

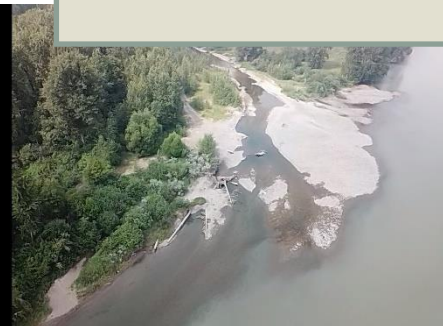
Sensitive Habitat Inventory Mapping and Aquatic Habitat Index

Lemieux Creek

March 2023



**Secwepemc
Fisheries
Commission**



Lemieux Sensitive Habitat and Inventory Mapping and Aquatic Habitat Index

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Table of Contents

List of Figures	4
List of Tables	5
Introduction	6
Methodology.....	7
Stream Centreline	7
Point Features	8
Thompson Shuswap Salmon Collaborative (TSSC) Data Explorer.....	8
Key Species.....	9
Interior Fraser Coho Salmon	9
Chinook Salmon	10
Sockeye Salmon	11
Rainbow Trout.....	12
Habitat Suitability and Productive Capacity	12
Impact rating.....	14
Summary of Results	15
Disturbance factors and land use distribution.....	15
Stream channel and hydraulic character	15
Fish habitat results.....	15
Erosion	17
Modification.....	18
Obstruction	19
Enhancement	20
Level of Impact (LOI)	20
AHI.....	21
Discussion.....	21
Recommended Actions	22
References	25
Appendices.....	27
Appendix A: Supplementary Figures and Tables.	27
Appendix B – Map sets.....	27

List of Figures

Figure 1. Reach breaks delineating segments 1-5 in Lemieux creek.	8
Figure 2. . Historic Chinook, Coho, and Sockeye spawner abundance for Lemieux Creek.....	9
Figure 3. Relative weighting of a given life history stage or attribute.....	16
Figure 4. Distribution of total length of mapped fish habitat features (blue), and density of features (orange).....	17
Figure 5. Total length of eroding streambank by segment.....	17
Figure 6. Above: Erosion resulting from livestock access and grazing of riparian vegetation.	17
Figure 7. Left: The severe bank steepness along the road has prevented riparian vegetation from taking hold and resulted in riprap collapsing into the stream. Right: A pylon demarks risk to motorists where the road is collapsing into the stream.....	18
Figure 8. Total length of modified features by segment.	19
Figure 9. Above: Water depths became too shallow for fish passage (left) and eventually dried up (middle). A beaver dam at the mouth was monitored and partially removed to allow adult migration (right).	20
Figure 10. AHI Segment Scores.	21
Figure 11. Overview of the mapped extent of Lemieux Creek.	27
Figure 12. Restoration Opportunity 1.....	28
Figure 13. Restoration opportunities 2 (downstream, lower right polygon of map) and 3 (upstream, upper left polygon in picture).	29
Figure 14. Restoration opportunity 2.	21
Figure 15. Restoration opportunity 3 (left and right)..	21
Figure 16. Above: Restoration opportunity 4. Left: map outlining the area of interest. Right: A cone was placed by road crews to mark a section of collapsing road.....	30
Figure 17. A long section of riprap along the road confines the stream. The banks are too steep for vegetation and are sloughing road material into the creek.	30
Figure 18. Left: Restoration opportunity areas of interest. Opportunity 5 is located downstream (lower polygon pictured), and opportunity 6 is located just upstream (upper polygon pictured. Right: Collapsing banks of restoration opportunity 5.....	31
Figure 19. Eroding banks and cattle access of restoration opportunity 6..	31
Figure 20. Restoration opportunity 7.	32
Figure 21. Eroding banks and cattle access of restoration opportunity 6 Above: Eroding banks and livestock access at opportunity 7.....	33
Figure 22. Left: Dilapidated bridge at opportunity 7. Right: Eroding banks and livestock access of opportunity.....	33

List of Tables

Table 1. Overview of centreline features.....	7
Table 2. Lengths of the 5 surveyed stream segments.....	8
Table 3. Overview of point features.....	8
Table 4. Timing of freshwater habitat usage by Coho (CO), Chinook (CH), and Sockeye (SO) salmon.....	9
Table 5. Relative value (RV) of fish habitat features.....	13
Table 6. Relative value and weighted scores of mapped substrate composition.....	13
Table 7. Level of Impact rating criteria. Nil=3; Low =2; Mod=1; High=0.....	15
Table 8. Areal abundance of fish habitat features.....	16
Table 9. Summary of modification features in the Lemieux Creek.	18
Table 10. Summary of obstructions in the Lemieux Creek.	19
Table 11. Relative impact scores and overall stream condition of the Lemieux Creek.	20
Table 12. Opportunities for potential restoration efforts in Lemieux Creek.	23

Introduction

Lemieux Creek is located in Little Fort, BC and is a watercourse with significant fisheries and cultural value. There are over 16 species documented within Lemieux creek. These include 4 species of anadromous Pacific salmon, as well as kokanee, rainbow trout, brook trout, burbot, and 8 species of non-game fish. Lemieux Creek is one of the largest salmon spawning streams in the North Thompson watershed. Most spawning occurs in the section 4-8 km from the mouth. Water shortages in the creek are well documented, and periodic dewatering of the creek occurs near the 7 km mark. These low flows occur regularly and impede fish passage. A spawning and rearing channel was constructed in 1988 and is 7.6 km from the mouth. It was observed to be non-functional in the fall of 2022. The coho population has also been enhanced each year since 1983 with releases from the Dunn Creek Hatchery. Lemieux Creek is subject to the negative effects of development and water shortages and was proposed for designation as a sensitive stream (under the Fish Protection Act) in 2000, however it was not designated as such (Anderson, 2004).

Sensitive Habitat Inventory Mapping (SHIM) was conducted with funding from BCSRIF in Lemieux Creek in the fall of 2022. The project goals of BCSRIF include:

- 1) Identifying and addressing freshwater habitat threats to at-risk Sockeye, Chinook, and Coho salmon, as well as Steelhead trout.
- 2) Identifying sensitive habitat areas and guide future restoration actions with relevant long term climate change considerations where applicable.

SHIM is a methodology that maps and compiles data in British Columbian watercourses (Mason and Knight, 2001). The Lemieux Creek SHIM was conducted along an 11.3 km length that extended upstream from the confluence with the North Thompson River. The intent of the project was to provide baseline information on the channel condition and environmental values in order to inform management decisions and prioritize future restoration. An Aquatic Habitat Index (AHI) was developed to identify areas of sensitive habitat based and their relative value to key fish species. A Level of Impact score was generated using the processed field data to evaluate stream and bank conditions. These rating systems can be used to monitor changes as the river continues to evolve.

The SHIM survey will provide:

- a. A detailed map and data set identifying important spawning and rearing habitat for target fish, as well as other specific areas of note in the watershed (e.g., unstable or eroding banks, beaver ponds, log jams, landowner concerns, etc.).
- b. The current state of freshwater habitat, watercourses and riparian communities will be documented.

The completed SHIM will be made available to multiple user groups for use in longer term watershed recovery planning, prioritizing habitat restoration projects and for monitoring changes in the watershed due to future disturbances.

Methodology

Technicians recorded biophysical and anthropogenic attributes using a Trimble R2 unit and an iPad tablet. SHIM is a high-level planning tool designed for watercourses in residential, commercial, agricultural, industrial, and recreational land use areas. The full standards for data collection can be viewed at: https://cmnmaps.ca//cmn/files/methods/shim_manual/shim_10jun02.pdf

The data collected can be used to:

- Identify sensitive habitats for fish and wildlife.
- Assist in determining setbacks and fish/wildlife sensitive zones.
- Monitor for changes in habitat resulting from disturbance.
- Highlight areas of channel instability and water quality.
- Provide baseline mapping data for future monitoring.
- Map and identify riparian vegetation available to wildlife and fisheries resources.
- Provide preliminary data for analyses which can be used to indicate potential trends in resources that may require further study.

Stream Centreline

Stream centreline was mapped along the centre of bankful width. Centreline was divided into segments based on hydraulic class (gradient), riparian class, substrate, land use and disturbance factors (Table 1). Segments were designated when these conditions remained sufficiently uniform for at least 100 m.

Table 1. Overview of centreline features.

Main Attribute	Detailed feature collected
Hydraulic character	Cascade; Falls; Glide; Riffle; Riffle-pool; Slough; Wetland; Other
Gradient	Degrees
Primary character (state of stream)	Modified; Natural; Wildfire; Other
Secondary character	Beaver pond; Ephemeral; Flumed; Intermittent; Side-channel; Wetland; Braided; Other
Riparian corridor	Unvegetated; Shrubs/grasses; Coniferous; Deciduous; Mixed Forest
Seral stage	Early seral; Mid-seral; Late seral; Local natural potential
Canopy closure	0-20; 20-40; 40-70; 70-90; >90
Substrate	Organics; Fines; Gravel; Cobble; Boulder; Bedrock
Bankful width	(m)
Wetted width	(m)
Disturbance factors	Agriculture; Fire; Forestry; Linear roads; Urban development, Recreation; Natural
Floodplain connectivity	Yes/No
Spawning gravels	Yes/No/Potential; Anadromous; Resident; Anadromous/Resident
% Instream cover	Boulder; Deep pools; LWD; SWD; Overstream vegetation;
Line length	(m)

Five segments were designated over the 11.3 km of stream surveyed. Segment 1 begins at the mouth and extends 1.35 km to the bridge at Highway 24. Segment 2 begins just past the bridge and extends 1.03 km upstream, and Segment 3 extends another 2.73 km upstream. Segments 4 and 5 extend 4.46 km and 1.71 km along Lemieux Creek Road (Figure 1, Table 2).

Table 2. Lengths of the 5 surveyed stream segments.

Segment	Length (m)	% of surveyed stream length (11,282.59 m)
1	1349.66	12.0%
2	1031.47	9.1%
3	2733.94	24.2%
4	4455.81	39.5%
5	1711.71	15.2%



Figure 1. Reach breaks delineating segments 1-5 in Lemieux creek.

Point Features

Point features provide a measure of fish habitat quality and relative disturbance. Table 3 provides a list of features surveyed for and mapped.

Table 3. Overview of point features.

Main Attribute	Detailed features collected
Bank disturbance	Type; Length; Image
Culvert	Type; Barrier (yes/no); Length/diameter; Slope; Image
Erosion	Source erosion; Length; Image
Enhancement	Type; Length/width; Image
Fish Habitat	Type; Length/width; Image
Gold Panning	Length/width; Image
Obstruction	Type; Length; Image
Modification	Type; Length; Image

Thompson Shuswap Salmon Collaborative (TSSC) Data Explorer

Field data was synced to the Trimble Connect app at the end of each day and backed up on ArcGIS Online. Each mapped attribute had an associated picture, together making up a detailed photo log. This database will be incorporated into the public TSSC Mapping Tool and can be accessed online. Corrections and adjustments can be made to the database as necessary.

Key Species

The key species considered in this report are Rainbow trout, Chinook salmon, Coho salmon, and Sockeye salmon. Figure 2 depicts historic spawner abundance of Chinook, Coho, and Sockeye salmon in Lemieux Creek. Pink salmon also spawn in Lemieux creek during odd years, although specific population data are not available. The largest return of Coho salmon occurred in 2012, with 3246 spawners. The average return since 1975 has been 736, with an average of 1254 from 2011-2019. Table 4 displays timing of freshwater use for Chinook, Sockeye, and Coho salmon.

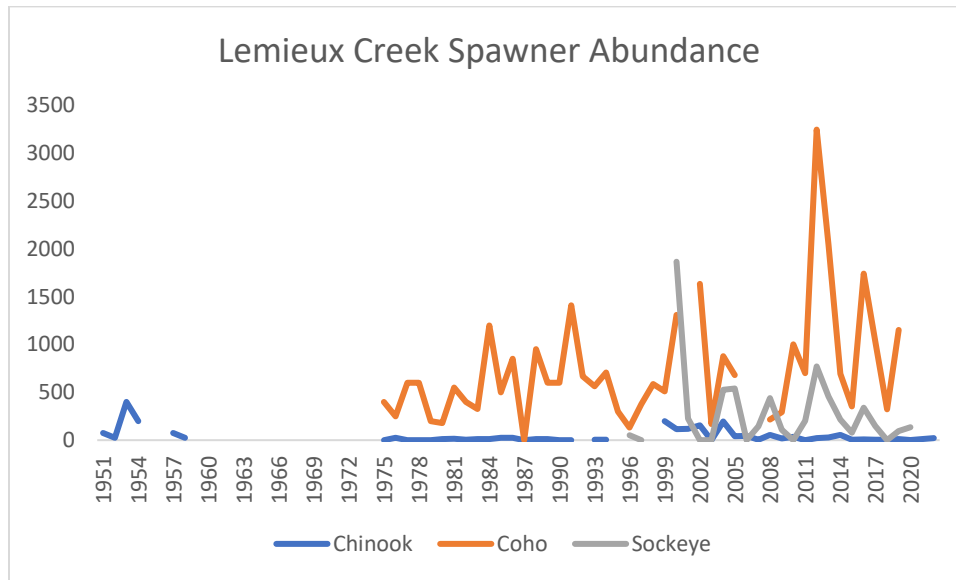


Figure 2. Historic Chinook, Coho, and Sockeye spawner abundance for Lemieux Creek.

Table 4. Timing of freshwater habitat usage by Coho (CO), Chinook (CH), and Sockeye (SO) salmon.

Life History Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Incubation	CO, CH, SO	CO, CH, SO	CO, CH, SO	CO, CH, SO	CO, CH, SO				CH, SO	CH, SO	CO, CH, SO	CO, CH, SO
Juvenile Rearing	CO, CH	CO, CH	CO, CH	CO, CH	CO, CH	CO, CH	CO, CH	CO, CH	CO, CH	CO, CH	CO, CH	CO, CH
Migration and Spawning	CO	CO						CH, SO	CO, CH, SO	CO, CH, SO	CO	CO

Interior Fraser Coho Salmon

Interior Fraser coho (IFC) are a genetically distinct population of Coho salmon (*Oncorhynchus kisutch*). Populations from the middle/upper Columbia colonized the Fraser River watershed via post-glacial lake connections. The Columbia populations are now extinct, and IFC are the remaining representatives of this unique hereditary group (Northcote and Larkin 1989). Coho salmon have a high degree of spawning site fidelity, which also contributes to the large number of genetically distinct populations within the species. There are five sub-groups within IFC: the North Thompson, South Thompson, Lower Thompson, Fraser Canyon area, and Middle/Upper Fraser (Holtby and Ciruna, 2007).

Coho were designated *Endangered* by COSEWIC in 2002. Their decline has been attributed to poor conditions in the marine environment, overexploitation, and freshwater habitat loss. A slight reverse in the trend has led to them being redesignated as *Threatened* (COSEWIC, 2016).

Adult Migration

Adults return to spawn at 3 years of age, so their success depends equally on quality freshwater and marine habitats. Appropriate flows, depths, and temperatures are necessary for migrating, holding, and spawning adults. Deep pools, woody debris, and healthy riparian areas with overhanging vegetation provide cover and cooler temperatures for returning adults.

Spawning and Incubation

Spawning and egg incubation occurs in a variety of habitats and is not thought to be limiting. Coho spawn in the late fall, often in very small streams and the side channels of larger rivers. Discharge decreases in the fall and winter, putting redds at risk of dewatering and freezing if spawning occurs too early.

Ideal streams are lake-headed, which provides stability of flow and temperature (Decker and Irvine, 2013). Spawning site preference is given to riffle-pool transitions, with groundwater upwelling and good circulation. Groundwater also moderates ambient stream temperatures, further decreasing the risk of dewatering or freezing (McRae et al., 2012). Eggs are usually deposited in areas less than 30 cm deep and in gravels and cobbles less than 15 cm in diameter (Sandercock, 1991). Eggs are particularly vulnerable to siltation, predation, freezing, and disease. The eggs hatch in the spring and the juveniles remain in freshwater for up to 18 months before journeying to the ocean.

Juvenile Rearing Habitat

Fry emerge from the gravel during spring freshet, when high discharge causes increased bed shear and the creation of flooded habitats. These ephemeral floodplains are shallow and warm quickly. This accelerates the growth of terrestrial plants and prey species (invertebrates and plankton), providing areas of elevated growth conditions for juveniles in the spring (Jeffries et al., 2007). Channel complexity is also important and gradients of less than 3% are preferred. Pools, backwaters and beaver ponds have the highest density of juveniles (Decker and Irvine, 2013). Groundwater ponds, side-channels, and other off-channel habitats support Coho overwinter and during summer low flow.

Chinook Salmon

Adult Migration

Interior systems with snow-dominated hydrological regimes tend to support populations of stream-type Chinook that overwinter for a year or more. Chinook that spawn and rear in Lemieux creek are stream-type and are a part of the Designatable Unit (DU) 17 North Thompson Summer 5₂ Chinook (*Endangered*). Sufficient depths and velocities are required for migration and access to spawning grounds. The sensitive thermal and flow conditions in Lemieux Creek impact timing and location of spawning and have limited spawning and survival in the past. Deep pools, woody debris, and overhanging vegetation provide necessary cover and holding areas for migrating Chinook.

Spawning and Incubation

Chinook spawn in a broad range of depths and water velocities provided there is adequate sub gravel flow. Areas upstream of riffles and pool tail-outs are favoured, especially below logjams and woody debris. Redds can be very large—up to 10 m²—and flow conditions can change significantly between spawning and hatching. Ground water and hyporheic flow mediate the effects of highly variable discharges in smaller watercourses outside mainstem rivers (DFO, 2020).

Juvenile Rearing Habitat

Juveniles rearing in freshwater prefer shallow areas with low velocities and small substrate size. Ideal stream temperatures are between 10-14 degrees. Pools provide important overwintering and summer low water habitat, as well as a productive environment for prey species. Ephemeral habitats related to the timing and intensity of freshet provide access to prey and protection from predators. Due to their shallow depths and gentle flows, these seasonal wetlands warm earlier than mainstem waters. This accelerates growth of aquatic invertebrates, insect larvae, plankton and other prey species. Juvenile salmon rearing in these areas display accelerated growth and have been dubbed “floodplain fatties” when compared to the smaller juveniles in adjacent rivers. As a result of their improved condition and increased mass, these juveniles have higher outmigration survival and a decreased risk of predation (Katz et al., 2017). Flooding presents a liability to infrastructure, residential and agricultural land. Access to historic floodplains has been disrupted or degraded in many watersheds to protect these human developments. Remaining floodplain access is a critical component of rearing habitat.

Sockeye Salmon

Adult Migration

Kamloops-Early Summer Sockeye spawn in Lemieux Creek. Migrating adults require adequate freshwater temperatures and depths while moving upstream. River temperatures below 15°C are ideal for survival and limit temperature-related pre-spawn mortality (Gilhousen, 1990). As temperatures increase, cardiorespiratory function decreases. This leads to decreased swimming ability, increased stress, susceptibility to disease, and heat shock (Eliason et al. 2011). Other factors negatively impacting migration include turbidity, dissolved oxygen, and instream barriers. Sockeye can jump a maximum of 2.1 m high in order to clear barriers, provided the pool depth below the barrier is 1.5x the height of the required leap (Bjornn and Reiser, 1991).

Spawning and Incubation

Spawning may occur in temperatures ranging from 1 to 20 °C in a variety of substrate sizes... Similar to other salmon species, transitional areas between pools and riffles are favoured. This promotes favourable sub gravel flow to incubating eggs. Other habitat requirements impacting spawning include water velocity, depth, availability of instream cover, and water quality.

Sockeye have longer incubation periods than Coho and Chinook. The snow dominated hydrographs of the interior tend to produce a spring freshet followed by stable, declining flows during the incubation period (Mote et al. 2003). This stable period is critical for spawning success, as fluctuations can have drastic impacts on egg and alevin survival. Ideal temperatures range from 4.4 °C – 13.3 °C, while

temperatures below 3.1 °C and above 25.8 °C are recognized as lethal limits (Bjornn and Reiser, 1991). Siltation, freezing conditions and predation can also impact survival at this stage.

Juvenile Rearing Habitat

Newly emerged Sockeye fry generally migrate to their nursery lakes in April, where they inhabit the littoral zone. Juveniles move into the pelagic area in July as temperatures increase and remain there until outmigration the following spring.

Rainbow Trout

Rainbow trout (*O. mykiss*) are a member of the Salmonidae family and exhibit two distinct life histories: migratory and resident. Genetics and environmental conditions contribute to whether an individual fish will be migratory or resident. Stream residents remain in small headwaters their entire life. Freshwater migrants move to mainstems or to lakes as adults, returning to their natal stream to spawn. Individuals that migrate to lakes are typically much larger and switch from an insectivorous to piscivorous diet. The age at maturity is usually between 3 to 5 years of age. In some populations environmental cues trigger juveniles to migrate to the ocean, adopting an anadromous lifestyle. These fish return to natal streams to spawn and are referred to as Steelhead (COSEWIC, 2014).

Rainbow trout prefer cold, clear water with a fast current. They spawn over fine gravel substrates, both above and below pools at riffle transitions. Ideal substrate is 0.4-1.5 cm in diameter with low sediment and silt levels and high dissolved oxygen levels. Juveniles value shallow streams with abundant cover in the form of vegetated banks, overstream vegetation, woody debris, and boulder gardens. Pools and areas of sub-gravel flow are important overwintering habitat for juveniles and adults. Spawning occurs in the spring at stream temperatures of 10 to 15 degrees (Roberge et al, 2002).

Habitat Suitability and Productive Capacity

The habitat requirements of salmonids vary by species and life history stage. Depending on the time of year in the Lemieux Creek, migrant adults, eggs, rearing juveniles and resident adults will be present. Measures of habitat quality (Johnson and Slaney, 1996) generally depend on:

- Adult holding pools.
- Spawning gravel.
- Area and frequency of rearing ponds.
- Cover in pools and riffles (complexity).
- LWD (frequency and distribution).
- Extent of off-channel habitat.

An Aquatic Habitat Index (AHI) is a method of estimating the productive capacity and suitability of fish habitat. This methodology was developed for River Inventory Mapping (RIM) through cooperation between Fisheries and Oceans Canada and Ecoscape Environmental Consultants Ltd and adapted for this assessment. It uses the relative value of fish habitat features to rank segments from *Very High* to *Very Low* sensitivity. The relative value of each feature type depends on the key species and life history stages present. The AHI was adapted and calibrated through professional opinion and reference to other habitat indices developed for similar watercourses. Habitat features have been weighted to reflect their

relative habitat value (contribution to overall habitat sensitivity). Each habitat feature was assigned a score (where 1 = *low value*, 2 = *moderate value*, and 3 = *high value*) for each key species, for each life history stage. The relative value was calculated by summing species scores for a given feature and dividing by the maximum possible score. The weighted score is the product of the relative value of the feature and the weighting of a given life history stage (Table 5). This scoring system for segments was also applied to the substrate composition of a segment (Table 6).

Table 5. Relative value (RV) of fish habitat features.

Habitat Feature	Rearing		General Living		Spawning	
	RV	Wt. Score	RV	Wt. Score	RV	Wt. Score
Instream Vegetation	0.67	16.67	0.33	1.67	0.00	0.00
Boulder	0.50	12.50	0.33	1.67	0.33	8.33
Overstream Vegetation	0.50	12.50	0.17	0.83	0.00	0.00
Small Woody Debris	0.67	16.67	0.33	1.67	0.00	0.00
Deep Pool	1.00	25.00	0.83	4.17	0.67	16.67
Undercut Bank	0.67	16.67	0.50	2.50	0.33	8.33
Large Woody Debris	1.00	25.00	0.83	4.17	0.33	8.33
Groundwater Influence	1.00	25.00	1.00	5.00	1.00	25.00
Off-channel	1.00	25.00	1.00	5.00	0.50	12.50
Tributary	0.67	16.67	0.83	4.17	0.50	12.50
Substrate						

The relative spatial coverage of each feature type in a segment was multiplied by the relative habitat value and the weighted constant value that was calibrated for Lemieux Creek.

Table 6. Relative value and weighted scores of mapped 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

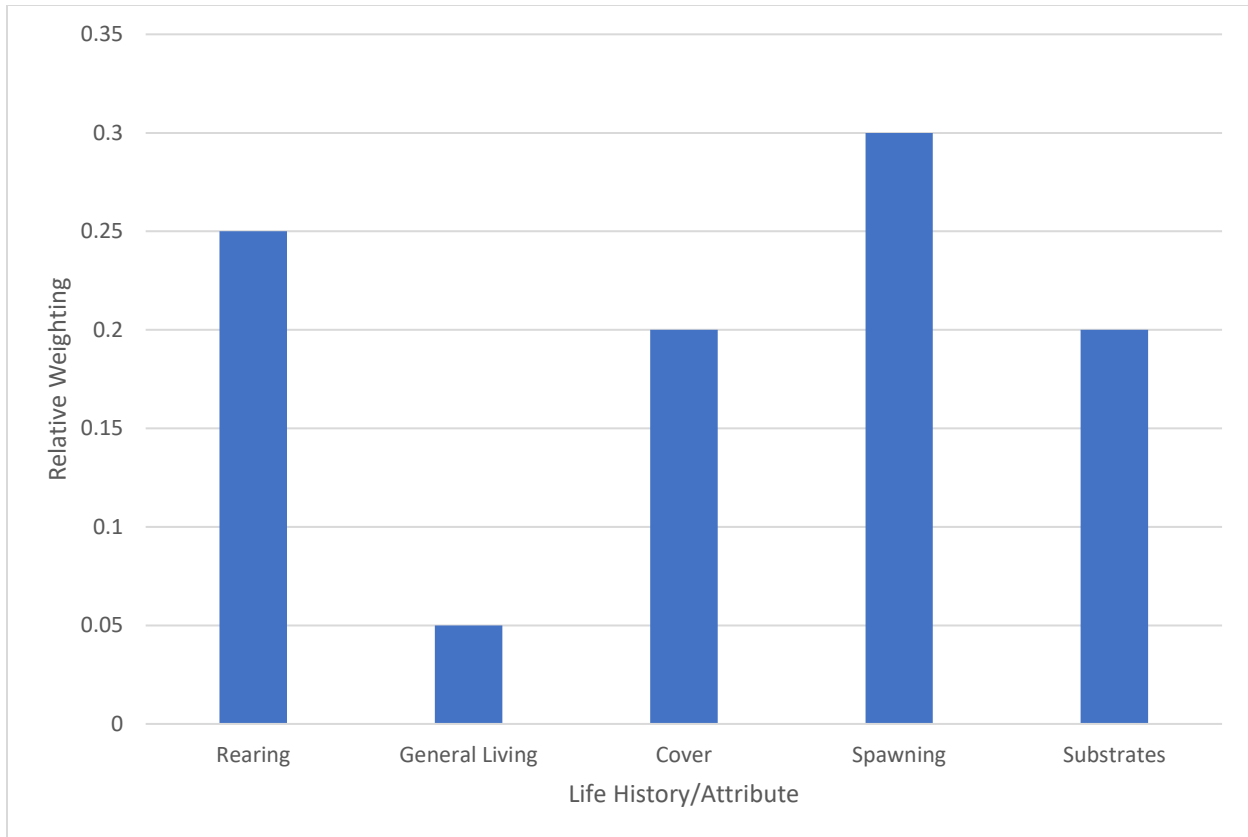


Figure 3. Relative weighting of a given life history stage or attribute.

The centreline AHI adapted for the Lemieux Creek considered the life history stages of spawning, rearing and general living. A score for each segment was calculated using the following equation:

$$AHI_{\text{segment}} = \sum [A_{sp}/A_t \times W_{sp}] + \sum [A_{gen}/A_t \times W_{gen}] + \sum [A_{rear}/A_t \times W_{rear}] + \sum [P_{sub} \times W_{sub}]$$

Where A represents area, sp represents a spawning habitat feature, t represents total stream area, W is the weighting of the habitat feature, P is the percent and sub is the substrate.

Impact rating

Baseline studies often require a measure of impact in a watercourse. A Level of Impact (LOI) describes existing environmental conditions. It is a qualitative assessment of the overall health of the bank condition and considers land use, riparian impacts, and disturbance/modification feature types and density. Generally, a *High* LOI score refers to a segment with >40% alteration along banks; *Moderate* is between 10 and 40%; *Low* is mainly natural with <10% alteration. The LOI provides a basis for future impact prediction and monitoring. In this report it is used in conjunction with measures of habitat suitability to create a priority list of habitat restoration sites and recommendations.

To compare the relative condition of each segment, each bank is assigned a condition of either *High*, *Moderate*, *Low*, or *Nil*. Banks with a rating of *Nil* are attributed a score of 3, while banks designated *High*

receive a score of zero. Thus, a segment with a rating of *Nil-Nil* scores a total of 6, while a *High-High* segment scores 0. This scoring system is further outlined in Table 7.

Table 7. Level of Impact rating criteria. Nil=3; Low =2; Mod=1; High=0	
Stream Bank Impact Rating	Combined Bank Condition Score
Nil-Nil	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	0

Summary of Results

Disturbance factors and land use distribution

As outlined in the stream centreline section, land use and disturbance factors are one of the main qualifiers of segment designation. The majority of the surveyed length was disrupted by agricultural (41%) and linear development (39%), with natural (14%) and urban development (6%) being the two other land uses present.

Stream channel and hydraulic character

The primary character of the Lemieux Creek is riffle-pool. Much of the stream has been modified by human development in the form of bridges, roads, powerlines, agriculture, and oil and gas pipelines. The result is a straighter channel with frequent, long sections of riprap placement to protect infrastructure. This also impacts riparian function, sediment transport, and water velocity.

Fish habitat results

Lemieux Creek has suitable habitat for anadromous and resident salmonids. Deep pools and large woody debris (LWD) are the most common fish habitat features (Table 8). Juvenile salmonids require deep pools and areas of groundwater upwelling for overwintering habitat and late summer, low water refugia. Deep pools are important holding areas for migrants and provide cover to spawning and resident fish. The tail outs of pools are common spawning areas, since they offer cover to adults and are often sources of groundwater upwelling. Other important fish habitat features like off-channel habitat, instream and overstream vegetation were most abundant in Reach 4. The largest contributions to high quality fish habitat occurred in reaches 3 and 5, which also had the greatest habitat complexity (feature density) (Figure 4).

Table 8. Areal abundance of fish habitat features.			
Feature Type	Total Area (m ²)	Cumulative Length	Relative linear abundance in surveyed area (8440.4 m)
Boulder	2072	283	2.5%
Deep Pool	9931.9	1543.5	13.7%
Groundwater Influence	901	501	4.4%
Instream Vegetation	213	60	0.5%
LWD	4111.6	1298.8	11.5%
Off-channel habitat	2480	1055	9.4%
Overstream Vegetation	1586.1	504.5	4.5%
Spawning Fish/redds	6	3	0%
SWD	456	160.5	1.4%
Tributary	199.5	163	1.4%
Undercut Bank	300	202	1.8%

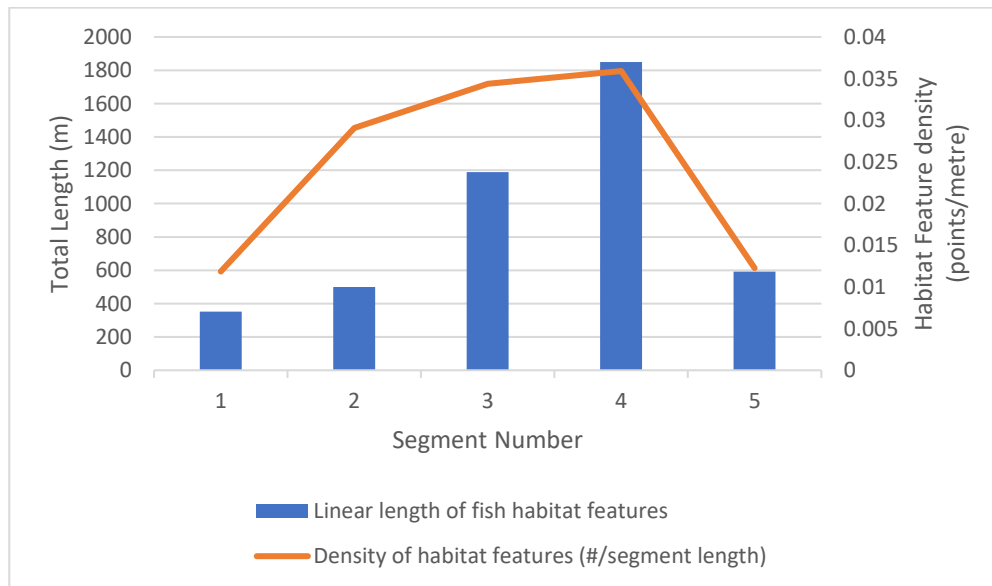


Figure 4. Distribution of total length of mapped fish habitat features (blue), and density of features (orange).

Erosion

The most significant erosion in Lemieux Creek occurs in segment 4 (Figure 5), where there is a high level of disturbance from agriculture and linear development. Much of the erosion in segments 2 and 4 is the result of livestock grazing and a lack of riparian vegetation (Figure 6). These areas of high disturbance facilitate the establishment of invasive species like knapweed, tansy, burdock, and reed canary grass. Decreased riparian vegetation leads to bank erosion, downcutting, increases in surface water velocity, and further prevents natural revegetation. Impacts from linear development can also lead to increases in water velocity, bank erosion, and other downstream effects like elevated compaction and embeddedness of substrate (Figure 7).

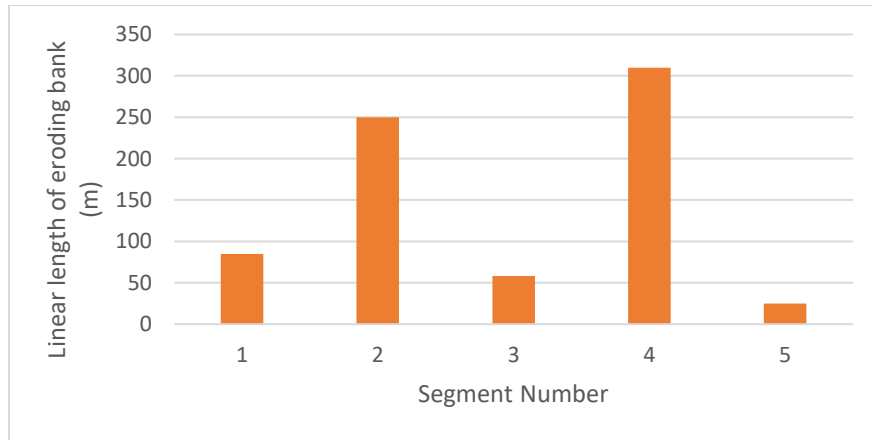


Figure 5. Total length of eroding streambank by segment.



Figure 6. Above: Erosion resulting from livestock access and grazing of riparian vegetation.



Figure 7. Left: The severe bank steepness along the road has prevented riparian vegetation from taking hold and resulted in riprap collapsing into the stream. Right: A pylon demarks risk to motorists where the road is collapsing into the stream.

Modification

Habitat modifications were recorded as point features and are summarized in Table 9. Riprap and bank stabilization efforts, along with livestock access points are the most common modifications to the channel. Segments 1 and 4 are the most heavily modified (Figure 8).

Table 9. Summary of modification features in Lemieux Creek.

Modification Type	Sum of Length (m)	Number of features mapped
Bridge	173	9
Dewatering ditch (Pipeline)	1	1
Fences	66.1	7
Garbage/pollution	9	4
Livestock Access	676	5
Old fisheries fence	2	1
Pump Station	11	4
Retaining wall/bank stabilization	185	5
Riprap	720	16

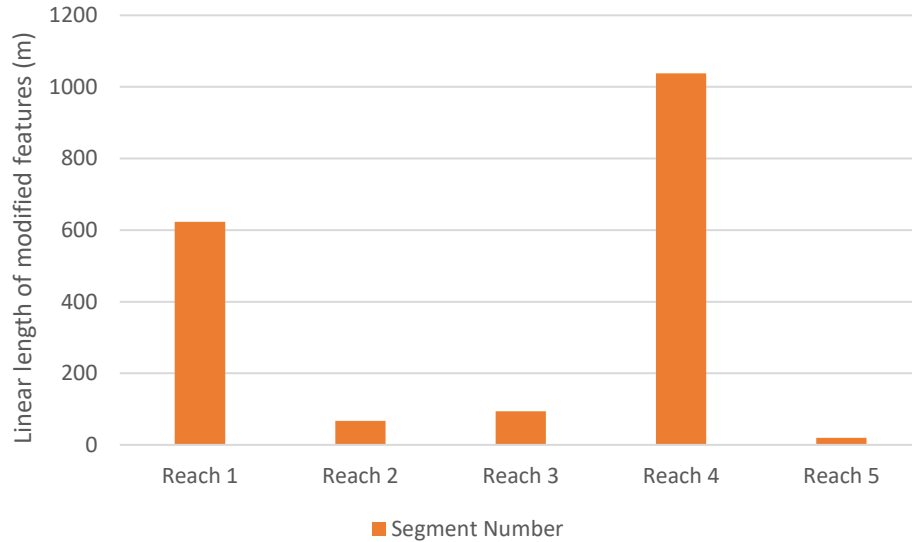


Figure 8. Total length of modified features by segment.

Obstruction

Obstructions were mapped as point features and are summarized in Table 10. Not all mapped features presented a permanent barrier to fish passage. Beaver dams create valuable wetlands which provide overwintering and late summer habitat for juvenile and resident salmonids. They are often porous enough to allow juvenile outmigration, however they can become barriers to adult migration in some cases. Beaver dams should be monitored during migration periods to ensure they are not preventing adult migrant passage.

Periodic dewatering at the mouth and in segment 4 (approximately 7 km upstream) has been reported. SFC observed these conditions at the time of the SHIM. The stream went subterranean at several points in Segment 4, remaining dry for stretches up to 500 m long (Figure 9). Water at the mouth was extremely shallow and fanned out, requiring sandbagging by crews to confine flows and create depths that allowed fish passage.

Table 10. Summary of obstructions in Lemieux Creek.

Obstruction Type	Sum of Length (m)	Number of features mapped
Beaver dam	37	6
Flow or Discharge	642	7
Log jam	10	2



Figure 9. Above: Water depths became too shallow for fish passage (left) and eventually dried up (middle). A beaver dam at the mouth was monitored and partially removed to allow adult migration (right).

Enhancement

A spawning channel was constructed in 1988 at 7.6 km. Previous reports determined that this channel contributes to dewatering of Lemieux Creek (Anderson, 2004). The spawning channel was excavated lower than the surrounding streambed of the creek in order to access groundwater for longer periods during summer low flows and during drought years. The intake of the spawning channel is plugged, and the spawning channel has been partially infilled with fine sediments. In addition to contributing to dewatering, it is likely the channel no longer provides the intended spawning habitat given the change in substrate, and that it may create a juvenile fish stranding hazard.

Level of Impact (LOI)

An LOI score was calculated for each segment based on its relative bank condition. Segment 1 was rated *high-high* because it is impacted by agricultural, urban, and linear development along the full length of both banks. Segments 2 and 4 were rated *mod-high* due to heavy agricultural land use, segment 3 was rated *low-low* and segments 4 and 5 *nil-low*. The overall stream condition score was 38.6% for Lemieux Creek (Table 11).

Table 11. Relative impact scores and overall stream condition of the Lemieux Creek.

Bank Impact Rating	Length of Segment	Bank Condition Score	% of stream length	Weighted segment Score
High-High	1349.66	0.0	12.0%	0.00
Mod-High	5487.28	1.0	48.6%	0.49
Low-Low	2733.94	4.0	24.2%	0.97
Nil-Low	1711.71	5.0	15.2%	0.76
Sum	11282.59			2.21/6
Overall Stream Condition				38.6%

AHI

The centreline AHI results are outlined in Figure 10. The AHI generated considered not only the amount of fish habitat features, but the relative value of each feature to the key fish species in Lemieux Creek. Segment 4 had the highest fish habitat value, making the greatest contribution to the overall aquatic habitat quality of the surveyed area.

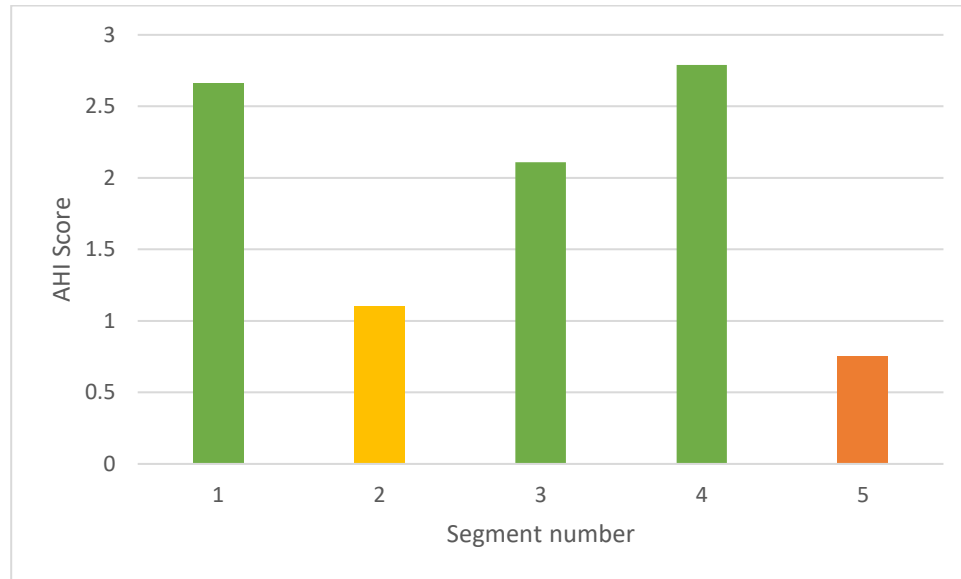


Figure 10. AHI Segment Scores.

Discussion

Segment 4 had the highest contribution to fish habitat values. It was the longest segment (39.5% of total surveyed stream length), had the greatest areal coverage of fish habitat, as well as the highest density of fish habitat features (complexity). Segment 1 had low feature density/complexity but high areal coverage of habitat due to the presence of several large beaver ponds. These beaver ponds provide cover and help buffer against low flows and high temperatures during summer months. Despite the high habitat values found in segments 1, 3 and 4, these segments were severely limited by anthropogenic features and activity, mainly agriculture and linear development. The first water licence in Lemieux Creek was issued in 1909 and logging began early as well (Anderson, 2004). Since then, human activity and development projects have expanded and include increasing residential encroachment and pipeline infrastructure.

Dewatering of the creek was observed near kilometre 7 and flow remained subterranean for several hundred metres. Surface flow was periodic for the next few kilometres upstream, and juvenile stranding was observed. This periodic dewatering has been regularly recorded by DFO, local residents and First Nations. This may be the result of surface water and groundwater interactions, but dewatering could be

exacerbated by a combination of unknown and unlicensed water usage, unknown well withdrawals, landscape changes from agricultural and rural development, and forestry practices. Earlier reporting concluded the DFO side channel likely contributes to nearby dewatering of the stream (Anderson, 2004).

The main factors adversely affecting fish habitat and ecologically significant riparian zones include:

- Agriculture and linear development impacts.
- Bank erosion and instability.
- Streamside grazing and cattle access in sensitive areas (segments 2, and 4).
- Channelization, modification from linear development (segment 1 and 3).
- Sedimentation resulting from agricultural activities and modifications.

These issues contribute to flow and temperature sensitivity in an already arid and drought sensitive ecosystem. They cause habitat fragmentation, stream confinement, impaired riparian/wetland function, increased siltation, bank destabilization/riparian disturbance. Dewatering highlights the importance of groundwater input to the watercourse, since baseflows downstream were sustained by groundwater. Groundwater is essential for the survival of fish populations during the late summer period, and moderates temperature. Groundwater is not licensed at this time in BC and there is a lack of groundwater information (Anderson, 2004).

Recommended Actions

The Lemieux Creek area makes up a distinct ecological community. The watershed has high social, ecological and cultural value. Conservation of intact ecosystems is often more cost effective when compared to the cost of restoration. The simplest way to do this is to design modifications using environmentally sensitive methods. Actions recommended to protect the natural integrity of Lemieux Creek include:

Action 1: Collaborate with fellow stakeholders and develop a system wide approach to restoration and water management.

Undertaking elaborate restoration efforts will not be meaningful if they do not consider downstream issues that impact fish passage, or the effective water management.

- Establish a flow monitoring site at the mouth to compare upper Lemieux and mouth discharges to make sure flows reflect a naturalized stream despite withdrawals (ensure there's not a deficit at the mouth).
- Gain a better understanding of cumulative effects of groundwater extractions. Develop a groundwater management/monitoring strategy.

Action 2: Monitor flow and fish passage conditions at the mouth.

- Combine short and long-term solutions to fish passage issues at the mouth.

Action 3: Address the degrading road infrastructure in segment 3.

- Erosion is occurring along bank left for several hundred metres as a result of confinement/channelization. Consider constructing energy dissipating structures.

Action 4: Restore aquatic habitat to pre-disturbance conditions.

- See Table 12 for a list of suitable restoration sites.

Action 5: Address degrading DFO side channel and determine the impacts on dewatering and fish stranding.

- Monitor dewatering, conduct necessary fish salvage, and install water level loggers in the channel and adjacent stream to determine at what flows the channel disconnects.
- Fish habitat benefits and impacts on low flows should be further investigated.

Action 6: Target education and outreach efforts that communicate the natural value of the area to stakeholders and water licence holders.

Action 7: Monitor habitat restoration efforts and changes in baseline conditions.

- Implement a monitoring program to measure effectiveness of restoration activity and protection measures.
- Use baseline SHIM data as a comparison.

Table 12. Opportunities for potential restoration efforts in Lemieux Creek.

Reach	Area of Interest	Concern	Length (metres)	Description
1	1	Modified/Channelized	400	This portion of the stream is impacted by linear development and agriculture. It has been highly modified and channelized, leading to a straightened channel with increased velocity, limited hydraulic complexity and decreased accommodation to ecosystem flux. As a result, fresh substrate is deposited at the mouth during each spring freshet, creating a broad gravel fan that causes migration issues at lower discharges.
		Obstruction	70	Low flows, fanning and aggradation at the mouth prevents migrating adults from entering the stream. This issue is expected to worsen as the effects of climate change progress.
2	2	Erosion/Riparian	40	A lack of riparian vegetation has led to erosion on the right bank.
	3	Erosion	40	The stream is eroding into pasture due to a lack of riparian vegetation. The fence has collapsed and eroded into the stream.
3	4	Erosion/Modification	50	The stream is confined by the road in this section, and riprap placements are collapsing into the channel.
4	5	Erosion	40	Lack of riparian vegetation along the pasture edge. Fencing is at risk of eroding

				into the stream.
	6	Modification, Livestock Access	200	Livestock access has devastated the riparian vegetation, leading to erosion, compaction, and nutrient input.
	7	Erosion, livestock access, exclusion fencing	130	Lack of exclusion fencing has led to decreased riparian vegetation, unstable banks and increased erosion. Landowner was receptive to getting work done.

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Appendices

Appendix A: Supplementary Figures and Tables.

Table 12. Length of disturbed bank and primary land uses by segment breaks.

Segment	Reach Length	Impacted bank (m)	Land Use (LB-RB)
1	1349.66	781.1	Linear-Urban Park
2	1031.47	319	Ag-Ag
3	2733.94	172	Natural/-Rural Residential
4	4455.81	1348	Ag-Ag
5	1711.71	47	Ag-Natural

Appendix B – Map sets

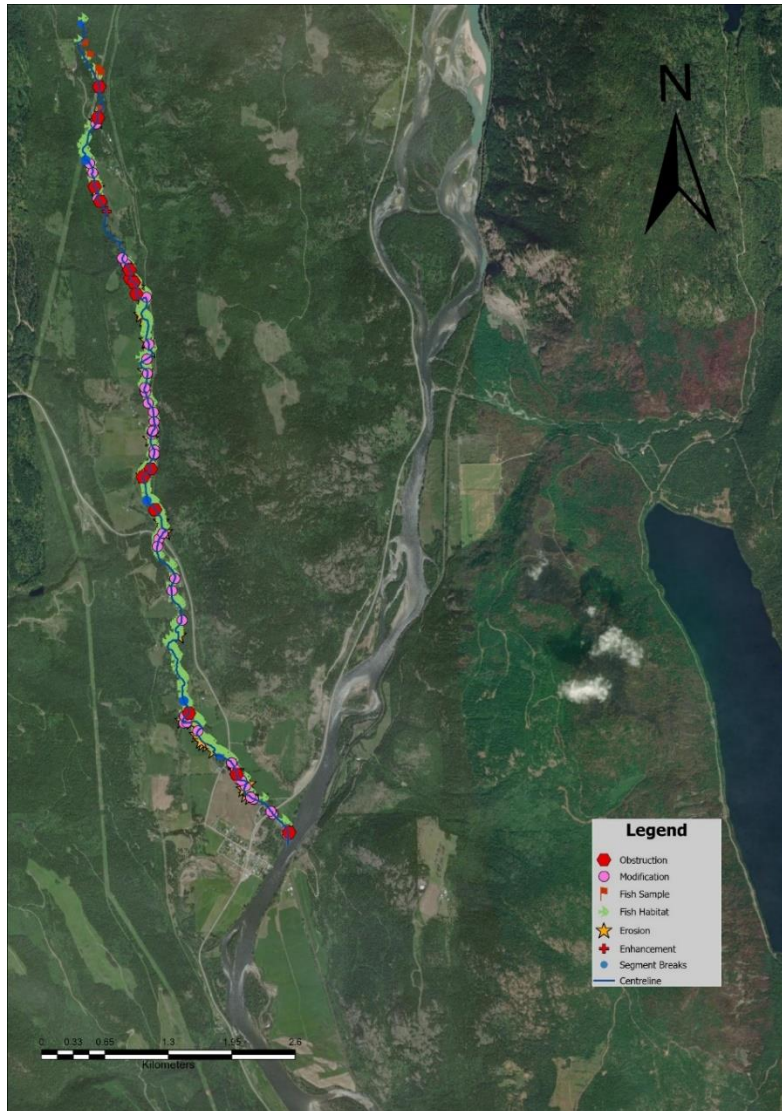


Figure 11. Overview of the mapped extent of Lemieux Creek.

Map set 1: Restoration opportunity 1

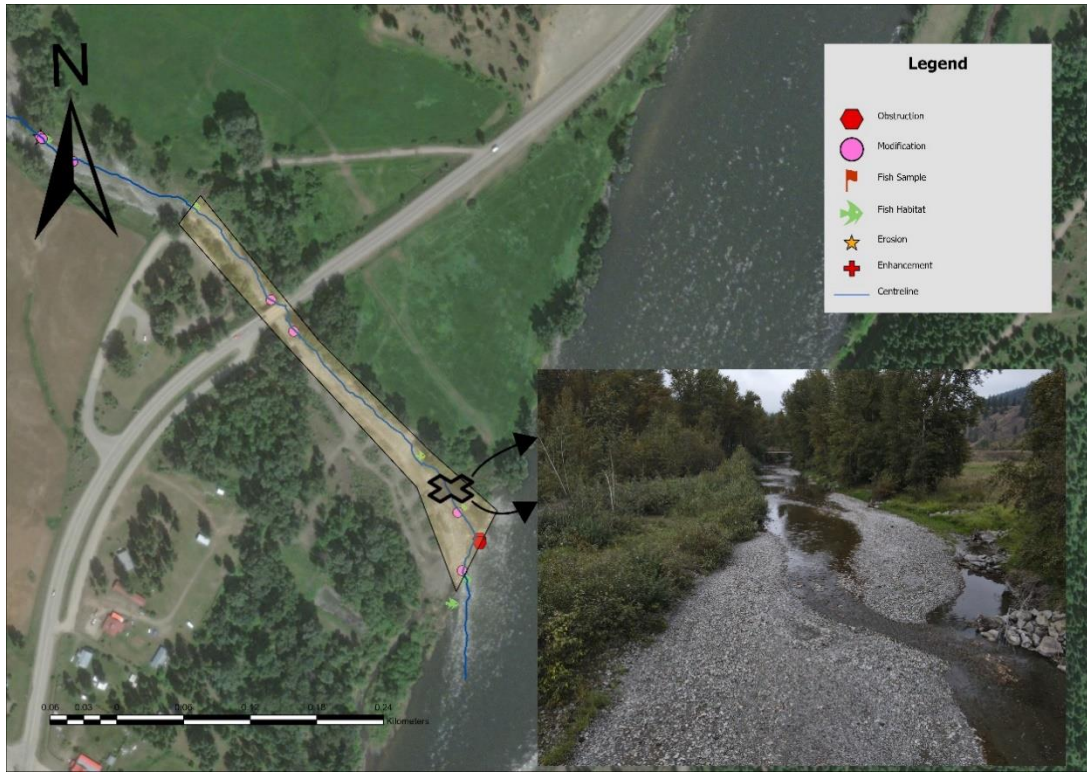


Figure 12. Restoration Opportunity 1.

Map set 2: Restoration opportunity 2

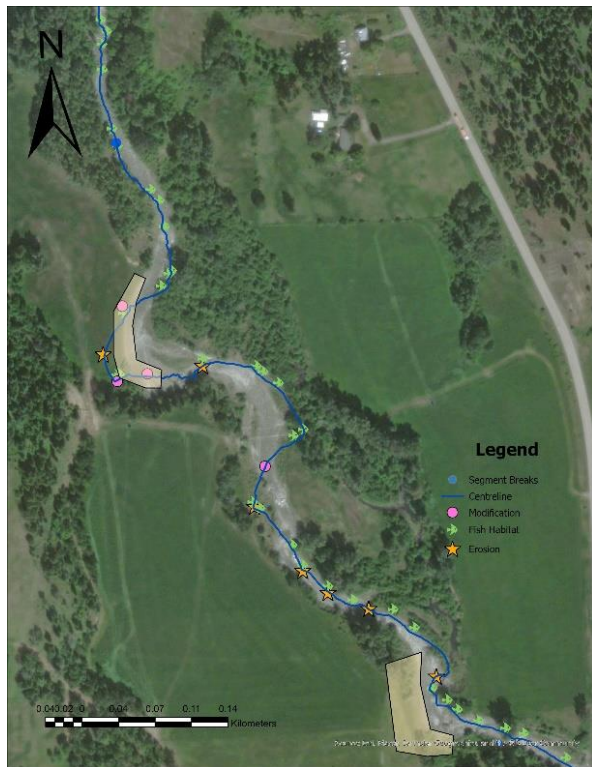


Figure 14. Restoration opportunities 2 (downstream, lower right polygon of map) and 3 (upstream, upper left polygon in picture).



Figure 13. Restoration opportunity 2.

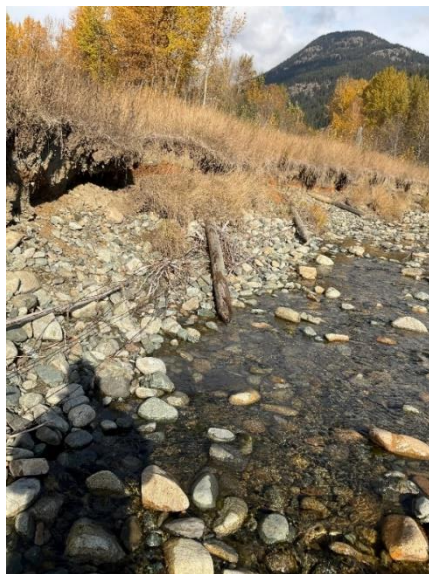


Figure 15. Restoration opportunity 3 (left and right).

Map set 3: Restoration opportunity 4

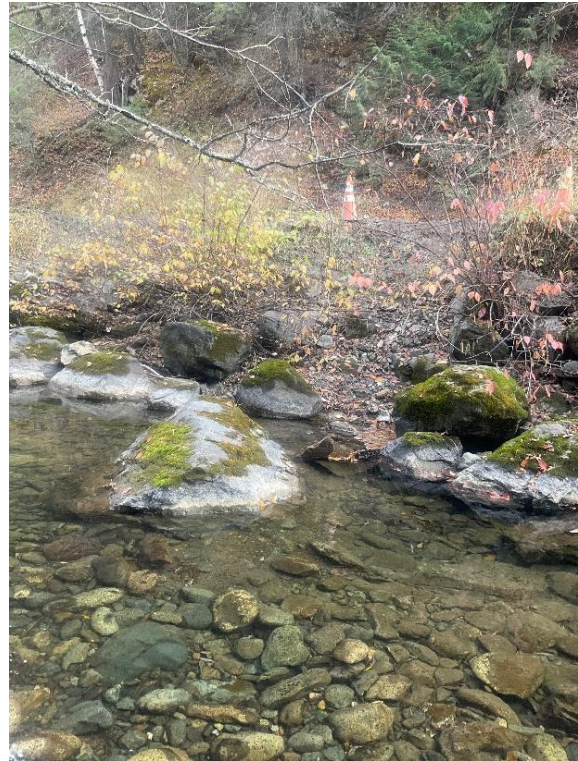
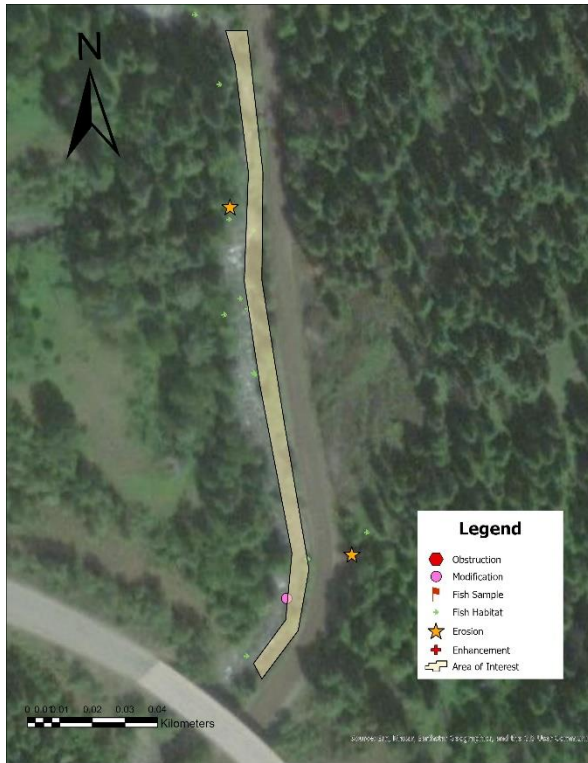


Figure 16. Above: Restoration opportunity 4. Left: map outlining the area of interest. Right: A cone was placed by road crews to mark a section of collapsing road.



Figure 17. A long section of riprap along the road confines the stream. The banks are too steep for vegetation and are sloughing road material into the creek.

Map set 4: Restoration opportunities 5 and 6



Figure 18. Left: Restoration opportunity areas of interest. Opportunity 5 is located downstream (lower polygon pictured), and opportunity 6 is located just upstream (upper polygon pictured). Right: Collapsing banks of restoration opportunity 5.



Figure 19. Eroding banks and cattle access of restoration opportunity 6.

Map set 5: Restoration opportunity 7

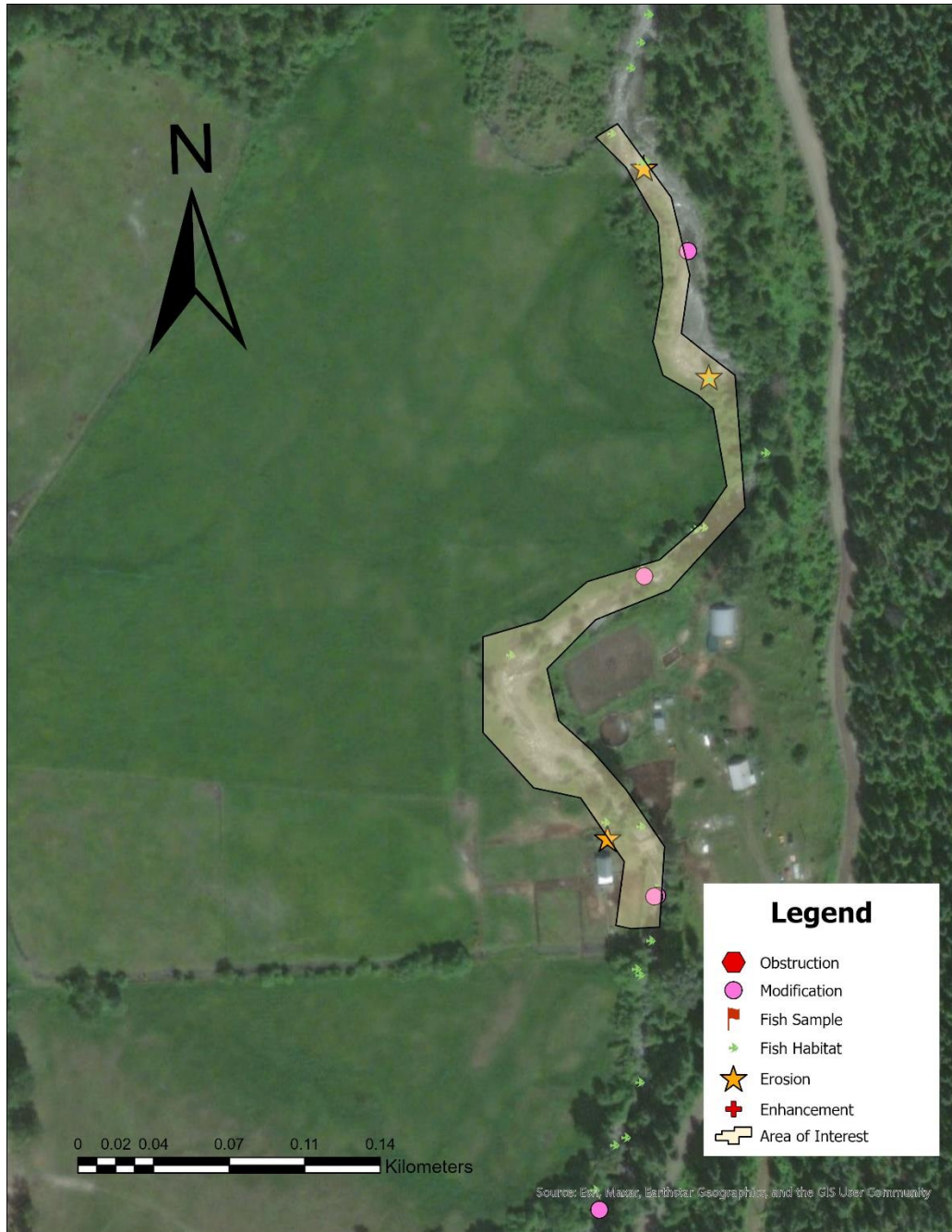


Figure 20. Restoration Opportunity 7.



Figure 22. Above: Eroding banks and livestock access of opportunity 7.



Figure 21. Left: Dilapidated bridge at opportunity 7. Right: Eroding banks and livestock access of opportunity.