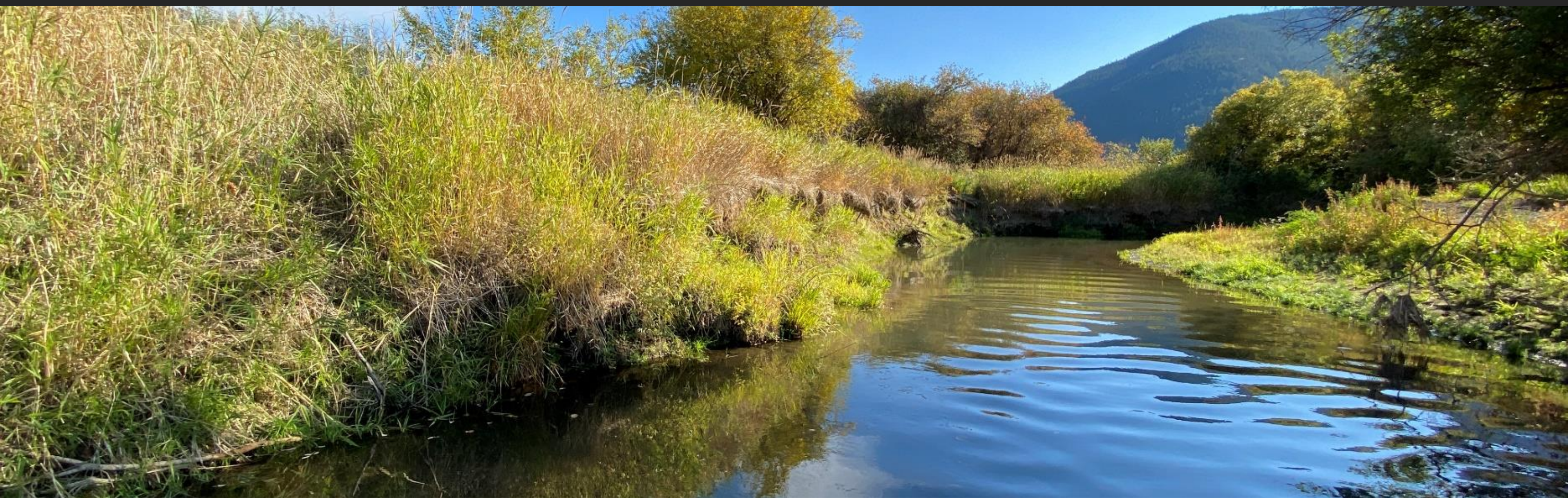
SENSITIVE HABITAT INVENTORY AND MAPPING AND AQUATIC HABITAT INDEX

SALMON RIVER



Prepared By:

Ecoscape Environmental Consultants Ltd.

Prepared for:

Yucwmenlúcwu
Splatsin Development Corporation

April 2022

SALMON RIVER
Sensitive Habitat Inventory and Mapping and Aquatic Habitat Index

Prepared For:

Yucwmenlúcwu
Splatsin Development Corporation

Prepared By:

ECOSCAPE ENVIRONMENTAL CONSULTANTS LTD.
102 - 450 Neave Court
Kelowna, BC
V1V 2M2

April 2022

Ecoscape File: 20-3631

ACKNOWLEDGEMENTS

This project would not have been realized without the assistance and contribution from the following individuals and organizations:

- Support through the Healthy Watersheds Initiative, which is delivered by the Real Estate Foundation of BC and Watersheds BC, with financial support from the Province of British Columbia.

Support for this project was provided by:

Yucwmenlúcwu, Splatsin Development Corporation (SDC)

Field Inventory Crew:

Kris Mohoruk, Ecoscape Environmental Consultants Ltd.
Scott McGill, Ecoscape Environmental Consultants Ltd
Kyle Hawes, Ecoscape Environmental Consultants Ltd
Scott Sanford, Ecoscape Environmental Consultants Ltd
Joshua Williams, Splatsin Development Corporation
Shanon Basil, Splatsin Development Corporation

The following parties contributed to the development of the Aquatic Habitat Index:

Kyle Hawes, Ecoscape Environmental Consultants Ltd
Jason Schleppe, Ecoscape Environmental Consultants Ltd

The principal author of this report was:

Kris Mohoruk, B.Sc., Ecoscape Environmental Consultants Ltd

Contributing author and supervisor was:

Kyle Hawes, B.Sc. R.P.Bio, Ecoscape Environmental Consultants Ltd

Geographical Information Systems (GIS) mapping and analysis was prepared by:

Robert Wagner, Ecoscape Environmental Consultants Ltd
Luke Crevier, Ecoscape Environmental Consultants Ltd

Recommended Citation:

Mohoruk, K., R. Wagner, L. Crevier, and K. Hawes. 2022. Salmon River Inventory, Mapping, and Aquatic Habitat Index. Ecoscape Environmental Consultants Ltd. Project File: 20-3631. 46pp + maps & appendices.

INFORMATION DISCLAIMER

The results contained in this report are based upon data collected during a single season inventory. Biological systems respond differently both in space and time. For this reason, the assumptions contained within are based upon field results, previously published material on the subject, and airphoto interpretation. The material in this report attempts to account for some of the variability between years and in space by using safe assumptions and a conservative approach. Data in this assessment was not analyzed statistically and no inferences about statistical significance are made if the word significant is used. Use of or reliance upon biological conclusions made in this report is the responsibility of the party using the information. Neither Ecoscape Environmental Consultants Ltd., nor the authors of this report is liable for accidental mistakes, omissions, or errors made in preparation of this report because best attempts were made to verify the accuracy and completeness of data collected, analyzed, and presented.

This is intended as a "*Living Document*". In so being, it may be continually edited and updated and may evolve and be expanded as needed, and serve a different purpose over time.

EXECUTIVE SUMMARY

A comprehensive inventory was completed for the Salmon River (SR) in September and October of 2021 from the SR outflow into Shuswap Lake near the City of Salmon Arm, to the Highway 97 crossing outside Westwold. The results of this data were used to complete an Aquatic Habitat Index (AHI). This Large River Inventory and Mapping approach (RIM) adapts the data collection methods and standards of Sensitive Habitat Inventory and Mapping (SHIM) (Mason and Knight, 2001) and Foreshore Inventory and Mapping. The resultant AHI uses many different criteria, such as biophysical, fisheries values, and anthropogenic characteristics to estimate the relative habitat value of river reaches and bank segments that were defined during the inventory. The habitat index classifies this information in a 5-class system from Very High to Very Low.

The SR flows a distance of approximately 150 km from its headwaters located at Salmon Lake, following Highway 97 through Westwold and Falkland, before meandering adjacent to Salmon River Road before outflowing into Shuswap Lake, west of the City of Salmon Arm.

In total, the SR supports populations of six of the seven species of Pacific salmon; Coho *(O. kisutch)*, Pink (*O. gorbuscha),* Steelhead (*O. mykiss*), Chum (*O. keta*), Sockeye (*O. nerka*) and Chinook *(O. tshawytscha)*, as well as the non-anadromous forms (freshwater only) Rainbow Trout, Dolly Varden (*Salvelinus malma*), and Kokanee*.* Non-salmonid fish include Burbot (*Lota lota*), Rocky Mountain Whitefish (*Prosopium williamsoni)*, Largescale Sucker (*Catostomus macrocheilus*)*,* Northern Pikeminnow (*Ptychocheilus oregonensis*), Redside Shiner (*Richardsonius balteatus*), and sculpin (*Cottus* spp.).

The SR was divided into 67 reaches based on river channel morphology and character. The left bank (facing downstream) was divided into 140 segments and the right bank was broken into 131 Segments. The total length of the left and right river-banks was 87.8 km and 87.6 km, respectively.

Combined, fields and rural lands accounted for almost 60% of the left bank and nearly 50% of the right bank (Table 13). Natural cottonwood riparian ecosystems (Mid Flood Bench) accounted for 11% and 13% of the left and right banks respectively. High severity bank erosion was documented on approximately 9.3 km (10.6%) of the left bank and 12.5 km (14.2%) of the right bank. Bank instability appeared to be largely attributed to the lack of riparian vegetation and encroachment associated with agricultural land use and rural and recreational disturbance.

Physical habitat in the SR was found very suitable for Chinook and Coho production and the SR has hosted significant historical spawning populations of Chinook and Coho. Rearing areas include low flood benches, backwaters, side channels and sloughs adjacent to spawning areas.

The SR generally has a *High - Very High* center line AHI score/rank, and *Low-Moderate* bank AHI score/rank, and is reflective of the high morphological and hydrological complexity of the system, while incurring significant riparian loss or reduction through agricultural activity and urban development.

73 water withdrawals were recorded within the SR channel. Water withdrawals can directly impact fish as fry can become trapped and lost in withdrawal canals. Initiative should be taken to ensure water withdrawals are properly screened to prevent small-bodied fish and fry entrainment. In addition to direct effects on fish, extensive water withdrawals (from both instream and shallow groundwater wells on the floodplain) can exacerbate the risks associated with low river flows

triggered by climate variability. Low summer flows have the potential to diminish the availability of suitable spawning habitat for a variety of fish species as waters recede through low floodplains and riverine marshes. Low flows have the added risk of stranding, trapping rearing juveniles in high quality backwater habitats, where survival depends on the availability of food, cover, and cool waters. Furthermore, low summer flows further elevate the risk to fish associated with elevated stream temperatures and increased stress on fish, which can lead to lethal consequences. Fish species such as Coho and Chinook may be forced to use lower reaches as low flows result in inaccessibility to formerly used higher reaches.

Recognizing the above, it is paramount that land use planning and management of the SR focus on conservation and restoration of floodplain and riparian ecosystems. Previous efforts to enhance the SR had occurred mainly during the 1990's, and were focused on bank stabilization, fencing, tree planting, and construction of a groundwater fed side channel. Further opportunities should be explored for improving in-water cover within the lower reaches of the SR where active spawning is most prevalent, and AHI is highest. Future riparian and channel-bank restoration should use bioengineering techniques, and include increasing channel complexity, creation of side channels, large woody debris, gravel sources, and more intact stream banks.

Further engagement with property owners regarding potential restoration, bank erosion protection, and fish habitat creation should be investigated. As these avenues can further bolster previous restoration efforts, while providing local community engagement and involvement in preserving the SR long term. Additional considerations should be made to limit agricultural impacts within the upper reaches of the SR, where bank erosion, substrate disturbance, and nutrient input from livestock is high.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

MAPS

APPENDICES

1.0 INTRODUCTION

In 2021, Ecoscape Environmental Consultants Ltd. (Ecoscape) was contracted by the Yucwmenlúcwu and the Splatsin Development Corporation (SDC) to complete a comprehensive inventory of the Salmon River (SR), and to subsequently develop an Aquatic Habitat Index (AHI). The following technical report outlines the project approach and presents and analyzes the results of both the Inventory and AHI phases of the project.

This report is intended as a "Living Document". In so being, it may be continually edited and updated and may evolve and be expanded as needed, and serve a different purpose over time.

Sensitive Habitat Inventory and Mapping (SHIM) and Foreshore Inventory and Mapping (FIM) are protocols used to collect baseline information regarding the current condition of watercourses (SHIM), shorelines (FIM), and associated riparian habitats. These inventories provide information on channel character, shore/bank types and condition, substrates, land use, and habitat modifications. This information is combined where possible, with other mapping resources such as previous fisheries inventories, recent orthophotos, and other information. A protocol was developed specifically for the Shuswap River to map large river habitat and character. This protocol, referred to as River Inventory and Mapping (RIM) was used in the current project to map the SR.

An Aquatic Habitat Index (AHI) is generated using the processed field data to determine the relative habitat value of the aquatic habitats and shoreline areas. The Aquatic Habitat Index uses many different criteria, such as biophysical, fisheries values, and anthropogenic characteristics to estimate the habitat value of a shoreline segment. The Habitat Index classifies this information in a 5-Class system from Very High to Very Low.

1.1 Project Background

As resource development and human populations increase in British Columbia, pressures for all resources and services have accelerated. Rapid growth has often overwhelmed the ability of local planners to manage land and preserve sensitive habitats (Mason and Knight, 2001). This has resulted in the loss or degradation of aquatic and riparian habitats that are critical for fish and a diverse wildlife assemblage. More specifically, rapid population growth and development around our large interior lakes and rivers is one of many factors that is impacting our fish and wildlife resources. This tremendous growth rate has resulted in commercial and residential developments around these large lakes and rivers. This rapid increase in population and development presents a significant challenge to plan and/or manage future growth around our large interior lakes and rivers. Accordingly, there is an urgent need to develop stronger tools and better methods to conserve, protect and reclaim these habitats.

SHIM is a recognized standards for fish and aquatic habitat mapping in urban and rural watersheds in British Columbia. SHIM attempts to ensure the collection and mapping of reliable, high quality, current, and spatially accurate information about local freshwater habitats, watercourses, and associated riparian communities.

SHIM is designed as a land-planning, computer-generated, interactive GIS tool that identifies sensitive aquatic and terrestrial habitats. It is intended to provide community, stewardship groups, individuals, regional districts, municipalities and First Nations with an effective, low-cost delivery system for information on these local habitats and associated current land uses.

SHIM and FIM have numerous applications and can:

- Provide current information not previously available to urban planners, to allow more informed planning decisions and provide inventory information for integration into Official Community Plans. In addition, this information can be used to educate the public as to the natural resource values of these systems and the impacts our activities have on them;
- Provide a catalogue of the current condition of the foreshore to aid with permit and compliance monitoring;
- Assist in the design of stormwater/runoff management plans;
- Monitor for changes in habitat resulting from known disturbance;
- Identify and map potential point sources of pollution;
- Help guide management decisions and priorities with respect to habitat restoration and enhancement projects;
- Assist in determining setbacks and fish/wildlife-sensitive zones;
- Identify sensitive habitats for fish and wildlife along watercourses;
- Provide a means of highlighting areas that may have problems with channel stability or water quality that require more detailed study;
- Provide baseline mapping data for future monitoring activities and development of a shoreline management plan; and
- Map and identify the extent of riparian vegetation available and used by wildlife and fish.

2.0 RIVER INVENTORY MAPPING

Biophysical surveys of the SR used the RIM methodology which adapted the data collection methods and standards of Sensitive Habitat Inventory and Mapping (SHIM) (Mason and Knight, 2001) and Foreshore Inventory and Mapping (FIM). Data was recorded using a Trimble Geo7x/Data Logger and iPad/Arrow 100 GNSS GPS backpack, and entered into a digital data dictionary. Data collection fields for respective biophysical and anthropogenic attributes are listed in the following sub sections. Data collection methods and processing standards can be reviewed in full at:

http://cmnmaps.ca/cmn/files/methods/SHIM_Methods.html

Entering data into the iPad/Arrow 100 GNSS GPS backpack (Left) using the data dictionary developed specifically for RIM (Appendix D). Marking up large format field maps for subsequent incorporation into GIS mapping and integration into the final data deliverables (Right).

2.1 Pre-Field / Start-up

Ecoscape reviewed all pertinent background information useful to the project and incorporated this data, where relevant, into respective watercourse features and their attributes.

Ecoscape obtained aerial imagery for the Salmon River system from the British Columbia Imagery Web Map Services.

Preliminary reach breaks (segments) were identified and right and left bank shoreline segments were determined. In addition, adjacent natural features of interest were identified (i.e., tributaries, side channels, islands, wetlands etc.) that otherwise may not be picked up during standard centerline surveys. Large format field maps were then produced, on which field staff transcribed various field data.

2.2 RIM Adapted SHIM/FIM for Large River Systems

The RIM data collection, data processing, and data deliverables were based on the mapping standards for SHIM (Mason and Knight, 2001), with consideration that the SR is a middle-sized river. The Data Dictionary (Version 6) is provided in Appendix D. This digital data collection format adapts both SHIM and FIM dictionaries into a common field data collection file, tailored to a spatial biophysical inventory on a middle-sized river system like the SR. The intent of this approach is to utilize a specific mapping protocol that can be used for middle sized river systems in British Columbia.

The upper section of the SR, from the headwaters at Salmon Lake, to the Highway 97 bridge crossing east of Westwold, was not field-surveyed. Bank and instream character and attributes were inferred from aerial imagery.

2.2.1 Centerline Survey

The centerline of the river channel was mapped along the center of the bankfull (not floodplain) width. While both banks and instream features were digitized using air photo interpretation. Comprehensive data for both the left and right river banks were collected independently of the stream centerline as unique "Right Bank" and "Left Bank" line features (reviewed below in Section 2.2.2).

The river was stratified into a series of successive reaches, each possessing and being characterized by different attributes or biophysical characteristics (i.e., hydraulic class, channel characteristics, substrate composition, and riparian class etc.) (**Table 1**).

Table 1. Overview of river centerline data fields collected using the 2017 SHIM data dictionary.

Stream Reference Information	Name; Watershed Code; Data; Time; Survey Conditions; Surveyors
Stream Segment Length	Linear measure along centerline of channel (m)
Stream Stage	Dry; Low; Moderate; High; Flood; Other
Primary Character	Modified; Natural; Other
Secondary Character	Beaver Pond; Ephemeral; Flumed; Intermittent; Side Channel; Wetland; Braided; Non-channelized; Other.
Channel width	Bankfull level (m); Wetted level (m)
Gradient	% grade
Salmonid Spawning	Yes/No/Potential; Species
Livestock Access	Yes/No; Comment
Hydraulic Character	Cascade; Cascade-Pool; Falls; Pool; Run; Glide; Riffle; Riffle-Pool; Riffle-Run; Slough; Lake; Wetland; Other
Crown Closure	1-20%; 21-40%; 41-70%, 71-90%, >90%
Bars	None; Side; Diagonal; Mid-channel; Spanning; Braided
Islands	None; Occasional; Split; Frequent – Irregular; Frequent – Regular; Anastomosing
Substrate Composition	% Organic; % Fines; % Gravel; % Cobble; % Boulder; % Bedrock
Embeddedness/Compaction	Degree of embeddedness of coarse substrates in fines (sand/silt)
% Instream Cover	Boulder; Deep Pool; Instream Vegetation; Large Woody Debris; Overstream Vegetation
Segment Impact Rating	See Table 2.
Left and Right Bank Fields	
Riparian Class	Row Crops; Broadleaf; Bryophytes; Coniferous forest; Planted Tree Farm; Disturbed Wetland; Dug out Pond; Exposed Soil; Floodplain; Herbs/Grasses; Highly Impervious; Medium Impervious; Low Impervious; Mixed Forest; Natural Wetland; Rock; Shrubs
Qualifier	Agriculture; Natural; Urban Residential; Rural Residential; Recreation; Disturbed; Unknown
Width and Slope	(m) and % grade, respectively.
Stage	Sparse Bryoidl Grass/Herb; Low Shrub; Tall Shrubs (2-10m); Sapling (>10m); Young Forest; Mature Forest; Old Growth
% Shrubs	<5%; 5-33%; 34-66%; 67-100%

Snags	No; <5; >=5
Veteran Trees	No; <5; >=5
Bank Stability	High; Medium; Low
Bank Material	Concrete; Gabions; Pilings; Stonework; Riprap; Retain Wall/Bank Stability; Sandbags; Wood; Bark Mulch; Asphalt; Dyke; Till; Fines; Gravel; Cobble; Boulder; Bed Rock; Other
Top of Bank	Yes; No
Comments	General comments about each bank.

A Level of Impact rating was included in the data dictionary and applied to the centerline reach information (**Appendix D**). This rating system was designed with the intent of providing a more measurable parameter in evaluating river condition and monitoring and evaluating habitat changes on local watercourses and associated riparian and floodplain communities. Individual reach scores were assigned based on the criteria outlined in **Table 2**. Weighted scores for respective impact ratings were obtained by dividing the cumulative length of reaches receiving the same impact rating by the total river length being evaluated to obtain a relative value (% of river length). This value was then multiplied by the respective Score (0-6) equaling the weighted score. The sum of weighted scores was then divided by the maximum attainable score (6)[1] and transformed into a percentage value or river grade. This scoring system precedes the Aquatic Habitat Index and, on its own, is a field measure of river/bank condition.

Table 2. Level of Impact rating criteria included in the SHIM data dictionary.

Stream Bank Impact Criteria[1]	Combined Stream Segment Score
Nil-Nil (*Nil impacts on both banks*)	6
Nil-Low	5
Nil-Mod	4
Nil-High	3
Low-Low	4
Low-Mod	3
Low-High	2
Mod-Mod	2
Mod-High	1
High-High (*Impact on both banks is high*)	0

[1.] Numeric Bank Impact Scores: Nil=3; Low=2; Mod=1; High=0

2.2.2 Left and Right Bank Mapping (adapted SHIM-FIM)

Conventional SHIM methods describe the right and left bank character and condition within a single stream centerline feature for respective reaches. To better map and evaluate the larger scale represented in the SR, the SHIM approach was modified (**Appendix D**), which

[1] A combined weighted score of 6 would be attained if all reaches were natural with no discernable human disturbance on either the right or left bank. In other words, the river is pristine.

adapts the FIM field attributes into the data dictionary. Through this approach, left and right bank lines were logged in the field independently of one another (similar to FIM shoreline mapping) and data fields were populated separate from the Centerline. Individual segments were determined as relatively homogenous sections of shoreline based on vegetation structure, physical character, and general land use. Shoreline sections that displayed a consistent pattern or distribution of different biophysical units/features interspersed with anthropogenic units (e.g., clearings and fields) were also considered as a single segment. An example of this would be through rural areas; where remnant natural pockets along the riverbank are interspersed with rural residences and small agricultural clearings. Shoreline segments were determined and assigned independently of river reaches. However, the adjacent river reach was identified in the data for each shoreline segment (e.g., Left Bank Segment 25, River Reach 11).

Large format laminated posters of the River were marked-up to illustrate river and riparian features, attribute lines (e.g., bank armouring) and points (e.g., water withdrawals). These features were then digitized in the office to supplement GPS field data. **Table 3** summarizes the data fields that were collected for each bank segment.

Table 3. Overview of data collected for right and left bank segments during the field inventory.

Category	Menu/Data Fields
Primary Shore Type	Cliff/Bluff; Rocky Shore; Gravel; Sand; Confluence (alluvial fan); Wetland; Other; Flood Low Bench; Flood Mid Bench; Flood High Bench
Slope	Bench; Low (0-5%); Moderate (5-20%); Steep (20-60%); Very Steep (60%+)
Land Use (Observed)	Agriculture; Commercial; Conservation; Forestry; Industrial; Institution; Multi Family; Natural Area; Park; Recreation; Rural; Single Family; Urban Park
Level of Impact	None; Low (<10%); Medium (10-40%); High (>40%)
Livestock Access	Yes/No
Relative Condition	%Disturbed; %Natural
% Shore Type Distribution	%Cliff/Bluff; % Rocky; % Gravel; % Sand; % Confluence; % Wetland; % Other; % Flood Low Bench; % Flood Mid Bench; % Flood High Bench
% Landuse Distribution	Agriculture; Commercial; Conservation; Forestry; Industrial; Institution; Multi Family; Natural Area; Park; Recreation; Rural; Single Family; Urban Park
Bank Stability	High; Medium; Low; Eroding and % Eroding
Bank Material	Clay; Silt; Sand; Gravel; Cobble; Boulder; Bedrock
Comments	Provided with various categories listed above

2.2.3 Feature Mapping

Morphological, habitat, and anthropogenic features were marked with both the GPS and described on field maps and later digitized as points and polygons into the modified SR data dictionary. These features, summarized in **Table 4**, provide a more quantitative measure of relative disturbance/modification, and aquatic habitat quality/complexity (e.g., aerial abundance of spawning substrates/coarse woody debris measure etc.).

Table 4. Overview of watercourse and habitat attributes that were collected using the Data Dictionary developed for this project (Adapted from Module 3, Mason and Knight, 2001). The complete data dictionary can be found in Appendix D.

Main Attribute	Detailed Feature Collected
Modifications	Type (retaining wall/water withdrawal/bridge/dock etc.) material; length; photo
Culvert Attributes	Type-Material; Condition; Barrier; Size; Baffles
Obstruction Attributes	Type-Material; Barrier; Size; Photo
Stream Discharge Attributes	Point of Discharge; Type-material; Size
Erosion Feature	Type of Erosion; severity; exposure; material
Fish Habitat Attributes	Type of Habitat (Spawning/rearing/cover); Size; Slope; Photo
Enhancement Areas	Type of Enhancement; Potential or existing enhancement
Wildlife Observations	Type of Observation; Wildlife species; Photo
Wildlife Tree Attributes	Type of Tree; Size; Location
Near Waterbody Attributes	Type of Waterbody (spring/side channel/pond etc.); Size
Wetland Attributes (Polygon feature)	Wetland Type-Class; Photo
Representative Photograph Location	Location; Direction

2.3 Instream Morphology and Habitat Feature Polygonization

The spatial extents of side channels, backwaters, and associated riverine wetlands and floodplain communities were identified and mapped. Relative habitat scores were applied to each type to be used in analysis and habitat index calculations (Section 4.1).

The river channel, extending to the outer limits of the mean annual high water level (to include low bench floodplain areas) was estimated using field inventory data and air photo interpretation. The spatial extents of the channel formed the basis for subsequent stratification of habitat units within (Map Set 1). Habitat units were classified based on complex hydraulic and instream habitat feature classes as one of the following in Table 5.

Table 5. Hydraulic and instream habitat feature classes assigned to Salmon River and associated low flood and wetland polygons

BW	Backwater	RN	Run
CO	Confluence	P	Pool
G	Glide	RF	Riffle
GB	Gravel/Sandbar	WN	Wetland
RP	Riffle/Pool		

2.4 Riparian Polygonization

Broad vegetation communities/habitat types were stratified within a 50-m band along the right and left riverbanks (Map Set 1). Polygons were classified according to Table 6. In addition, site qualifiers (Table 7) were assigned to each polygon to reflect the estimated level of disturbance and habitat quality and condition.

The river channel boundary was established at the estimated mean annual floodplain level to include riparian marshes and low bench floodplain sites. Thus, mid bench floodplain ecosystems (i.e., black cottonwood ecosystems) were included in the 100 m riparian band and not factored into the stream channel analysis (Section 4.2).

Table 6. Broad vegetation communities (Habitat Types) used for classification of stratified polygons occurring along the Salmon River (50-m band) from Westwold to Shuswap Lake (adapted from Mackenzie and Moran (2004) and Lloyd et al. (1990).

Map Code	Name	Description
B	Broadleaf Forest	Upland broadleaf forest ecosystem above the active floodplain predominated by trembling aspen or birch
C	Coniferous Forest	Upland coniferous forest ecosystems above the active floodplain. Including high bench sites along the Salmon River.
CF	Cultivated Field	
CW	Open Coniferous Woodland	Open ponderosa pine/Interior Douglas-fir woodlands with grassland dominated understory
FL	Low Flood Bench	Low bench ecosystems occur on sites that are flooded for moderate periods (< 40 days) of the growing season, conditions that limit the canopy to tall shrubs, especially willows and alders. Annual erosion and deposition of sediment generally limit understory and humus development.
FM	Mid Flood Bench	Middle bench ecosystems occur on sites briefly flooded (10–25 days) during freshet, allowing tree growth but limiting tree species to only flood-tolerant broadleaf species such as black cottonwood.
SF	Seasonally Flooded	Fields / croplands that are intermittently flooded in periods of high flows; found throughout the Salmon River Valley in agricultural crop fields adjacent to the Salmon River.
GB	Gravel/Sand Bar	Gravel/Sand Bar
GN	Grassland	Natural grassland ecosystems generally not containing shrub or tree strata
M	Mixed Forest	Upland mixed stand seral forest. High bench site along the Salmon River. Tree canopy mix of trembling aspen, birch, cottonwood, lodgepole pine, interior Douglas-fir, and spruce.
RZ	Road Surface	Road Surface
RU	Rural	Rural areas containing houses, outbuildings, driveways, and landscaping. A native tree canopy may be present, but it is perforated by development and the understory plant associations have been partly removed. In higher disturbed sites the tree canopy is very limited to absence and natural plant associations sparse to absent.
SB	Silt Bluff/ Exposed Bank	Steep, sparsely vegetated silt bank.
SH	Shrub	Persistently disturbed shrub sites that are not included within low flood bench.
UR	Urban	Urban areas containing higher population densities in single and high density housing, in addition to extensive infrastructure build-up. The native tree canopy is very limited to absence and natural plant associations sparse to absent.
WN	Wetland/Marsh	A marsh is a shallowly flooded mineral wetland dominated by emergent grass-like vegetation. A fluctuating water table is typical, with early-season high water tables dropping through the growing season. Exposure of the substrate in late season or during dry years is common.

Table 7. Site qualifiers assigned to each polygon (Table 6) to reflect the estimated level of disturbance and habitat quality and condition.

d	Ditch
hd	Highly disturbed, fragmented/broken canopy. Analogous to a partly treed rural site. Highly disturbed wetland and fragmented by land use and agricultural practices. The ecological function of this feature is severely impaired by human and associated activities.
md	Moderately disturbed treed riparian area. The habitat community structure may be fragmented or perforated by some land clearing and rural disturbances.
ld	Low disturbance, not recently disturbed. Containing natural tree canopy and understory vegetation associations.
f	Narrow riparian fringe generally less than 5-m wide but occasionally up to 10-m.
n	Natural, undisturbed site
pa	Urban Park/Recreational Area

2.5 Data Processing and Quality Assurance and Control

The Resource Inventory Committee and SHIM Methodology (Mason and Knight, 2001) provide specific requirements for quality assurance and quality control. These standards, such as GPS settings/precision, logging intervals, and data management and deliverables were followed throughout the field inventory stages of the project.

GPS settings and use were in accordance with Resource Inventory Committee Standards to ensure the collection of spatially accurate data. The coordinate system used was UTM Zone 10 North, North American Datum 83.

Field data was differentially corrected using base data provided by UNAVCO, Republic, WA.

Data dictionary tools designed for ARC View 3.x were employed to process the data and to export the data into ESRI shapefiles. Subsequent processing and mapping was completed using ArcGIS 10.2/ArcGISPro. Processed GPS data (shapefiles) were then converted into geodatabases.

To ensure Quality Assurance and Control the following tasks were followed during completion of this project:

- Field data collected was backed onto the local server and field computer at the end of each field day.
- All field data collected during the field inventories was post processed by the field inventory biologist, Kris Mohoruk, B.Sc.
- We reviewed each attribute collected during the field survey as part of a quality control / assurance process. The final database has been provided to Splatsin Development Corporation and project partners at the completion of the project. Corrections and adjustments to the database will be made as necessary.
- We integrated this assessment with additional GIS information provided by other parties.

2.6 Photo Log

SHIM/FIM standards require that a detailed photo log accompany and be incorporated into the database. All photos were entered into a log for location and subject reference. In addition, coordinate locations (UTM Zone 10 North, North American datum 83 Canada) where photos were taken was entered into the GPS to enable spatial referencing on the ground for each photo.

3.0 SALMON RIVER KEY FISH SPECIES

The SR flows a distance of approximately 150 km, starting from its headwaters located at Salmon Lake at elevations over 930 m, meandering through the valley before following along British Columbia Highway 97 and Salmon River Road, until its eventual confluence with Shuswap Lake west of the City of Salmon Arm.

The SR supports spawning populations of six of the seven species of Pacific salmon; Coho *(O. kisutch)*, Pink (*O. gorbuscha),* Steelhead (*O. mykiss*), Chum (*O. keta*), Sockeye (*O. nerka*) and Chinook *(O. tshawytscha)*, as well as the non-anadromous forms (freshwater only) Rainbow Trout, Dolly Varden (*Salvelinus malma*), and Kokanee (FIDQ 2022).

Non-salmonid fish include Burbot (*Lota lota*), Largescale Sucker (*Catostomus macrocheilus*), Rocky Mountain Whitefish (*Prosopium williamsoni* Northern Pikeminnow (*Ptychocheilus oregonensis*), Redside Shiner (*Richardsonius balteatus*), and sculpin (*Cottus* spp.).

The Interior Fraser population of Coho was initially assessed by COSEWIC as Endangered in May of 2002 and was later reassessed in 2016 where the status was changed to Threatened. The Lower Thompson, Spring population of Chinook was desigated as Endangered by COSEWIC in November 2020 (COSEWIC, 2002; COSEWIC, 2016).

Because of their importance to commercial, recreational and Indigenous fisheries, the following were selected as key species for matrix development (to assign relative habitat scores) in this study: Chinook Salmon, Coho Salmon, Rainbow Trout, and, Sockeye.

3.1 Chinook Salmon

In British Columbia Chinook salmon spawn in over 250 rivers and streams (McPhail 2007). Chinook are the largest of seven species of Pacific salmon and have the widest distribution. They have sustained First Nations for thousands of years, provide important recreational and commercial harvesting opportunities, and were an important part of the colonization of British Columbia.

Chinook stocks exhibit both ocean type and stream type life history patterns. Ocean type Chinook rear in freshwater for several months and migrate to the ocean in the first fall while stream type Chinook rear in freshwater for one year before migrating to the ocean (DFO 1997a).

REPRODUCTION

Ocean-type Chinook return to the Middle Shuswap River system in July with peak spawning occurring between October 2nd and 21st, whereas stream-type juveniles overwinter and out-migrate after their first or second year (Arc Environmental Ltd 2001; Shearing 2013). Stream-types typically have large ocean-migrations and return prior to spawning, in the late spring or summer (Shearing 2013).

Chinook females choose the spawning site and appear to prefer sites with subgravel flow (e.g., In the tail-outs of pools immediately above riffles or in upwelling sites; McPhail, 2007). Chinook eggs are the largest of the species of Pacific salmon and require higher rates of flow and oxygen than other species. As with most other species of Pacific salmon, adults will die after spawning.

AGE, GROWTH AND MATURITY

Chinook eggs incubate through the winter period and fry emerge in the early spring. As with the other species discussed, their incubation period varies with water temperatures. Once emerged, the diet of fry includes adult chironomids as well as chironomid larvae and pupae, terrestrial insects taken from the surface, and nymphs of larvae of aquatic insects (McPhail 2007). Upon emergence, Chinook fry are often moved downstream by flows from areas where they incubated (Groot and Margolis 1991). Their habitat range is often keyed to flow velocities rather than habitat types. They range widely in habitat use but generally will occupy boulder areas in faster waters.

Downstream timing appears to be correlated strongly with size (Groot and Margolis 1991). They will eventually move out to the Pacific and return 4-5 years later to spawn as adults.

Juvenile rearing is not well understood but both natal streams and lakes are utilized. Lakes and larger natal streams provide overwintering freshwater habitat for stream type Chinook, which allows fish to attain significant body mass allowing for subsequent salt water adaptation (DFO 1997). Ocean type Chinook likely realize a greater benefit from the productivity of larger lakes (DFO 1997).

HABITAT INDEX MATRIX

Chinook adults are heavily dependent on deep pools where they may hold for up to 8 weeks before moving out to spawning grounds. Their spawning areas must have larger diameter clean gravels which will afford adequate percolation of flows and oxygen to meet incubation requirements. They are particularly sensitive to movements of silt or reductions in flow during the incubation period.

3.2 Coho Salmon

LIFE HISTORY

Coho Salmon (*Oncorhynchus kisutch*) are an important species and range through hundreds of coastal and interior streams in British Columbia. Interior Fraser River Coho Salmon are genetically unique and can be distinguished from Lower Fraser River Coho. Studies of the genetic structure of Interior Fraser Coho indicate that there are five distinct populations. Three are within the Thompson (North Thompson, South Thompson, and Lower Thompson regions) and two are within the Fraser (the area between the Fraser Canyon and the Thompson-Fraser confluence and the Fraser River and tributaries above the Thompson-Fraser confluence) (Interior Fraser Coho Recovery Team 2006). Middle Shuswap River Coho, are considered part of the South Thompson sub-population (Shearing 2013). The average number of mature individuals in the South Thompson sub-population between 2014 and 2016 was an estimated 5,600 (COSEWIC 2016). Coho in the province is managed federally by Fisheries and Oceans Canada.

Coho populations in British Columbia's Interior face many threats and challenges. So much so that in 2002 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) listed them as Endangered. COSEWIC was concerned that if Interior Fraser Coho distribution became too fragmented, genetic exchange within the populations may be insufficient to ensure long-term survival (COSEWIC 2002). However, in 2016, COSEWIC reassessed them as Threatened. Since the 2002 assessment, there was an observed trend in mature population numbers that indicated the decline previously observed had stopped, but there remained serious threats that could reverse the trend (COSEWIC 2016).

Between 1985 and 1993, annual returns, which includes catch and spawning escapement, averaged 161,000 without trend. Returns dramatically declined between 1994 and 2012, with an average return of 37,000 with little trend. Escapement was around 60,000 between 1985 and 1989 and dropped dramatically in 1997 to 16,000. In 2001 escapement increased to 39,000 but declined again in 2005 to 15,000. Escapement increased to 41,000 in 2012 but reduced to 21,000 in 2014 (COSEWIC 2016).

While natural spawning is responsible for producing most of the Coho and Chinook Salmon escaping to the Interior Fraser River, Coho and Chinook stocks in the SR were supplemented by stocking programs between 1984 until 1994, through the Eagle River hatchery (DFO 1997a). It was found that fry released in the upper river had an approximate 2-fold increase in survival relative to coho fry released in the lower river and attributed the poor survival in the lower river to depleted water supply during August and early September when irrigation demands are high (DFO 1997a).

Interior Fraser Coho require adequate freshwater and marine habitats to survive and reproduce. These fish spawn in freshwater and the juveniles normally spend one full year in freshwater before migrating to the sea as smolts. The distribution of spawning habitat for Coho Salmon is usually clumped within watersheds, often at the heads of riffles in small streams and in side-channels of larger streams. However, Interior Fraser Coho are commonly observed spawning in mainstems of larger rivers during periods of low flow, presumably when tributary and side-channel habitats are less accessible.

The outlook for Interior Fraser Coho is highly uncertain and depends on the magnitude of negative impacts due to fishing, habitat perturbations, and climate related changes in survival. A return to higher survivals, combined with continued low exploitation rates, conservation of existing habitat, and habitat restoration, could produce increases in escapements and subsequently population recovery. However, if survival rates are at low levels, such as those recorded in 2005, spawner numbers will continue to decrease, possibly resulting in the eventual extinction of Interior Fraser Coho. Since there is no predictor of future survival rates, a cautious approach to harvest and habitat management will be required to ensure the long-term viability of Interior Fraser Coho (Interior Fraser Coho Recovery Team 2006).

REPRODUCTION

The timing of river entry and spawning varies with latitude and distance from the ocean. Thompson Coho stocks return at age 3 to the lower Fraser between late October and November and spawning occurs from mid-October to December (Arc Environmental Ltd. 2001). Spawning Coho are the most secretive of Pacific salmon and most reproduction behavior occurs at night.

Coho have similar tendencies to Rainbow Trout in their selection of rearing habitat (Griffith 1986). They prefer sites with sub-gravel flow as is found in tail-outs of pools immediately above riffles or upwelling sites. They prefer smaller tributary and headwater streams often not much more than 1m in width. Eggs incubate over winter and hatch in the spring. Incubation timing is dependent on water temperatures as with all other salmonids in the Thompson system.

Fry emerge from late March through late May and early June (DFO 1997b). Juveniles spend one year in freshwater, rearing initially in their natal streams and subsequently moving downstream to rear and overwinter in rivers and lakes (DFO 1997b). Migration likely occurs between mid-April and early May.

AGE, GROWTH AND MATURITY

In British Columbia, Coho fry usually reach 80-90mm in their first year (McPhail 2007). Coho fry in interior streams normally spend 1 to 2 years in nursery streams before out-migrating to the Pacific Ocean. They are primarily drift-feeders and take the drifting stages of aquatic insects from the water column or terrestrial insects from the surface. Coho prefer pools and backwater areas. They will aggregate in backwaters, side-channels and quiet embayments along stream margins. They will eventually emigrate to larger rivers and will search out off-channel overwintering areas such as beaver ponds and flooded wetlands (McPhail 1997). In winter they will seek cover under woody debris, undercut banks, cobbles and move deeply into root wads.

HABITAT INDEX MATRIX

The Habitat Index Matrices indicate that Coho adults require cascade areas, confluence areas, pools, riffles, runs, cover and access to small streams in upper watersheds. They will hide under cut banks and root wads and will search for suitable gravel in upwelling areas and tail-outs of pools.

Coho juveniles depend heavily on pools, backwaters, in-stream vegetation areas, low and middle flood benches, marsh areas, side channels, cobble areas and large woody debris. Tributary stream confluences are important as are small, stable streams which provide rearing habitat. These streams will support Coho through their incubation period and their first year of rearing. Adequate year-round flows and cool temperatures afforded by well-developed riparian zones are important. Some fry will move to the main rivers where they will seek back-waters, flood benches and beaver dams.

Coho in south central B.C. will usually rear for 1 year in freshwater and then begin their migration to the ocean. They will spend 18 months at sea before returning as adults to spawn. As with other Pacific salmon (except for Steelhead and coastal Cutthroat) they die after spawning.

3.3 Rainbow Trout

LIFE HISTORY

Rainbow Trout are spring spawners and migrations into spawning streams are triggered by rising water temps (above 5°C) and rising water levels (McPhail 2007). Streams are critically important for the nursery phase of Rainbow Trout juvenile rearing. Unlike Pacific salmon, Rainbow Trout adults can survive spawning and it has been determined that about 10% will live on to spawn a second time (McPhail 2007).

Rainbow Trout juveniles rearing in small streams tend to be highly connected with riffles, runs and large woody debris. These areas provide the best habitat for cover and feed consisting of small aquatic insects. They need to select streams that provide suitable habitat to survive summer and winter extremes for up to three years. Low summer flows, caused by agricultural irrigation diversions can have significant impact on smaller streams. Rainbow Trout juveniles can also be displaced by other fish, such as Coho, which tend to compete heavily for prime feeding areas as they have similar diets (Griffith 1986).

In rivers, Rainbow Trout will normally establish territories in shallow water along stream margins (Slaney and Northcote 1974). During their adult phase in streams and rivers they occupy riffles, runs, glides and pools and tend to occur in deeper and faster water than juveniles (McPhail 2007). As they grow, terrestrial insects are added to their diet and so riparian areas along river margins become increasingly important to them (McPhail 2007).

AGE, GROWTH AND MATURITY

Some Rainbow Trout will live their entire life cycle in small streams or rivers (resident) while others are of an adfluvial nature and will move down to large lakes. Information is limited on downstream migration traits but it is believed that they travel in the freshet and utilize cover habitats along the way to escape their predators (McPhail 2007). Adfluvial trout can live up to 8 years before maturing with the norm being 5 or 6 (MOE Okanagan Region Files). Their biggest obstacle in lakes is anglers who target them extensively. Rainbows can tolerate temperatures up to 27^0C but anything higher can be lethal (Lee and Rinne 1980 in McPhail 2007). In adfluvial populations, Rainbow Trout rely heavily on Kokanee and Sockeye forage once they move to large lake habits.

HABITAT INDEX MATRIX

The Habitat Index Matrices developed for this study indicate that Rainbow Trout depend heavily on pools, runs, riffles, boulder areas and cover afforded by riparian vegetation or in-stream woody debris. Log jams associated with pools are also used extensively for feeding and hiding. Tributary stream confluences are important as are small, stable streams that provide rearing habitat for juveniles and resident populations.

3.4 Sockeye Salmon

LIFE HISTORY

Sockeye salmon (*Oncorhynchus nerka*) are the third most abundant of the seven species of Pacific salmon (Groot and Margolis, 1991). In British Columbia Sockeye tend to have similar life history traits as kokanee with a few major exceptions. As with Kokanee, Sockeye fry normally will spend their first year in a freshwater lake – before the long journey to the Pacific Ocean. This anadromous tendency allows them to become much larger than Kokanee as there is more abundance of feed in the north Pacific than in interior lakes. Sockeye spend from one to four years in the ocean before returning to fresh water to spawn.

REPRODUCTION

Sockeye spawn in the fall, usually when water temperatures drop below 12°C. In the Middle Shuswap River this normally occurs in late September, with peak spawning generally occurring between October 10th and 20th (Arc Environmental Ltd. 2001; McPhail 2007). As with Kokanee, Sockeye will form dense aggregations on spawning grounds. They will normally choose larger spawning substrates than kokanee which tends to cause separation in spawning locations. Like other Pacific salmon, Sockeye will defend their redds until too weak to maintain position and die after spawning.

Even in larger rivers, Sockeye tend to spawn in shallow riffle areas (Groot and Margolis 1991). There are exceptions; however, and it is clear that they have the ability to detect and utilize groundwater upwelling areas. Fecundity varies from about 2,000 to 4,000 eggs related to female size (Groot and Margolis, 1991). Incubation times vary related to water temperatures and in the Shuswap River they tend to emerge from gravels in early spring (April and May) then immediately begin their downward migration to Mabel Lake. Sockeye spend their first-year rearing in freshwater lakes prior to migrating downstream to the Pacific (Arc Environmental Ltd., 2001). Fry need to move downstream quickly to lakes where they begin feeding or they will not survive. They move downstream under cover of darkness to avoid predators.

Sockeye, unlike Kokanee, in the Middle Shuswap River, cycle on a four-year rotation and can vary considerably in numbers from year to year. Dominant cycle years have been documented in 1994 and 1998, with escapements of 31,806 and 15,262, respectively (Arc Environmental Ltd. 2001). Sockeye tend to spawn in areas above nursery lakes or in some cases just below (McPhail 2007).

AGE, GROWTH AND MATURITY

As with Kokanee, Sockeye fry once emerged from the gravel normally will migrate downstream under cover of darkness to their nursery lake for a period of rearing, usually lasting one year. McPhail (2007) suggests that the migrating fry will look for cover areas in organic debris or boulder substrate if the migration cannot occur in one night. They will then resume their downstream travel once darkness returns.

HABITAT INDEX MATRIX

The Habitat Index Matrices developed for this study tend to be very similar for Sockeye as they are for Kokanee. Spawning gravel attributes score very high for adult spawning and juvenile incubation while rearing and cover attributes score low due to their tendency to spend most of their juvenile stage rearing in lakes, and then the remainder of their adult life rearing in the Pacific Ocean

4.0 AQUATIC HABITAT INDEX

AHI scores derived for each reach of the river channel and left and right bank segments are analogous to the current productivity, which is defined as the sum of relative habitat values for all subareas occurring within a defined area (i.e., river channel extents of a respective reach) (Minns 1997). The AHI is a categorical scale of relative habitat value that ranks the river channel and bank segments in a range between *Very High* and *Very Low*. Our approach to development of the index incorporated the following components:

1. Utilization of all existing data that occurs in a spatial GIS format to develop the index.
2. Species Accounts (Section 3), developed to inform life history scores for discrete instream habitat units/features for key species of the Salmon River.
3. The AHI was developed and calibrated using professional opinion similar to other habitat indices that have been developed for lake systems. Criteria were reviewed for relevancy and weighted appropriately (i.e., representative of the contribution to overall habitat sensitivity).

The data previously collected for this project involved numerous spatial data layers and is substantially more complicated to develop than an AHI developed for a lake ecosystem. The dynamic nature of riverine ecosystems required that three separate layers of data be collected as part of the inventory phase. One layer of data was attributed to the primary character of the river and habitat features within, one layer was used to describe the right bank, and one layer was used to describe the left bank.

4.1 Centerline (instream) Reach Scoring Matrix

The high level survey intensity of the SR yielded fine-scale mapping of instream habitat features (points). The measured relative spatial coverage of each feature type within respective reaches was then multiplied by the relative habitat value and weighted constant value that was calibrated for the SR.

Habitat Feature	Relative Habitat Value
Instream Vegetation	0.2
Boulder	0.4
Over Stream Vegetation	0.4
Small Woody Debris	0.6
Deep Pool	0.7
Undercut Bank	0.7
Large Woody Debris	0.8
Rearing	0.9
Spawn Habitat	1

Habitat unit classes (Section 3.1) were assigned a relative habitat value for each key fish life history stage/habitat quality categories. The relative productivity value was defined for each habitat unit as the sum of all production scores accrued by each of the fish species during the time they spend any part of their life history in that area (e.g., for spawning, rearing, and feeding) or accrued elsewhere as a result of a strict habitat requirement to use that area of habitat (e.g., for staging, migration, or cover).

Habitat unit: Fish life history and habitat requirement matrices were developed to determine the relative habitat value for each habitat unit. Life history stages considered were:

- Spawning
- Rearing
- General Living/Feeding

Habitat Requirement categories included:

- Substrate composition
- Cover (habitat complexity)

Life history accounts informed the relative values assigned to each habitat unit for each species and life history stage. The relative habitat unit values are presented in the following matrices (**Tables 8-10**). A 3-class score was assigned to each matrix cell; where 1 = *low value*, 2 = *moderate value*, and 3 = *High value*. The sum of species scores for each habitat unit were then transformed to a relative habitat value, which was calculated as the habitat unit score / maximum habitat unit score. The life history and habitat attributes were then weighted (**Table 9**) based on the relative importance of these components in the index for production.

Table 8. Fisheries relative habitat values (RHV) and weighted scores for aquatic and riparian habitat features.

		Rearing		General Living		Cover	
Habitat Variable	**Code**	**RHV**	**Wt. Score**	**RHV**	**Wt. Score**	**RHV**	**Wt. Score**
Backwater	BW	1.00	28.75	0.23	1.31	0.20	3.45
Confluence	CO	0.72	20.76	0.91	5.23	0.83	14.38
Low Flood Bench (graminoid)	FL	0.57	16.25	0.11	0.65	0.08	1.44
Low Flood Bench (shrub-willow)	FL	0.35	10.00	0.11	0.65	0.08	1.44
Mid Flood Bench	FM	0.11	3.19	0.07	0.39	0.05	0.86
Glide	G	0.44	12.78	0.36	2.09	0.27	4.60
Lake	LK	0.44	12.78	0.68	3.92	0.72	12.36
Large Woody Debris	LWD	1.00	28.75	0.91	5.23	0.98	16.96
Mixed Forest	M	0.11	3.19	0.07	0.39	0.07	1.15
Pool	P	1.00	28.75	1.00	5.75	1.00	17.25
Riffle	RF	0.72	20.76	0.82	4.70	0.67	11.50
Riverine Marsh	RM	1.00	28.75	0.16	0.91	0.15	2.59
Run	RN	0.72	20.76	0.80	4.57	0.57	9.78
Side Channel	SC	0.89	25.56	0.84	4.84	0.70	12.08

Table 9. Relative value and weighted scores for mapped instream substrate composition.		
Substrate Class	**Relative Value**	**Weighted Score**
Organic	0.3	6.0
Fines (silt/sand)	0.2	4.0
Gravel	1.0	20.0
Cobble	0.6	12.0
Boulder	0.5	10.0
Bedrock	0.1	2.0
Pebble	1.0	20.0

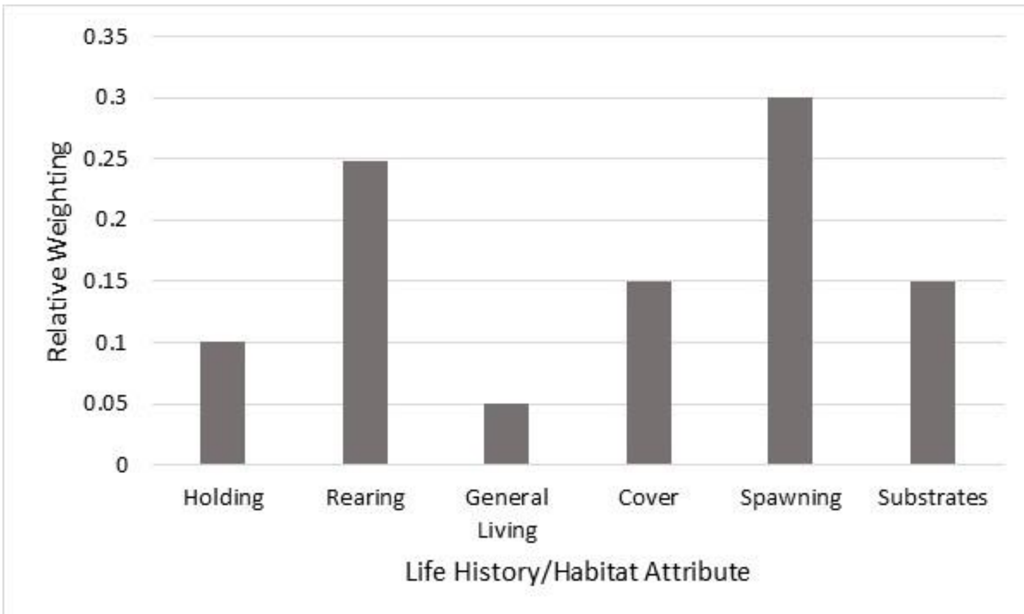


Figure 1. Relative weighting of life history and habitat attributes for instream AHI scores.

4.2 Riparian Polygon Scoring Matrix

Relative habitat values were assigned to riparian polygons (delineated within the 100-m riparian band) based the sum of values of four categories: Wildlife habitat rating; biodiversity rating; nutrient value/leaf and litter fall; and large woody debris recruitment (Table 10). The sum of relative habitat unit scores were then added to the other parameters of the bank AHI system relating to the current level of impact, degree of bank modifications, and current severity of erosion (caused by human activities).

Table 10. Ecological category: riparian habitat unit rating matrix (relative habitat value).

Habitat Type	Code	Qualifier	Wildlife Rating	LWD	Biodiversity Rating	Nutrients
Broadleaf Forest	B	hd	0.40	0.30	0.30	0.40
		b	0.40	0.70	0.30	0.30
		ld	0.70	0.40	0.70	0.80
		n	0.80	1.00	0.80	0.90
Backwater	BW		0.80	0.00	1.00	0.50
		d	0.40	0.70	0.30	0.30
Cliff/Scree/Talus	CS		0.10	0.00	0.20	0.10

Habitat Type	Code	Qualifier	Wildlife Rating	LWD	Biodiversity Rating	Nutrients
Coniferous Forest	C	b	0.30	0.60	0.30	0.30
		hd	0.40	0.50	0.30	0.40
		p	0.50	0.50	0.30	0.50
		pb	0.50	0.50	0.30	0.50
		md	0.50	0.60	0.40	0.50
		ld	0.60	0.70	0.50	0.60
		n	0.70	0.80	0.60	0.60
Cultivated Field	CF		0.10	0.00	0.10	0.10
Dry Gulley	DG		0.10	0.00	0.10	0.10
Grassland	GN	hd	0.10	0.00	0.00	0.00
		b	0.10	0.00	0.10	0.10
		pb	0.30	0.00	0.20	0.10
		md	0.50	0.00	0.30	0.10
		ld	0.60	0.00	0.40	0.20
		n	0.60	0.00	0.40	0.20
Low Flood Bench	FL	b	0.50	0.00	0.50	0.30
		hd	0.50	0.00	0.50	0.30
		f	0.60	0.00	0.60	0.30
		md	0.60	0.00	0.60	0.30
		pb	0.60	0.00	0.60	0.30
		ld	0.70	0.00	0.70	0.30
		n	0.90	0.00	0.90	0.40
Low Flood Bench - Graminoid	FLG	b	0.50	0.00	0.50	0.30
		hd	0.50	0.00	0.50	0.30
		md	0.50	0.00	0.50	0.30
		pb	0.50	0.00	0.50	0.30
		f	0.70	0.00	0.70	0.30
		ld	0.70	0.00	0.70	0.30
		n	0.90	0.00	0.90	0.40
Low Flood Bench - Shrub	FLS	b	0.40	0.00	0.30	0.30
		hd	0.40	0.00	0.30	0.30
		f	0.40	0.00	0.50	0.50
		pb	0.50	0.00	0.60	0.30
		md	0.60	0.00	0.60	0.30
		ld	0.70	0.00	0.70	0.30
		n	0.90	0.00	0.90	0.40
Mid Flood Bench	FM	f	0.40	0.40	0.50	0.40
		hd	0.40	0.40	0.50	0.40
		b	0.40	1.00	0.50	0.40
		md	0.60	0.80	0.60	0.70
		ld	0.80	1.00	0.80	0.90
		n	1.00	1.00	1.00	1.00
Mixed Forest	M	md	0.60	0.70	0.60	0.40
		pb	0.60	0.80	0.70	0.40
		ld	0.70	0.80	0.80	0.50
		n	0.90	1.00	1.00	0.60
Open Coniferous Woodland	CW	b	0.40	0.60	0.20	0.20
		c	0.40	0.60	0.20	0.20
		hd	0.40	0.50	0.30	0.40
		md	0.50	0.60	0.40	0.50
		pb	0.50	0.60	0.40	0.50
		ld	0.60	0.70	0.50	0.60
		n	0.70	0.80	0.60	0.70
Railway	RL		0.00	0.00	0.00	0.00
River	RI		0.80	0.00	0.80	0.00
		d	0.30	0.00	0.40	0.00
		hd	0.50	0.00	0.50	0.00
		md	0.60	0.00	0.70	0.00
		ld	0.60	0.00	1.00	0.00
		n	0.60	0.00	1.00	0.00
Road Surface	RZ		0.00	0.00	0.00	0.00
		hd	0.00	0.00	0.00	0.00
Rural	RU	b	0.00	0.00	0.00	0.10

Habitat Type	Code	Qualifier	Wildlife Rating	LWD	Biodiversity Rating	Nutrients
		hd	0.00	0.00	0.00	0.10
		md	0.30	0.20	0.20	0.30
		pa	0.50	0.00	0.50	0.30
		ld	0.40	0.40	0.40	0.40
Seasonally Flooded	SF		0.20	0.00	0.20	0.20
Shrub	SH	hd	0.20	0.00	0.10	0.20
		f	0.30	0.00	0.20	0.30
		md	0.40	0.00	0.30	0.30
		pb	0.40	0.00	0.30	0.30
		n	0.40	0.00	0.50	0.30
		ld	0.50	0.00	0.40	0.50
Silt Bluff/Exposed Bank	SB		0.20	0.00	0.20	0.10
Side Channel	SC		0.50	0.00	0.60	0.30
Shrub-Steppe	SS	f	0.30	0.00	0.30	0.10
		hd	0.40	0.00	0.30	0.10
		md	0.60	0.00	0.50	0.10
		ld	0.70	0.00	0.60	0.10
		n	0.80	0.00	0.70	0.10
Urban	UR		0.00	0.00	0.00	0.10
		pa	0.00	0.00	0.00	0.00
Wetland	WN		1.00	0.00	1.00	0.40
		b	0.60	0.00	0.50	0.10
		hd	0.60	0.00	0.50	0.10
		ld	0.80	0.00	0.80	0.40
		md	0.80	0.00	1.00	0.60
		n	1.00	0.00	1.00	0.40

4.3 AHI Logic, Calibration, and Ranking

As part of the index development for the Salmon River RIM, index development and calibration involved multiple iterations - assigning different weights to each of the parameters within the various habitat units, life history and ecological matrices. Following each iteration, the resultant sensitivity outputs were reviewed and scrutinized by fisheries biologists at Ecoscape. Calibration of the index was ultimately finalized using professional judgment.

The AHI provides a categorical scale of relative habitat value that ranks the centerline and shoreline segments in a range between *Very High* and *Very Low* sensitivity. The index is relative, because it only assesses the sensitivity of one shoreline area relative to another within the extents of the river being examined. Index scores and rankings developed for the Salmon River may not be directly transferable to other river systems without re-calibration. The following provides a definition for each AHI ranking:

- *Very High* – Reaches/Segments ranked as *Very High* are considered integral to the maintenance of fish and wildlife species and generally contain important natural riparian and floodplain areas, complex mosaics of habitat units supporting high biodiversity and productivity values, and high value/use salmonid spawning, rearing, and general living habitats. These areas should be considered the highest priority for conservation and protection.
- *High* - Reaches/Segments ranked as *High* are considered to be very important to the maintenance of fish and wildlife species along and within the river and areas can be

ranked as *High* for a variety of reasons. These areas should be considered a priority for maintaining current conditions and a high prioritization for conservation should be given to these areas.

- *Moderate* - Reaches/Segments ranked as *Moderate* are areas that are common along the river, and have likely experienced some habitat alteration. These areas may contain important habitat areas, such as shore holding areas (deep pools), but these areas are generally considered more appropriate for development. Because areas of high habitat value may be present, caution should be taken when considering changes in land use to avoid unnecessary harm or degradation to existing habitat values.
- *Low* – Reaches/Segments that are generally highly modified. These areas have been impaired through land development activities. A common symptom along the river is high bank instability and bank erosion exacerbated by the removal/absence of riparian vegetation. Development within these areas should be carried out in a similar fashion as *Moderate* shoreline areas. However, restoration objectives should be set higher in these areas during redevelopment.
- *Very Low* – Segments that are extremely modified and not adjacent to any known important habitat characteristics.

After reviewing the distribution of the data from the iterations, logical breaks in the scores were used to determine the AHI rankings (discussed above). The breaks created reflect the clustering of scores based upon the output of the results, which somewhat mimic a normal distribution (although an analysis of data distribution was not conducted).

4.3.1 Centerline – Instream Zone AHI Logic

The AHI for each channel reach was calculated as the sum of life history scores for each reach. **Table 11** presents the categories, relative category weightings, and logic for the Centerline AHI scoring.

The centerline AHI scores for respective reaches (AHI_{reach}) was calculated using the following,

$$AHI_{reach} = \sum\left[\frac{A_h}{A_t} \times W_h\right] + \sum\left[\frac{A_{sp}}{A_t} \times W_{sp}\right] + \sum[P_{sub} \times W_{sub}] + \sum\left[\frac{A_{hold}}{A_t} \times W_{hold}\right] \quad (1)$$

where *A* represents the area of a described river feature (such as *h* is habitat, *sp* is spawning, and *hold* is holding), *P* represents a percentage of the area, A_t represents the total area of the river channel contained with the subject reach, and *W* represents the relative weighting given to the described river feature (**Tables 8-11**).

Table 11. The parameters and logic for the Centerline of the Salmon River

Category	Criteria	Category Weighting	Logic
General Living	Instream Habitat unit and Hydraulic Class polygons	5%	% Area * Category Score
Rearing	Instream Habitat unit and Hydraulic Class polygons	25%	% Area * Category Score
Holding	Mapped deep pool features	10%	% Area * Category Score
Spawning Habitat[1]	Records collected during 2021 field inventory	30%	% total spawning area * Category Score
Substrates	% composition estimated during 2021 field inventory	15%	% Area * Category Score
Cover	Instream Habitat unit and Hydraulic Class polygons	15%	% Area * Category Score

[1.] For the AHI spawning polygons they were split according to identified reach breaks to allow a reach by reach analysis. To accomplish this, the data was transformed and described as a percentage of the total river area available for individual reaches for mapped anadromous spawning use and suitable habitats.

4.3.2 Riverbank – Riparian Band AHI Logic

The left and right bank AHI segment scores (AHI_{bank}) were calculated using Equation 2.

$$AHI_{Segment} = \sum[P_{nat} \times W_{nat}] + \sum[P_{wildlife} \times W_{wildlife}] + \sum[P_{LWD} \times W_{LWD}] + \sum[P_{biodiv} \times W_{biodiv}] + \sum[P_{alloch} \times W_{alloch}] + \sum[P_{retain} \times W_{retain}] + \sum\left[\frac{L_{dock}}{L_t} \times W_{dock}\right] + \sum\left[\frac{L_{erosion}}{L_t} \times W_{erosion}\right]$$

(2)

where *L* is the length of the bank of a described river feature. **Table 12** presents the categories, relative category weightings, and logic for the riverbank AHI scoring.

Table 12. The parameters and logic for the banks of the Salmon River

Category		Criteria	Maximum Relative Value (Score)	Percent of the Category	Logic
Percent Natural		Percent Natural	4	100	% Natural Value ($\%_{nat}$)* Category Score (P_n)
Wildlife [a]		Wildlife	5	100	% Area * Category Score
Large Woody Debris Recruitment [a]		Large Woody Debris Recruitment	5	100	% Area * Category Score
Biodiversity [a]		Biodiversity	5	100	% Area * Category Score
Leaf and Litterfall [a]		Allochthonous/Productivity	5	100	% Area * Category Score
Impairments	Erosion	Low	-0.75	5	% of Segment Length * Score
		Moderate	-1.5	10	% of Segment Length * Score
		High	-4.5	32	% of Segment Length * Score
		Extreme	-7.5	53	% of Segment Length * Score
	Bank Armouring	Retaining wall, rip rap	-2		% of Segment Length * Score

a. See Table 11 for rating matrix and relative habitat values

5.0 INVENTORY SUMMARY OF RESULTS

The SR flows a distance of approximately 150 km from its headwaters near Salmon Lake, to its confluence at Shuswap Lake. The SR was divided into 67 reaches based on river channel morphology and character, from its confluence at Shuswap Lake to where the riverbed becomes dry at the Highway 97 bridge crossing directly east of the town of Westwold. The total length of the left and right riverbanks was 87.8 km and 87.6 km respectively.

5.1 Stream Primary Character

5.1.1 Shore Type Relative Distribution

Combined, fields and rural lands accounted for almost 60% of the left bank and nearly 50% of the right bank (Table 13). Natural cottonwood riparian ecosystems (Mid Flood Bench) accounted for 11% and 13% of the left and right banks respectively. Low and middle bench site associations occur in the geomorphologically dynamic portion of the floodplain and are maintained by a combination of prolonged flooding and site erosion/sedimentation (Mackenzie and Moran 2004). Low bench ecosystems occur on sites that are flooded for moderate periods (< 40 days) of the growing season, conditions that limit the canopy to tall shrubs, especially willows and alders. Annual erosion and deposition of sediment generally limit understory and humus development (Mackenzie and Moran 2004). Middle bench ecosystems occur on sites briefly flooded (10–25 days) during freshet, allowing tree growth but limiting tree species to only flood-tolerant broadleaf species such as black cottonwood (Mackenzie and Moran 2004).

Table 13. Vegetation/Landcover class distribution along the left and right banks of the Salmon River.

Vegetation/Landcover Class	Left Bank	Right Bank
Seasonally Flooded Field	39%	35%
Mid Flood Bench - Natural	11%	13%
Cultivated Field	10%	6%
Rural	11%	7%
Low Flood Shrub - Natural	5%	5%
Low Flood Graminoid - Low Disturbance	5%	4%
Low Flood Shrub - Low Disturbance	3%	3%
Low Flood Shrub - Fringe	2%	2%
Mid Flood Bench - Low Disturbance	2%	3%
Low Flood - Low Disturbance	2%	1%
Mixed Forest - Natural	2%	5%
Mid Flood Bench - High Disturbance	1%	<1%
Low Flood Graminoid - Natural	1%	1%
Mid Flood Bench - Moderate Disturbance	1%	1%
Mid Flood Bench - Fringe	1%	1%

Vegetation/Landcover Class	Left Bank	Right Bank
Low Flood - Natural	1%	2%
Low Flood - High Disturbance	<1%	1%
Mixed Forest - High Disturbance	<1%	1%
Mixed Forest - Low Disturbance	<1%	2%
Low Flood Shrub - Moderate Disturbance	<1%	1%
Mixed Forest - Moderate Disturbance	<1%	1%

Low Flood Bench

Mid Flood Bench

Mixed Forest/Flood High Bench

Coniferous Forest


Confluence *Backwater*


Silt Bluff *Landslide*

5.1.2 Land Use Relative Distribution

On the left bank, over 55.1 km (63%) was still natural, not recently disturbed (**Figure 3**). On the right bank, 61.0 km (70%) of the segments were natural, not recently disturbed. Urban development was more prominent within the lower reaches of the SR; however, agricultural activity was prominent throughout the SR, and dominated the upper reaches. Various types of land use observed along the SR have been highlighted below.


Natural Area


Agriculture

Infrastructure

Rural

Single Family (Urban)

Recreational

5.2 Stream Channel and Hydraulic Character

The hydraulic character of the SR is dominantly riffle-pool (RP) over 52 km (59%) of total mapped area (**Figure 2**). The second most dominate hydraulic characteristic is run (RN) and totaled 28 km (32%).

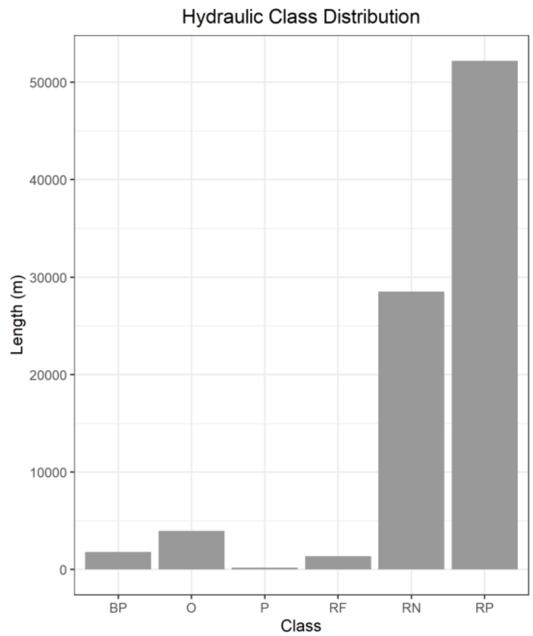


Figure 2. Salmon River hydraulic class distribution over the 88.1 km river centreline length.

5.3 Fish Habitat

In the absence of low flow considerations, physical habitat in the SR was found very suitable for Chinook, Steelhead, and Coho production. Over stream vegetation, important for instream cover and shading, amounts to about 1.67% of the instream area. Deep pools, important for cover and general living as well as holding areas for anadromous migrations, amount to about 1.60% of the instream area. Large woody debris (LWD) provides important structural cover/complexity for fish, and accounted for 1.17% of the instream area. These features account for about 4.4% of the total mapped instream area of SR. Spawning habitat for Chinook and other salmonid species was identified, and accounted for 0.46% of the instream area of SR.

The data summarized in **Table 14** and illustrated on Map Set 2 was also incorporated into the AHI (Section 6.1).

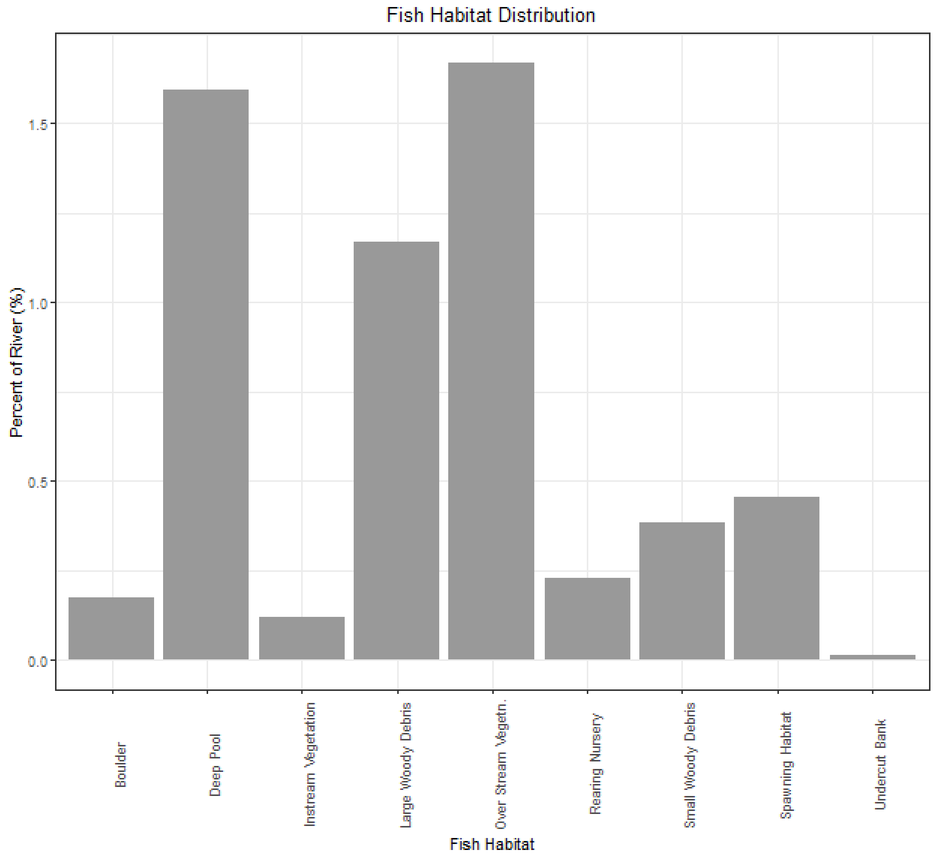


Figure 3. Relative distribution of key habitat elements mapped during the Salmon River inventory. Percentage values shown in the illustration represent the estimated instream coverage.

Table 14. Habitat spatial coverage summary for entire instream area of Salmon River.

Habitat type	Total habitat area (m²)	Percentage of instream area
Boulder	2,910	0.174%
Deep Pool	26,653	1.595%
Instream Vegetation	1,970	0.118%
Large Woody Debris	19,559	1.171%
Over Stream Vegetation	27,879	1.668%
Rearing	3,813	0.228%
Small Woody Debris	6,426	0.385%
Spawning Habitat	7,630	0.457%
Undercut Bank	258	0.015%


Large woody debris and associated spawning habitat.


Backwater (rearing)


Side channel (rearing/spawning)

5.4 Modifications

Instream and bank modifications and features were recorded in the field as points and summarized in **Table 15**. It should be noted that general clearing/removal of riparian vegetation and encroachment by agricultural development was recorded as individual points and captured within the percent disturbed field for individual shore segments.

73 water withdrawals (intakes) were documented along the SR channel. Wells (domestic and agricultural) that draw from the shallow groundwater associated with the SR were not mapped in this project scope as they would be setback from the river channel and not visible during the field survey. Bank armoring (rip rap) was recorded on over 6.5 km of the left bank and about 6.1 km of the right bank. Linear development along the SR has notable impacts with 79 bridges, and associated riparian alteration from agriculture, riparian clearing (i.e., other), road, and water withdrawal.

Table 15. Summary of anthropogenic features and modifications catalogued during the Salmon River Inventory.

Feature	Bank	Sum of Length (m)[1]	Count of Modification Type
Bridge	Both	562	79
Fencing	Both	66	3
	Left	536	16
	Right	714	10
Livestock Access	Left	418	25
	Right	1,719	50
	Both	410	4
Livestock Crossing	Both	198	20
General riparian modifications (e.g., riparian clearing)	Both	165	6
	Left	3,826	54
	Right	2,487	41
Pipe Crossing	Both	3	7
Retain Wall/Bank Stabilization	Right	198	10
	Left	130	10
	Both	27	5
Rip Rap	Both	200	13
	Left	6,632	171
	Right	6,484	158
Road	Both	8	1
	Left	43	3
	Right	-	1
Water Withdrawal	Left	20	43
	Right	11	30

1. The total lengths of the left (LB) and right river banks (RB) were 87.8 km and 87.6 km, respectively.

Bridge

Water Withdrawal (Improperly screened intakes result in impingement or entrainment of fish).

Pipeline Crossing

Rip rap and Bank Stabilization

5.5 Bank Stability and Erosion

High severity bank erosion was documented on approximately 9.3 km (10.6%) of the left bank and 12.5 km (14.2%) of the right bank (**Table 16**). Bank instability appeared to be largely attributed to the lack of riparian vegetation and encroachment associated with agricultural land use and rural and recreational disturbance. Other features, however, were natural such as cut banks and silt bluffs. All erosion features are shown in Map Set 2 and are included in the data deliverables. Bank segments with prominent erosion are listed in **Table 17**.

Table 16. Summary of riverbank integrity and erosion along the Salmon River.

		Sum of erosion length (m)[1]	Percent of respective riverbank
Left		**9,925**	**11.3%**
	High (>10 m sq)	9,275	10.6%
	Moderate (5-10 m sq)	457	0.5%
	Low (<5 m sq)	193	0.2%
Right		**13,363**	**15.3%**
	High	12,470	14.2%
	Moderate	610	0.7%
	Low	283	0.3%
Total		**23,288**	

The total length of the left and right riverbanks was 87.8 km and 87.6 km respectively.

High Severity Erosion

Moderate Severity Erosion

Table 17. Summary of prominent left bank and right bank erosion by segment.

Left Bank			Right Bank		
Segment	High Severity (m)	Moderate Severity (m)	Segment	High Severity (m)	Moderate Severity (m)
134	229	10	120	240	
32	185		1	200	
117	185		56	150	
39	180		124	130	
30	150		36	120	
85	145		52	100	
51	135		57	80	
42	130		109	80	
138	125		75	70	15
70	112		129	70	
123	105		77	60	
8	100		103	60	
23	90		61	55	9
140	90		73	50	
28	80		108	50	
44	75		117	50	6
139	75		8	40	
15	70		18	40	
34	65		34	30	8
22	60		58	30	
105	60		85	30	
14	50		115	30	
19	50				
35	50				
63	50				
131	50				
45	45				
119	45				
133	44				
31	40				
49	40				
10	35				
126	35	6			
55	32				
13	30				
25	30				
33	30				
76	30				
81	30				
132	30				
135	30				

5.6 Salmon River Condition Score

A condition score was assigned to each river reach. This rating system was designed with the intent of providing a more measurable parameter in evaluating the watercourse condition and monitoring and evaluating habitat changes on local watercourses and associated riparian and floodplain communities.

The sum of weighted scores equaled 2.49 (out of 5), with the Salmon River receiving a condition score of 49.8% (**Table 18**).

Table 18. Level of impact rating / condition score for the Salmon River.

Impact Rating	Total Length (m)	Condition Value Score	Percent of River	Weighted Score
Nil-Low	2,305.296	5	2.62%	0.13
Nil-Mod	1,254.640	4	1.42%	0.06
Nil-High	2,738.636	3	3.11%	0.09
Low-Low	7,380.011	4	8.38%	0.34
Low-Mod	36,143.329	3	41.04%	1.23
Low-High	13,553.936	2	15.39%	0.31
Mod-Mod	12,221.223	2	13.88%	0.28
Mod-High	5,198.420	1	5.90%	0.06
High-High	7,273.457	0	8.26%	0.00
Sum	88,068.9			2.49
			Condition Score	**49.8%**

[1] Condition references the condition of both banks. E.g., high-high translates to high level of impact on both banks over the reach. Numeric Bank Impact Scores: Nil=3;Low=2; Mod=1; High=0

6.0 AQUATIC HABITAT INDEX RESULTS

The AHI results summarized below are illustrated in Map Series 2 and the raw AHI analysis scores are included in Appendices A – C with centerline and bank segment information. Section 6.1 summarizes the AHI scores and resultant rankings (i.e., *Low – Very High*) for the 67 reaches of the SR, represented in the maps and data analysis as the *centerline*. Section 6.2 summarizes the AHI scores and resultant rankings for the respective left and right bank segments.

6.1 The River

The Salmon River was largely assessed as having a High Aquatic Habitat Index rating. Moderate and Low rates reached were secondary and accounted for approximately 12% and 13% of the SR (**Table 19**). The centerline/reach AHI rankings are illustrated in **Figure 7**. The total AHI analysis score across is illustrated in **Figure 8**.

Table 19. Relative AHI rank distribution (by length) of the Salmon River.

AHI Category	Total Length (m)	Percent of River
Very High	30,115	35%
High	35,068	40%
Moderate	10,898	12%
Low	11,988	13%
	88,069	100%

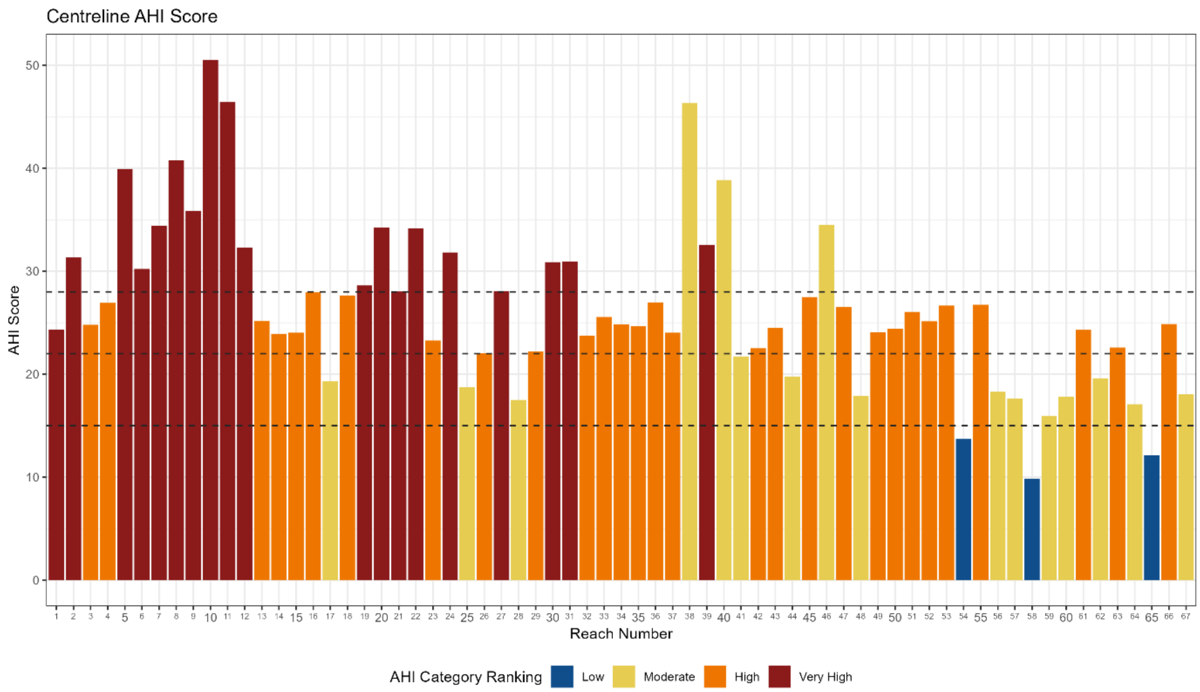


Figure 4. Centerline/reach AHI scores and AHI Rank values (Low/Moderate/High/Very High).

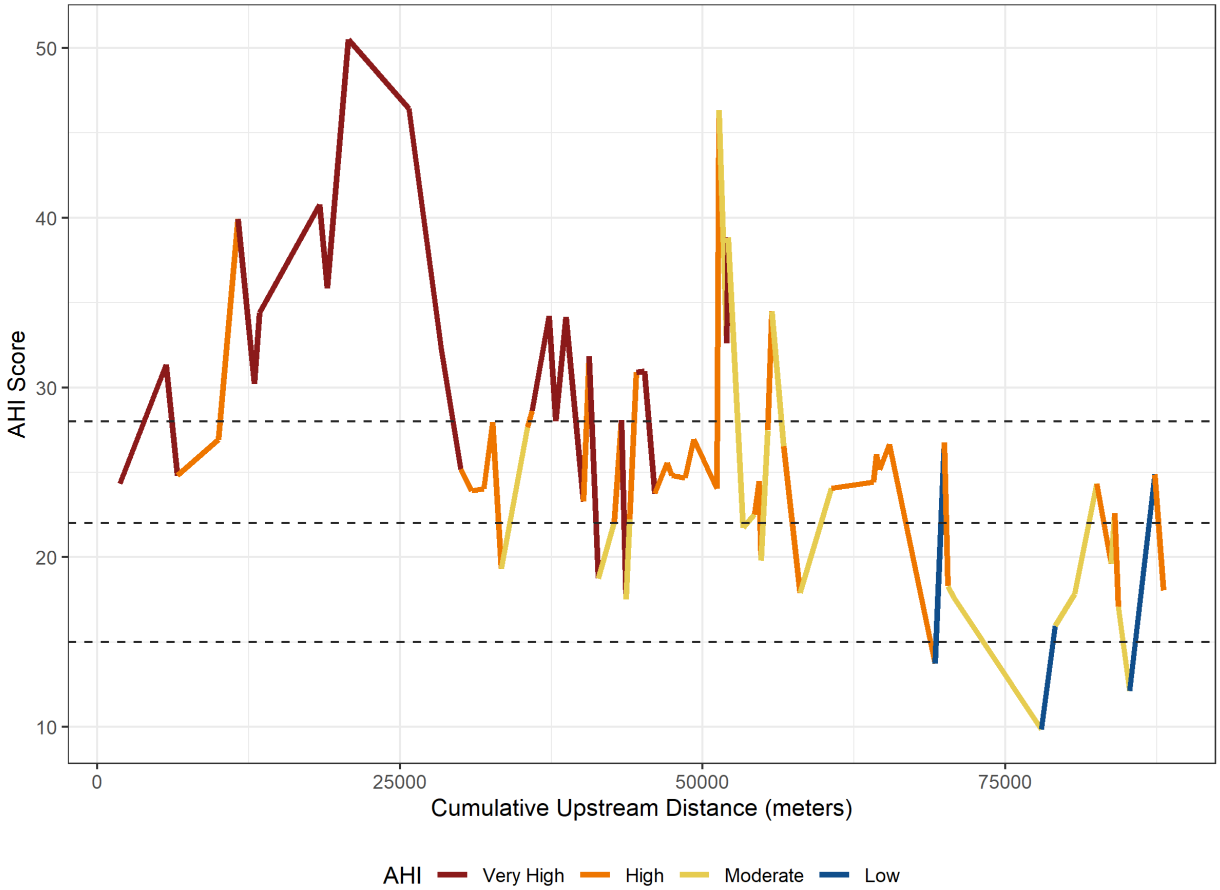


Figure 5. Cumulative AHI score across total length of Salmon River.

6.2 The Banks

The AHI relative ratings along the right and left banks resulted in values higher in Low and Moderate AHI ratings, as many area within both banks had cleared or reduced riparian area from agriculture activity and general urbanization. Segments scoring Moderate and Low were 43% and 34% for the Left bank, and 35% and 26% for the right bank. **Figures 8** and **9** illustrate respective segment scores on the left and right banks.

Table 20. Relative AHI rank distribution (by length) of the left and right banks (looking downstream) of the Salmon River.

Segment/AHI Ratings		Sum of Segment Length (m)	Percent of Bank
Left	Very High	5,021	6%
	High	14,919	17%
	Moderate	37,548	43%
	Low	29,901	34%
Right	Very High	16,954	19%
	High	17,256	20%
	Moderate	30,583	35%
	Low	22,782	26%

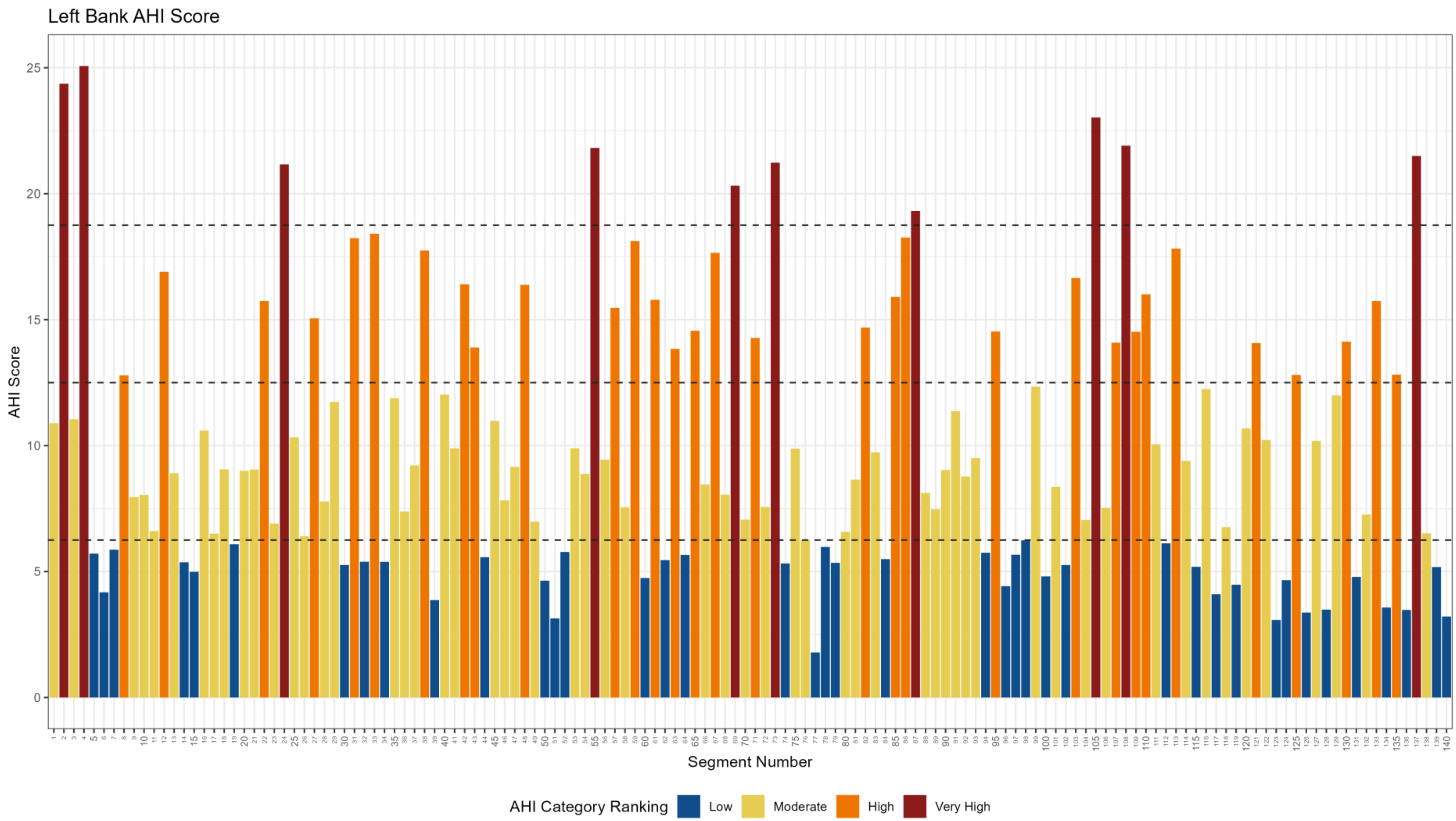


Figure 6. Left bank segment AHI scores.

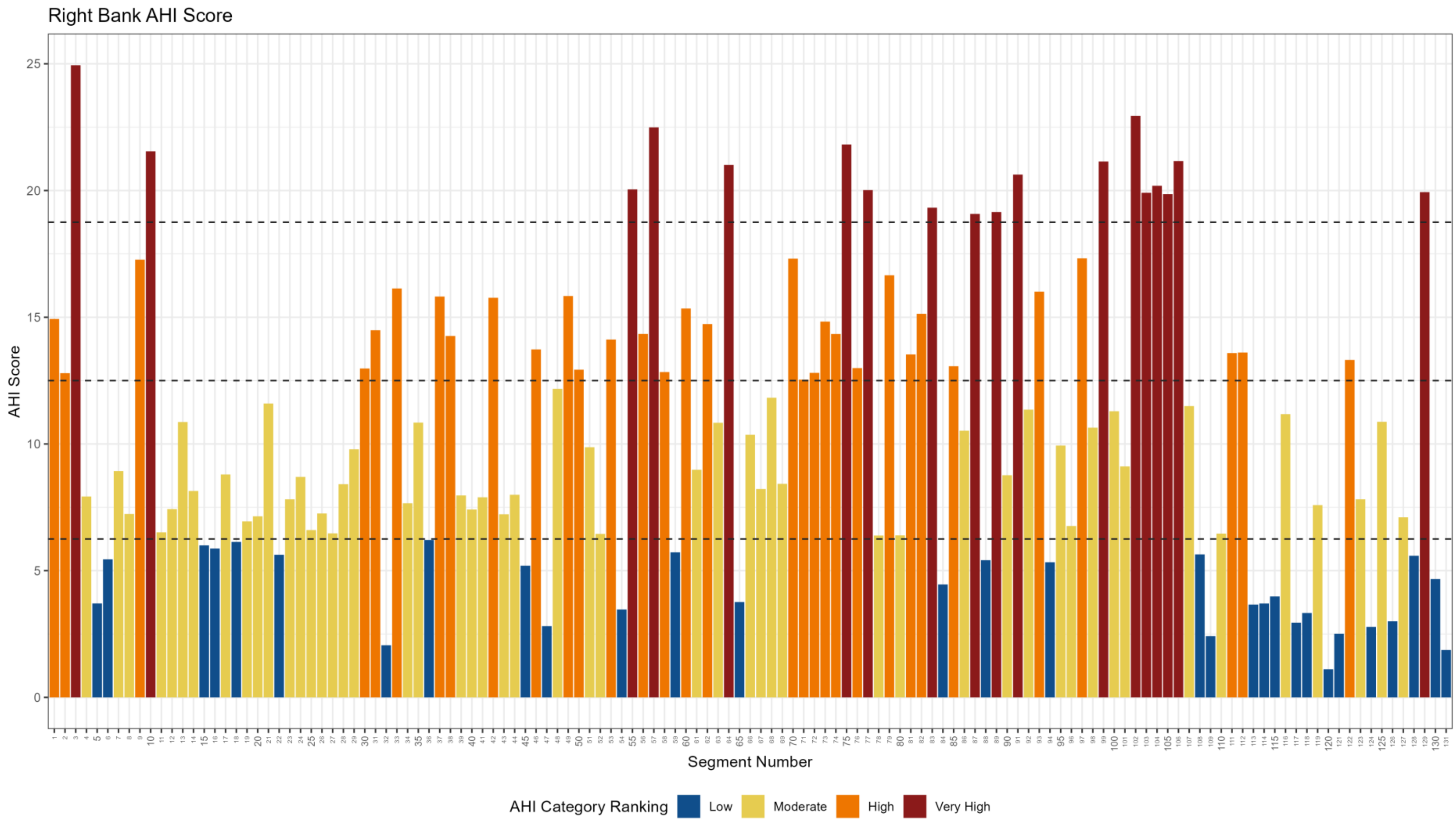


Figure 7. Right bank segment AHI scores.

7.0 RESTORATION POTENTIAL

Extensive restoration efforts have been invested into the Salmon River and riparian and bank condition is naturalizing. The extensive works that have occurred over the years has managed many high priority areas. However, numerous priorities and opportunities persist with about 57% of the river still highlighted as having good potential. **Table 21** highlights reaches where restoration efforts should be focused. Restoration opportunities were higher within segments downstream of the Highway 97 and Salmon River Road intersection, where previous enhancements had occurred, and spawning potential was greater.

Table 21. Highlighted reaches with higher restoration priority.

Reach Number	Comment
7	Potential for restoration through LWD structures
8	Potential for riparian restoration along exposed banks
9	Restoration through creation of instream cover needed
10	Restoration through creation of riparian and instream cover needed
11	Restoration through riparian and instream cover needed
14	Potential for riparian restoration along exposed banks
15	Restoration through instream cover needed
18	Restoration through instream cover needed
19	Revegetation of cleared riparian banks needed
26	Bank erosion protection and installation of fish habitat structures needed
27	Erosion protection of banks and installation of fish habitat structures needed
28	Bank erosion protection and enhancement of fish habitat structures needed
29	Bank erosion protection greatest opportunity for enhancement
30	Bank erosion protection and replacement of existing enhancement structures needed
35	Potential for LWD structures - creation of deep pools needed
36	Restoration through instream, over stream cover needed. Potential to partner with landowners for LWD erosion structures
38	Salmon habitat enhancement could occur due to location through, LWD and boulder install - good substrate for spawning
40	Potential for areas near large pools for LWD and rock install
42	Opportunities for more log placement and rock within residential areas
45	Identified opportunities for partnering with farms regarding stream bank restoration
47	Opportunity to partner with landowners to input LWD/boulder to create fish habitat
48	Mostly bank restoration; however, meandering flows could alter and remove future restoration if implemented.
50	Greatest opportunity is LWD and boulder restoration along agriculture properties - look at developing management plan for areas of high variability.
58	Largest opportunity is bank stabilization, and fish ladder within dammed area. Potential for install LWD structures - high amount of rearing channel
59	Erosion control and fencing of cattle greatest opportunity within section
62	Cattle fencing and erosion protection needed

7.0 DISCUSSION

Flood ecosystems are intensively used by many wildlife species. These are lush habitats with structural elements often not found in adjacent uplands. In addition, the low flood sites may provide critical rearing habitat for juvenile salmonids during seasonal inundation periods. The *High* AHI scores/ranks support this ecological statement; where the mosaic of riparian habitats and complex instream habitat subunits and diverse fish life history utilization combine to represent the highest centerline and bank AHI scores throughout the SR.

The areal extent of flood associated ecosystems remains constant in a stream reach over time, given no fundamental change in water regime or sediment load, but their location in the floodplain changes in response to stream channel changes (Mackenzie and Moran 2004). Flood ecosystems are maintained by a combination of annual flooding, erosion, channel movement, and deposition, which modify the site conditions on the floodplain regularly. Middle bench ecosystems will succeed low benches as sites accumulate sediments and become raised above the stream. With human influence, continued isolation of middle or low bench ecosystems from the regular flooding, through sediment accumulation or stream channel changes, hastens the natural succession and can lead to the formation of seral ecosystems that progress towards modified high bench ecosystems (Mackenzie and Moran 2004).

The SR generally has a *High - Very High* center line AHI score/rank, and *Low-Moderate* bank (i.e., segment) AHI score/rank, and is reflective of the high morphological and hydrological complexity of the system, while having incurred significant riparian loss or reduction through agricultural activity and urban development. The *High* AHI scores/ranks on the SR are threatened by a variety of instream and upland activities. The loss of riparian vegetation from logging, hay/crop production, livestock activity, infrastructure, and urban development limit the natural river cooling mechanisms, in turn, exacerbating rising river temperatures caused by increasingly hot and arid climates, and has previously been a noted issue within the system (DFO 1997a). Stream bank destabilization additionally leads to wider and shallower stream sections, consequently increasing temperatures. Juvenile rearing is affected by local river temperature variations prompting fish to seek colder groundwater inflows and shade. However, many natural areas continue to occur throughout the majority of the central and lower sections of the system, and these high value habitats should be protected as they are critical to maintaining water quality and regulating temperatures throughout the SR.

Agricultural and ranching practices result in high nutrient loading, which can lead to increased biological oxygen demand and subsequent habitat impairments (e.g., algae blooms and substrate fouling), and disruption of spawning and rearing habitat important to resident and anadromous fish. Plants and bacteria in the riparian zone remove excess nutrients through assimilation processes, however a lack of channel complexity can confine nutrients. Transient hydrological zones such as pools, eddies, channel margins and backwaters effectively remove excess nutrient loading (Johnson 2016). Agricultural side channels and runoff locations provide insight into point-source nutrient loading, where systems may benefit from floodplain reconnection or runoff diversion. Agricultural and ranching practices are most prevalent between Falkland and Westwold (i.e., reaches 58 and 65), where agriculture and livestock activity is widespread. To mitigate further encroachment from livestock, local ranchers should be encouraged to limit livestock activity instream through installation of exclusion fencings.

73 water withdrawals were recorded within the SR channel. Not all observed withdrawals were operational during mapping; however, they collectively represent risk to fish and aquatic production with respect to low flows, channel dewatering, lethal stream temperatures, and fish stranding during periods of high withdrawal rates. Water withdrawals can directly impact fish as fry can become trapped and lost in withdrawal canals. Initiative should be taken to ensure water withdrawals are properly licensed to avoid overallocation of flows and intakes properly screened to prevent small-bodied fish and fry entrainment and impingement. The Department of Fisheries and Oceans (DFO) *Freshwater Intake End-of-Pipe Fish Screen Guidelines* can be used to determine appropriate screen sizes.

In addition to direct effects on fish, extensive water withdrawals (from both instream and shallow groundwater wells on the floodplain) can exacerbate the risks associated with low river flows triggered by climate variability. A dried section of the SR directly east of Westwold has been noted during previous assessments from a “continuous belt of unconsolidated deposits” (DFO 1997a); however, low flows may worsen as climate variability increases. Low summer flows have the potential to diminish the availability of suitable spawning habitat for a variety of fish species as waters recede through low floodplains and riverine marshes. Low flows have the added risk of stranding, trapping rearing juveniles in high quality backwater habitats, where survival depends on the availability of food, cover, and cool waters.

Furthermore, low summer flows further elevate the risk to fish associated with elevated stream temperatures and increased stress on fish, which can lead to lethal consequences. Several perished fish were observed during mapping, while local property owners reported observation of die offs of fish within the SR near their properties (K. Mohoruk, personal communication 2021). Fish species such as Coho and Chinook may be forced to use lower reaches as low flows result in inaccessibility to formerly used higher reaches.

An increase in riparian bandwidths and tree canopy closure, and instream cover through ongoing restoration should be a fundamental objective to help mitigate the increasing risk of low flows and associated adverse ecological effects. Furthermore, it is imperative that constructive regulations (Environmental Flow Needs) are set to limit overallocation and excessive water withdrawals from the SR during drought periods and that enforcement measures are implemented to remove unlicensed intakes.

Recognizing the above, it is paramount that land use planning and management of the SR focus on conservation and restoration of floodplain and riparian ecosystems. Previous efforts to enhance the SR has occurred and was previously focused on bank stabilization, fencing, tree planting, and construction groundwater fed side channels. Further opportunities should be explored for improving in-water cover within the lower reaches of the SR where active spawning is most prevalent, and AHI scores are highest. For example, reaches 8 and 9 are of Moderate potential for restoration along exposed banks through increasing riparian vegetation, and creating instream cover for fish through large woody debris (LWD) structures. In addition - as seen in reach 41, opportunities to partner with local landowners should be explored to install erosion control structures (i.e., rip rap and willow staking) along with fish habitat structures (log/rock weirs) to stabilize areas of high erosion, while creating fish habitat. Multiple property owners expressed interest in constructing bio-engineered erosion control structures and implementing riparian restoration if government or private programs were available to do so (K. Mohoruk, personal communication 2021). Areas of previous restoration - as seen in reach 27, could benefit from additional structures, or replacement of historic enhancement structures to future improve stream complexity, minimize erosion, and enhance areas of high habitat value for fish. Future riparian and channel-bank restoration should use bioengineering techniques, and include increasing channel complexity, creation of side channels, large woody debris, gravel sources, and more intact stream banks.

Large woody debris and bank stabilization on the SR as seen in reach 41.

Higher severity bank erosion is highlighted in Section 5.5 above and depicted in the accompanying maps and spatial data. The majority of sites are a result of riparian clearing and consequential bank destabilization. Ongoing riparian restoration and expansion will promote increased bank stability over time. In addition, some armouring and bioengineering should be implemented to provide more immediate stabilization. Hard armoring (i.e., rip rap) of gravel banks is discouraged as it can reduce the supply of gravel through natural stream channel migration processes. Rathr,armoring should focus on using bio-engineered solutions (i.e., rock in conjunction with large woody debris riparian planting) that still allow for natural stream processes such as channel migration and gravel and LWD recruitment.

The SR is a high value anadromous and resident system regardless of individual reach AHI scores. A lower AHI reach score does not imply that particular reach is of low value. Rather the combination of habitat attribute values in that reach contribute less to fisheries and aquatic production than other reaches. However, lower scoring reaches are still important for migration and general living. For example, reaches between Westwold and Falkland had minimal natural riparian vegetation, and were impacted by agriculture and ranching activity, however, still provided valuable rearing opportunities for juvenile fish.

Conservation of existing riparian conditions is paramount to prevent a reduction in bank AHI scores for respective segments. The scores and corresponding rankings established in this analysis should form the baseline when reviewing current and proposed activities along the SR. The review of existing or proposed activities should be measured against these baseline AHI scores using the metrics and relative habitat value scores for riparian band habitat units of the Bank AHI (net change analysis). In doing so, such activities and the potential impacts and modifications they may cause can be evaluated in accordance with the Canadian Policy for the management of fish habitat; where No Net Loss is the guiding principle.

Further engagement with property owners regarding potential riparian restoration, bank stabilization, and fish habitat creation should be investigated. As these avenues can further bolster previous restoration efforts, while providing local community engagement and involvement in preserving the SR long-term. Additional considerations should be made to limit agricultural and ranching impacts within the upper reaches of the SR, where bank erosion, substrate disturbance, and nutrient input from livestock is high.

8.0 CLOSURE

This document has been prepared for the exclusive use of the Yucwmenlúcwu and project partners. It has been prepared based upon information collected during the comprehensive field inventory and other related documentation.

Questions or comments in reference to this report, and the data presented should be forwarded to the undersigned.

Respectfully Submitted,
ECOSCAPE Environmental Consultants

Kris Mohoruk, B.Sc.
Natural Resource Biologist
kmohoruk@ecoscapeltd.com

Luke Crevier, B.Sc,
Data Analyst
lcrevier@ecoscapeltd.com

Robert Wagner
GIS Specialist

Kyle Hawes, R.P.Bio
Senior Aquatic Biologist
khawes@ecoscapeltd.com

REFERENCES

Arc Environmental Ltd. 2001. Shuswap River Fish/Aquatic Information Review. Prepared for BC Hydro.

British Columbia Ministry of Environment (BC MOE). Fisheries Inventory Data Queries (FIDQ). 2022. https://a100.gov.bc.ca/pub/fidq/viewWatershedDictionary.do

COSEWIC 2002. COSEWIC assessment and status report on the coho salmon Oncorhynchus kisutch (interior Fraser population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. viii + 34 pp.

COSEWIC. 2016. COSEWIC assessment and status report on the Coho Salmon Oncorhynchus kisutch, Interior Fraser population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 50 pp.

Department of Fisheries and Oceans (DFO). 1997a. Assessment of Salmonid Habitat in the Salmon River, Salmon Arm.

Department of Fisheries and Oceans (DFO). 1997b. Strategic review of fisheries resources for the South Thompson-Shuswap Habitat Management Area. Fraser River Action Plan.

Department of Fisheries and Oceans. 1998. Salmon watershed planning profiles for the Thomson Nicola Habitat Management Area. Fraser River Action Plan.

Department of Fisheries and Oceans. 1999. Stock assessment of Thompson River/Upper Fraser River coho salmon.

Department of Fisheries and Oceans. 2016. DRAFT Thompson Steelhead Recovery and Management Plan.

Griffith, R. P. 1986. Rainbow trout production and implications of coho salmon enhancement in the Bessette Creek Drainage, tributary to the Middle Shuswap River. Fisheries Improvement Unit. BC Fisheries Branch.

Groot, C. and L. Margolis (eds). 1991. Pacific salmon life histories. University of British Columbia Press, Vancouver, B.C.

Interior Fraser Coho Recovery Team. (2005). Species at risk proposed recovery strategy: coho salmon (interior Fraser River populations), Oncorhynchus kisutch. Fisheries and Oceans Canada. 137p.

Irvine, J.R., K. Wilson, B. Rosenberger and R. Cook. 1999. Stock assessment of Thompson River/ Upper Fraser River coho salmon. Fisheries and Oceans Canada. Canadian Stock Assessment Secretariat. Research Document 99/28.

Johnson, T.A.N., Kaushal, S.S., Mayer, P.M., Smith, R.M. and Sivirichi, G.M. 2016. Nutrient retention in restored streams and rivers: A global review and synthesis. Water, 8, 116; 28pp.

Kosakoski, G.T. and R.E. Hamilton. 1982. Water requirements for the fisheries resource of the Englishman River, Vancouver Island, B.C. Department of Fisheries and Oceans.

Levy D.A. and E. Parkinson. 2014. Independent review of the science and management of Thompson River steelhead. Prepared for Thompson Steelhead Technical Subcommittee c/o Cook's Ferry Indian Band, Spences Bridge, BC. 104p.

LGL Limited Environmental Research Associates, 2007. Development of an annual salmonid productivity assessment program for the Nicola River Watershed.

Lloyd, D., K.Angove, G. Hope, and C. Thompson. 1990. A guide to site identification and interpretation for the Kamloops Forest Region. Land Management Handbook No. 23. February, 1990. BC Ministry of Forests.

Lorz, H. W., and T. G. Northcote. 1965. Factors affecting stream location, timing and intensity of entry by spawning Kokanee (*Oncorhynchus nerka)* into an inlet of Nicola Lake, British Columbia. J. Fish. Res. Board Can. 22; 665-687.

Mackenzie, W.H., and Jennifer Moran. 2004. Wetlands of British Columbia - A guide to identification. British Columbia Ministry of Forests, Forests Science Program. 287pp.

Mason, B., and R. Knight. 2001. Sensitive Habitat Inventory and Mapping. Community Mapping Network, Vancouver, British Columbia. 315pp + viii. M. Johannes, Editor.

McPhail, J.D. 2007. The Freshwater Fishes of British Columbia. University of Alberta Press.

Ministry of Environment. 2000. Overview of Interior Fraser Steelhead Management Report for the Fraser Steelhead Working Group.

Ministry of Forests, Lands and Natural Resource Operations Lake and River Files. 2011. Fish and Wildlife Branch, Penticton, B.C.

Ministry of Water, Land and Air Protection. 2004. Accounts and measures for managing identified wildlife. Identified Wildlife Management Strategy. Version 2004.

Minns, C. 1997. Quantifying “no net loss” of productivity of fish habitats. Can. J. Fish. Aquat. Sci. 54: 2463-2473.

Resource Inventory Committee. 2001. Reconnaissance (1:20000) fish and fish habitat inventory: Standards and procedures. Version 2. 170pp.

Resource Inventory Committee. 2001. Standards for Fish and Fish Habitat Maps. Version 3.0. Province of British Columbia. 66pp.

Shearing, G. 2013. Anadromous salmon spawning habitat in the middle Shuswap River. SEC Shearing Environmental Consultants. Prepared for: Fish and Wildlife Compensation Program Coastal.

Slaney, P.A., and T.G. Northcote. 1974. Effects of prey abundance on density and territorial behavior of young Rainbow Trout *(Salmo gairdneri)* in laboratory stream channels. J. Fish. Res. Board Can. 31:1201-1209.

Turcotte LA, Shrimpton JM. Assessment of spawning site fidelity in interior Fraser River Coho salmon Oncorhynchus kisutch using otilith microchemistry, in British Columbia, Canada. J Fish Biol. 2020; 1-9.

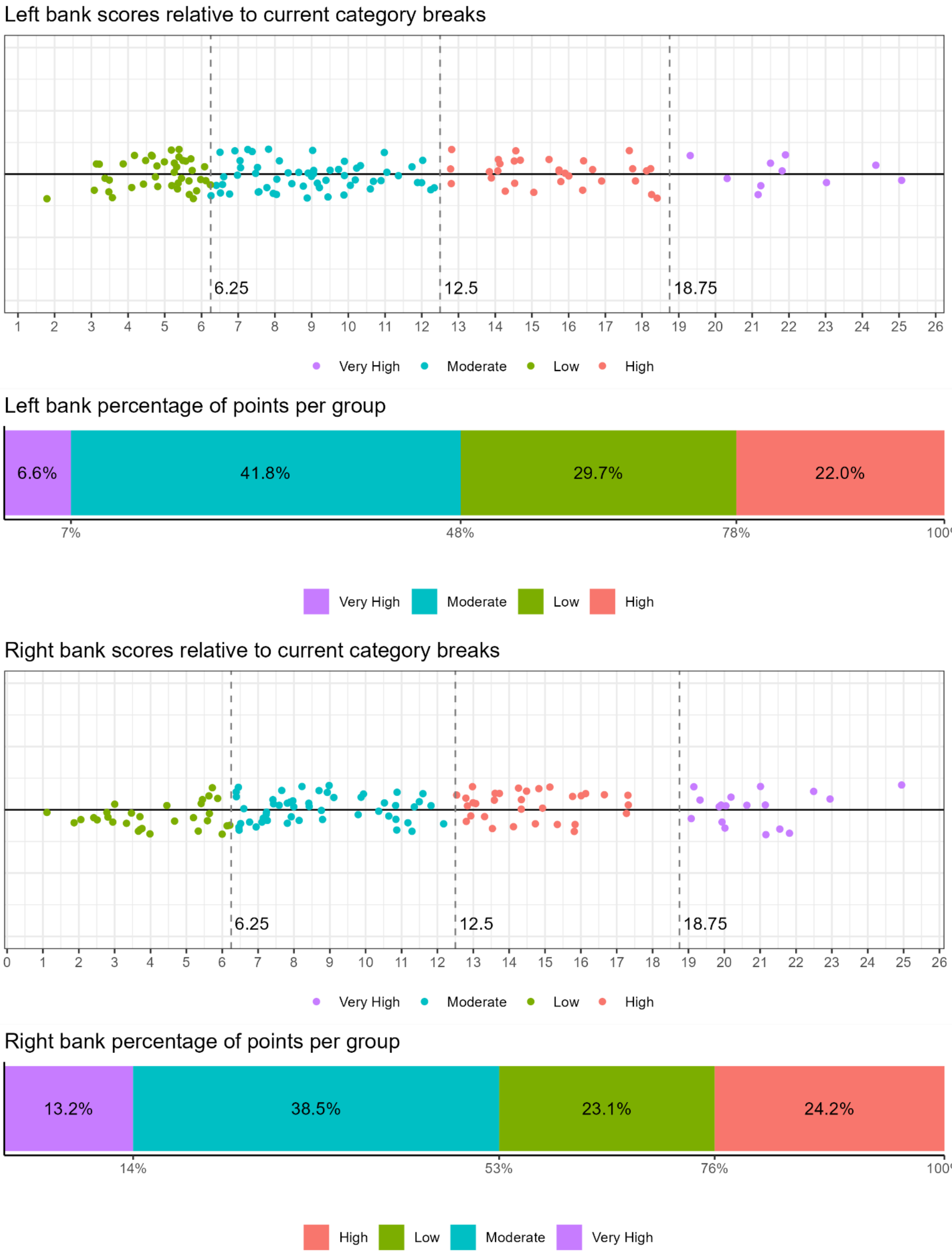
MAPS

APPENDIX A

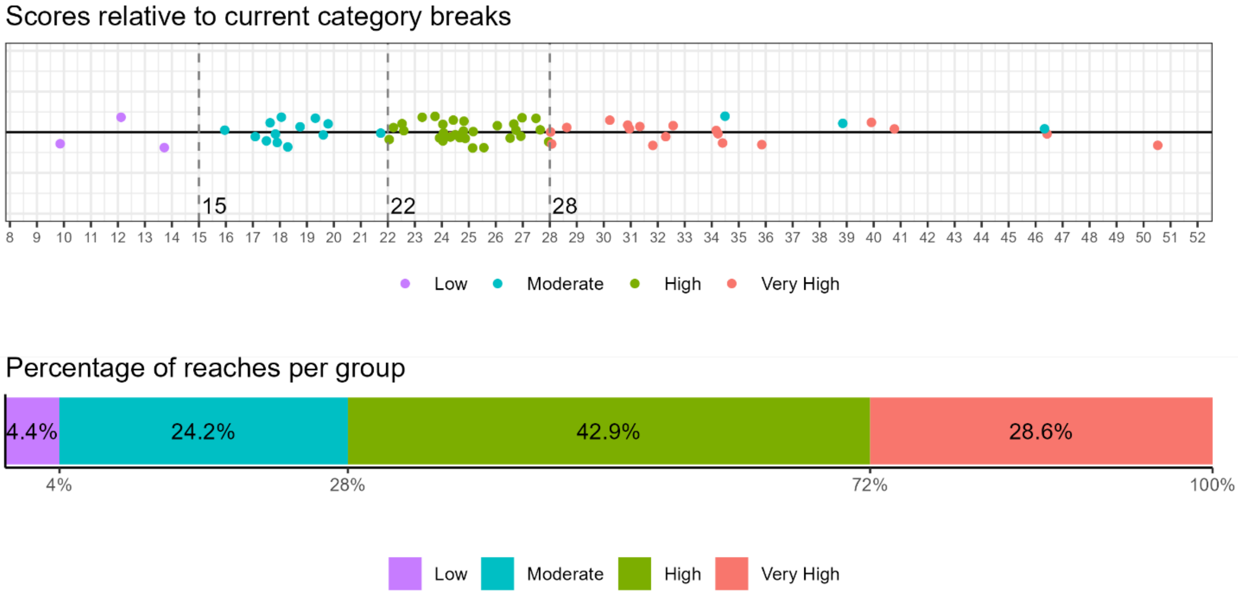
Salmon River Reach Data (centerline survey) with AHI Scores

APPENDIX B

Centerline and Bank Aquatic Habitat Index Analysis



Left and Right Bank AHI score distribution



<u>Centerline AHI score distribution</u>