Harrison River Tributaries Salmon Habitat Assessment

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BACKGROUND

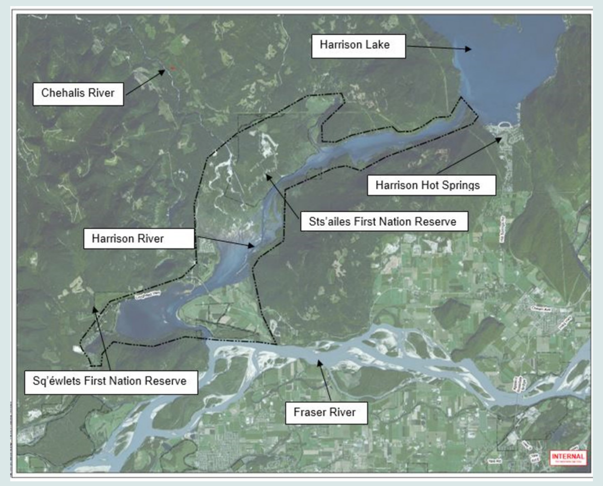
In 2010, the Harrison River was designated as Canada's first International Salmon Stronghold by the North American Salmon Stronghold Partnership (PFRCC 2010). The ecological significance of this area comes from the watershed's natural diversity and productivity, which supports all five Pacific salmon species (Oncorhynchus spp.), including unique runs of Chinook salmon (O. tshawytscha) sockeye salmon (O. nerka) and steelhead trout (O. mykiss) (Ennis 2011, David Moore, pers. comm., 2017). The salmon provide a significant source of nutrients to the Harrison River and surrounding ecosystems and are at the heart of economic and cultural values for local Aboriginals.

The Lower Harrison Watershed has been severely impacted by loss of riparian areas from forest harvesting and accretion of channels due to water management and flooding (Pearson and Chiavaroli 2010). Many of the Harrison River tributaries no longer support historical levels of salmon productivity (Ritchie and Springer, Unpublished) because of habitat loss, habitat accretion, barriers to fish passage, loss of habitat complexity, the ingress of invasive species (e.g., Eurasian watermilfoil [Myriophyllum spicatum] and reed canary grass [Phalaris arundinacea]). It is suspected these ecological losses have also resulted in socio-economic losses.

The Harrison Salmon Stronghold Working Group (led by the Sts'ailes, in collaboration with other local organisations and community members, non-government organisations, as well as federal, provincial and regional governments) has fostered partnership efforts for restoring and maintaining the Harrison Salmon Stronghold. Concurrently, the Harrison Fisheries Authority (Sts'ailes - Sq'éwlets Fisheries Group) has recognized the need for an investigation of historical and current habitat values to identify and prioritize future fisheries restoration opportunities along the Harrison River.

Project Rationale

Past enhancement and restoration activities in the region have been largely reactive, (e.g., offsetting emergency dike work and industry driven development). This critical area for salmonids requires a large-scale proactive approach to future planning, management, and implementation of restoration activities.



Project Objectives

The purpose of this study is to develop a current, comprehensive, and interactive database on the state of fish habitat health in the watershed.

The objectives of the project are to:

1) Develop a comprehensive screening tool informed by ecological, economic and cultural filters (based on Scarfe, 1997); and
2) Produce an interactive database identifying historic and potential restoration opportunities within Harrison watershed.

This will assist resource managers and community members in identifying and prioritizing restoration opportunities.

METHODS

Two Phase Study Approach

1) Habitat mapping to determine existing conditions and identify potential restoration opportunities
2) Rank identified potential opportunities based on their potential value to society based on a Screening Tool developed by Scarfe (1997).

Phase 1: Habitat Mapping

The process of habitat mapping consisted of three steps as described below.. The second phase consisted of desktop predictive mapping to assess fish habitat, evaluate possible limiting factors and identify preliminary areas for potential restoration efforts using ArcView® 10.5. Finally, field surveys were also conducted to collect local data, identify and assess fish habitat and restoration opportunities and perform quality assurance (QA) checks on desktop mapping. The habitat mapping attributes used are provided in **Appendix A.**

1. Acquisition of Orthoimagery and LIDAR

- Obtain 47 km2 of high resolution orthoimagery and LIDAR data (From Terra Remote Sensing, October 2017) to provide a detailed and current overview of terrestrial and hydrological features in the Lower Harrison Watershed.
- Digital imagery was acquired at a 10 cm pixel resolution, with a vertical accuracy of approximately 10 cm.
- LiDAR was acquired as bare earth, allowing for digital elevation models of the ground below vegetation, and a second layer with the vegetation elevations.

2. Mapping Output in GIS (ArcMap)

- LIDAR data and orthoimagery was used to map existing and potential fish habitat at a scale of approximately 1:1000.
- Waterbodies were mapped as polygons; additional polygons were then created in areas identified as potential habitat, and areas that could serve to connect existing channels and around salmon habitat stressors (e.g., culverts and beaver dams)
- Potential habitat was determined by identifying elevation depressions in the LIDAR data that could be feasibly converted to fish habitat (e.g., historic channels)
- Each polygon was classified using a series of attributes including: habitat (upland, accreted, ephemeral, wet), stressor type, and salmon life-stage usage or potential usage. Secondary attributes included: riparian vegetation type, crown closure, water velocity, channel depth, substrate type, channel morphology, and instream cover.

3. Field Surveys and Ground Truthing

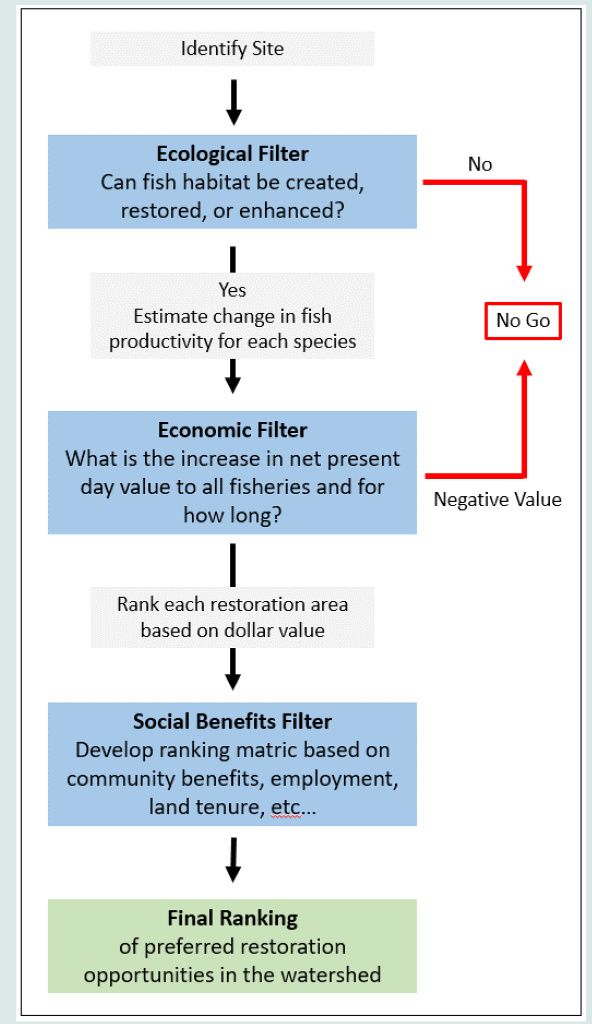
- Field surveys were conducted over four trips during the period of October 5 to 7and 24 to 27, 2016, and March 15, 20 and 21, 2017.
- Collect local data, identify and assess fish habitat and restoration opportunities, and cross reference desktop mapping. Site characteristics, as well as hydrological and water quality data, were collected on a standardized site card form.
- Investigate the presence of stressors and disturbances (e.g., beaver dams and invasive plants), anthropogenic disturbances (e.g., culverts), and aquatic areas lost due to past natural disturbance (i.e., flooding leading to channel cut-off or accretion). variables.
- A total of 88 sites were investigated via boat, by road, and on foot.

Phase 2: Ranking using Scarfe (1997) Screening Tool

Scarfe (1997) proposed a screening approach that considers a project's value to society based on the potential environmental, economic, and social benefits the restoration project may yield.

Ranking

Identified potential restoration sites were ranked by ecological benefits and economic benefits. Sites with greater ecological benefits (i.e., greater productivity) were ranked higher than those with low ecological benefits. Sites with greater economic benefits (i.e., more cost effective) were ranked higher than those with low economic benefits.



I. Ecological Filter

Proposed restoration projects are first evaluated based on an ecological benefits filter, which considers primarily the potential restoration and/or enhancement of local fish populations (i.e., net gain in productivity), but also improvements to the overall ecological health of the watershed (e.g., improvements to water quality, to wildlife, riparian lands and wetlands).

Projects with limited or nil net benefit to the ecology of the area, according to a predefined threshold, are filtered out of the process at this point.

Calculation of Ecological Values

The formula used to estimate fisheries benefit (i.e., the increase in biomass that may result from the restoration works)

P= S*K*Y

where:

P = fish production (i.e., new body mass per unit area).
S = area (m2) of streambed restored.
K = estimated number of adult fish, of each species, that will result from restoration
Y = the average weight of an adult fish for each species included in the assessment.

Table 1. Estimated Fish Production Benefits (K)

Species	Survival Rate		Estimated Average Production (No. adult fish/m²)		
	Fry/ Freshwater	Smolts/ Marine	Enhanced Channel	New Channel	New Off-channel Pond
Chinook salmon	0.680	0.041	0.017	-	-
Coho salmon	0.680	0.098	0.025	0.066	0.068
Chum salmon	0.069	0.007	0.470	1.580	n/a
Pink salmon	0.070	0.028	2.110	-	n/a
Sockeye salmon	0.093	0.073	6.330	-	n/a
Steelhead trout	0.330	0.160	0.003	-	-
Rainbow trout	n/a	n/a	0.040	-	-
Cutthroat trout	n/a	n/a	0.023	-	-

II. Economic Filter

Economic benefits are often time-dependent and gradual (Scarfe 1997), so all the costs and future benefits accrued throughout the lifespan of a project are brought into present values, and an appropriate real discount rate is applied. The resulting net present value (NPV) allows assessing the true potential economic benefits of a project over the its full life cycle.

Table 2. Suggested Average Weights for Adult Salmonids (Y)

Species	Average Weight (kg)
Chinook salmon	8.5
Coho salmon	3.0
Chum salmon	4.5
Pink salmon	1.5
Sockeye salmon	2.5
Steelhead trout	4.0
Rainbow trout	-
Coastal cutthroat trout	-

Calculation of Economic Values

The economic benefits to fisheries were calculated as a balance between the fish productivity and the estimated cost of each potential restoration project. The benefits from restoration accumulate over the entire life of a restoration project, so Scarfe (1997) proposed converting all costs and benefits into present values. Scarfe's net present value (NPV) formula is as following:

$$NPV = B_0 - C_0 + \frac{B_1 - C_1}{1 + r} + \frac{B_2 - C_2}{(1 + r)^2} + \cdots + \frac{B_T - C_T}{(1 + r)^T}$$

where:

BY = the aggregate benefits made available by the project in a given year (Y); BY = P x Commercial Value
CY = the costs incurred with respect to the project in the same year (Y); CY = construction + yearly maintenance
r = the selected real discount rate for the study; r = 0%

Table 3. Commercial Value of Adult Salmonids (Harrison Fisheries Authority)

Species	Commercial Value
Chinook salmon	$2.50/lb
Coho salmon	-
Chum salmon	$2.29/lb
Pink salmon	$1.40/lb
Sockeye salmon	$2.11/lb
Steelhead trout	-
Rainbow trout	-
Coastal cutthroat trout	-

III. Social Benefits Filter

As restoration projects may generate other benefits that are of value from a social perspective, a social benefits filter is also considered when assessing potential restoration projects. Such benefits include local employment, partnerships, social and cultural values, educative opportunities, etc. The social filter is complex and may identify areas that have relative values (e.g., high, medium low), or binary values (e.g., culturally sensitive areas that cannot be disturbed). The social benefits filter is a final process that allows areas to be chosen or dismissed due to their significance to the local stakeholders.

Consideration of Social Benefits Values

The primary source of information for preliminary social benefits values was traditional ecological knowledge gathered from interviews with members of the Sts'ailes community. Four Sts'ailes elders were interviewed by Morgan Ritchie in 2016; their interviews were summarized and supplemented with interviews conducted by Ritchie and Springer (Unpublished) in 2009. Research questions driving the Sts'ailes TEK interviews included:

1) What are the main salmon populations, including their spawning locations, and rearing habitat?
2) What are some traditional fishing practices, technologies, and locations?
3) What changes to important salmon spawning and rearing waterways have you observed?
4) What are some examples of traditional and contemporary management and maintenance of salmon fisheries and habitats?

Due to the complex nature of a social benefits filter, additional information needs to be gathered before the filter can be applied to the restoration sites.

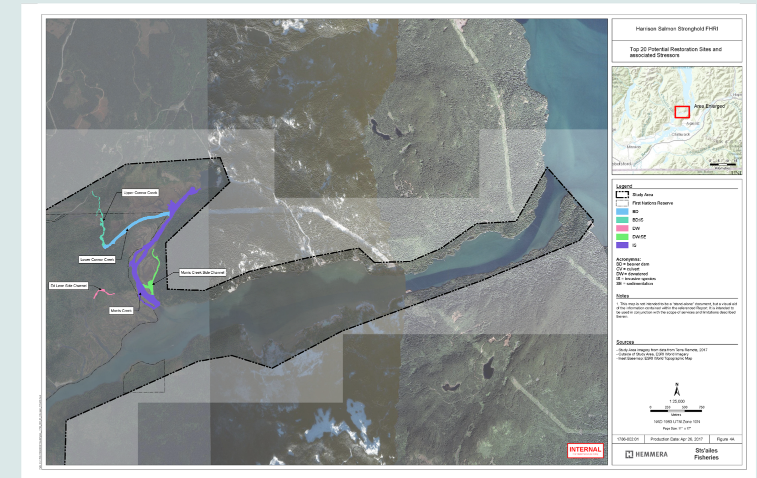
RESULTS

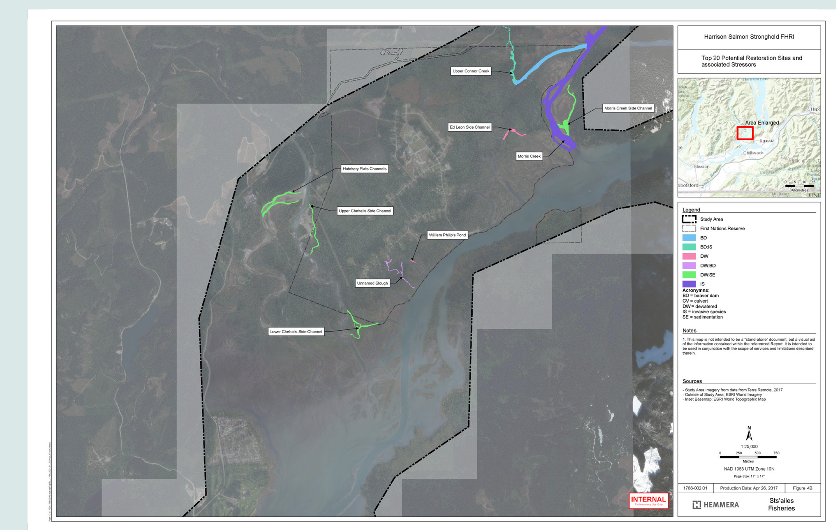
Phase 1: Habitat Mapping

A total of 88 sites were identified and assessed. From these, 20 were selected as potential restoration opportunities based on primary fish habitat (e.g., wet, ephemeral, accreted, or upland), site stressor (e.g., beaver bam, culvert, erosion, invasive species, etc.), site access, and feasibility of creating rearing or spawning habitat for the target fish species.

The 20 identified potential restoration opportunities were put through the Screening Tool model.

Figures show the 20 identified potential restoration opportunities along the Harrison River.





Phase 2: Ranking using Scarfe (1997) Screening Tool

I. Ecological Filter

Ecological benefit vales were calculated based the estimated production of target species for restoration works of either New Habitat or Enhanced Habitat.

- 13 restoration opportunities were considered New Habitat
- 3 restoration opportunities were considered Enhanced Habitat
- 4 restoration opportunist were considered a mix of New and Enhanced Habitat

Estimated net production values of each of the 20 potential restoration sites are listed and ranked in Table 4.

II. Economic Filter

The purpose of the economic benefits filter is to provide an estimate of the comparable net present value of a project, in the context of fisheries benefits (i.e., the Aboriginal commercial fisheries and the local recreational fishery) over the average life span of a created or enhanced habitat (20 years).

The normalized value ($/m2) of each of the 20 potential restoration sites are listed and ranked in Table 4.

Table 4. Ranking of Twenty Potential Restoration Sites

Habitat Restoration Site	Ecological Benefits		Economic Benefits		Overall Ranking
	Pounds of Adult Salmonids	Ranking	($/ m²)	Ranking	
Morris Creek	8,245,333	1	1,875	1	1
Hatchery Flats Channels	346,029	6	1,841	2	2
E. Sq'éwlets Slough	240,623	7	1,816	3	3
Lower Chehalis Side Channel	190,620	8	1,815	5	4
West Sq'éwlets Slough	932,775	2	1,509	13	5
Morris Creek Side Channel	377,429	4	1,770	11	6
Bateson Slough S.	576,553	3	1,062	15	7
Bateson Slough N.	373,590	5	1,096	14	8
HR Bridge E.	85,841	13	1,805	6	9
Ed Leon Side Channel	112,038	12	1,789	7	10
Upper Chehalis Side Channel	139,686	11	1,779	10	11
William Philips Pond	16,724	20	1,815	4	12
Kilby Channel	56,019	16	1,779	9	13
HR Bridge W.	43,920	18	1,787	8	14
Lower Conner Creek	162,547	9	355	19	15
Harrison Mills N. Option 1	139,919	10	477	18	16
E. Sq'éwlets Slough Ext.	41,438	19	1,718	12	17
Harrison Mills N. Option 2	82,700	14	623	17	18
Unnamed Slough	55,529	17	980	16	19
Upper Connor Creek	56,370	15	301	20	20

III. Social Benefits Filter

Due to the complex nature of a social benefits filter, one has not yet been applied to the restoration sites. However, results from interviews with Sts'ailes members indicate interviewees agree enhancement and ongoing maintenance of salmon spawning and rearing areas is important. These interviewees would particularly like to see the sloughs between Morris Creek and the Chehalis River cleared of vegetation and sediment so they return to their pre-deteriorated condition, and are made suitable for salmon spawning and rearing once again.

DISCUSSION

The habitat map and screening tool presented in this study were developed to assist decision-makers and community members identifying and prioritizing economically feasible and socially valuable restoration opportunities in the Lower Harrison Watershed. While the habitat map provides an overview of fish habitat conditions and limiting factors, the screening tool allows for potential restoration opportunities to be evaluated from an ecological, economic and (eventually) social perspective.

These tools constitute a strong platform to develop a large-scale, long-term plan for fish habitat restoration in the Lower Harrison Watershed. The interactive and user-based nature of these tools will also facilitate greater community engagement during the planning process by providing visual representations of existing limiting factors to fish productivity and potential restoration opportunities. This creates a central source of information that can be consulted and contributed to over time; and a series of criteria based filters that projects may be evaluated and prioritized on.

All 20 projects are expected to specifically benefit chum and coho salmon, by directly improving spawning and rearing habitat conditions. The various restoration efforts are also expected to benefit other fish species through functions such as improved water quality and redundancies in migration routes. Habitat restoration may also benefit other components of the ecosystem, such as benthic macroinvertebrate communities, amphibians, birds, wildlife, riparian habitat, and native aquatic vegetation.

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