SOCIETY FOR ECOSYSTEM RESTORATION
IN NORTHERN BRITISH COLUMBIA

PEA-F22-F-3577-DCA Restoring Fish Passage in the Peace Region

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

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Acknowledgement

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

Many thanks to the McLeod Lake members of council that took the time to meet and discuss big picture goals for this collaboration. Thank you to Nathan Prince for viewing sites in the field, liaising with numerous players and tying this work together with the numerous other initiatives the Nation is advising and steering.

Executive Summary

Introduction

This report is available as pdf and as an online [interactive report](https://newgraphenvironment.github.io/fish_passage_parsnip_2021_reporting/) at https://newgraphenvironment.github.io/fish_passage_parsnip_2021_reporting/. We recommend viewing online as the web-hosted version contains more features and is more easily navigable. Please reference the website for the latest version number and download the latest pdf from https://github.com/NewGraphEnvironment/fish_passage_parsnip_2021_reporting/raw/master/docs/parsnip2021.pdf

This project builds on Society for Ecosystem Restoration Northern BC (SERNbc) work in 2019 - 2020 which can be referenced [here](#) (Allan Irvine 2020). In 2019, following a literature review, analysis of fish habitat modelling data, the Provincial Stream Crossing Inventory System (PSCIS) and a community scoping exercise within the McLeod Lake Indian Band habitat confirmation assessments were conducted throughout the Parsnip River watershed. At 17 sites where habitat confirmation assessments were conducted, crossings were rated for fish passage remediation priority. During the habitat confirmations a total of approximately 15 km of stream was assessed with 10 crossings rated as high priorities for rehabilitation, three crossings rated as moderate priorities and four crossings rated as low priorities.

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.

SERNbc is working together with the Peace Region Fish and Wildlife Compensation Program (FWCP), the McLeod Lake Indian Band, the Provincial Fish Passage Technical Working Group (FPTWG), road/rail tenure holders and other FWCP stakeholders/partners to prioritize, plan and fund the restoration of fish passage at Parsnip River watershed road crossing structure barriers previously ranked as high or moderate priorities. In 2021/2022 we were able to source funding from the Ministry of Forests, Lands and Natural Resource Operations and Rural Development to initiate replacement of a high priority crossing in the Missinka River watershed with a clearspan bridge. With support from FWCP in 2023 remediation of fish passage at the site will be completed and works at an additional high priority site (Chuchinka-Arctic FSR) will be initiated. Additionally, through the ongoing development of open source analysis and data presentation tools we are identifying and highlighting sites with potential connectivity issues and are planning on the ground works to assess opportunities. Planning, field assessments and follow up reporting will continue to include engagement with road/rail tenure holders, build awareness for connectivity issues in the wider community and build capacity for ecosystem restoration in the Peace Region.

Goal and Objectives

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

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

Study Area and Background

Tse'khene

The Parsnip River watershed is located within the south-eastern portion of the 108,000 km^2 traditional territory of the Tse'khene from the [McLeod Lake Indian Band](). The Tse'khene *"People of the Rocks"* are a south westerly extension of the Athabascan speaking people of northern Canada. They were nomadic hunters whose language belongs to the Beaver-Sarcee-Tse'khene branch of Athapaskan ("History - Who We Are" n.d.). Extensive work is underway to preserve the language with resources such as First Voices available [online]() and in [app form]() for iphone and ipad devices (First People Cultural Council 2022; Language and Council 2022).

The continental divide separates watersheds flowing north into the Arctic Ocean via the Mackenzie River and south and west into the Pacific Ocean via the Fraser River (Figure [1]()). The Parsnip River is a 6th order stream with a watershed that drains an area of 5597km^2. The mainstem of the river flows within the Rocky Mountain Trench in a north direction into Williston Reservoir starting from the continental divide adjacent to Arctic Lakes. Major tributaries include the Misinchinka, Colbourne, Reynolds, Anzac, Table, Hominka and Missinka sub-basins which drain the western slopes of the Hart Ranges of the Rocky Mountains. The Parsnip River has a mean annual discharge of 147.3 m^3/s with flow patterns typical of high elevation watersheds on the west side of the northern Rocky Mountains which receive large amounts of precipitation as snow leading to peak levels of discharge during snowmelt, typically from May to July (Figures [2]() - [3]()).

Construction of the 183 m high and 2134 m long W.A.C. Bennett Dam was completed in 1967 at Hudson's Hope, BC, creating the Williston Reservoir (Hirst 1991). Filling of the 375km^2 reservoir was complete in 1972 and flooded a substantial portion of the Parsnip River and major tributary valleys forming what is now known as the Peace and Parsnip reaches. The replacement of riverine habitat with an inundated reservoir environment resulted in profound changes to the ecology, resource use and human settlement patterns in these systems (Hagen et al. 2015a; Pearce 2019; Stamford, Hagen, and Williamson 2017a). Prior to the filling of the reservoir, the Pack River, into which McLeod Lake flows, was a major tributary to the Parsnip River. The Pack River currently enters the Williston Reservoir directly as the historic location of the confluence of the two rivers lies within the reservoir's footprint.
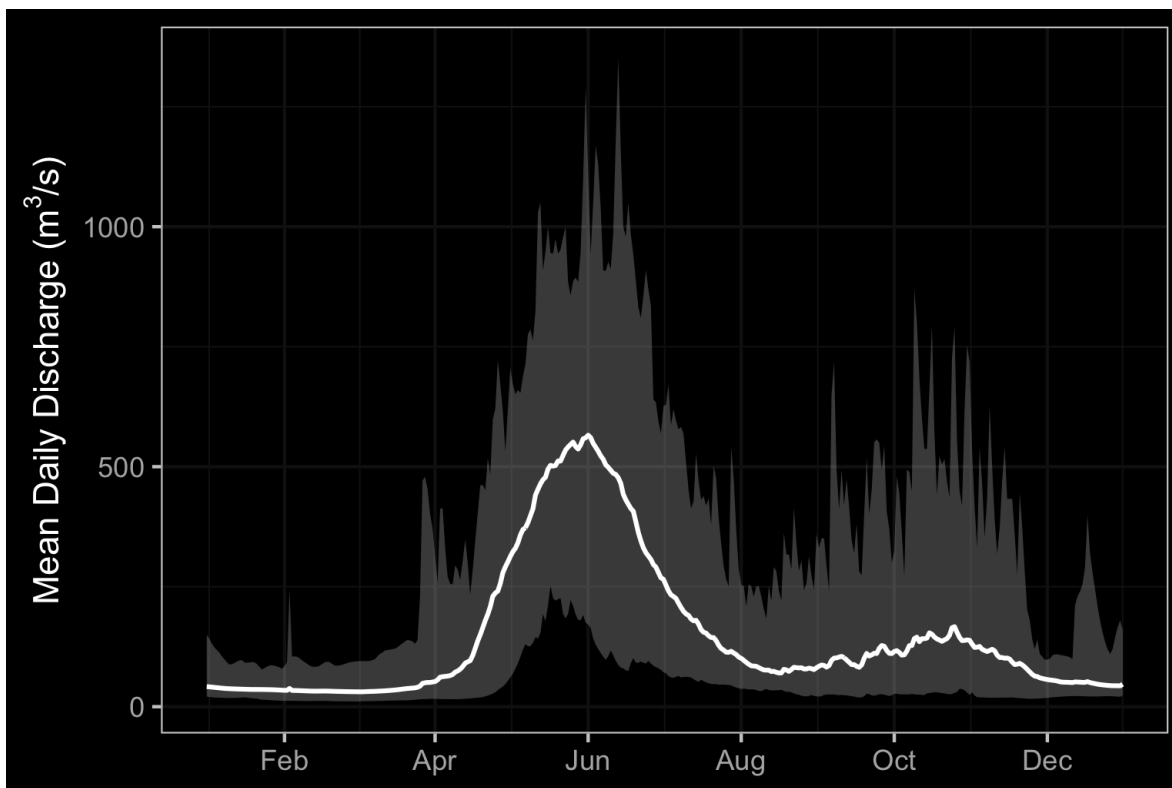
Figure 1: Overview map of study area

Figure 2: Parsnip River Above Misinchinka River (Station #07EE007 - Lat 55.08194 Lon -122.913063). Available daily discharge data from 1967 to 2019.
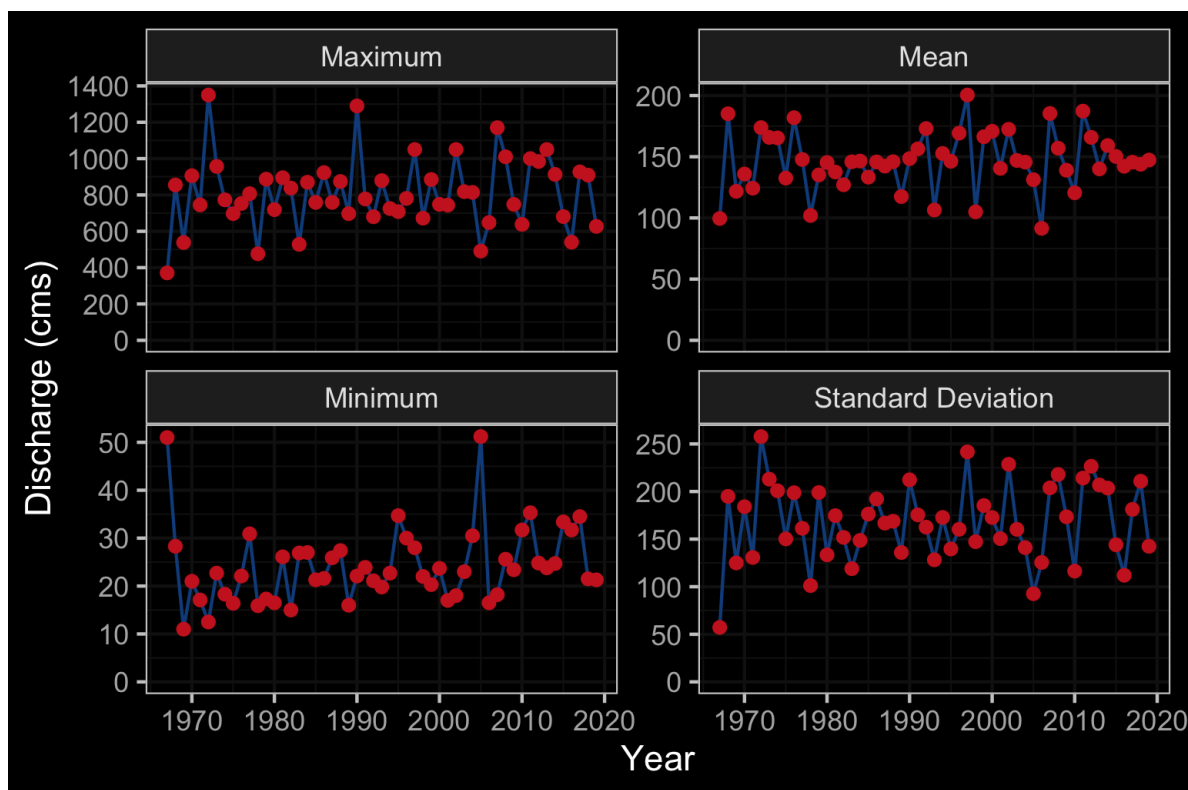
Figure 3: Summary discharge statistics (annual maximum, minimum, mean and standard deviation) for Parsnip River at hydrometric station #07EE007.

Fisheries

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

Table 1: Fish species recorded in the Parsnip River watershed group.

Scientific Name	Species Name	Species Code	BC List	Provincial FRPA	COSEWIC	SARA
Catostomus catostomus	Longnose Sucker	LSU	Yellow	–	–	–
Catostomus commersonii	White Sucker	WSU	Yellow	–	–	–
Catostomus macrocheilus	Largescale Sucker	CSU	Yellow	–	–	–

Fisheries

Scientific Name	Species Name	Species Code	BC List	Provincial FRPA	COSEWIC	SARA
Coregonus clupeaformis	Lake Whitefish	LW	Yellow	–	–	–
Cottus aleuticus	Coastrange Sculpin (formerly Aleutian Sculpin)	CAL	Yellow	–	–	–
Cottus asper	Prickly Sculpin	CAS	Yellow	–	–	–
Cottus cognatus	Slimy Sculpin	CCG	Yellow	–	–	–
Couesius plumbeus	Lake Chub	LKC	Yellow	–	DD	–
Lota lota	Burbot	BB	Yellow	–	–	–
Mylocheilus caurinus	Peamouth Chub	PCC	Yellow	–	–	–
Oncorhynchus mykiss	Rainbow Trout	RB	Yellow	–	–	–
Oncorhynchus nerka	Kokanee	KO	Yellow	–	–	–
Osmerus dentex	Rainbow Smelt	RSM	Unknown	–	–	–
Prosopium coulterii	Pygmy Whitefish	PW	Yellow	–	NAR (Nov 2016)	–
Prosopium cylindraceum	Round Whitefish	RW	Yellow	–	–	–
Prosopium williamsoni	Mountain Whitefish	MW	Yellow	–	–	–
Ptychocheilus oregonensis	Northern Pikeminnow	NSC	Yellow	–	–	–
Rhinichthys cataractae	Longnose Dace	LNC	Yellow	–	–	–
Richardsonius balteatus	Redside Shiner	RSC	Yellow	–	–	–
Salvelinus confluentus	Bull Trout	BT	Blue	Y (Jun 2006)	SC (Nov 2012)	–
Salvelinus fontinalis	Brook Trout	EB	Exotic	–	–	–
Salvelinus malma	Dolly Varden	DV	Yellow	–	–	–
Salvelinus namaycush	Lake Trout	LT	Yellow	–	–	–
Thymallus arcticus	Arctic Grayling	GR	Yellow	–	–	–

Bull Trout

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

A study of bull trout critical habitats in the Parsnip River was conducted in 2014 with the Misinchinka and Anzac systems identified as the most important systems for large bodied bull trout spawners accounting for a combined total of 65% of spawners counted. The Table River was also highlighted as an important spawning destination accounting for an estimated 15% of the spawners. Other watersheds identified as containing runs of large bodied bull troutspawners included the Colbourne, Reynolds, Hominka and Missinka River with potentially less than 50 spawners utilizing each sub-basin (Hagen et al. 2015a). Hagen and Weber (2019b) have synthesized a large body of information regarding limiting factors, enhancement potential, critical habitats and conservation status for bull trout of the Williston Reservoir and the reader is encouraged to review this work for context. They have recommended experimental enhancements within a monitoring framework for Williston Reservoir bull trout (some spawning and rearing in Parsnip River mainstem and tributaries)

which include stream fertilization, side channel development, riparian restoration and fish access improvement.

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

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

Arctic Grayling

A detailed review of Arctic grayling life history can be referenced in Stamford, Hagen, and Williamson (2017b). Since impoundment of the Williston Reservoir, it appears that physical habitat and ecological changes have been the most significant factors limiting Arctic grayling productivity. Although these changes are not well understood they have likely resulted in the inundation of key low gradient juvenile rearing and overwintering habitats, isolation of previously connected populations and increases in abundance of predators such as bull trout (Shrimpton, Roberts, and Clarke 2012; Hagen, Pillipow, and Gantner 2018).

Migration of mature adult Arctic grayling occurs in the spring with arrival at known spawning locations coinciding with water temperatures of 4°C. Spawning in the Parsnip watershed appears to occur between late-May and late-June within sites located primarily within the lower reaches of the Anzac and Table rivers as well as within the Parsnip River mainstem. Side-channel and multiple-channel locations containing small gravels appear to be selected for spawning. Currently, the primary distribution of Williston Arctic grayling appears to be among fourth order and larger streams (Williamson and Zimmerman 2005; Stamford, Hagen, and Williamson 2017b). Stewart et al. (2007) report that Arctic grayling spawn in large and small tributaries to rivers and lakes, intermittent streams, within mainstem rivers as well as lakes, most commonly at tributary mouths. Although past study results indicate that 0+ grayling appeared to overwinter in lower reaches of larger tributaries (i.e. Table, Anzac rivers) as well as the Parsnip River and that few age-1+ grayling have been sampled in tributaries, habitat use in small tributaries and the extent they are connected with the mainstem habitats of all core areas is not well understood. Between 1995 and 2019, Arctic grayling population monitoring has been conducted in the Table River in nine out of 25 years (8 years for the Anzac) using snorkel surveys. Results from 2018 are 2019 are intended to contribute to the

assessment of the conservation status of the species in the Parsnip Core area (Hagen, Pillipow, and Gantner 2018).

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

Methods

Engagement

From May 2021 to the time of reporting SERNbc and McLeod Lake staff have been actively engaging with the following groups to discuss the project, solicit input, prioritize sites and plan fish passage remediation.

- McLeod Lake Indian Band members of council
- BCTS Engineering
- CN Rail
- Canadian Forest Products (Canfor)
- Sinclar Forest Projects Ltd. (Sinclar)
- Northern Engineering - Forests, Lands, Natural Resource Operations and Rural Development (FLNR)
- BC Ministry of Transportation and Infrastructure
- Fish Passage Technical Working Group
- Planning foresters and biologists Ministry of Forests, Lands, Natural Resource Operations and Rural Development (restructured into Ministry of Forests and Ministry of Land, Water and Resource Stewardship)
- Fisheries experts

Environmental Stewardship Initiative

The Environmental Stewardship Initiative(ESI) is a collaborative partnership between the Province and First Nations with projects designed to focus on ecosystem assessment, restoration, enhancement, research and education . To date, four regional environmental stewardship projects have been developed. A governance working group with representatives from all four stewardship forums provides governance oversight and guidance for the ESI. The Parsnip River watershed group is within the Regional Strategic Environmental Assessment Forum (RSEA) area.

Working together with McLeod Lake Indian Band we are leveraging RSEA initiatives by overlaying Parsnip River watershed group fish passage planning data with the Recreational Opportunity Spectrum Inventory data to facilitate discussions with partners and stakeholders about how long term landscape stewardship goals of McLeod Lake Indian Band relate to stream crossing infrastructure upgrades/removals within their traditional territory. The inventory data summarizes recreation opportunities as combinations of settings and probable human experience opportunities organized along a spectrum of classes. The spectrum is set out in terms of seven classes as follows: Primitive (P), Semi-primitive Non-motorized (SPNM), Semi-primitive Motorized (SPM), Roaded Natural (RN), Roaded Modified (RM), Rural (R), Urban (U). The general idea is that areas towards the primitive end of the spectrum provide more opportunities for First Nations groups such as the McLeod Lake Indian Band to exercise their rights as indigenous people in pristine areas within their traditional territory (United Nations General Assembly 2007).

Habitat Modelling

Through this initiative as well as other SERNbc led initiatives (A. Irvine 2021, [2021] 2022), as well as through direction from the Provincial Fish Passage Remediation Program and connectivity restoration planning conducted by Canadian Wildlife Federation and others (Mazany-Wright et al. 2021; A. Irvine 2022), `bcfishpass` has been designed to prioritize potential fish passage barriers for assessment or remediation. The software is under continual development and has been designed and constructed by Norris ([2020] 2021) using 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 [2020] 2021). On potentially accessible streams, scripts identify known barriers (ex. waterfalls >5m high) and additional anthropogenic features which are primarily road/railway stream crossings (i.e. culverts) that are potentially barriers. To prioritize these features for assessment or remediation, scripts report on how much modelled potentially accessible aquatic habitat the barriers may obstruct. The model can be refined with known fish observations upstream of identified barriers and for each crossing location, the area of lake and wetland habitat upstream, species documented upstream/downstream, an estimate of watershed area (on 2nd order and higher streams), mean annual precipitation weighted to upstream watershed area and channel width can be collated using `bcfishpass`, `fwapg` and `bcfishobs`. This, information, can be used to 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.

`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 rainbow trout (20%) and bull trout (25%) are likely to be capable of ascending.

Gradient, channel size and stream discharge are key determinants of channel morphology and subsequently fish distribution. High value rearing, overwintering and spawning habitat preferred by numerous species/life stages of fish are often located within channel types that have relatively low gradients and large channel widths (also quantified by the amount of flow in the stream). Following delineation of "potentially accessible habitat", the average gradient of each stream segment within habitat classified as below the 20% and 25% thresholds was calculated and summed within species and life stage specific gradient categories. Average gradient of stream line segments can be calculated from elevations contained in the provincial freshwater atlas streamline dataset. To obtain estimates of channel width upstream of crossing locations, where available, `bcfishpass` was utilized to pull average channel gradients from Fisheries Information Summary System (FISS) site assessment data (MoE 2019b) or PSCIS assessment data (MoE 2021) and associate with stream segment lines. When both FISS and PSCIS values were associated with a particular stream segment, 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 upstream watershed areas associated with each stream segment and a mean annual precipitation weighted by upstream watershed area was calculated. In April of 2021, Bayesian statistical methods were used to model channel width in all provincial freshwater atlas stream segments where measurements had not previously been taken, based on the relationship between watershed area and mean annual precipitation weighted by upstream watershed area (Thorley and Irvine 2021).

`bcfishpass` and associated tools have been designed to be flexible in analysis, accepting user defined gradient, channel width and stream discharge categories (MoE 2019b). Although currently in draft form, and subject to development revisions, gradient and channel width thresholds for habitat with the highest intrinsic value for a number of fish species in the Parsnip River watershed group have been specified and applied to model habitat upstream of stream crossing locations with the highest potential intrinsic value (Table **??**). Thresholds were derived based on a literature review with references provided in Table **??**. Output parameters for modelling are presented in Table **??**.

Online Mapping

An online mapping portal was

Results and Discussion

Partnership Funding

SERN was able to aquire $105,000 of partnership funding from FLNR ($80,000) and the Provincial Fish Passage Technical Working Group ($25,000) towards the 2021/2022 program. Additionally, we have obtained a commitment for $25,000 of partnership funding from the the Provincial Fish Passage Technical Working Group towards the 2022/2023 program.

Planned Remediations

0.0.1 PSCIS Crossing 125179 - Tributary to Missinka River

We are working together with McLeod Lake and Sinclar to advance crossing [125179 (Tributary to Missinka River)](#). Works to replace the crossing are planned for summer of 2022. A map of the watershed is provided in map attachment [093I.116](#).

Although this crossing is used to access an area of significant cultural value to McLeod Lake due to high recreational values [(unmotorized primitive)](#), and is located within a watershed where expansion of "unmotorized primitive" values will occur in the future through deactivation of roads and reforestation, this site was selected as appropriate for restoration for the following reasons:

```
  + At the time of reporting there was significant harvesting and
silviculture obligations in areas accessed by the FSR.
  + The Missinka River watershed is designated as a fisheries
sensitive watershed under the *Forest and Range Practices Act*
[@beaudry2013Assessmentassignmenta]
  + @hagen_etal2015Criticalhabitats have identified the Missinka River
watershed as containing critical spawning and juvenile rearing habitat
for large body adult sa'ba (bull trout) with potentially less than 50
spawners utilizing the watershed.
  + The Missinka River watershed is utilized by a possibly genetically
distinct, self-sustaining dusk'ihje (Arctic grayling) population with
the mainstem of the river providing critical habitat for fry and adult
fish
  + The subject tributary is documented as containing sa'ba.
  + A bridge design was commissioned for the site in 2020 through
funding from FWCP (project PEA-F20-F-2967) so preparations for
replacement could be made in a timely fashion.
  + $80,000 of partnership funding was acquired by SERNbc from FLNR to
implement fish passage restoration at the site in 2022 according to
the design aquired for the site in 2019/2020. Sinclar Forest Projects
Ltd. is the road permit holder at this site and was awarded a contract
to initiate delivery of the bridge installation. Sinclar will be
sending out a request for proposals for the structure replacement to
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three qualified contractors soon in hopes to have a contract in place
this winter so we can hit the ground running next summer.  Project
coordination expertise by Sinclar are being provided in-kind.  The
\$80,000 awarded to Sinclar by FLNR was spent on the following
measures:
        - Water Sustainability Act Permit Application
        - Environmental Management Plan assessment and documentation
        - Source, purchase and mobilization of steel girders, modular
timber deck and lock block abutment as per site design
```

Leveraging support from FWCP, Sinclar will obtain portions of the remaining funding for this work planned for the summer of 2022 through the forestry appraisal system.

Table 2: Summary of fish habitat modelling for PSCIS crossing 125179.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0	0	–
ST Lake Reservoir (ha)	0	0	–
ST Wetland (ha)	0	0	–
ST Slopeclass03 Waterbodies (km)	0	0	–
ST Slopeclass03 (km)	0	0	–
ST Slopeclass05 (km)	0	0	–
ST Slopeclass08 (km)	0	0	–
ST Spawning (km)	0	0	–
ST Rearing (km)	0	0	–
CH Spawning (km)	0	0	–
CH Rearing (km)	0	0	–
CO Spawning (km)	0	0	–
CO Rearing (km)	0	0	–
CO Rearing (ha)	0	0	–
SK Spawning (km)	0	0	–
SK Rearing (km)	0	0	–
SK Rearing (ha)	0	0	–
All Spawning (km)	0	0	–
All Rearing (km)	0	0	–
All Spawning Rearing (km)	0	0	–

[*] Model data is preliminary and subject to adjustments.

PSCIS 125000 - Tributary to Parsnip River

We are working together with McLeod Lake and Sinclar to advance the replacement of crossing 125000 (Tributary to Parsnip River) on the Chuchinka-Arctic FSR. A map of the watershed is provided in map attachment 093I.111. The crossing was prioritized for restoration for the following reasons:

```
  + At the time of reporting there was significant harvesting and
silviculture obligations in areas accessed by the FSR.
  + With an outlet drop of 40cm the culvert in place is a complete
barrier to upstream fish passage with very low likelihood of any fish
movement upstream.
  + The culvert in place is likely over 30 years old, is undersized
and is at risk of washout.  A washout event would result in
significant deposition of material downstream of the road and negative
impacts on local fisheries values.
  + The FSR accesses McLeod Lake reservation lands  (ID: Arctic Lake
10) located near the outlet of Arctic Lake.
  + This site is in the general vicinity of the outlet of Arctic Lake
which has been identified as a high priority area for taloo'azi
(kokanee) and sa'ba by participants in FWCP supported information
gathering work [@pearce2019FirstNations].
  + The FSR accesses the Arctic Lake Provincial Park which has
significant historic and recreational values.  A canoe launch area for
the Parsnip River is also located at the upper Parsnip River Bridge.
  + There are no other stream crossing structures on the mainstem of
this tributary that impede fish passage.
  + The stream has a large channel width at the crossing location
(4.4m) and has an estimated 3.5km of mainstem habitat less than 5%
gradient available upstream of the crossing with rainbow Trout and
sculpin confirmed as present immediately below the crossing. Habitat
was rated as high value for salmonid rearing and spawning in surveys
conducted in 2019.
```

Table 3: Summary of fish habitat modelling for PSCIS crossing 125000.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0	0	–
ST Lake Reservoir (ha)	0	0	–
ST Wetland (ha)	0	0	–
ST Slopeclass03 Waterbodies (km)	0	0	–
ST Slopeclass03 (km)	0	0	–
ST Slopeclass05 (km)	0	0	–
ST Slopeclass08 (km)	0	0	–
ST Spawning (km)	0	0	–
ST Rearing (km)	0	0	–
CH Spawning (km)	0	0	–
CH Rearing (km)	0	0	–
CO Spawning (km)	0	0	–
CO Rearing (km)	0	0	–
CO Rearing (ha)	0	0	–
SK Spawning (km)	0	0	–
SK Rearing (km)	0	0	–
SK Rearing (ha)	0	0	–
All Spawning (km)	0	0	–
All Rearing (km)	0	0	–
All Spawning Rearing (km)	0	0	–

[*] Model data is preliminary and subject to adjustments.

PSCIS 125231 - Tributary to Table River

We are working together with McLeod Lake and Canfor to advance crossing 125231 (Tributary to Table River) on the Chuchinka-Table FSR for the following reasons:

```
  + Table River watershed is designated as a fisheries sensitive
watershed under the authority of the *Forest and Range Practices Act*
due to significant downstream fisheries values and watershed
sensitivity [@beaudry2014Assessmentassignmenta]. Special management is
required in the crossing's watershed to protect habitat for sa'ba and
dusk'ihje and includes measures (among others) to limit equivalent
clearcut area, reduce impacts to natural stream channel morphology,
retain old growth attributes and maintain fish habitat/movement.
  + @hagen_etal2015Criticalhabitats have identified the Table River
watershed and several tributaries as containing critical spawning and
juvenile rearing habitat for large body sa'ba with an estimated
```

+ The Table River (along with the Anzac River) is identified as the
primary core of post-Williston dusk'ihje distribution in the Parsnip
River watershed with life history, migration behaviours and critical
habitats summarized in @hagen_etal2015Criticalhabitats. The mainstem
of the Table River contains critical habitats for all life stages of
dusk'ihje with adults observed moving among mainstem locations and
tributaries during summer.
  + The culvert in place is likely over 30 years old, is undersized
and is at risk of washout. A washout event would result in
significant deposition of material downstream of the road and negative
impacts on local fisheries values.
  + The subject tributary is documented as containing rainbow trout
with habitat present also suitable for sa'ba rearing and spawning.
  + At the time of reporting there was significant harvesting planned
and silviculture obligations outstanding in areas accessed by the FSR.
  + With an outlet drop of 60cm, the culvert in place is a complete
barrier to upstream fish passage with very low likelihood of any
upstream fish migration.
  + There are no other stream crossing structures on the mainstem of
this tributary that impede fish passage. There is a newly installed
bridge upstream and the culvert under the CN railway downstream was
considered passable according to the provincial protocol
[@moe2011Fieldassessment].
  + The stream has a large channel width at the crossing location
(4.0m) and has an estimated 875m habitat available upstream with
average gradients mapped at less than 10%. Habitat was rated as high
value for salmonid rearing and spawning in surveys conducted in 2019.

Table 4: Summary of fish habitat modelling for
PSCIS crossing 125231.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0	0	–
ST Lake Reservoir (ha)	0	0	–
ST Wetland (ha)	0	0	–
ST Slopeclass03 Waterbodies (km)	0	0	–
ST Slopeclass03 (km)	0	0	–
ST Slopeclass05 (km)	0	0	–
ST Slopeclass08 (km)	0	0	–
ST Spawning (km)	0	0	–
ST Rearing (km)	0	0	–
CH Spawning (km)	0	0	–
CH Rearing (km)	0	0	–
CO Spawning (km)	0	0	–
CO Rearing (km)	0	0	–
CO Rearing (ha)	0	0	–
SK Spawning (km)	0	0	–
SK Rearing (km)	0	0	–
SK Rearing (ha)	0	0	–
All Spawning (km)	0	0	–
All Rearing (km)	0	0	–
All Spawning Rearing (km)	0	0	–

[*] Model data is preliminary and subject to adjustments.

0.0.2 PSCIS 125345 - Tributary to Parsnip River

BCTS is planning to deactivate the Chuchinka-Colbourne FSR between where 125345 (Tributary to Parsnip River) is located and the Chuckhinka-Anzac FSR to the south. The work is schedule for July and August of 2022. BCTS was able to engage the Forest Carbon Initiative about the project, who has confirmed that they have funding available for a full road rehabilitation on this section and are able to fund the replanting and road decompaction. This full scale rehabilitation will provide more intensity towards re-vegetation and access management than traditional deactivation practices. We have been in contact with CN Rail to advocate for the removal of crossing 57687 located under the railway immediately upstream of the PSCIS crossing 125345 and the FSR. Discussions are ongoing and we are hopeful action will be taken by CN this summer to remediate crossing 57687 as well.

Table 5: Summary of fish habitat modelling for
PSCIS crossing 125345.

Habitat	Potential	Remediation Gain	Remediation Gain (%)
ST Network (km)	0.0	0	–
ST Lake Reservoir (ha)	–	0	–
ST Wetland (ha)	–	0	–
ST Slopeclass03 Waterbodies (km)	0.0	0	–
ST Slopeclass03 (km)	0.0	0	–
ST Slopeclass05 (km)	0.0	0	–
ST Slopeclass08 (km)	0.0	0	–
ST Spawning (km)	0.0	0	–
ST Rearing (km)	0.0	0	–
CH Spawning (km)	0.0	0	–
CH Rearing (km)	0.0	0	–
CO Spawning (km)	0.0	0	–
CO Rearing (km)	0.0	0	–
CO Rearing (ha)	–	0	–
SK Spawning (km)	0.0	0	–
SK Rearing (km)	0.0	0	–
SK Rearing (ha)	–	0	–
All Spawning (km)	5.0	0	0
All Rearing (km)	13.3	0	0
All Spawning Rearing (km)	13.3	0	0

[*] Model data is preliminary and subject to adjustments.

Habitat Modelling

In December of 2021, Bayesian statistical methods were used to update our model of stream channel width based on a power model derived by Finnegan et al. (2005) which relates stream discharge to watershed area and mean annual precipitation. Data (n = 24849) on watershed size, mean annual precipitation and measured channel width was extracted from the provincial freshwater atlas (FLNRORD 2021; GeoBC 2022), the BC Data Catalouge fisheries datasets (MoE 2020, 2021) and Wang et al. (2012) utilizing `bcfishpass` (Norris [2020] 2021) and `fwapg` (Norris [2019] 2021). This data used to model channel width using Bayesian statistical methods analyzing the relationship between the input variables. The details of this analysis and resulting formula are documented in Thorley, Norris, and Irvine (2021) and were used to estimate channel width of stream segments in the Parsnip River watershed to facilitate modelling of highest intrinsic fisheries habitat value. The analysis is attached as a technical appendix at https://www.poissonconsulting.ca/f/859859031.

We are leveraging this project together with numerous others to contributing to the open source development of `bcfishpass` and `fwapg` and using these database building and habitat/connectivity modeling tools to conduct reproducible analysis/presentation of fish passage restoration opportunities in the Parsnip River watershed in order to facilitate outreach, prioritize sites and provide the background information necessary to communicate restoration plans/actions effectively.

Working with Ministry of Environment and Climate Change Strategy we have accessed historic electrofishing data for the entire province from British Columbia databases to begin developing evidence based approaches to modelling the highest value habitat for individual fish species. This work is an important step to increasing our state of knowledge, informing our field data collection and data management protocols provincially as well as for informing fish passage restoration investment decisions and monitoring outcomes. This work leverages many initiatives throughout the province and is briefly detailed here with preliminary results presented as a digital attachment here (Amies-Galonski et al. 2022).

Fisheries

Although it should not be assumed that all habitat types have been historically sampled equally, a review of available fisheries data for the Parsnip River watershed stratified by different habitat characteristics can provide insight into which habitats may provide the highest intrinsic value for fish species based on the number of fish captured in those habitats in past assessment work. Figures 4 - 6.

Table 6: Summary of historic
salmonid observations
vs. stream gradient category
for the Parsnip River
watershed group.

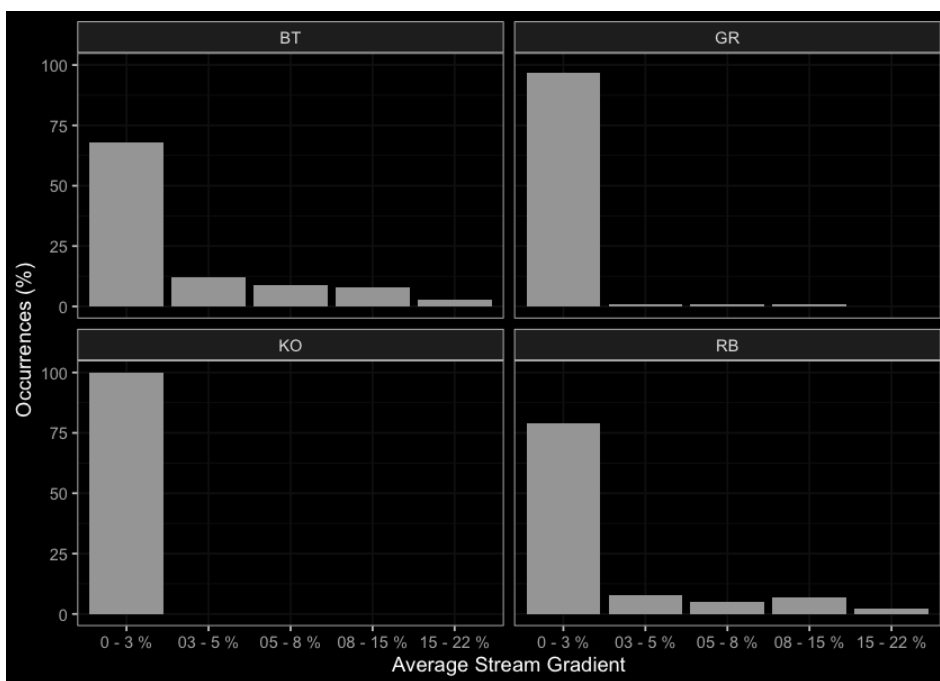| species_code	Gradient	Count	total_spp	Percent
BT	0 - 3 %	160	236	68
BT	03 - 5 %	29	236	12
BT	05 - 8 %	21	236	9
BT	08 - 15 %	20	236	8
BT	15 - 22 %	6	236	3
GR	0 - 3 %	224	230	97
GR	03 - 5 %	2	230	1
GR	05 - 8 %	2	230	1
GR	08 - 15 %	2	230	1
KO	0 - 3 %	17	17	100
RB	0 - 3 %	327	415	79
RB	03 - 5 %	32	415	8
RB	05 - 8 %	22	415	5
RB	08 - 15 %	27	415	7
RB	15 - 22 %	7	415	2

Figure 4: Summary of historic salmonid observations vs. stream gradient category for the Parsnip River watershed group.

Table 7: Summary of historic salmonid observations vs. channel width category for the Parsnip River watershed group.

| species_code	Width	Count	total_spp	Percent
BT	0 - 2m	11	236	5
BT	02 - 04m	25	236	11
BT	04 - 06m	29	236	12
BT	06 - 10m	35	236	15
BT	10 - 15m	30	236	13
BT	15m+	103	236	44
BT	–	3	236	1
GR	04 - 06m	5	230	2
GR	06 - 10m	7	230	3
GR	10 - 15m	14	230	6
GR	15m+	200	230	87
GR	–	4	230	2
KO	0 - 2m	1	17	6
KO	06 - 10m	3	17	18
KO	15m+	1	17	6
KO	–	12	17	71
RB	0 - 2m	23	415	6
RB	02 - 04m	51	415	12
RB	04 - 06m	37	415	9
RB	06 - 10m	36	415	9
RB	10 - 15m	34	415	8
RB	15m+	141	415	34
RB	–	93	415	22
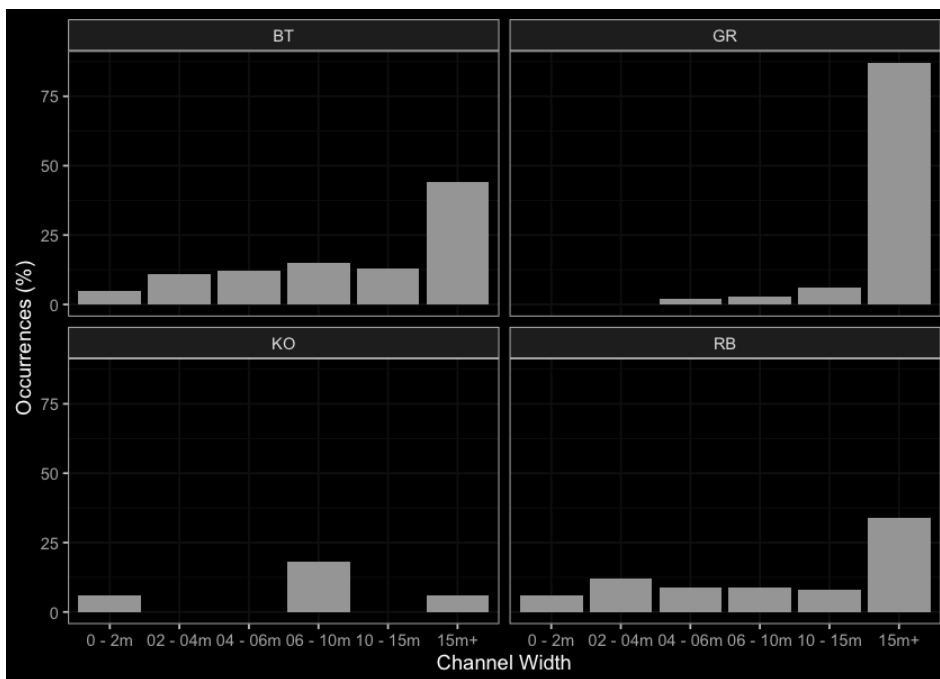
Figure 5: Summary of historic salmonid observations vs. channel width category for the Parsnip River watershed group.

Table 8: Summary of historic salmonid observations vs. watershed size category for the Parsnip River watershed group.

| species_code	Watershed	upstream_area_ha	Count	total_spp	Percent
BT	0 - 2500ha	16	2	236	1
BT	0 - 2500ha	75	1	236	0
BT	0 - 2500ha	76	1	236	0
BT	0 - 2500ha	85	1	236	0
BT	0 - 2500ha	90	1	236	0
BT	0 - 2500ha	93	3	236	1
BT	0 - 2500ha	96	1	236	0
BT	0 - 2500ha	100	1	236	0
BT	0 - 2500ha	112	1	236	0
BT	0 - 2500ha	128	1	236	0
BT	0 - 2500ha	133	1	236	0
BT	0 - 2500ha	155	1	236	0
BT	0 - 2500ha	168	1	236	0
BT	0 - 2500ha	175	1	236	0
BT	0 - 2500ha	192	1	236	0
BT	0 - 2500ha	214	2	236	1
BT	0 - 2500ha	226	1	236	0
BT	0 - 2500ha	294	1	236	0
BT	0 - 2500ha	297	1	236	0
BT	0 - 2500ha	324	1	236	0
BT	0 - 2500ha	330	1	236	0
BT	0 - 2500ha	347	1	236	0
BT	0 - 2500ha	356	1	236	0
BT	0 - 2500ha	374	2	236	1
BT	0 - 2500ha	404	1	236	0
BT	0 - 2500ha	422	1	236	0
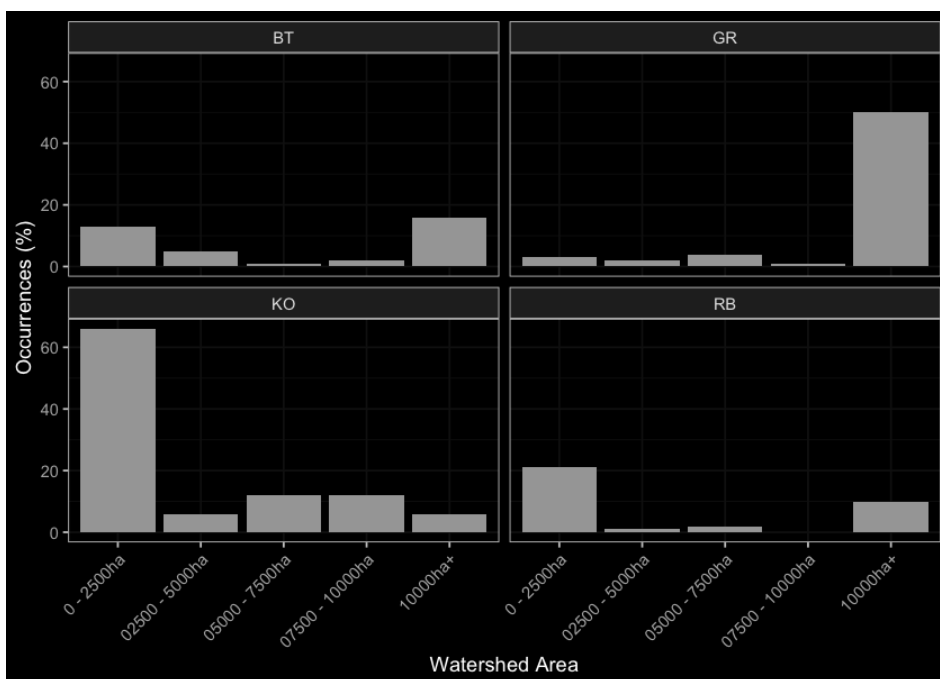
Figure 6: Summary of historic salmonid observations vs. watershed size category for the Parsnip River watershed group.

Recomendations

A multi-year plan with one to two structure replacements (or removals) each year with works at each site phased over two years each is recommended. This approach will facilitate progress at a minimum of one site per year and allows ample time for planning, coordination and funding acquisition related to each restoration. Multi-year planning allows an inclusive environment to solicit funding collaboration with the numerous potential partners and stakeholders in the watershed (i.e. Sinclar, Canfor, CN Rail, Coastal Gas Link, FLNR, fish passage technical working group, Ministry of Transportation and Infrastructure, McLeod Lake, Treaty 8 Nations, etc.).

- In 2023/2024 we propose replacement of crossings where preparations were made in 2022/2023 in partnership with Sinclar. Sinclar has committed to obtaining portions of the funding for this work through the forestry appraisal system and we will actively engage with partners and stakeholders to obtain other funding contributions. Additionally, we propose preparations for structure replacement at an addition two sites that can be completed in the following fiscal. This model of progress is proposed to continue through 2025/2026 fiscal.

- In 2022/2023 we will work together with BCTS and other interested parties to rehabilitate and monitor the Chuchinka-Colbourne FSR where 125345 (Tributary to Parsnip River) will be removed and the road deactivated/decompacted and planted in 2022. We will continue to engage with CN to advance remediation of passage at crossing 57687 located under the railway immediately upstream of this site.

- We recommend continuing to engage FWCP partners and stakeholders to explore and clearly communicate fish passage issues in the Parsnip River watershed, build relationships and obtain partnership funding commitments while collaboratively prioritizing, planning and delivering fish passage restorations.

- We recommend continuing to implement capacity building programs that will provide resources and skills for watershed stakeholders and partners to engage in watershed restoration planning activities and on the ground works as well as to monitor outcomes of project initiatives.

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yesno_0.1.2          zip_2.2.0
  zyp_0.10.1.1
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