams Creek which drains Williams Lake, there are reports of sockeye salmon ascending from the Fraser River to Williams Lake and in theory spawning in the San Jose River. It is thought that these fish are from the Quesnel stock (Williams Lake Tribune 2022).

On Five Mile Creek Between the highway and the San Jose River there are two previously unassessed crossings modelled as closed bottom structures. The first (`modelled_crossing_id` 17500597) is modelled as 300m downstream and the second (`modelled_crossing_id` 17500595) is modelled as located approximately 1km downstream. There are numerous unassessed modelled crossings upstream of the highway as well as four dams documented between approximately 4km and 10km upstream of the highway.

At crossing 198400, Five Mile Creek is a fourth order stream with a watershed area upstream of the crossing of approximately 63.1km^2. The elevation of the watershed ranges from a maximum of 1061m to NAm at the crossing (Table 4.9). Upstream of the crossing sucker (general), longnose

sucker, white sucker, largescale sucker, chub (general), peamouth chub, northern pikeminnow, longnose dace, leopard dace, redside shiner, burbot, lake whitefish, all pacific salmon, pink salmon, coho salmon, rainbow trout, kokanee, sockeye salmon, brook trout, and lake trout have been recorded (MoE 2023a; Norris [2018] 2023). Numerous lakes and wetlands are located in the Five Mile Creek watershed including Dugan Lake (96ha), Goldpan Lake (41ha) and Cariboo Bill Lake (30ha).

On assignment from Ministry of Transportation and Infrastructure in 2010, Triton Environmental Consultants Ltd. (2014) captured rainbow trout downstream of the culvert with minimal effort however no fish were captured upstream of the crossing with 108 seconds of electrofishing effort. Caribou Envirotech Ltd. (2005) sampled Five Mile Creek and an unnamed lake (00089SAJR) located approximately 5km upstream of the highway to provide information related to planning for construction of a dam on the lake. They documented taht the portion of Five Mile Creek located immediately downstream of the unnamed lake was a man-made ditch divided into drainage channels for water dispersal downstream. The noted that water temperatures were likely to be very high in the summer months and ranked the habitat value as “very poor”.

Table 4.9: Summary of derived upstream watershed statistics for PSCIS crossing 198400 on Five Mile Creek.

Site	Area Km	Elev Site	Elev Min	Elev Max	Elev Median	Elev P60	Aspect
999	63.1	–	–	1061	938	927	S

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

4.3.1 Crossing Characteristics

Although not documented in the PSCIS database, before remediation, Triton Environmental Consultants Ltd. (2014) reported that the Five Mile Creek culvert at PSCIS crossing 198400 was a 1.0m diameter, 45m long, round, non-embedded culvert with a gradient of 3% and ranked as a barrier to upstream migration according to the provincial protocol (MoE 2011b). However, Triton Environmental Consultants Ltd. (2014) also reported that the culvert was “likely passable to adult fish during most flow conditions with the exceptions of freshet or flood flow”.

The highway crossing on Five Mile Creek was assessed on September 16, 2022. PSCIS crossing 198400 was embedded 80cm at the outlet of the culvert with no embeddedness at the inlet. Due to the length of the 2.25m diameter round pipe (55m), a lack of embeddedness and culvert slope (3%) the structure ranked as a barrier to upstream fish passage according to the provincial protocol (Table 4.7).

Table 4.10: Summary of fish passage assessment for PSCIS crossing 17501664.

Location and Stream Data	•	**Crossing Characteristics**	–
Date	2022-09-16	Crossing Sub Type	Round Culvert
PSCIS ID	–	Diameter (m)	2.25
External ID	17501664	Length (m)	55
Crew	AI	Embedded	Yes
UTM Zone	9	Depth Embedded (m)	0.4
Easting	570699	Resemble Channel	Yes
Northing	5774416	Backwatered	No
Stream	Five Mile Creek	Percent Backwatered	–
Road	Highway 97	Fill Depth (m)	8
Road Tenure	MoTi	Outlet Drop (m)	0
Channel Width (m)	2.1	Outlet Pool Depth (m)	0.1
Stream Slope (%)	5	Inlet Drop	No
Beaver Activity	No	Slope (%)	3
Habitat Value	Medium	Valley Fill	Deep Fill
Final score	21	Barrier Result	Barrier
Fix type	Add Substrate to Further embed the CBS	Fix Span / Diameter	–

Location and Stream Data	•	Crossing Characteristics	–

Comments: MoTi effectiveness monitoring site. Culvert has been replaced with horizontally drilled pipe. Outlet of the culvert is embedded 80 cm. It is only the top 2 1/2 m of pipe that is not fully embedded with natural substrate. Although this culvert may score as a barrier with the Provincial metric conditions within the pipe are very similar to those upstream within the natural step-pool channel.

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

4.3.2 Stream Characteristics

Upstream of the highway, the stream was surveyed for m. The dominant substrate was fines with boulders sub-dominant.Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as boulders and overhanging vegetation.The average channel width was 2.3m, the average wetted width was 2.1m, and the average gradient was 5.2%. Water temperature was 10.8°C, pH was 8.3 and conductivity was 814uS/cm. The dominant substrate was fines with boulders sub-dominant.Total cover amount was rated as moderate with undercut banks dominant. Cover was also present as boulders and overhanging vegetation.The average channel width was 2.3m, the average wetted width was 2.1m, and the average gradient was 5.2%. (Table 4.11). At the time of the survey flows were high (bankfull depth) due to recent rain events and the water was very turbid. Habitat value was assessed as low due to poor water quality and the small size of the stream.

Table 4.11: Summary of habitat details for ara surveyed upstream of PSCIS crossing 198400 on Five Mile Creek.

Site	Length Surveyed (m)	Channel Width (m)	Wetted Width (m)	Pool Depth (m)	Gradient (%)	Total Cover	Habitat Value
198400_us	–	2.3	2.1	0.5	5.2	moderate	–

4.3.3 Discussion

Five Mile Creek is a small system utilized by rainbow trout near the highway. High levels of turbidity noted during the site visit along with past reporting by Caribou Envirotech Ltd. (2005), Triton Environmental Consultants Ltd. (2014) indicate that the area upstream of the crossing had been impacted by fire, cattle use of riparian areas and the installation of dams and associated water drainage structures.

Replacement of crossing structures for small streams on large highways can be extremely expensive, requiring significant resources and time to complete. Although not ideal for facilitating upstream fish migration, horizontal drilling of pipes (versus the installation of open bottom structures) can help reduce costs related to construction and proper embedding of these pipes with substrate similiar to that found in adjacent natural reaches can provide conditions suitable for upstream fish migration. Although the highway crossing ranked as a barrier to upstream migration, embedding the pipe for its full length would result in a ranking of “potential” barrier and likely provide channel roughness conditions suitable for all life stages of rainbow trout to migrate upstream. For this reason we recommend the addition of large cobble and boulder substrate at the upstream end of the pipe. We also recommend that silt fencing installed for erosion and sediment control during construction be removed at the same time.

Figure 4.12: Left: Habitat within construction footprint upstream of PSCIS crossing 198400 in Five Mile Creek. Right: Habitat upstream of construction footprint adjacent to crossing 198400 in Five Mile Creek.

5 Conclusion

Fish passage restoration works at Bittner Creek, Cross Creek and Five Mile Creek demonstrate significant investments in aquatic ecosystem stewardship with benefits apparent at all three sites. Each site provides opportunities to learn from past actions and will help build our state of knowledge going forward.

Effectiveness monitoring provides opportunities to collect data on fish populations and their behavior, which can help build the state of knowledge about habitat utilization, health and migration patterns. Additionally, this data can be used to inform future management decisions and planning. Whenever possible, baseline and follow up sampling of fish upstream and downstream of crossings should be conducted. When possible and likely follow up sample timing permits, Passive Integrated Transponders (PIT tags) should be inserted into species of interest to track movement and health over time. If not conducted beforehand, fish salvage during preparation for dewatering before construction could provide opportunities for tagging with minimal costs over and above those already necessary for construction salvage. This would require collaboration between project managers, consultants conducting salvages and other developers of the overall effectiveness monitoring program but would result in an increase in our state of knowledge of how fish use remediated systems and help standardize effectiveness monitoring protocols.

Environmental practitioners, road tenure holders, First Nations, regulators, academia, non-profit organizations, and local stewardship groups must collaborate and invest time to create a comprehensive effectiness monitoring program for fish passage restoration that best benefits stakeholders, fish populations and aquatic ecosystems impacted by infrastructure. This will enable informed decisions, responsible allocation of investments, and ensure the long-term sustainability of fish populations and aquatic ecosystems impacted by linear infrastructure.

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Changelog

fish_passage_moti_2022_reporting 0.0.2 (2024-07-11)

- Correct utm error for Cross Creek
- update packages
- add changelog
- use staticimports functions

fish_passage_moti_2022_reporting 0.0.1 (2023-05-03)

- Initial release

Session Info

Information about the computing environment is important for reproducibility. A summary of the computing environment is saved to `session_info.csv` that can be viewed and downloaded from https://github.com/NewGraphEnvironment/fish_passage_moti_2022_reporting/blob/main/data/session_info.csv.

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##  system   aarch64, darwin20
##  ui       RStudio
##  language (EN)
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##  tz       America/Vancouver
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##  rstudio  2024.04.1+748 Chocolate Cosmos (desktop)
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/Applications/RStudio.app/Contents/Resources/app/quarto/bin/tools/aarch6-
```

```
4/ (via rmarkdown)
##
## — Packages
──────────────────────────────────────────────────────────────────────────────
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##  lifecycle         1.0.4      2023-11-07 [1] CRAN (R 4.4.0)
##  lubridate       * 1.9.3      2023-09-27 [1] CRAN (R 4.4.0)
##  magick          * 2.8.3      2024-02-18 [1] CRAN (R 4.4.0)
##  magrittr          2.0.3      2022-03-30 [1] CRAN (R 4.4.0)
##  memoise           2.0.1      2021-11-26 [1] CRAN (R 4.4.0)
##  mime              0.12       2021-09-28 [1] CRAN (R 4.4.0)
##  miniUI            0.1.1.1    2018-05-18 [1] CRAN (R 4.4.0)
```

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##  munsell           0.5.1      2024-04-01 [1] CRAN (R 4.4.0)
##  openssl           2.1.2      2024-04-21 [1] CRAN (R 4.4.0)
##  pagedown        * 0.20       2022-12-13 [1] CRAN (R 4.4.0)
##  pdftools        * 3.4.0      2023-09-25 [1] CRAN (R 4.4.0)
##  pillar            1.9.0      2023-03-22 [1] CRAN (R 4.4.0)
##  pkgbuild          1.4.4      2024-03-17 [1] CRAN (R 4.4.0)
##  pkgconfig         2.0.3      2019-09-22 [1] CRAN (R 4.4.0)
##  pkgload           1.3.4      2024-01-16 [1] CRAN (R 4.4.0)
##  plyr              1.8.9      2023-10-02 [1] CRAN (R 4.4.0)
##  png               0.1-8      2022-11-29 [1] CRAN (R 4.4.0)
##  poisspatial     * 0.1.0.9000 2024-05-14 [1] Github
(poissonconsulting/poisspatial@39f7e18)
##  poisutils         0.0.0.9010 2024-05-14 [1] Github
(poissonconsulting/poisutils@8310dc4)
##  prettyunits       1.2.0      2023-09-24 [1] CRAN (R 4.4.0)
##  processx          3.8.4      2024-03-16 [1] CRAN (R 4.4.0)
##  profvis           0.3.8      2023-05-02 [1] CRAN (R 4.4.0)
##  progress          1.2.3      2023-12-06 [1] CRAN (R 4.4.0)
##  progressr         0.14.0     2023-08-10 [1] CRAN (R 4.4.0)
##  promises          1.3.0      2024-04-05 [1] CRAN (R 4.4.0)
##  proxy             0.4-27     2022-06-09 [1] CRAN (R 4.4.0)
##  ps                1.7.6      2024-01-18 [1] CRAN (R 4.4.0)
##  purrr           * 1.0.2      2023-08-10 [1] CRAN (R 4.4.0)
##  qpdf              1.3.3      2024-03-25 [1] CRAN (R 4.4.0)
##  R6                2.5.1      2021-08-19 [1] CRAN (R 4.4.0)
##  rappdirs          0.3.3      2021-01-31 [1] CRAN (R 4.4.0)
##  raster          * 3.6-26     2023-10-14 [1] CRAN (R 4.4.0)
##  rayshader       * 0.37.3     2024-02-21 [1] CRAN (R 4.4.0)
##  Rcpp              1.0.12     2024-01-09 [1] CRAN (R 4.4.0)
##  readr           * 2.1.5      2024-01-10 [1] CRAN (R 4.4.0)
##  readwritesqlite * 0.2.0      2022-10-16 [1] CRAN (R 4.4.0)
##  readxl          * 1.4.3      2023-07-06 [1] CRAN (R 4.4.0)
##  remotes           2.5.0      2024-03-17 [1] CRAN (R 4.4.0)
##  rfp             * 0.0.0.9000 2024-07-01 [1] local
##  rgl               1.3.1      2024-03-05 [1] CRAN (R 4.4.0)
##  rlang             1.1.3      2024-01-10 [1] CRAN (R 4.4.0)
##  rmarkdown       * 2.27       2024-05-17 [1] CRAN (R 4.4.0)
##  roxygen2          7.3.1      2024-01-22 [1] CRAN (R 4.4.0)
##  RPostgres       * 1.4.7      2024-05-27 [1] CRAN (R 4.4.0)
##  rprojroot         2.0.4      2023-11-05 [1] CRAN (R 4.4.0)
##  RSQLite           2.3.6      2024-03-31 [1] CRAN (R 4.4.0)
##  rstudioapi        0.16.0     2024-03-24 [1] CRAN (R 4.4.0)
##  sass              0.4.9      2024-03-15 [1] CRAN (R 4.4.0)
##  scales            1.3.0      2023-11-28 [1] CRAN (R 4.4.0)
##  servr             0.30       2024-03-23 [1] CRAN (R 4.4.0)
##  sessioninfo       1.2.2      2021-12-06 [1] CRAN (R 4.4.0)
##  sf              * 1.0-16     2024-03-24 [1] CRAN (R 4.4.0)
```

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##  shiny             1.8.1.1    2024-04-02 [1] CRAN (R 4.4.0)
##  shrtcts         * 0.1.2      2024-05-14 [1] Github
(gadenbuie/shrtcts@41051cf)
##  snakecase         0.11.1     2023-08-27 [1] CRAN (R 4.4.0)
##  sp              * 2.1-4      2024-04-30 [1] CRAN (R 4.4.0)
##  staticimports     0.0.0.9001 2024-07-04 [1] local
##  stringi           1.8.4      2024-05-06 [1] CRAN (R 4.4.0)
##  stringr         * 1.5.1      2023-11-14 [1] CRAN (R 4.4.0)
##  svglite           2.1.3      2023-12-08 [1] CRAN (R 4.4.0)
##  sys               3.4.2      2023-05-23 [1] CRAN (R 4.4.0)
##  systemfonts       1.0.6      2024-03-07 [1] CRAN (R 4.4.0)
##  terra             1.7-71     2024-01-31 [1] CRAN (R 4.4.0)
##  tibble          * 3.2.1      2023-03-20 [1] CRAN (R 4.4.0)
##  tidyhydat       * 0.6.1      2024-01-11 [1] CRAN (R 4.4.0)
##  tidyr           * 1.3.1      2024-01-24 [1] CRAN (R 4.4.0)
##  tidyselect        1.2.1      2024-03-11 [1] CRAN (R 4.4.0)
##  tidyverse       * 2.0.0      2023-02-22 [1] CRAN (R 4.4.0)
##  timechange        0.3.0      2024-01-18 [1] CRAN (R 4.4.0)
##  tzdb              0.4.0      2023-05-12 [1] CRAN (R 4.4.0)
##  units             0.8-5      2023-11-28 [1] CRAN (R 4.4.0)
##  urlchecker        1.0.1      2021-11-30 [1] CRAN (R 4.4.0)
##  usethis         * 2.2.3      2024-02-19 [1] CRAN (R 4.4.0)
##  utf8              1.2.4      2023-10-22 [1] CRAN (R 4.4.0)
##  uuid              1.2-0      2024-01-14 [1] CRAN (R 4.4.0)
##  V8                4.4.2      2024-02-15 [1] CRAN (R 4.4.0)
##  vctrs             0.6.5      2023-12-01 [1] CRAN (R 4.4.0)
##  viridisLite       0.4.2      2023-05-02 [1] CRAN (R 4.4.0)
##  vroom             1.6.5      2023-12-05 [1] CRAN (R 4.4.0)
##  websocket         1.4.1      2021-08-18 [1] CRAN (R 4.4.0)
##  withr             3.0.0      2024-01-16 [1] CRAN (R 4.4.0)
##  xfun              0.44       2024-05-15 [1] CRAN (R 4.4.0)
##  xml2              1.3.6      2023-12-04 [1] CRAN (R 4.4.0)
##  xtable            1.8-4      2019-04-21 [1] CRAN (R 4.4.0)
##  yaml              2.3.8      2023-12-11 [1] CRAN (R 4.4.0)
##  yesno             0.1.2      2020-07-10 [1] CRAN (R 4.4.0)
##
##  [1] /Library/Frameworks/R.framework/Versions/4.4-
arm64/Resources/library
##
##
```

Attachment 1 - Raw Data

Raw assessment data included in digital format at https://github.com/NewGraphEnvironment/fish_passage_moti_2022_reporting/raw/master/data/habitat_confirmations.xls