LOUIS CREEK
SENSITIVE HABITAT INVENTORY & MAPPING
& AQUATIC HABITAT INDEX

DRAFT







Prepared By:

Ecoscape Environmental Consultants Ltd.

Prepared For:

Secwepemc Fisheries Commission and Simpcw Resources Group

March 31, 2023

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LIMITATIONS

This report has been prepared by Ecoscape and is intended for the sole and exclusive use of Secwepemc Fisheries Commission and Simpcw Resources Group, for the purposes set out in this report. The results contained in this report are based upon data collected during a single season inventory of each creek over a period of two years. 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 are 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. Any use of this report by a third party, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Ecoscape accepts no responsibility for damages, if any, suffered by any third party as a result of actions or decisions made based on this report.

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

In 2021 Ecoscape Environmental Consultants Ltd. (Ecoscape) was contracted by the Secwepemc Fisheries Commission and Simpcw Resources Group and Simpcw First Nation to complete a comprehensive inventory, riparian mapping and development of an Aquatic Habitat Index (AHI) of Louis Creek (the stream). Secwepemc Fisheries Commission retained Ecoscape to survey from Whitecroft to about 41 kms downstream and Simpcw Resources Group retained Ecoscape to map approximately 1.6 km from the outlet to the Thompson River and from Whitecroft upstream approximately 4.2 kms (surveyed area of interest, AOI).

Sensitive Habitat Inventory and Mapping (SHIM) protocols were used to collect baseline information regarding the current condition of the watercourses and associated riparian habitats. These inventories provide information on channel character, 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.

The head waters of Louis Creek originate from Eileen Lake until it flows approximately 57 kms north west to its confluence with the North Thompson River, which is within the traditional territory of Simpcw First Nation and the Secwepemc First Nation. Louis Creek is a 4th order stream, with a total watershed area of approximately 515 km^2. Louis Creek was divided into 34 segments and a total surveyed AOI of 46.8 km. Louis Creek at one point supported all seven species of Pacific Salmon, however in recent years the stream is better known for its populations of Coho (*O. kisutch*) and Chinook (*O. tshawytscha*). 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 North Thompson, stream spawning Spring and Summer populations of Chinook were designated as Endangered by COSEWIC in 2018 (COSEWIC, 2002; COSEWIC, 2018).

The hydraulic character of Louis Creek is predominantly riffle-pool on over 37 km (~80%) of the 48.6 kms surveyed AOI. To a lesser extent, the stream also has long stretches of more run morphology, totaling about 8.0 km (16.4%). In addition, segments 22 and 24 there were characterized by cascade/pool morphology. Cultivated field was the predominant habitat on both banks, accounting for about 24% of the total mapped area of each bank. Mixed forests were generally evenly disturbed on both banks at about 17% of each bank. Natural cottonwood riparian ecosystems (Mid Flood Bench) accounted for about 14% and 19% of the left and right banks respectively.

The Very High and High AHI scores/ranks was limited, accounting for 8.8% and 15.7% of the surveyed AOI, respectively. These high valued habitats are threatened by a variety of instream and upland activities. Agriculture was the primary land use observed, with 83% of the right and 65% of the left bank. Following agricultural, rural residential was most dominant on the left bank at 21% and natural was next most dominant land use on the right bank at 10%. Agricultural 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) impacting sensitive benthic macroinvertebrates, and 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. Agricultural side channels and runoff locations provide insight into point-source nutrient loading, where systems may benefit from floodplain reconnection or runoff diversion.

Not only does agricultural activities increase nutrient loading, impacts of livestock access and crossing of the instream habitat of the stream was extensive. Livestock access and crossings combined accounted for a total length of approximately 5.3 kms combined across both banks and instream, where approximately 73% of the total length of livestock access/crossings was instream. A total of 15 priority livestock exclusion fencing sites were identified, which equates to a maximum of approximately 23 kms of fencing required across both banks. It should be noted that 23 kms is likely the worst-case scenario as in many instances, fencing was present but was either not continuous or was in disrepair and livestock was not fully excluded from the stream. If fencing is installed/repaired in these areas, and riparian vegetation restored, impacts to spawning and rearing habitat will be significantly reduced.

Furthermore, these agricultural areas had narrow riparian bands with extension clearing particularly in segments 9 and 10. Agricultural areas are commonly associated with minimal riparian vegetation and lack of structural instream complexity, leaving little rearing habitat for salmonids and other key fish species. Agricultural areas were often characterized by very narrow riparian bands (< 5 m) of primarily Alder species and in some instances (e.g., segment 9), almost no riparian vegetation was remaining. The removal of riparian vegetation in these agricultural areas has also resulted in significant bank erosion and fine sediment deposits, which infills suitable spawning habitat.

It is paramount that landuse planning and management of the stream focuses on conservation and restoration of floodplain and riparian ecosystems. In addition, opportunities should be explored to increase the relative abundance of off channel and back water habitats, make natural upper reaches that are currently obstructed accessible, and protect cold water refuge habitats for improved salmon rearing/nursery potential. For example, the culvert at the downstream extent of segment 30 is functioning as an obstruction to fish passage for certain species/age classes, which is precluding these species from suitable rearing/spawning habitat further upstream. Restoring a functional connection for fish and improving in-water cover may increase the habitat suitability and likelihood of upper reaches being used by juveniles and/or spawning adults.

Further investigation into the direct impacts to fish and spawning substrates by livestock access should be evaluated. It is recommended that the priority restoration sites provided for each stream be prioritized and implemented as soon as possible to restore and enhance the habitat for the at-risk populations of Coho and Chinook.

The stream has a high productive value for anadromous and resident fish species regardless of individual segment AHI scores. A lower AHI segment score does not imply that particular segment is of low value. Rather, the combination of habitat attribute values in that segment contribute less to fisheries and aquatic production than other segments. However, these lower scoring segments are still important for migration and general living. The review of existing or proposed activities should be measured against these baseline AHI scores as a means of conducting a 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.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

1.0 INTRODUCTION

In 2021 Ecoscape Environmental Consultants Ltd. (Ecoscape) was contracted by the Secwepemc Fisheries Commission and Simpcw Resources Group and Simpcw First Nation to complete a comprehensive inventory, riparian mapping and development of an Aquatic Habitat Index (AHI) of Louis Creek (the stream). Secwepemc Fisheries Commission retained Ecoscape to survey from Whitecroft to about 41 kms downstream and Simpcw Resources Group retained Ecoscape to map approximately 1.6 km from the outlet to the Thompson River and from Whitecroft upstream approximately 4.2 kms (surveyed area of interest, AOI).

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 expand as needed, and serve a different purpose over time.

Sensitive Habitat Inventory and Mapping (SHIM) protocols were used to collect baseline information regarding the current condition of the stream and associated riparian habitats. These inventories provide information on channel character, 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.

An Aquatic Habitat Index (AHI) is generated using the processed field data to determine the relative habitat value of the aquatic habitats. The AHI uses many different criteria, such as biophysical, fisheries values, and anthropogenic characteristics to estimate the habitat value of a stream 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, rivers and creeks 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 waterbodies and watercourses. This rapid increase in population and development presents a significant challenge to plan and/or manage future growth around our large interior lakes, rivers and creeks. 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 has 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;
- 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 SHIM METHODOLOGY

The biophysical survey of the stream used the data collection methods and standards of Sensitive Habitat Inventory and Mapping (SHIM; Mason and Knight, 2001).

Data was collected using an iPad and an EOS – Arrow 100 Submeter GNSS Receiver and Data Collector working in an ArcGIS Online application. 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 with the use of the GNSS Receiver and Data Collector

2.1. Centerline Survey

The centerline of the stream channel was mapped along the center of the bankfull (not floodplain) width. The stream was stratified into a series of successive sections (segments), each possessing and being characterized by different attributes or biophysical characteristics (i.e., hydraulic class, channel characteristics, substrates composition, and riparian class, etc.; Table 1). The stream segmentation and associated attributes were the fundamental unit of the centerline survey with point features providing a more quantitative measure of relative disturbance/modification and aquatic habitat quality/complexity (i.e., area abundance of deep pools, spawning substrates, large woody debris, bank erosion, etc.). Furthermore, the right and left bank character and condition within the stream centerline feature for respective segments is documented (Table 1).

The stream was stratified into a series of successive segments, 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. Overview of stream 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 segment information. This rating system was designed with the intent of providing a more measurable parameter in evaluating stream conditions and monitoring and evaluating habitat changes on local watercourses and associated riparian and floodplain communities. Individual segment 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 the segments receiving the same impact rating by the total stream length evaluated to obtain a relative value (% of stream 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 stream grade. This scoring system precedes the Aquatic Habitat Index and, on its own, is a field measure of stream/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. Biophysical Units / Features

The biophysical units / features provide a quantitative measure of relative disturbance/modification and aquatic habitat quality/complexity. Table 3 provides a complete list of biophysical units / features collected using the SHIM Data Dictionary.

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

Table 3. Overview of biophysical units / features collected using the SHIM Data Dictionary (Mason and Knight, 2001)

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
Photograph Location	Location; Direction.

2.3. Riparian Polygonization

Broad vegetation communities/habitat types were stratified within a 50-m band along the right and left streambanks. Polygons were classified according to Table 4. In addition, site qualifiers (Table 5) were assigned to each polygon to reflect the estimated level of disturbance and habitat quality and condition.

Table 4. Broad vegetation communities (Habitat Types) used for classification of stratified polygons within a 50 m band on either bank along the mapped length of Louis Creek (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
BW	Backwater	
C	Coniferous Forest	Upland coniferous forest ecosystems above the active floodplain. Including high bench sites along the Salmon River.
CF	Cultivated Field	Cultivated fields (i.e., hayfields, row crops, orchards)
CL	Cleared	Areas that have been cleared
CW	Open Coniferous Woodland	Open ponderosa pine/Interior Douglas-fir woodlands with grassland dominated understory
FL	Flow 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.
FLG	Flow Flood-Graminoid	Graminoid dominated low flood bench ecosystem
FLS	Low Flood-Shrub	Shrub dominated low flood bench ecosystem
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.
GB	Gravel/Sand Bar	Gravel/Sand Bar
GN	Grasslands	Natural grassland ecosystems generally not containing shrub or tree strata
M	Mixed Forest	Upland mixed stand seral forest. High bench site along the surveyed AOI. Tree canopy mix of trembling aspen, birch, cottonwood, lodgepole pine, interior Douglas-fir, and spruce.
PA	Pasture	Although similar to rural, these areas are more devoid of a fragmented tree canopy and are more modified/irrigated grassland ecosystems. Less modified than cultivated fields.
PS	Pine Savannah	Open ponderosa pine canopy grassland dominated ecosystem
RI	River	Tributaries
RL	Railway	Railway and associated fill slopes, armouring and other modifiers
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.
RZ	Road Surface	Road Surface
SC	Side Channel	Side channels of the stream
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.
SH	Shrub	Persistently disturbed shrub sites that are not included within low flood bench.
SL	Landslide	Landslide

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 5. Site qualifiers assigned to each polygon (Table 4) to reflect the estimated level of disturbance and habitat quality and condition

Map Code	Description
d	Ditch
f	Narrow riparian fringe generally less than 5-m wide but occasionally up to 10-m.
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.
ld	Low disturbance, not recently disturbed. Containing natural tree canopy and understory vegetation associations.
md	Moderately disturbed treed riparian area. The habitat community structure may be fragmented or perforated by some land clearing and rural disturbances.
n	Natural, undisturbed site
pa	Urban Park/Recreational Area

2.4. Data Processing & Quality Assurance

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.

The coordinate system used was UTM Zone 11 North, North American Datum 83. Data collection using the EOS system is supported by real-time corrections and provides sub-metric precision.

Processing and mapping was completed using 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 and synced to ArcGIS Online;
- All field data collected during the field inventories was post processed by the field inventory biologist, Leanne McDonald, B.Sc., R.P.Bio., P.Ag.;
- We reviewed each attribute collected during the field survey as part of a quality control / assurance process. The final database has been provided to the Secwepemc Fisheries Commission and project partners at the completion of the project. Corrections and adjustments to the database will be made as necessary.

2.5. Photo Log

SHIM 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.

3.0 KEY FISH SPECIES

Louis Creek at one point supported all seven species of Pacific Salmon, however in recent years the stream is better known for its populations of Coho (*O. kisutch*) and Chinook (*O. tshawytscha*). Table 6 provides a list of anadromous salmonids, freshwater salmonids, and non-salmonid species documented/seen in the stream.

Table 6. Fish species documented in Louis Creek (BC MOE, 2023)

Common Name	Scientific Name
Anadromous Salmonids	
**Chinook	*Oncorhynchus tshawytscha*
*Chum	*Oncorhynchus keta*
**Coho	*Oncorhynchus kisutch*
*Cutthroat	*Oncorhynchus clarki clarki*
*Pink	*Oncorhynchus gorbuscha*
*Sockeye	*Oncorhynchus nerka*
*Steelhead	*Oncorhynchus mykiss*
Freshwater Salmonids	
*Bull Trout	*Salvelinus confluentus*
*Dolly Varden	*Salvelinus malma*
**Rainbow Trout	*Oncorhynchus mykiss*
Non-salmonid Species	
**Mountain Whitefish	*Prosopium williamsoni*
**Mussels	*Anodonta* spp.
Prickly Sculpin	*Cottus asper*
Slimy Sculpin	*Cottus cognatus*
*Torrent Sculpin	*Cottus rhotheus*

* Last observed between 1992 and 1998
**Observed in 2022 when conducting the inventory

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 North Thompson, stream spawning Spring and Summer populations of Chinook were designated as Endangered by COSEWIC in 2018 (COSEWIC, 2002; COSEWIC, 2018).

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, Coho, and Rainbow Trout. Chinook and Coho were the primary species of focus when it came to evaluating the condition of the stream. Spawning Chinook was in the system during the fall surveys downstream of Whitecroft whereas Coho was seen in the system later in the fall upstream of Whitecroft. Their presence was recorded and validated through the identification of spawning habitat.

3.1. Chinook Salmon

LIFE HISTORY

In British Columbia Chinook (*Oncorhynchus tshawytscha*) 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.

The Chinook population in Louis Creek is a part of the North Thompson, Stream, Summer Population, which exhibit stream-type life history variants and summer run-timing (COSEWIC, 2018). Ocean type Chinook rear in freshwater for several months and migrate to the ocean in the first fall, whereas stream type Chinook rear in freshwater for one year before migrating to the ocean (DFO, 1997).

The North Thompson populations have been assessed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2018). This summer run of chinook spawning in the North Thompson River has steeply declined in abundance. Declines in marine and freshwater habitat quality, and harvest, are threats facing this population.

REPRODUCTION

North Thompson River Chinook are summer run typically returning to the Lower Fraser River by mid-July with spawning starting in Louis Creek in August and September.

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.

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). The average number of mature individuals in the North Thompson sub-population between 2014 and 2016 was an estimated 8,100 (COSEWIC, 2016).

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 Salmon escaping to the Interior Fraser River, Coho stocks in the North Thompson system is supplemented by the Dunn Creek Hatchery managed by the Simpcw First Nation at the north end of Dunn Lake. The hatchery has been a Coho facility since 1989 providing Coho salmon to the stream for coded wire tagging program, and for operating enumerations fences on the stream (DFO, 2015). It is estimated that mean annual smolt releases of 14,000 have been made since 1990 and wild smolts have not been enumerated. A fence in Louis Creek was installed in 1985 approximately 10 km upstream from the confluence with the North

Thompson River to monitor fish released at the fence and as a proxy for escapement upstream of the fence (Irvine et al., 1999).

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 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. In 1996 it was found that fish returning to the stream appeared to show higher rates of long freshwater rearing (i.e., ages 2.1 and 3.1; Irvine et al., 1999). 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 1 m in width.

AGE, GROWTH AND MATURITY

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, 1997). 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, 1997). Migration likely occurs between mid-April and early May.

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, instream 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 (*Oncorhynchus mykiss*) are an important game fish and are considered the number one target for anglers in the British Columbia interior. It is apparent that there are two forms of trout in the system; a resident population that lives its entire life cycle in the river and adjoining tributaries, and an adfluvial form that spends the majority of its life in large lakes but migrates to rivers and streams to spawn or feed (Ministry of Environment files, 2011). There are many similarities between these two groups as far as spawning requirements, early rearing and adult life forms and accordingly these life forms will be grouped in this discussion.

Rainbow Trout in the system, both in lake forms and resident river populations are heavily sought after by anglers and tend to be easily overfished.

REPRODUCTION

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. Maturing adults will migrate into these streams during freshet flows (April and May) and will spawn on the receding flows following. 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 (Ministry of Environment files, 2011). Their biggest obstacle in lakes is anglers who target them extensively. Rainbows can tolerate temperatures up to 27°C but anything higher can be lethal (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.

4.0 CULTURAL SIGNIFICANCE

The following summary of the history and significance of the stream was prepared by Shae McMurter of Simpcw Resources Group to provide cultural context and insight:

Archaeological surveys have revealed historical presence of Simpcw Nation in Louis Creek, unearthing winter sites and cache pits. This is likely where the community would hunt and fish, which much of Simpcw culture is centralized around (Simpcw.com, n.d.). It is known that the lake drainages from Louis Creek have been used for "aboriginal food fisheries", targeting kokanee, lake trout and burbot (Rood and Hamilton, 1995). Today, salmon are celebrated in the Simpcw culture, through community events such as Coho day and the Raft

River First Fish Ceremony. Furthermore, the nation actively works to protect the integrity of fisheries, with ongoing stream walks, red surveys, selective fish harvesting, and many other programs ran through the Dunn Creek Hatchery.

These efforts are vital, as salmon are a keystone species ecologically, and culturally. Salmon and first nation community's health are proven to be interdependent, influencing economic, physical, spiritual, cultural, social, and mental wellbeing (Earth Economics, 2021). Salmon provides nourishment, plays a role in traditional ceremonies, and offers common connection for community members who practice traditional fishing methods. Simpcw First Nation is focused on advancement of its people, while simultaneously protecting the land, for generations to come (Simpcw.com, n.d.). This goal can be further advanced through the protection of Salmon species in the territory.

In 1994 approximately 21% of the area [adjacent to the stream] *was logged, which is the threshold at which hydrological impacts begin to occur (Rood and Hamilton, 1995). In 2018, Louis Creek was designated as a Fisheries Sensitive Watershed, under the Forest and Range Practices Act, 2002. This designation is awarded under the premise that the watershed: has significant fisheries values and watershed sensitivity. Once protected under the FRPA, hydrological impacts are considered more stringently, so that logging pace is slowed and does not destabilize the fish habitat.*

Community members can recall times when Louis Creek was much more abundant with Salmon and would actively fish the creek, however, today very little fishing occurs on Louis Creek, as the Salmon numbers are not as high as they once were (pers. Comm. Pat Matthew, 2022). The single noticeable land use change has been the channelization of the Creek, sometime in the early 1970s. The channelization made for a deeper main channel, and consequently removed log jams. Salmon would use these log jams as holding pools, which are key components of Salmon habitat. These log jams also offered cultural significance, as community members would utilize them while fishing, by climbing on top of the logs to access good fishing spots while remaining covered. The channelization also greatly decreased riparian complexity and made for large sediment movement into the North Thompson River, greatly impeding Coho access.

5.0 AQUATIC HABITAT INDEX METHODOLOGY

The Aquatic Habitat Index (AHI) is a categorical scale of relative habitat value and condition that ranks the shoreline of a lake, river channel and bank segments, or in this case, the stream channel, in a range between Very High and Very Low. AHI was initially developed for Foreshore Inventory Mapping (FIM) to primarily assess the level of shoreline developments in increasingly urbanized areas. The index was revised for large River Inventory Mapping (RIM). The data collected for the RIM project involved numerous spatial data layers and was substantially more complicated to develop than the AHI developed for lake ecosystems.

5.1. AHI Logic, Calibration & Ranking

The AHI logic was adapted for the Louis Creek SHIM. The AHI that was previously revised for RIM projects was revised further given the scale of these creeks compared to larger river systems. AHI for SHIM focused on the instream values and associated riparian character and condition as recorded in the centerline feature class only. As such, the scoring matrix focused on extent and distribution of instream fish habitat features, with particular focus on density of spawning habitat features, large woody debris for shelter and cover, and deep pools and rearing features, as they are both representative of rearing habitat with a secondary assessment of riparian and streambank quality.

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 stream segments in a range between Very High and Low sensitivity. The following provides a definition for each AHI ranking:

- *Very High* – 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* – 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* – 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* – 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.

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).

5.2. Instream Biophysical Units Scoring Matrix

The high-level survey intensity yielded fine-scale mapping of instream fish habitat features (points). Fish habitat features 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 (Table 7). 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 based on the relative importance of these components in the index for production (Table 8). Density of spawning habitat was weighted highest at 4 times that of the density of the other instream features. The measured relative spatial coverage of each feature type within respective segments was then multiplied by the relative habitat value and weighted constant value that was calibrated for the stream.

Table 7. Relative Habitat Values used in AHI matrix for Fish Habitat Features in Louis Creek

Habitat Feature	Relative Habitat Value	Weighted Score
Instream Vegetation	0.2	12
Boulder	0.4	24
Over Stream Vegetation	0.4	24
Small Woody Debris	0.6	36
Deep Pool	0.7	42
Undercut Bank	0.7	42
Large Woody Debris	0.8	48
Rearing	0.9	54
Spawning Habitat	1	60

Table 8. Relative value and weighted scores for mapped instream substrate composition

Substrate Class	Relative Habitat 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

Table 9. Relative value and weighted scores for level of impact rankings

Level of Impact Ranking	Variable	Weighted Score
Nil-Nil	10	0.00
Nil-Low	9	-0.83
Nil-Mod	7	-1.67
Nil-High	5	-2.50
Low-Low	8	-1.67
Low-Mod	4	-2.50
Low-High	6	-3.33
Mod-Mod	3	-3.33
Mod-High	2	-4.17
High-High	1	-5.00

The AHI for each stream segment was calculated as the sum of life history scores for each segment. Table 10 presents the categories, relative category weightings, and logic for the Centerline AHI scoring.

The centerline AHI scores for respective segments (AHI segment) was calculated using the following,

$$AHI_{segment} = \sum\left[\frac{A_h}{A_t} \times W_h\right] + \sum\left[\frac{A_{sp}}{A_t} \times W_{sp}\right] + \sum[P_{sub} \times W_{sub}] + \sum\left[\frac{A_{hold}}{A_t} \times W_{hold}\right]$$

(1)

:where A represents the area of a described stream feature (such as h is habitat, sp is spawning, and hold is holding), P represents a percentage of the area, At represents the total area of the stream channel contained with the segment, and W represents the relative weighting given to the described habitat feature.

Table 10. The parameters and logic for the Centerline of the South Thompson 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	10	% Area * Category Score
Segment Level of Impact Rating	Level of impact rating	-5	% Area * Category Score
Spawning[1] Habitat	Instream Habitat units	60	% total spawning area * Category Score scores combined for Chinook, and Coho
Substrates	% composition estimated during field inventory	20	% Area * Category Score
Cover	Instream Habitat unit and Hydraulic Class polygons	5	% Area * Category Score

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

6.0 RESULTS

The head waters of Louis Creek originate from Eileen Lake until it flows approximately 57 kms north west to its confluence with the North Thompson River, which is within the traditional territory of Simpcw First Nation and the Secwepemc First Nation. Louis Creek is a 4th order stream, with a total watershed area of approximately 515 km^2 (BC MOE, 2023; Pehl, 2009).

Louis Creek was divided into 34 segments and a total surveyed AOI of 46.8 km (Map Set 1). *It should be noted that segment 4 represents the approximately 7.1 km canyon that was not surveyed and as such is not included in the 46.8 km surveyed AOI. However, the centerline and riparian habitat distribution were digitized and coded using ortho-imagery and profession judgement.*

6.1. Riparian Habitat Distribution

Cultivated field was the predominant habitat on both banks, accounting for about 24% of the total mapped area of each bank (Table 11; Figure 1). Mixed forests were generally evenly disturbed on both banks at about 17% of each bank. Natural cottonwood riparian ecosystems (Mid Flood Bench) accounted for about 14% and 19% 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 11. Broad vegetation community distribution along the left and right banks of Louis Creek

Broad Vegetation Community – Site Modifier	% Left Bank	% Right Bank
B-f	0.00	0.30
BW-md	0.04	0.00
BW-n	0.02	0.00
BW	0.02	0.10
C-hd	0.34	0.00
C-ld	5.21	0.46
C-md	0.40	0.00
C-n	5.93	2.27
CF-hd	22.78	23.74
CF-ls	0.70	0.00
CF-md	0.94	0.96
CL-hd	0.26	0.98
CL-l	0.28	0.91

CL-md	0.14	0.78
CW-ld	1.43	3.25
CW-md	0.00	0.35
CW-n	6.59	3.39
FL-l	0.00	0.32
FLG-hd	0.00	0.03
FLG-ld	0.65	2.29
FLG-md	0.48	0.27
FLG-n	0.00	0.04
FLS-hd	0.00	0.03
FLS-ld	9.32	7.21
FLS-md	0.20	0.09
FLS-n	0.00	0.04
FM-hd	0.85	1.82
FM-ld	5.02	9.40
FM-md	5.29	5.03
FM-n	2.53	2.21
FM-r	0.80	0.52
GB-n	0.03	0.01
GN-hd	0.00	0.06
GN-ld	0.16	0.04
GN-md	0.00	1.12
M-f	0.04	0.00
M-l	0.00	0.15
M-ld	14.62	14.18
M-md	2.49	1.95
M-r	0.00	0.95
PA-ls	0.48	0.22
PS-ld	0.27	3.5
PS	0.04	0.00
RI-d	0.01	0.00
RI-hd	0.00	0.10
RI	0.02	0.03
RU-hd	2.11	1.01
RU-ld	0.00	0.50
RU-md	1.34	1.79
RZ-hd	0.97	1.02
SC	0.03	0.15
SF-d	0.06	0.00
SF-hd	0.32	0.00
SF-l	2.09	1.41
SF-md	3.01	2.29
SH-f	0.52	0.67
SH-ld	0.00	0.14
SH-md	0.00	0.05
SH-r	0.06	0.09
SL-s	0.10	0.47
UR-hd	0.64	1.03
UR-pa	0.08	0.00
WN-d	0.00	0.01
WN-hd	0.02	0.25
WN-md	0.27	0.00

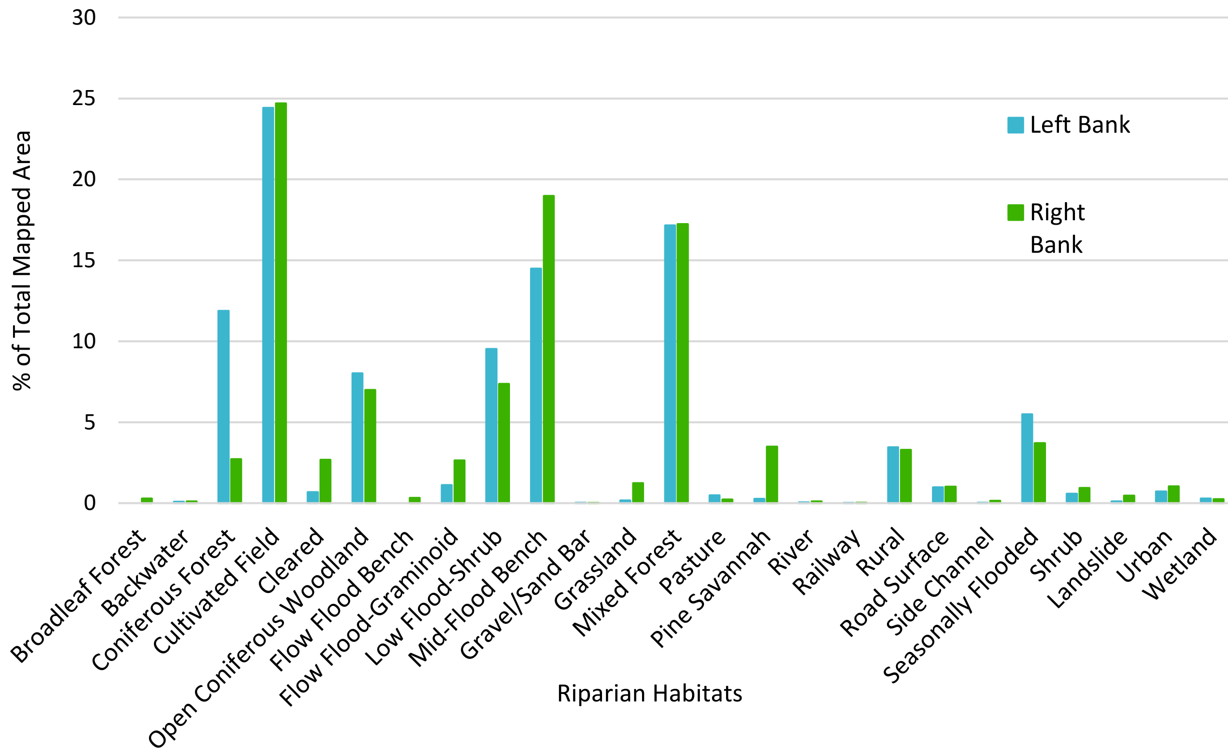

Figure 1. Riparian habitats and their relative distribution across the mapped 50 m riparian band from the approximate bankfull width of Louis Creek

6.2. Land Use Relative Distribution

Utilizing the qualifier data associated with each stream segment, relative land use was determined (Figure 2**Error! Reference source not found.**). Agriculture was the primary land use observed, with 83% of the right and 65% of the left bank. Following agricultural, rural residential was most dominant on the left bank at 21% and natural was next most dominant land use on the right bank at 10%. The following photo plates illustrate the land use classes/character described in this inventory.

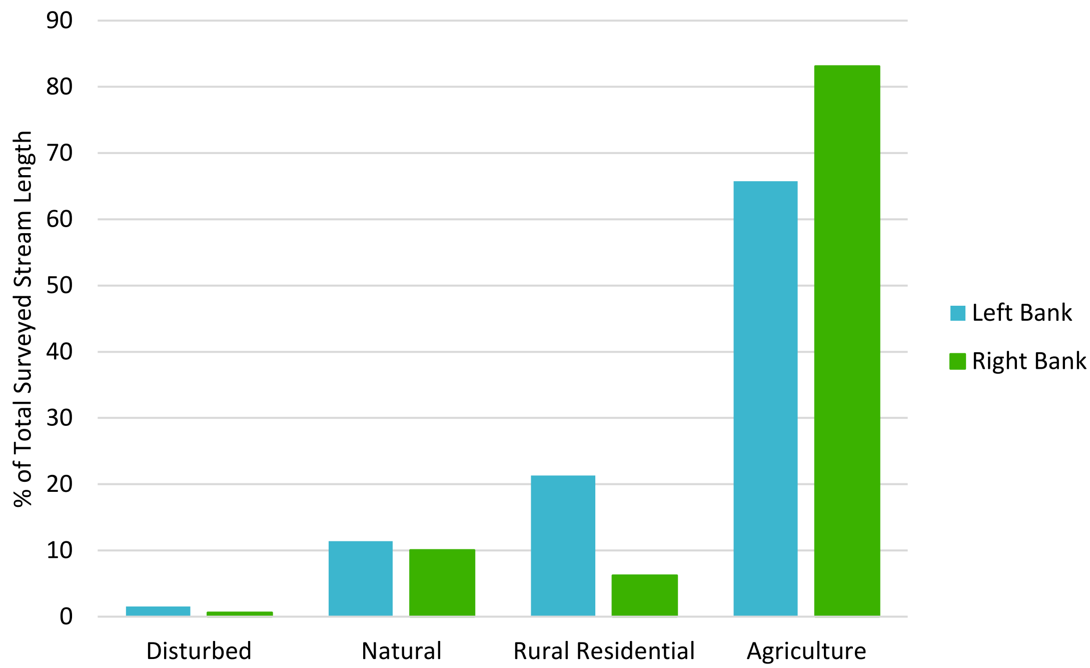

Figure 2. Relative land use distribution along the left and right bank of Louis Creek

Disturbed

Natural

Rural Residential

Agriculture

6.3. Stream Channel & Hydraulic Character

The hydraulic character of Louis Creek is predominantly riffle-pool on over 37 km (~80%) of the 48.6 kms surveyed AOI (Figure 3). To a lesser extent, the stream also has long stretches of more run morphology, totaling about 8.0 km (16.4%). In addition, segments 22 and 24 there were characterized by cascade/pool morphology. These segments had the steepest grades within the study area at ~3% and 2.5% respectively and both had 50% cobble and 30% boulder substrates. Alternatively, the three segments with run morphology had no cobble or boulder substrates and were comprised of between 55% and 90% fines. The larger substrates, particularly boulders, were infrequent across the surveyed AOI (<48% of the segments had boulders). Whereas fines were common with 82% of the 33 segments having at least 5% fines, with segment 9 be comprised of 90% fines and ~0.2% grade.

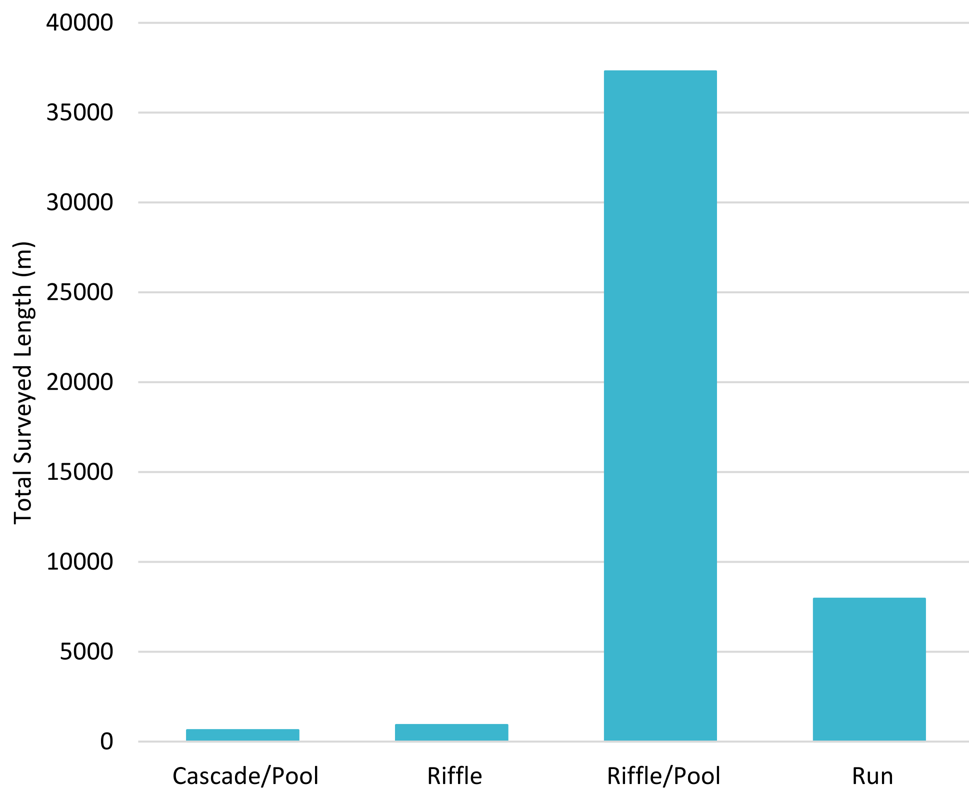

Figure 3. Louis Creek hydraulic class distribution over the 46.8 km surveyed area of interest

Riffle-Pool

Cascade-pool

6.4. Fish Habitat

Salmonid 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, instream vegetation areas, low and middle flood benches, marsh areas, side channels, cobble areas and large woody debris, which is consistent with what was observed in the stream. Key rearing areas for Chinook were described by Federenko and Pierce (1982) as flooded pastures, backwaters and sloughs adjacent to spawning areas being the preferred areas for rearing. Chinook juveniles prefer habitat with cover such as overhanging vegetation and undercut banks over habitat without cover (Bergendorf, 2002).

A total of 18 spawning or spawned Chinook were observed, whereas there was a total of 116 Coho observed all within about 4.2 kms (segments 30-34) when the stream was nearly fully frozen over. In addition, an estimated 176 salmonid fry were seen, 6 trout, 22 mountain whitefish and 3 sculpin. The adult salmonids were often observed at the crest of riffles, or taking shelter in large woody debris clusters or undercut banks.

Deep pools account for about 835.5 ha of the total surveyed instream area of fish habitat features in the stream, or 40.7% (Table 12; Figure 4), providing ideal rearing and holding areas for anadromous migrations. Large woody debris (LWD) is the next most dominant fish habitat feature in the creek and accounts for 742.8 ha of instream area, or 36.2% of the total instream area of fish habitat features. LWD provides important structural cover/complexity for fish. Rearing habitat was likely underestimated in the stream as most rearing observed was associated with other features such as large woody debris clusters, undercut banks, backwater areas, side channels and tributaries. Over stream vegetation provides shade, low over-hanging cover, and nutrients via leaf and litter fall and accounts for approximately 14.7% of the total over stream area of the stream.

Suitable spawning habitat areas account for about 23.8 ha or 1.2% of the total instream area of fish habitat features. The 1.2% represented a total of 127 spawning habitat features (i.e., suitable substrates and/or redd observed; Figure 5). All of the spawning habitat documented between segments 1 and 29 was Chinook, whereas all of the spawning habitat documented in segments 30 to 34 was Coho. This generally corresponds to the spawning data collected from stream walks conducted by Simpcw Resources Group and the Department of Fisheries and Oceans. Segments 30 and 34 had the greatest number of spawning habitat features or redds as well as the greatest density of spawning features (m^2 of redd/m); segment 30 had 0.05 spawning habitat features per linear length and 0.02 area of spawning habitat features per linear length and segment 34 had 0.04 spawning habitat features per linear length and 0.03 area of spawning habitat features per linear length. No spawning habitat features was documented in several segments, including segments 5, 9, 10, 19, 22-24 and 31, all of which corresponded with agricultural or rural residential land use, with segment 31 being entirely ditched. It appeared that a number of Chinooks were spawning in segments 7 and 8 before the heavily disturbed segments 9 and 10 (see Sections 6.5 and 6.6). *It should be noted that surveying segment 30 and beyond was conducted when there was significant snow cover, which may have impacted the detection of Coho redds.*

Tributary stream confluences are important as are small, stable streams, which provide rearing habitat. These streams will support salmonids 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. Side channels and small tributaries were relatively unknown across the surveyed AOI of the stream, with only 63 waterbodies recorded including some major tributaries such as MacGilvray Creek and Cahility Creek. Segment 8 accounted for 30% of all of the mapped side channels and tributaries, followed by segment 14 at 16%.

The data summarized in Table 12 and illustrated in the Map Set was also incorporated into the AHI (Section 6.8).

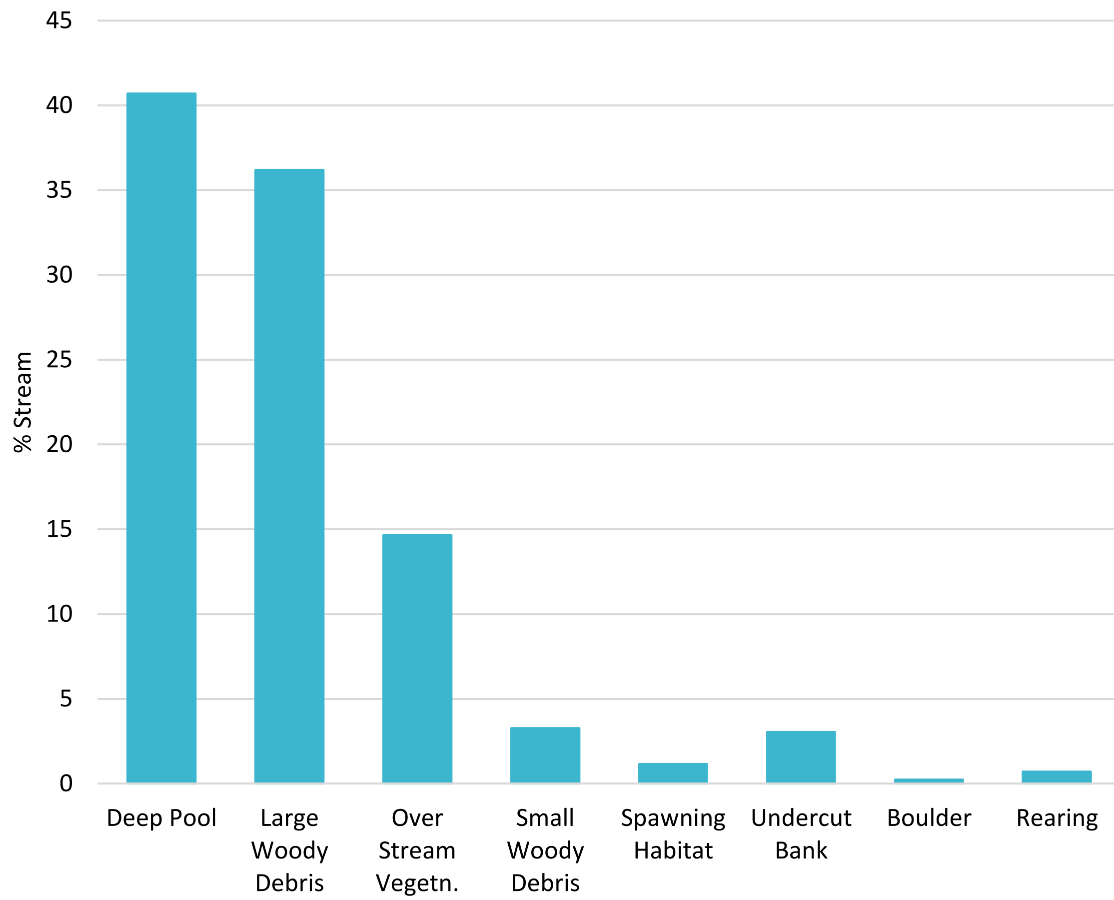

Figure 4. Relative distribution of key habitat elements mapped within the Louis Creek surveyed AOI. Percentage values shown in the illustration represent the estimated spatial coverage of each respective feature over the total instream area of the fish habitat features

Table 12. Mapped aerial coverage and linear extents of fish habitat across the surveyed AOI of Louis Creek

Row Labels	Combined Area (ha)	Cumulative Length (m)	Relative linear abundance (%) across surveyed AOI (46,814 m)
Deep Pool	835.49	3157.40	6.74
Large Woody Debris	742.77	3325.10	7.10
Over Stream Vegetation	300.98	1824.90	3.90
Small Woody Debris	67.30	418.10	0.89
Spawning Habitat	23.75	217.30	0.46
Undercut Bank	62.49	1569.40	3.35
Boulder	4.84	24.00	0.05
Rearing	14.52	77.00	0.16

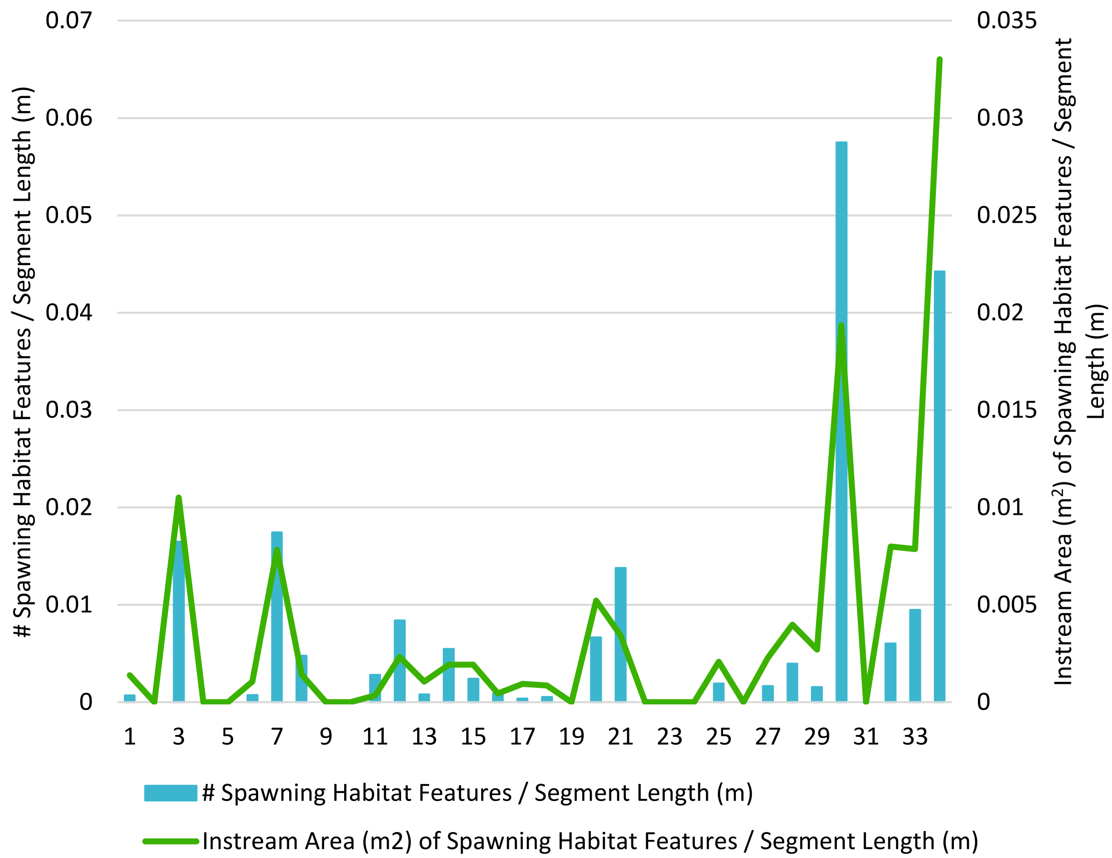

Figure 5. Density of number of spawning habitat features (blue bars) and density in total area of spawning habitat features per total length of each segment (green line) in surveyed AOI of Louis Creek

Large woody debris and deep pool

Chinook Spawning habitat

Overstream vegetation

Rearing habitat

6.5. Modifications

Instream and bank modifications and features were recorded in the field as points and summarized in Table 13. It should be noted that general clearing/removal of riparian vegetation and encroachment by field and urban and rural development was not recorded as individual points and instead were captured within the percent disturbed field for individual shore segments.

Livestock access and crossings were abundant in surveyed AOI of Louis Creek. Livestock access and crossings combined accounted for a total length of approximately 5.3 kms combined across both banks and instream. Segment 9 alone accounted for an estimated 1 km, segment 12 was 920 m, and several other segments were over 500 m each. Approximately 73% of the total length of livestock access/crossings was instream.

Bridges were another prevalent feature on the stream, with 25 bridges recorded across the entire surveyed AOI, four of which were dilapidated and instream. Bank armouring (rip rap) encompassed approximately 2.2 kms with a nearly even distribution across the left and right bank. Pump stations (eight), pipe crossings (three) and water withdrawals (ten) were not common modifications.

Table 13. Summary of anthropogenic features and modifications catalogued within the surveyed AOI of Louis Creek

Feature	Bank	Sum of Length (m)[1]	Count of Modification Type
Bridge	Both	124	31
	Instream	25.5	4
Catchbasin	Instream	0[2]	1
	Right	0[2]	1
Culvert	Instream	0[2]	4
Livestock Access	Both	137	3
	Left	732	35
	Right	399	39
	Instream	263	4
Fences	Both	219	25
	Left	853	30
	Right	750	33
	Instream	3.10	14
Livestock Crossing	Both	2.00	1
	Left	5.00	1
	Right	125	2
	Instream	3472	53
Garbage/Pollution	Instream	21.8	11
	Left	6.50	2
	Right	4.00	3
Other (i.e., general riparian modifications/encroachments, old bridge abutments)	Both	1.00	1
	Left	6.00	2
	Right	8.00	3
	Instream	8.50	6
Retain Wall/Bank Stabilization	Both	14.30	3
	Left	8.50	2
	Right	26.2	4
Pipe Crossing	Both	0.30	3
Pump Station	Left	0[2]	1
	Right	0[2]	7
Water Withdrawal	Instream	0[2]	1
	Left	1	5
	Right	0[2]	4
Rip Rap	Both	70.0	9
	Left	1078	45
	Right	1113	64
Trail	Left	14.0	1
	Right	34.0	7
	Instream	9.00	2
Road	Instream	2.00	1
	Right	0[2]	1

1. The total surveyed area of interest was 46,814 m.
2. Number of features were recorded but lengths were not always recorded.

Bridge

Culverts

Livestock Crossing

Rip rap

6.6. Bank Stability & Erosion

Erosion in Louis Creek was fairly extensive, accounting for a total of approximately 6.7 kms, 83% of which was due to lack of riparian vegetation. Combining the erosion documented on both banks, segment 7, 9 and 16 all equated to a total length of erosion of 467 m in each segment. The left and right bank had equal distribution of erosion at 3.3 kms each. Of the 6.7 kms of erosion recorded, 75% of it had a severity of high. Erosion appeared to diminish past segment 20 (Table 14; Figure 6).

It should be noted that surveying segment 30 and beyond was conducted when there was significant snow cover, which may have impacted the detection of erosion sites.

Table 14. Summary of streambank integrity and erosion along Louis Creek

	Sum of erosion length (m)[1]	Percent of surveyed area of interest
Left	3289.60	7.03
>10 m^2 (high)	2487.10	5.31
5-10 m^2 (medium)	727.30	1.55
<5 m^2 (low)	75.20	0.16
Right	3397.10	7.26
>10 m^2 (high)	2553.50	5.45
5-10 m^2 (medium)	547.70	1.17
<5 m^2 (low)	295.90	0.63
Total	**6686.70**	**14.28**

1. The total length of the surveyed AOI was 46,814.83 m.

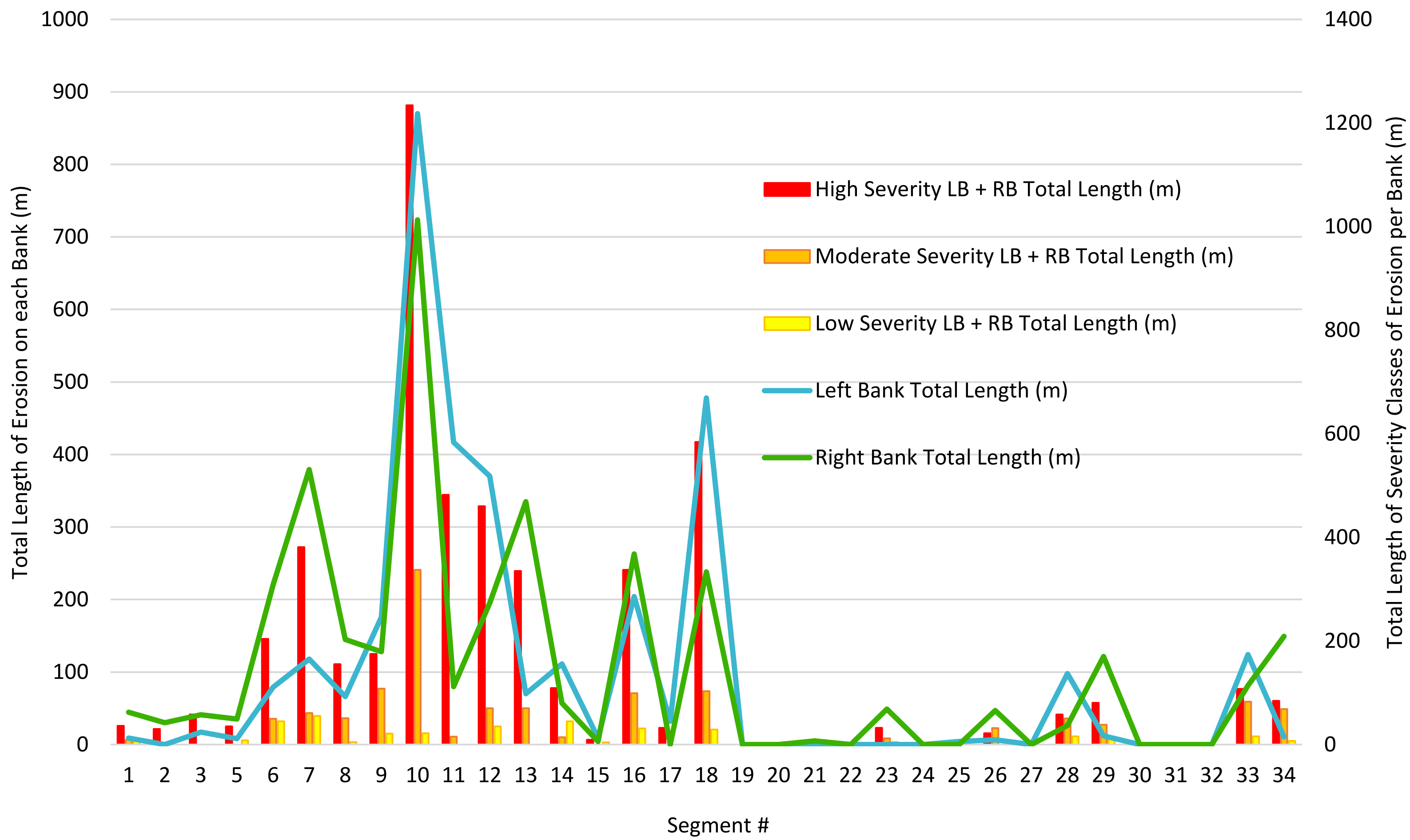

Figure 6. Total length of erosion per bank and length of each severity class across all 33 segments and surveyed AOI of Louis Creek

6.7. Level of Impact

A condition score was assigned to each stream segment. The sum of weighted scores equated to 2.96 (out of 6), with Louis Creek receiving an overall stream grade of 49.3%

Table 15. Level of impact rating / condition score for Louis Creek

Impact Rating	Sum of Length (m)	Condition Value Score[1]	% of Creek	Weighted Score
Nil-Nil	7,949	6	17	1.02
Nil-Low	6,014	5	13	0.64
Low-Low	724	4	1	0.06
Low-Mod	8,773	3	19	0.56
Mod-Mod	11,337	2	24	0.48
Mod-High	8,825	1	19	0.19
High-High	3,192	0	7	0
Sum	**46,815**	-	**100**	**2.96**
			Condition Score	2.96/6.00 = 49.3%

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

6.8. Aquatic Habitat Index

The AHI summarized in Table 16 are illustrated in the Map Set. The majority of the stream was assessed as having a Moderate AHI at approximately 60.0% of the surveyed AOI. The Very High AHI segments corresponded to the same segments with the greatest number of spawning habitat features. Similarly, the segments with a Low AHI generally correspond to the same segments with little to no spawning habitat features recorded.

Table 16. Relative AHI rank distribution (by length) of surveyed AOI of Louis Creek

AHI Category	Total Length (m)	Percent of Creek
Very High	7240.10	8.78
High	4108.83	15.73
Moderate	28103.80	60.03
Low	7362.10	15.47
	46,814.83	100.00

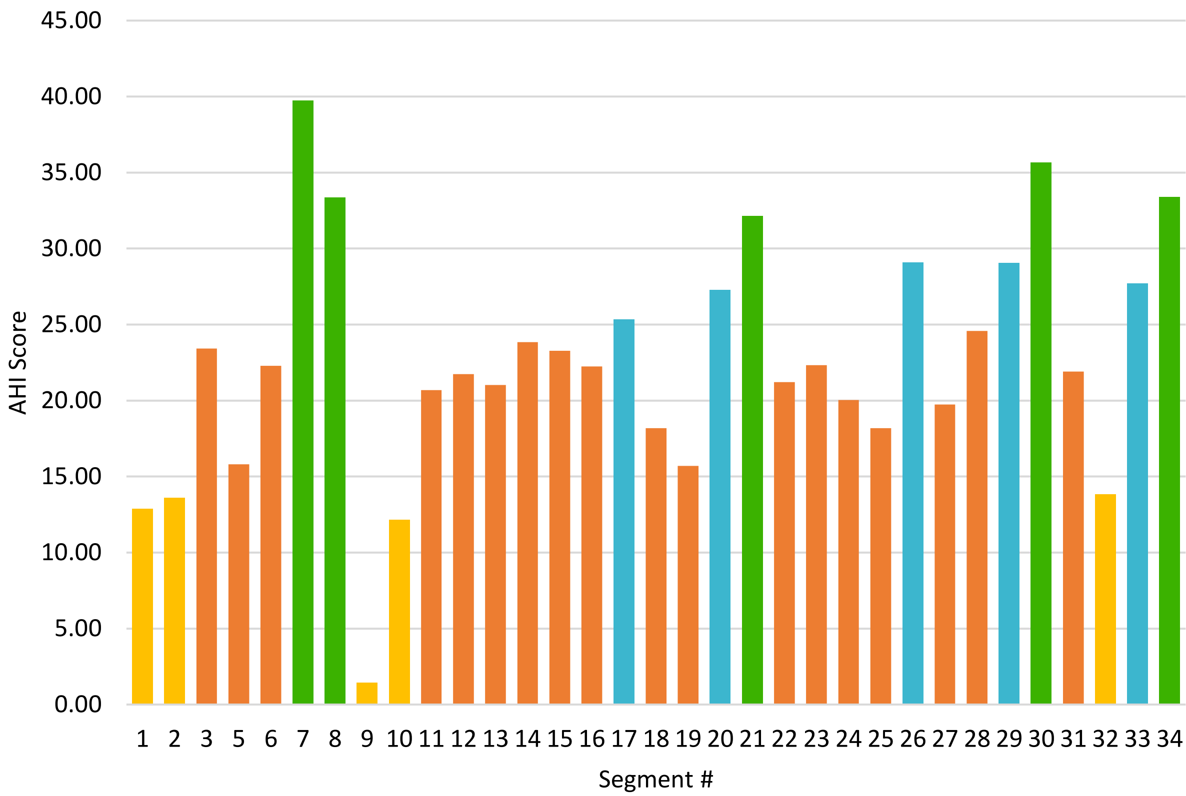

Figure 7. Louis Creek stream segment AHI scores and AHI rank values (Very High = green, High = blue, Moderate = orange, and Low = yellow)

6.9. Priority Restoration Sites

A total of 35 bank erosion areas of concern equating to approximately 2.6 kms across both banks was recorded. Of the 35 bank erosion areas of concern, 11 were also mapped as Priority Restoration Sites due to their proximity to documented spawning habitat. In addition, one culvert that was assessed by the Simpcw Resources Group was determined to be a barrier to fish passage, and as such, was also mapped as a priority restoration site.

A total of 15 priority livestock exclusion fencing sites were identified, which equates to a maximum of approximately 23 kms of fencing required across both banks. It should be noted that 23 kms is likely the worst-case scenario as in many instances, fencing was present but was either not continuous or was in disrepair and livestock was not fully excluded from the stream. Total length of priority erosion sites and livestock exclusion fencing per bank, per segment is provided in Table 17, illustrated in the Map Set and the GIS data deliverables.

Table 17. Summary of priority erosion/restoration sites and livestock exclusion fencing sites within the surveyed AOI of Louis Creek

Segment #	Erosion Area of Concern Total Length (m)		Priority Restoration Sites Total Length (m)		Priority Livestock Exclusion Fencing Total Length (m)		
	Left Bank	Right Bank	Left Bank	Right Bank	Left Bank	Both Banks	Right Bank
6							
7	40	271	40	226			
9						1500	
10	300	387				4000	
11	367	65					
12	290	135	210	100		1500	
13		335				600	
14	55						500
15						700	
16	30					400	
18	120					650	
20							25
22							7
25							1600
28	32		32			200	
29				32			
31					350		
34						440	430

Priority Erosion Site

Priority Exclusion Fencing Site

Priority Restoration Site (i.e., culverts barrier to fish passage)

7.0 SUMMARY

The preceding report has summarized the detailed Sensitive Habitat Inventory and Mapping (SHIM) and Aquatic Habitat Index (AHI) data collected on Louis Creek in the fall of 2022, which is situated within the North Thompson River watershed centralized north of Kamloops, BC. This report is intended as a "Living Document". In so being, it may be continually edited and updated and may evolve and expand as needed, and serve a different purpose over time.

SHIM protocols were used to collect baseline information regarding the current condition of the stream and associated riparian habitats. These inventories provide information on channel character, 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.

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

The Very High and High AHI scores/ranks was limited, accounting for 8.8% and 15.7% of the surveyed AOI, respectively. These high valued habitats are threatened by a variety of instream and upland activities. The loss of riparian vegetation hay/crop production, livestock, infrastructure, and urban development limit the natural stream cooling mechanisms in turn exacerbating rising stream temperatures caused by increasingly hot and arid climates such as those found in the lower reaches of the North Thompson. Stream bank destabilization additionally leads to wider and shallower stream sections, consequently increasing temperatures and silting up suitable spawning gravels. Juvenile rearing is affected by local stream temperature variations prompting fish to seek colder groundwater inflows and shade. Many of the natural areas of the stream continue to occur throughout the majority of the upper watershed and these high value habitats should be protected as they are critical to maintaining water quality and regulating temperatures throughout the streams.

As summarized by Shae McMurter of Simpcw Resources Group: *Louis Creek has been studied for over 40 years, beginning when the Ministry of Environment identified that Louis Creek has high fish values, and predicted the potential carrying capacity of Coho Salmon (Ptolemy, 1981). When the potential was compared to observations, the observations were found to be a full order of magnitude lower. Salmon fisheries health in Louis Creek is largely impacted and limited by land use, particularly agriculture. Studies have revealed that land use practices on Louis Creek have reduced riparian vegetation by half (Miles, 1996). Agriculture takes up a large portion of water demand on Louis Creek, with total demands amounting to 50% of the flow in average years and higher during dry years (Rood and Hamilton, 1995). The DFO acknowledged the degradation of Louis Creek being largely due to agriculture and forestry harvest, with majority of the riparian vegetation edge being destroyed specifically from agriculture (Irvine et al., 1999). Furthermore, out of all the small watersheds in the Thompson- Okanagan, Louis Creek was ranked 12th in risk priority, based on water quality and extent, and sensitivity of water users (Cooper, 2011).*

Agricultural 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) impacting sensitive benthic macroinvertebrates, and 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.

Not only does agricultural activities increase nutrient loading, impacts of livestock access and crossing of the instream habitat of the stream was extensive. Livestock access and crossings combined accounted for a total length of approximately 5.3 kms combined across both banks and instream, where approximately 73% of the total length of livestock access/crossings was instream. Areas with prevalent livestock access had a tendency to be the same segments with erosion and substrates comprised primarily of organics and fines, with very little suitable cobble substrates for spawning. However, in some instances spawning is occurring adjacent to livestock access/crossing such as segment 12 and 34. This poses an imminent threat to Coho/Chinook redds in the fall and eggs through the winter.

A total of 15 priority livestock exclusion fencing sites were identified, which equates to a maximum of approximately 23 kms of fencing required across both banks. It should be noted that 23 kms is likely the worst-case scenario as in many instances, fencing was present but was either not continuous or was in disrepair and livestock was not fully excluded from the stream. If fencing is installed/repaired in these areas, and riparian vegetation restored, impacts to spawning and rearing habitat will be significantly reduced.

Furthermore, these agricultural areas had narrow riparian bands with extension clearing particularly in segments 9 and 10. Agricultural areas are commonly associated with minimal riparian vegetation and lack of structural instream complexity, leaving little rearing habitat for salmonids and other key fish species. Agricultural areas were often characterized by very narrow riparian bands (< 5 m) of primarily Alder species and in some instances (e.g., segment 9), almost no riparian vegetation was remaining. The removal of riparian vegetation in these agricultural areas has also resulted in significant bank erosion and fine sediment deposits, which infills suitable spawning habitat.

Moreover, upland activities can impact floodplains. Several bank restoration features were observed, some of which were more successful than others (see photos below). The successful restoration site was recorded in segment 18 as we understand nearly 15 years ago, whereas the restoration work completed in segment 9 was only conducted several years ago but is failing in places and not excluding livestock access. Future riparian and channel-bank restoration should use similar bioengineering techniques as the successful enhancement example, which include increasing channel complexity, large woody debris, gravel sources, and more intact stream banks. Benefits of these activities will include bank stabilization and habitat restoration.

Successful enhancement documented in segment 18

Failing enhancement documented in segment 9

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. This risk is compounded by the high demand for water extraction for agricultural activities during summer low flow periods, which has been found to have significant impacts on the Coho populations (Interior Fraser Coho Recovery Team, 2006). Considering prolonged periods of significant drought are becoming increasingly more common in the interior of BC with the effects of climate change, the impacts affecting spawning and rearing habitat and migration routes are consequently increasing. 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 for spawning.

It is paramount that landuse planning and management of the stream focuses on conservation and restoration of floodplain and riparian ecosystems. In addition, opportunities should be explored to increase the relative abundance of off channel and back water habitats, make natural upper reaches that are currently obstructed accessible, and protect cold water refuge habitats for improved salmon rearing/nursery potential. For example, the culvert at the downstream extent of segment 30 is functioning as an obstruction to fish passage for certain species/age classes, which is precluding these species from suitable rearing/spawning habitat further upstream. Restoring a functional connection for fish and improving in-water cover may increase the habitat suitability and likelihood of upper reaches being used by juveniles and/or spawning adults.

Further investigation into the direct impacts to fish and spawning substrates by livestock access should be evaluated. It is recommended that the priority restoration sites provided for each stream be prioritized and implemented as soon as possible to restore and enhance the habitat for the at-risk populations of Coho and Chinook.

The stream has a high productive value for anadromous and resident fish species regardless of individual segment AHI scores. A lower AHI segment score does not imply that particular segment is of low value. Rather, the combination of habitat attribute values in that segment contribute less to fisheries and aquatic production than other segments. However, these lower scoring segments are still important for migration and general living. The review of existing or proposed activities should be measured against these baseline AHI scores as a means of conducting a 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.

8.0 CLOSURE

This Document has been prepared for the exclusive use of the Secwepemc Fisheries Commission 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,

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Louis Creek SHIM Map Set

APPENDIX A: Louis Creek Centerline Data