Babine Wild Sockeye

Habitat Rehabilitation 2016

Lake Babine Nation Fisheries

Submitted To:
Pacific Salmon Commission
Attn: Angus Mackay

Prepared by:
Lake Babine Nation Fisheries

Table of Contents

List of Tables

List of Figures

Appendix A List of Tables

1.0 Introduction

Skeena River sockeye salmon (*Oncorhynchus nerka*) returns (catch plus escapement) increased substantially after Babine Lake enhancement facilities were constructed and continued throughout the 1980's – 1990's. Since the early 2000's, Skeena River sockeye returns have declined to lower levels and appear to be in conjunction with recent Babine Lake production declines. Escapements to enhanced Pinkut Creek and Fulton River continue to exceed spawning requirements, even with the recent declines in total production. Escapements to the unenhanced late-runs exhibit a long-term declining trend and escapements have been much lower than historic in the last two- three decades. Escapements to the early-timed and mid-timed unenhanced runs have also shown a decline (Cox-Rogers and Spilsted, 2012). These declines may be related to changes in accessibility to spawning habitats and quality and quantity of spawning habitat as it relates to water quantity and water quality.

Escapement to many of the unenhanced early-timed tributaries are constrained due to naturally changing habitat conditions concerning: 1) lake waves creating sills at the stream mouths; 2) low flows; 3) in some cases, increased water temperatures. Road Crossings in forested areas where logging roads and logging activity occur have long been known to be significant sources of sediment input into streams (Packer, 1967; Rothwell, 1983). Due to the widely recognized impacts of sedimentation on aquatic fauna and culvert crossings, which can be barriers to upstream fish migration, Best Management Practices (BMPs) have been designed to prevent or minimize the amount of sediments entering streams at road crossings and ensure road crossings permit upstream fish passage (e.g. FOC, 1993; WALP, 2004; Government of Alberta Transportation, 2011). Sockeye spawning streams with sills obstructing adult sockeye fish passage include: Five Mile Creek, Nine Mile Creek, Tachek Creek, Sockeye Creek, Pierre Creek, Twain Creek, Four Mile Creek, and Six Mile Creek. These eight streams have been prescribed for rehabilitation utilizing a mini-excavator mounted on a relatively small barge to clear out the accumulated sediment and in some cases place rock to increase and concentrate the stream flow at it mouth.

In regard to increasing low flows, water augmentation is believed to be of potential benefit to some streams supporting spawning sockeye salmon, specifically Tachek, lower Tahlo

Creek, Morrison River, and Nine Mile Creek. Stream low flow conditions in 2014 obstructed approximately 30 to 40k sockeye spawners from spawning on their natal grounds in the mid-timed Tahlo and Morrison systems (Lake Babine Nation Fisheries (LBNF), unpublished data, LBNF staff observations); however, increased precipitation could change this situation. This is a significant number of sockeye and given the landscape characterized by many lakes and wetlands, water augmentation on an appropriate scale is feasible. The feasibility study parameters that are required to be explored include technical, biological, and financial aspects. A topographic survey of potential channel locations needs to be conducted.

The primary purpose of the 2016 Babine wild sockeye habitat rehabilitation project was to identify habitat projects that could stop and/or reverse the declines in wild Babine sockeye stocks. In year 2 of this project, several objectives were set to help achieve that purpose. Specific objectives were as follows:

1. Completion of further feasibility studies and a cost-benefit analysis regarding (i) water augmentation into wild sockeye spawning streams, particularly Tachek Creek and (ii) the installation of breakwaters offshore of Four Mile and Six Mile creeks to prevent lake waves building sills at their mouths on Babine Lake to enable access to early-timed sockeye spawners.

2. Increase the knowledge base and identify data gaps through data collection and workshops involving biologists, researchers and natural resource managers that have worked within the Babine Lake watershed regarding hydrological functioning including groundwater inputs, management of alluvial fans at three priority creeks - Six Mile, Nine Mile, and Sockeye creeks

3. Conduct surveys and feasibility studies in regard to potentially implementing “soft channelization” of the lower fan channel, at the mouths of certain streams in order to concentrate flows and enable sediment movement through the alluvial fans.

4. Conduct a GIS-based high level analysis of land resource use centered on pressure indicators in order to more fully understand the processes of change to the freshwater ecosystem in the upper Babine watershed;

5. Through data collection and review and information sharing at workshops, bring to light limiting factors related to spawning and rearing habitat, such as potential impacts related to land use, including road development and forest harvesting, that may be limiting wild sockeye production throughout the Babine Lake watershed.

1.1 Variation of Funded Activities

Field activities varied from the above proposed objectives due to PSC Northern Fund Committee recommendations that included reconsidering Objectives 2 and 4 and conducting some thinking regarding the cost and benefits in relation to the past and current methods used to mitigate adverse effects resulting from wave-built sills and sediment accumulation on the lower section of the stream fans. In particular, the Northern Fund suggested that restorative concepts to improve sockeye spawner access be evaluated based on the cost-benefit of stream enumeration crews creating access with hand tools as required.

Conceptual planning in 2015 during Year 1 of the Babine Sockeye Habitat Rehabilitation Monitoring considered potential rehabilitation site works including:

- breakwaters to mitigate wave action creating sills at the stream mouths;
- excavation of sediment to deepen stream channels;
- water augmentation into the lower fan reaches.

In 2015, monitoring of these concepts was implemented to various degrees. However, it was recommended in 2016 by Suskwa Research Consulting that further understanding of upslope processes centered on water and sediment movement directly or indirectly affecting the stream channels was imperative prior to any hasty site works. In this 2016 project, fieldwork was conducted to increase understanding of the current conditions and thus bring awareness to potential rehabilitation site works, if any. To that end, project components consisted of identifying landscape characteristics, hydrological functioning, land and resource use activities, climate change projections and trends, a relatively high-scale GIS-based analysis that utilized Wild Salmon Policy habitat pressure and state indicators, a road-stream crossing assessment that was intended to proportionately represent road crossings and drainage structures throughout the upper Babine sub-basins that support sockeye spawning, and a pilot Unmanned Aerial Vehicle (drone) survey of typical sockeye spawning habitat in Nine Mile Creek.

2.0 Background

On average, the Babine Watershed provides spawning and rearing habitat for 90% of the Skeena sockeye run (Cox-Rogers and Spilsted 2012). The Skeena sockeye run supports both Alaskan and Canadian commercial fisheries, recreational fisheries, and food, social, and ceremonial harvest for all Skeena Nations. In the 1950s and 1960s, it was concluded that productivity of Babine Lake was limited by spawning habitat (Johnson 1956, 1958, 1961). This conclusion led to the construction of spawning channels on two natural lake-headed streams in the upper Babine Watershed; Pinkut Creek and Fulton River under the Babine Lake Development Project (BLDP). These enhanced spawning channels were built between 1965 and 1971 (Ginetz 1977). Since the construction of these spawning channels the Fulton and Pinkut sockeye have become the dominant Babine sockeye populations, increasing from approximately 30% to 70% as noted by Cox-Rogers and Spilsted (2012). Figure 1 shows the proportion of and change to upper Babine wild sockeye in relation to enhanced stocks from 1950 to 2010.

Based on the number of spawners per suitable spawning habitat area, suitable spawning habitat availability appears to be limiting in some wild sockeye spawning tributaries such as Pierre Creek due to a natural barrier to upstream passage, and in average to low water years, Sockeye Creek, Tachek Creek and Cross Creek due to a lack of wetted spawning gravels due to limited water quantity (LBNF, personal observations). A lack of spawning gravels in other spawning tributaries such as lower Tahlo, Cross Creek upstream of the road crossing, and Tsezakwa Creek, have also been documented (LBNF, personal observations) and may be due to a lack of instream large woody debris (LWD) retaining spawning gravels during high flow events.

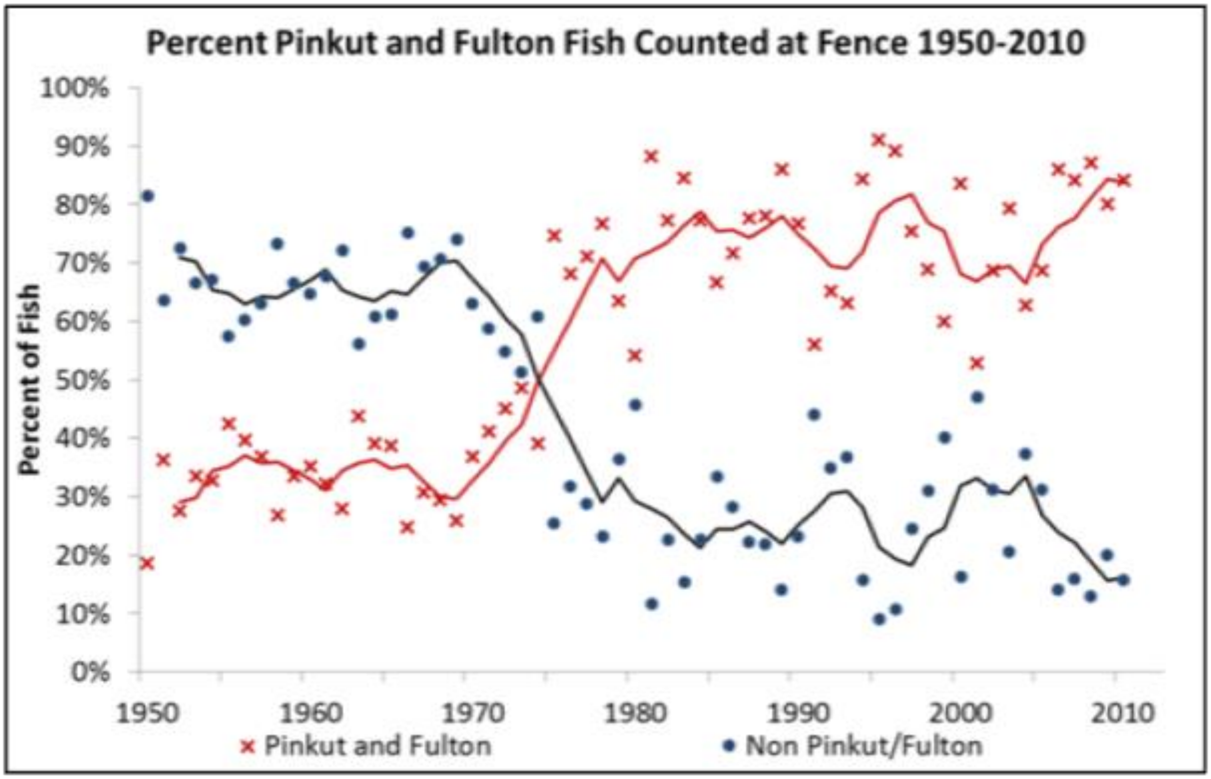


Figure 1. Proportion of Babine Watershed sockeye originating from enhanced versus wild stocks from 1950 to 2010.

3.0 Methods

3.1 Study Area

The Babine Wild Sockeye Habitat Rehabilitation project was conducted within the upper Babine Watershed, which is located northeast of Burns Lake and Smithers, BC at approximately 54°45′N 126°00′W. The Babine Watershed covers about 10,477 km^2 making it the largest drainage in the Skeena (Levy and Hall 1985, Rabnett and Gottesfeld 2002). However, the upper Babine Watershed located upstream of Nilkitkwa River drains approximately 6,584 km^2. The upper Babine Watershed is situated on the Nechako Plateau, which is generally below 1,500 m elevation. The bedrock geology of the Nechako Plateau is comprised of flat or gently dipping Tertiary lava flows that cover older volcanic and sedimentary rocks of the Takla and Hazelton Groups and intrusive rocks of Tertiary age. A series of faults separates the plateau from the uplifted Skeena Mountains. The surficial geology is dominated by widespread glacial activity, leaving glaciolacustrine and glaciofluvial deposits in and around Babine Lake (Levson 2002).

Other than the Morrison system and a few minor streams, the vast majority of streams supporting sockeye spawning and draining into Babine Lake are typically draining the low-relief, forested Nechako Plateau, which is characterized by rolling hills with entrenched stream channels showing major relief. There are few lake headed systems or headwater wetland complexes and thus minor contributions to base flows from water storage. All streams flow through canyon sections, which exhibit anadromous barrier falls before debauching onto the alluvial fan. The alluvial fans are typically unstable due to sediment deposition from upstream sources resulting in periodic avulsions. Sediment transport capacity by streamflow was rated by Suskwa Consulting as moderate to high from the headwaters down onto the fans. Glaciolacustrine sediments developed during deglaciation are predominantly comprised of clays, silts and sand occurring in low-lying regions, particularly up to about 150\m above the present level of Babine Lake. In general, past and current sediment deposition contributes to no connection between the stream and lake due to sub-surface flows in periods of drought and thus impeded access to returning sockeye spawners. This is the nexus of constrained access for sockeye.

This project assessed the watershed on a sub basin scale, with a focus on those streams supporting wild sockeye salmon as shown in Figure 1. Many of the sockeye-bearing tributaries to Babine Lake contain bedrock canyons that transport sediment from upper reaches to the large alluvial fans, where sockeye and other species of Pacific salmon spawn and rear.

The Babine Watershed is in the traditional territory of the Lake Babine Nation as depicted in Figure 2. There are five Lake Babine Nation communities surrounding Babine Lake; Woyenne, Donald's Landing, Tachet, Old Fort and Fort Babine. The Lake Babine Nation Food, Social and Ceremonial (FSC) harvest relies on Babine sockeye. In addition, when returns allow, commercial sockeye harvests occur at the Babine River counting fence and the mouth of the Fulton River.

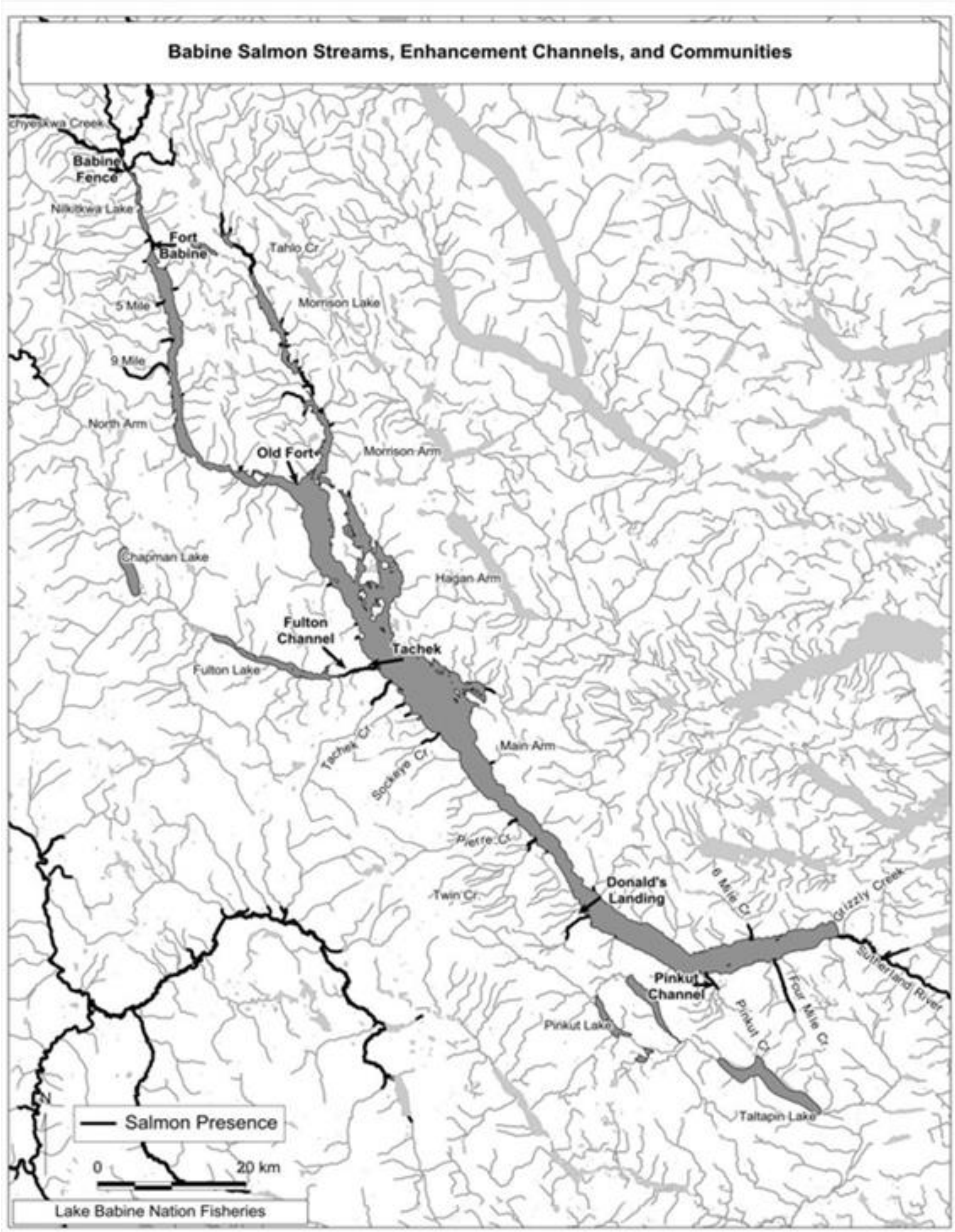


Figure 2. Sockeye Salmon distribution and major spawning tributary locations in the Upper Babine Watershed

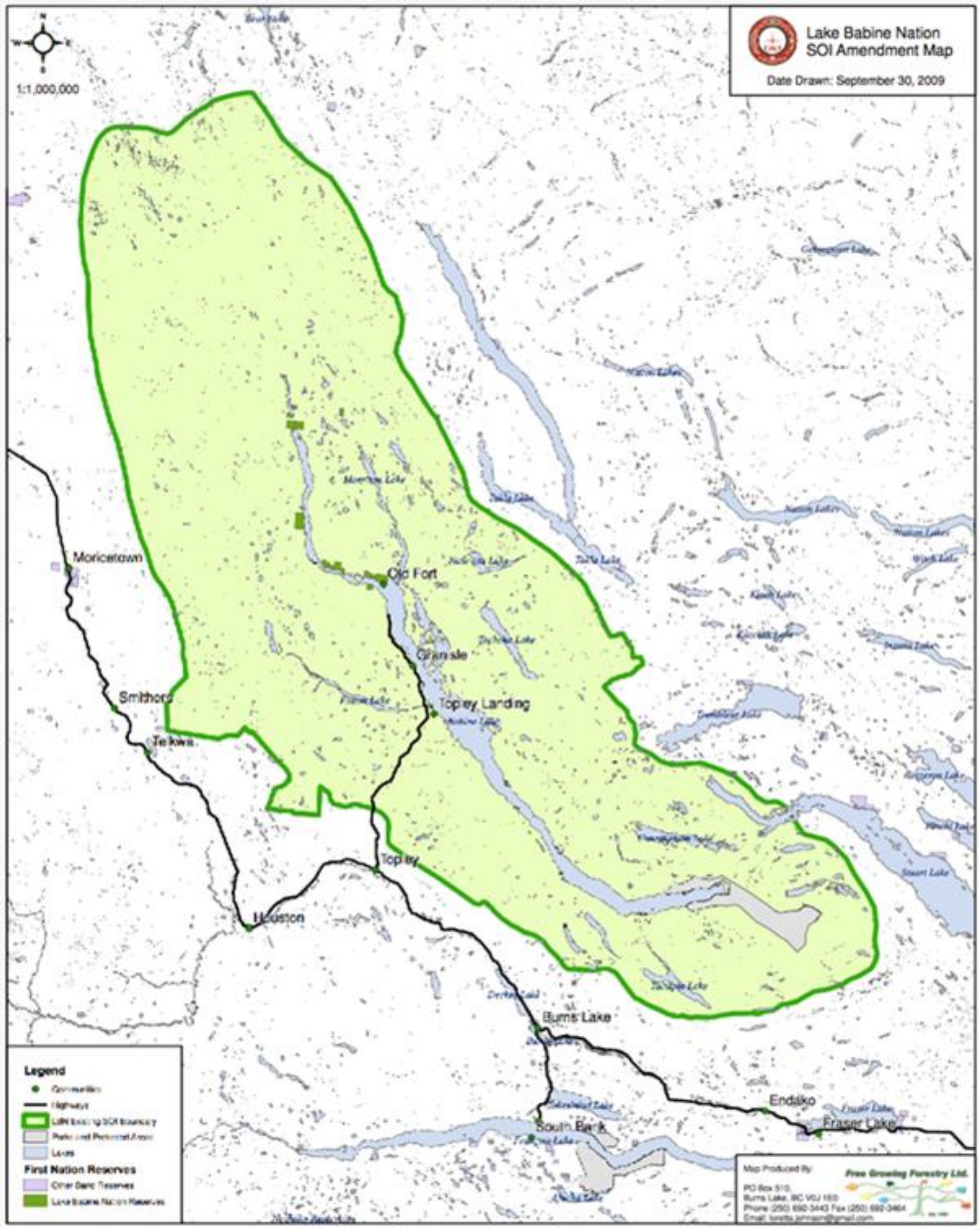


Figure 3. Lake Babine Nation Statement of Intent Boundary.

3.2 Stream Crossing Assessment Protocol

Stream crossings in the mid and upper sections of thirteen sockeye bearing sub-basins were assessed by LBNF biologists and technicians with guidance from Suskwa Research Consulting. Approximately 140 stream crossings were assessed in the Tsezakwa, Nine-mile, Five-mile, Boucher, Morrison, Twain, Cross, Tachek, Six-mile, Bairnsfather, Four-mile, and Sockeye sub basins. This work was conducted with the intention of gaining insight into the issues of sediment accumulation near the creek mouths, the adequacy of stream crossings, water loss due to diversion or blockages, maintenance issues if any, and the degree of compliance regarding provincial and federal fish and fish habitat legislation and regulations.

Stream crossings were selected prior to field work by locating intersections of creeks with roads on 1:20,000 TRIM maps of the area. Different attributes were collected for culverts and bridges. Culverts were assessed using a modified Parker method (Parker 2000). The following data were collected at each culvert:

(1) culvert material;

(2) culvert shape;

(3) culvert embeddedness;

(4) culvert length;

(5) culvert slope;

(6) culvert wetted width;

(7) high water mark;

(8) culvert water depth;

(9) outfall drop;

(10) fill slope depth;

(11) pool depth at outfall.

Wetted width, water depth, bankfull width, bankfull depth, stream gradient, substrate, fish habitat quality and beaver activity above and below each culvert were recorded. Finally, comments on sediment input and required maintenance were recorded. Photographs were taken upstream and downstream at the inlet and outlet, with additional photos being taken at the crews' discretion.

The bridge crossing assessment consisted of recording wetted width, water depth, bankfull width, and bankfull depth below the bridge deck, stream gradient, fish habitat quality, substrate, and observations on sediment input. Photographs were taken upstream, downstream, left, and right below the bridge deck and of the abutments.

Data was input into and analysed in Microsoft Excel. Comments on maintenance and sediment input were used to rank culvert condition; these ranks were then input into a prioritization model to identify a strategic portfolio of high-priority stream crossings that require remediation or replacement. Using the BC MOE standards for barrier determination, culvert passability was assessed. Subsequently, passability and other site attributes were entered into a matrix to prioritize sites for remediation (BC FLNRO et al. 2012, Parker 2000, Rabnett and Wilson 2008). If sites were determined to be ditch or cross drainage structures during their assessment, they were not included in the prioritization matrix.

The prioritization matrix was modified from the matrix used in Parker (2000), based on the information available in the area as shown in Table 1. The attributes assessed for each crossing are as follows: (1) fish habitat value to be gained upstream of the culvert road crossing, subjectively evaluated by the contractor and field crew based on a "complexity of limiting factors"; (2) if the crossing created a barrier; (3) the length of new upstream habitat to be gained if the barrier was removed; (4) the percent of the stream barred if the crossing did create a barrier, and (5) if the crossing was limiting to an upstream barrier; meaning if there was a crossing upstream that had potential to create another barrier.

Table 1. Matrix used to prioritize stream crossings, based on Parker 2000.

Habitat Value		Barrier		Upstream Habitat		% Stream Barred		Limiting to Upstream Barrier	
Observed	10	Barrier	10	≥ 1km	10	>70%	10	Yes	5
Inferred	6	Potential Barrier	6	<1km, ≥ 500m	6	51-70%	6	No	0
Unknown	3	Passable	3	<500m	3	<50%	3		
No	0								

Percent stream barred, as defined in Parker (2000) is the “total map wheel distance of fish-bearing length of main channel on which the culvert lies ÷ the stream length above the barrier” (length of habitat to be gained). Fish species was not included in this investigation given the dated information available on fish species distribution for the Babine Lake watershed tributaries assessed by this investigation.

3.3 Cost Benefit Analysis of Sediment Removal and Management techniques at Four Mile Creek, Six Mile Creek and Sockeye Creek.

It was recommended by Sockeye Rehabilitation Project participants that a cost-benefit analysis of the sockeye habitat rehabilitation projects proposed in 2015, including water (i) augmentation to Tachek Creek and Lower Tahlo Creek; (ii) the installation of log-boom structures to serve as wave breakers at Four Mile Creek and Six Mile Creek; (iii) gravel excavation at Four Mile and Six Mile Creek by excavator and (iv) soft channelization using re-vegetation, 6X6 non-treated timbers or natural, locally available woody debris or logs. The cost-benefit of each technique was qualitatively ranked as high, medium or low based on the cost of the technique relative to average sockeye salmon escapement to the stream the habitat improvement project would affect, and on probability of success. A high benefit-to-cost was ranked as high, a moderate benefit-to-cost was ranked as moderate, and a low benefit-to-cost was ranked as low. Due to a lack of genetic data for wild Babine sockeye populations, the ranking also assumed that there is no genetic difference between the Four Mile Creek and Six Mile Creek populations. If it is later determined that genetic differences do exist between these two populations, and between other populations, the benefit of implementing a given project would increase due to a higher conservation value of each spawning population.

3.4 GIS-based analysis of Potential Land Use Impact on Babine Lake tributary Salmon Habitat .

GIS analysis that utilized provincial data and Wild Salmon Policy habitat pressure and state indicators, conducted an assessment of the extent of land use impact throughout the Babine Lake watershed. The analysis included (i) the number of road-stream crossings and drainage structures; (ii) road density; (ii) riparian disturbance and (iv) overall habitat disturbance in relation to key salmon habitats.

3.5 Unmanned Aerial Vehicle (UAV) Pilot Study/Survey of sockeye spawning habitat in Nine Mile Creek.

A pilot study t Unmanned Aerial Vehicle (drone) survey of sockeye spawning habitat in Nine Mile Creek was conducted to determine the feasibility of using UAV technology for locating water sources that could be used for water augmentation and for assessing sockeye spawning habitat.

3.6 Babine Lake Wild Sockeye Habitat Rehabilitation Workshops

Two workshops, held on May 23, 2017 and June 12, 2017 were held with the following objectives:

1. Gather multi-discipline experts together to present and discuss research and monitoring activities in the Babine watershed that are pertinent to wild Babine sockeye
2. Using information from the multi-discipline experts and from the literature search and summary of state of Babine watershed habitat, facilitate a group discussion to determine current impacts and threats to wild Babine sockeye production and sustainability
3. Discuss gaps in information and requirements for collection of missing information
4. Facilitate discussion regarding developing approaches to restoring wild sockeye recruitment in the Babine system
5. Form partnerships with multi-discipline experts and stakeholders in the Babine watershed, with clearly defined roles and responsibilities, to design and implement small scale habitat rehabilitation projects

4.0 Results

4.1 High Restoration Priority Creeks –Cross Creek

Cross Creek is a second order sockeye-bearing tributary of Babine Lake that enters the lake at Pendleton Bay as shown in Figure 4. The area surrounding Pendleton Bay contains a Provincial Park and a small number of private residences. Cross Creek drains 35 km^2 and possesses excellent quality fish habitat for both anadromous and resident fish (LBNF, personal observations) with an average escapement of 500 sockeye (LBNF, unpublished data).

Cross Creek was identified as the only high priority creek due to the Babine Lake Road, located approximately 550m upstream road crossing blocking upstream passage to adult sockeye spawners as well as kokanee. It is likely that the Babine Lake Road crossing also impedes spawning adults of other species from accessing spawning habitat upstream of the culvert crossing including, but not limited to, coho salmon (*O. kisutch*), bull trout (*Salvelinus confluentus*) and mountain whitefish (*Prosopium williamsoni*) in the fall and adult rainbow trout (*O. mykiss*) and cutthroat trout (*O. clarkii*) during the spring when high freshet flows discharging through the twin culverts may create a velocity barrier to upstream migrating fish species. The Cross Creek culvert crossing would also be a barrier under both low flow and high flow conditions to smaller fish species including juvenile salmonids.

Fish species that have been confirmed in Cross Creek include sockeye, coho, kokanee, rainbow trout and prickly sculpins (*Cottus asper*), which utilize habitats up to an impassable falls located approximately 1.3 km upstream from it's mouth at Babine Lake. There is uncertainty as to whether or not fish, particularly rainbow trout, are found above this waterfall. Hydrology is snowmelt-dominated with headwater lakes and wetlands providing minor to moderate amounts of water storage and discharge. Cross Creek is characterized by several channel types, including a < 1% low-gradient complex channel type from its' mouth to approximately 200m upstream, which includes numerous side channels, excellent substrate, both for spawning and aquatic benthic invertebrate production and wetland/riparian overhead cover. The main channel increases in gradient slightly as it enters a mature conifer stand at which point the channel is highly dynamic, unconfined and braids and forming numerous side channels. The third reach, with a gradient of approximately 2-4%, also within the mature conifer forest and downstream from the road crossing, is defined by a single channel that becomes confined in places and substrate type becomes dominated by cobbles. Cobble remains the dominate substrate up to within a few hundred meters downstream from the water falls. Suitable spawning substrate upstream of the culvert is highly limiting and largely restricted to a few pool tail-outs. However, natural large woody debris inputs or gravel retaining woody structures would increase gravel retention upstream of the road crossing and increase salmonid spawning habitat. Juvenile salmonid rearing habitat is generally good to excellent throughout Cross Creek. Sections of high quality rearing habitat for resident adult salmonids such rainbow trout also occur throughout Cross Creek.

A GIS-based analysis was conducted of the Cross Creek drainage as a portion of the Donald's sub-basin with the results indicating high levels of riparian disturbance, high road density, high total land cover alteration, and a moderate stream crossing density; these indicator results are shown in Table 2.

Table 2. Summary of GIS analysis of the Donald's sub watershed.

Measure	Score
Accessible Stream Length (km)	94.80
Riparian Disturbance (%)	24.76
Road Density (km/km^2)	2.05
Stream Crossing Density (crossings per km^2)	0.27
Total land cover alteration (% of sub watershed effected by anthropogenic disturbances)	39.06

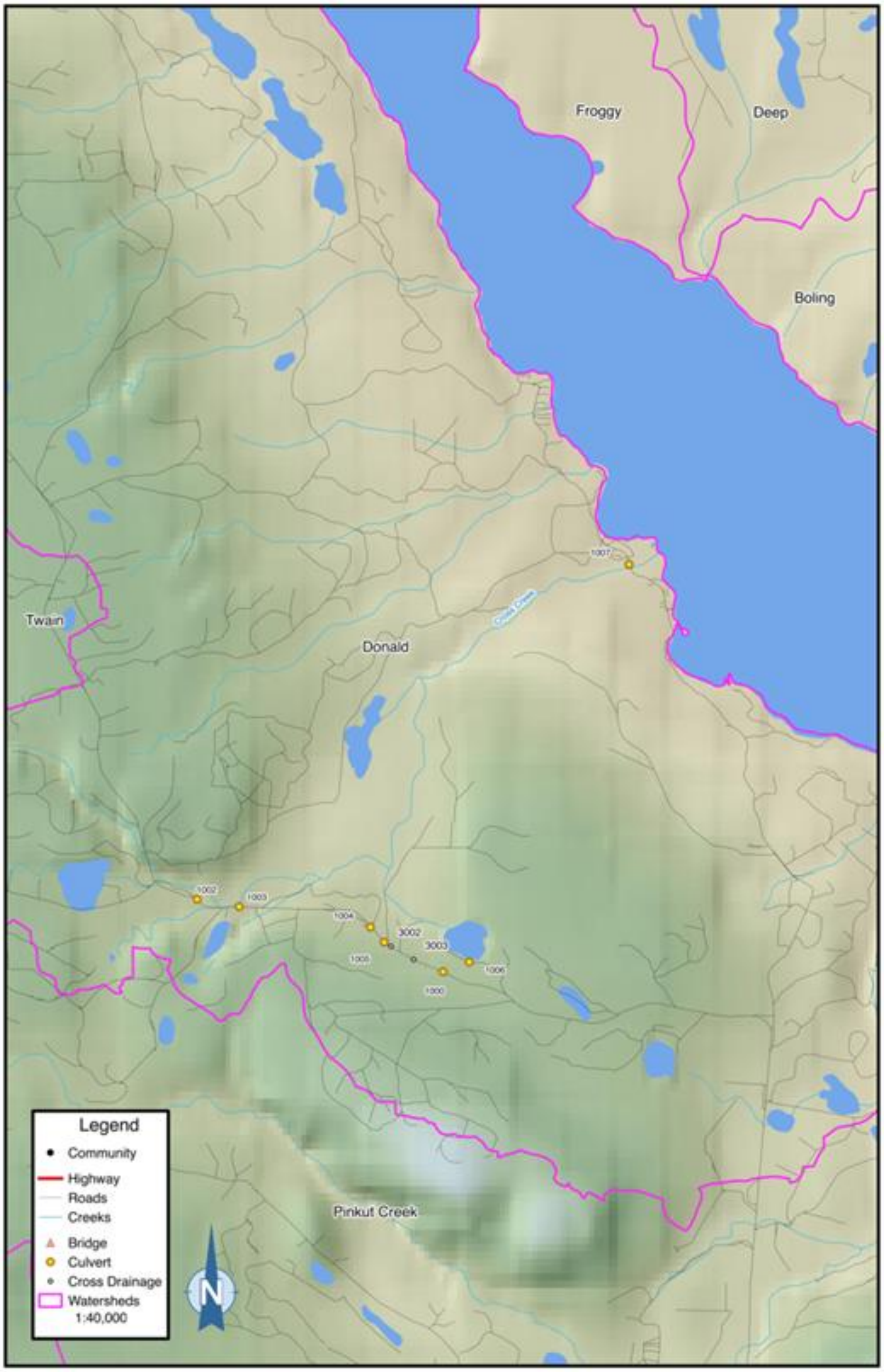


Figure 4. Stream crossings on the Cross Creek system assessed in the late summer and fall of 2016.

Ten stream crossings in the Cross Creek system were assessed. The lower mainstem crossing closest to Babine Lake located at approximately 550m upstream from Babine Lake consists of two larger elliptical culverts within the extent of sockeye spawning and rearing habitat. The majority of the assessed culverts within the Cross Creek system were found to be potential fish barriers using the provincial barrier determination protocol, two of which were assigned high restoration priority. Three of the assessed culverts in this system require maintenance that is unrelated to fish passage. Two crossings are fully or partially blocked and one is getting crushed and failing in the middle of the road as noted in Tables 3 to 5.

Figure 5. View lookng upstream at the outlet and view looking downstream at the inlets of culverts 1007 and 1008 on Cross Creek in September 2016, a high water year.

Culverts 1007 and 1008, which together make up the stream crossing ~550m upstream from Babine Lake, were assigned high restoration priority given their location within the extent of sockeye spawning and rearing habitat and their potential to cause a barrier to fish passage. On the date of the survey, the twin Cross Creek culverts had moderate outfall drops of 12 and 29 cm that have significant consequences to upstream adult and juvenile fish passage (Figure 5, left panel) and both culverts are minimally embedded at the inlet. Upstream of culverts 1007 and 1008, fish habitat was rated good to excellent for approximately 920m up to the impassable falls.

4.2 Moderate Priority Culverts

Stream crossings rated as moderate priority restoration are located upstream of impassable falls. There is confusion as to whether or not resident fish, particularly rainbow trout, are found upstream of these falls. Culvert 1001 was assigned moderate priority due to its large outfall drop shown in Figure 7, lack of embeddedness as depicted in Figure 8, length, and inferred fish habitat.

Figure 6. Looking upstream at the outlet (left panel) and downstream at the inlet of culvert 1001 in September 2016.

Culvert 1002 was assigned moderate restoration priority due to its length and outfall drop, shown in Figure 7, contributing to its potential to act as a barrier to fish passage. This culvert is also located within the extent of inferred fish habitat. In addition, higher levels of sediment were noted at the outlet of this culvert compared to that of the inlet (Figure 7, left panel). It is being crushed in the center allowing sediment to be carried downstream as well as posing a liability issue to traffic and the road prism.

Culvert 1003, Figure 8, was assigned moderate restoration priority because of its location within the extent of inferred fish habitat and its potential to create a barrier to fish passage.

Figure 7. Culvert 1002 looking upstream at the outlet (left panel) and looking upstream at the inlet (right panel). Note the difference in water clarity above and below the stream crossing.

Figure 8. Culvert 1003 looking downstream at the inlet (left panel) and looking upstream at the outlet (right panel).

Table 3. Cross Creek culvert 1000 stream crossing assessment.

Stream crossing codes, type and date visited	1000, Culvert, 26/09/16
Sub-basin and stream name	Cross Creek, unknown
Road System	Augier Main – R16857 07
Culvert type and size (mm)	CMP, 500
UTM (Zone, Northing, Easting)	10U 6039156 322277
Fish Presence, species	
Fish Habitat	No fish habitat
Crossing Responsibility	
Maintenance issue	Lower culvert buried at outlet
Recommendations	Excavate outlet where seepage is occurring.

(1-2) Both culverts at inlet, (3) Outlet upstream. Note: only one culvert is visible, (4) Outlet downstream

Table 4. Cross Creek culvert 1002 stream crossing assessment.

Stream crossing codes, type and date visited	1002, Culvert, 26/09/16
Sub-basin and stream name	Cross Creek, unknown
Road System	Augier Main - R16857 07
Culvert type and size (mm)	CMP, 1200
UTM (Zone, Northing, Easting)	10U 6040182 319255
Fish Presence, species	
Fish Habitat	Fish habitat – inferred
Crossing Responsibility	
Maintenance issue	Pipe crushed in center
Recommendations	Revisit site to assess necessity of replacement

(1) Inlet Downstream

(2) Inlet Upstream

(3) Outlet Downstream

(4) Outlet Upstream

Table 5. Cross Creek culvert 1004 stream crossing assessment.

Stream crossing codes, type and date visited	1004, Culvert, 26/09/16
Sub-basin and stream name	Cross Creek, unknown
Road System	Augier Main - R16857 07
Culvert type and size (mm)	CMP, 450
UTM (Zone, Northing, Easting)	10U 6939747 321396
Fish Presence, species	
Fish Habitat	Fish habitat - inferred
Crossing Responsibility	
Maintenance issue	Outlet buried
Recommendations	


(1) Inlet Downstream


(2) Outlet downstream

4.2.1 Twain Creek

Twain Creek flows into the southwest side of Babine Lake adjacent to the Augier Barge Landing and drains 13,890 hectares (Bellehumeur 1998) as shown in Figure 10. Between 2010 and 2016, the average annual sockeye escapement to this tributary was 6,143, which is lower than the average of 8,381 sockeye in the previous decade (LBNF, unpublished data), this is more than a 25% decadal decrease. In addition to sockeye salmon, rainbow trout, kokanee, prickly sculpins, and coho salmon have been observed in this tributary (FINS Consulting, 2000).

The 1998 Watershed Restoration Program (WRP) assessment noted that there were large sections of unstable soils surrounding Twain Creek (Bellehumeur 1998). These three main sediment producing slides located just downstream of the Twain Forest Service Road contribute large amounts of sediment to the alluvial fan reach. Figures 15 to 18 show the three slides, which are caused by erosion of the slope toe. The Twain Creek mainstem channel experiences periodic avulsions due to periodic landslides. The most notable recent avulsions occurred in 2005 and 2007. The 2005 avulsion resulted in channel movement in the lowest reach upstream of Babine Lake, with the creek mouth shifting to the north (LBN 2005, Figure 9). In 2007, three landslides occurred in the upper reaches of Twain Creek.

Figure 9. New mouth of Twain Creek created by a large avulsion in 2005.

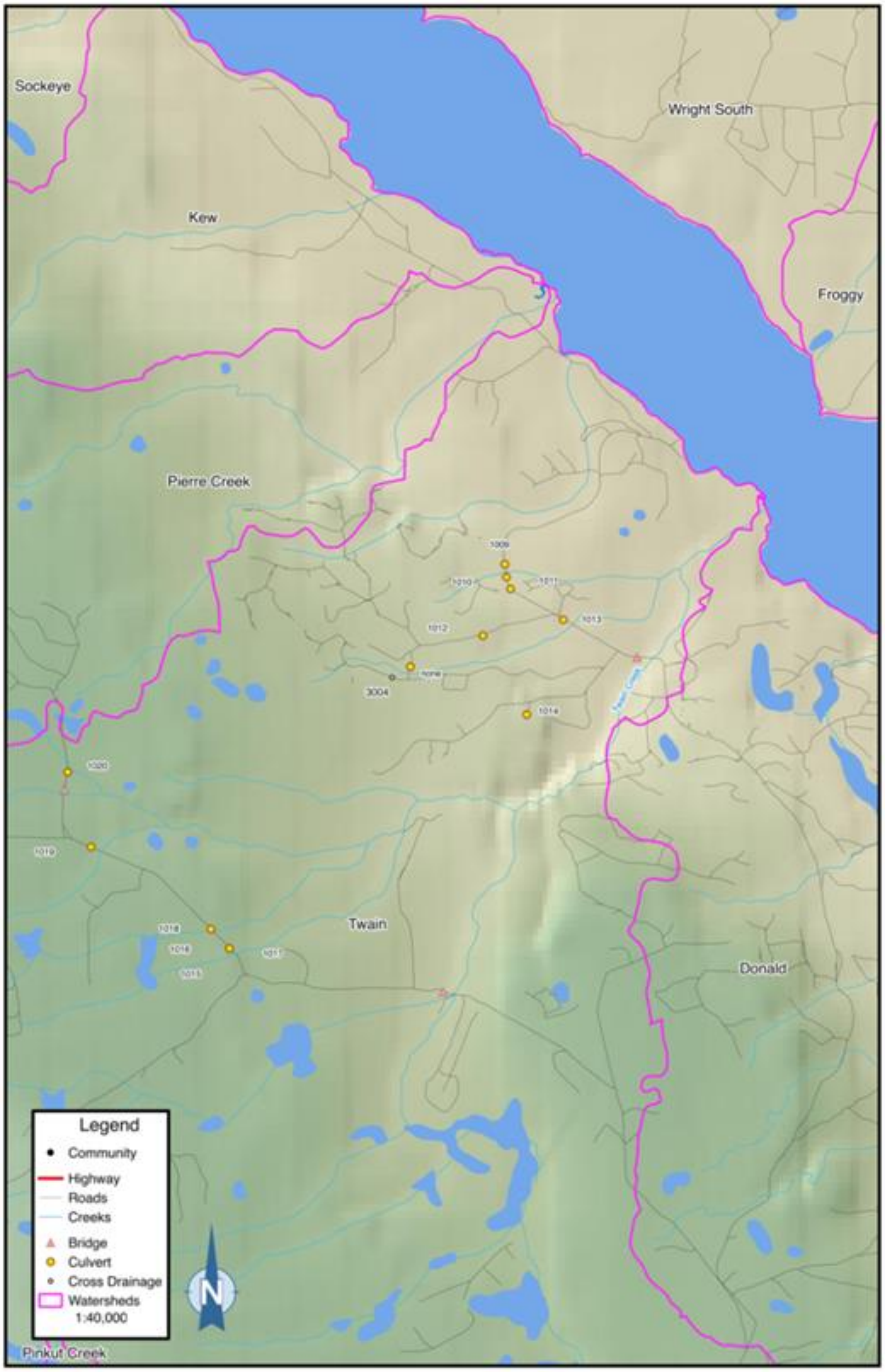


Figure 10. Stream crossings assessed in the Twain Creek watershed in 2016.

Figure 11. Actively eroding banks on Twain Creek where periodic landslides occur. Slide 1 looking upstream (top left panel) and looking downstream (top right panel) is the uppermost and largest slide. Slide 2 is illustrated in the (lower left panel. Slide 3, situated about 300m downstream of Slide 2, is shown in the bottom right panel.

4.2.1.1 Twain Creek GIS Analysis

The GIS-based analysis was conducted for the Twain Creek sub-basin. Results indicated moderate riparian disturbance, moderate road density, and moderate total land cover alteration with a low stream crossing density as shown in Table 6.

Table 6. Twain Creek sub-basin GIS analysis results.

Measure	Score
Accessible Stream Length (km)	6.47%
Riparian Disturbance (%)	10.70%
Road Density (km/km^2)	0.90
Stream Crossing Density (crossings per km^2)	0.04
Human Development Footprint (% of sub watershed effected by anthropogenic disturbances)	18.97%

4.2.1.2 Twain Creek Stream Crossing Assessments

Fifteen stream crossings structures – all culverts - in the Twain Creek sub-basin were assessed. One high priority crossing was identified, while the remaining 14 were categorized as low priority due to the lack of fish habitat in the upper reaches. However, five of the low priority culverts require maintenance as shown in Tables 7-11 below. In addition, sediment production and input from roads and ditches into streams is prevalent and relates to the lack of effort or understanding regarding water quality and high fisheries values. Sediment issues occur at seven sites rated as moderate and one site with high sediment inputs.

The Twain Creek sub-basin has one culvert categorized as high priority for remediation. Culvert 1013 was designated as a barrier to fish passage shown in Figure 12 below. Fish presence at this culvert is inferred and frogs were observed in the downstream pool where water was observed to be collecting at the inlet of the culvert.

Figure 12. Culvert 1013 looking downstream at the inlet (left panel) and upstream looking towards the inlet (right panel).

Table 7. Twain Creek system culvert 1014 stream crossing assessment.

Stream crossing codes, type and date visited	1014, Culvert, 22/09/16
Sub-basin and stream name	Twain, unknown
Road System	R10010 51
Culvert type and size (mm)	CMP, 500
UTM (Zone, Northing, Easting)	10U 6052426 315405
Fish Presence, species	
Fish Habitat	unknown
Crossing Responsibility	
Maintenance issue	Outlet buried, deactivated road. At time of inspection no flow in pipe, stream bed dry but appears to be diverted away from pipe.
Recommendations	Pipe is not functioning and could be removed, as road is deactivated.


(1) Inlet Upstream


(2) Inlet Downstream


(3) Though culvert (note no light)


(4) Inlet Downstream

Table 8. Twain Creek system culvert 1017 stream crossing assessment

Stream crossing codes, type and date visited	1017, Culvert, 23/09/16
Sub-basin and stream name	Twain Creek, unknown
Road System	R16857 14
Culvert type and size (mm)	CMP, 500
UTM (Zone, Northing, Easting)	10U 6049692 311586
Fish Presence, species	
Fish Habitat	No fish habitat
Crossing Responsibility	
Maintenance issue	One of three culverts. Pool at outlet is not connected to outlet of other culverts.
Recommendations	Excavate barrier to connect outflow of all culverts.

(1) Outlet (isolated pool)

(2) Outlet of other culverts

(3) Inlet Downstream (all culverts)

(4) Outlet Upstream

Table 9. Twain Creek system culvert 1018 stream crossing assessment

Stream crossing codes, type and date visited	1018, Culvert, 23/09/16
Sub-basin and stream name	Twain Creek, unknown
Road System	R16857 14
Culvert type and size (mm)	CMP, 550
UTM (Zone, Northing, Easting)	10U 6049940 311365
Fish Presence, species	
Fish Habitat	
Crossing Responsibility	
Maintenance issue	Outlet crushed, culvert offset from stream channel.
Recommendations	Revisit site to assess culvert placement. Mend outlet.




(1-2) Culvert outlet from both sides

(3-4) Culvert Inlet

Table 10. Twain Creek system culvert 1021 stream crossing assessment

Stream crossing codes, type and date visited	1021, Culvert, 23/09/16
Sub-basin and stream name	Twain Creek, unknown
Road System	WES1969 – R10010 726
Culvert type and size (mm)	CMP, 600
UTM (Zone, Northing, Easting)	10U 6050482 308414
Fish Presence, species	
Fish Habitat	No fish habitat
Crossing Responsibility	
Maintenance issue	Outlet slightly crushed
Recommendations	Mend outlet




(1-2) Outlet from the side and facing upstream. Note damage.

(3) Downstream and (4) upstream at the inlet.

Table 11. Twain Creek system culvert 3005 stream crossing assessment

Stream crossing codes, type and date visited	3005, ditch drainage culvert, 23/09/16
Sub-basin and stream name	Twain Creek
Road System	Wes1969-R10010 726
Culvert type and size (mm)	Plastic, 450
UTM (Zone, Northing, Easting)	10U 6050654 308293
Fish Presence, species	
Fish Habitat	
Crossing Responsibility	
Maintenance issue	Water pooled at inlet could not drain through culvert at time of assessment.
Recommendations	Revisit site to assess feasibility and effectiveness of further embedding the pipe.

(1) Downstream at the inlet and (2) the outlet.

4.2.2 Pierre Creek and Kew Creek

Pierre Creek and Kew Creek are located north of Twain Creek on the west side of Babine Lake. Between 2010 and 2016, Pierre Creek had an annual escapement average of 17,333 sockeye (LBNF, unpublished data). Kew Creek has a smaller annual return and is not regularly counted by Lake Babine Nation Fisheries crews. Both creeks were inaccessible by vehicle and foot as the road systems to the culvert crossing sites had been deactivated; therefore, the lower crossings were assessed by helicopter. In both cases, the crossings appeared to have little effect on the current paths of the creeks as evidenced in Figures 13 and 14.

Figure 13. View downstream to mouth of Kew Creek; deactivated road seen on right side of picture appeared to have little influence on the creek.

Figure 14. A deactivated road crossing on Pierre Creek near it's confluence with Babine Lake.

Pierre Creek sub-basin watershed has few development activities and all indicators are at or below the low thresholds as shown in Table 12. GIS analysis for Kew Creek showed that a moderate threshold had been reached for all indicators as shown in Table 12

Table 12. Pierre Creek sub-basin of GIS analysis summary.

Measure	Score
Accessible Stream Length (km)	57.78%
Riparian Disturbance (%)	1.78%
Road Density (km/km^2)	0.21
Stream Crossing Density (crossings per km^2)	0.18
Human Development Footprint (% of sub watershed effected by anthropogenic disturbances)	3.63%

Table 13. Summary of GIS analysis of the Kew Creek sub watershed.

Measure	Score
Accessible Stream Length (km)	22.83%
Riparian Disturbance (%)	14.32%
Road Density (km/km^2)	0.53
Stream Crossing Density (crossings per km^2)	0.25
Human Development Footprint (% of sub watershed effected by anthropogenic disturbances)	14.15%

4.2.3 Five-Mile Creek

Five-Mile Creek is a 10.3 km in length stream located on the west side of Babine Lake's North Arm with an annual average escapement of 207 sockeye between 2010 and 2016 (LBNF, unpublished data). This is about a quarter of the escapement in the previous decade, during which the creek had an annual average sockeye escapement of 867 (LBNF, unpublished data). In addition to sockeye, Five-Mile Creek supports Dolly Varden char (*Salvelinus malma*) and rainbow trout (Triton, 1999). Five-Mile Creek was designated as a BC Fisheries Sensitive Watershed in December 2005 (MOE, 2005). GIS analysis of the Five-Mile sub-basin found that riparian disturbance, road density, stream crossing density, and the human development footprint had reached a moderate threshold as shown in Table 14.

Table 14. Five-Mile Creek sub watershed GIS analysis summary.

Measure	Score
Accessible Stream Length (km)	76.41%
Riparian Disturbance (%)	7.05%
Road Density (km/km^2)	1.00
Stream Crossing Density (crossings per km^2)	0.51
Human Development Footprint (% of sub watershed effected by anthropogenic disturbances)	12.80%

4.2.3.1 Five Mile Creek Stream Crossing Assessments

The four culverts that were assessed within the Five-Mile sub-basin were listed as requiring high priority action. The stream crossing assessment locations are shown in Figure 16. Fish presence has been observed at all four sites. Two of the four culverts, 1093 and 1094, make up the major 4000 Road crossing (Nilkitkwa FSR) of the creek's mainstem, and were both determined to be passable by fish. Regular maintenance needs to be performed on these culverts as they had accumulated large amounts of debris at the time of assessment, which was observed to be restricting flow as noted in Tables 15 and 16. Culverts 1024 and 1025, located just upstream of the 4000 Road crossing, also form one crossing as depicted in Figure 15. Both culverts are perched, contributing to the potential for a fish barrier in this area of observed fish presence.

Figure 15. Culverts 1024 and 1025 looking downstream towards the inlets (left panel) and upstream towards the outlets (right panel).

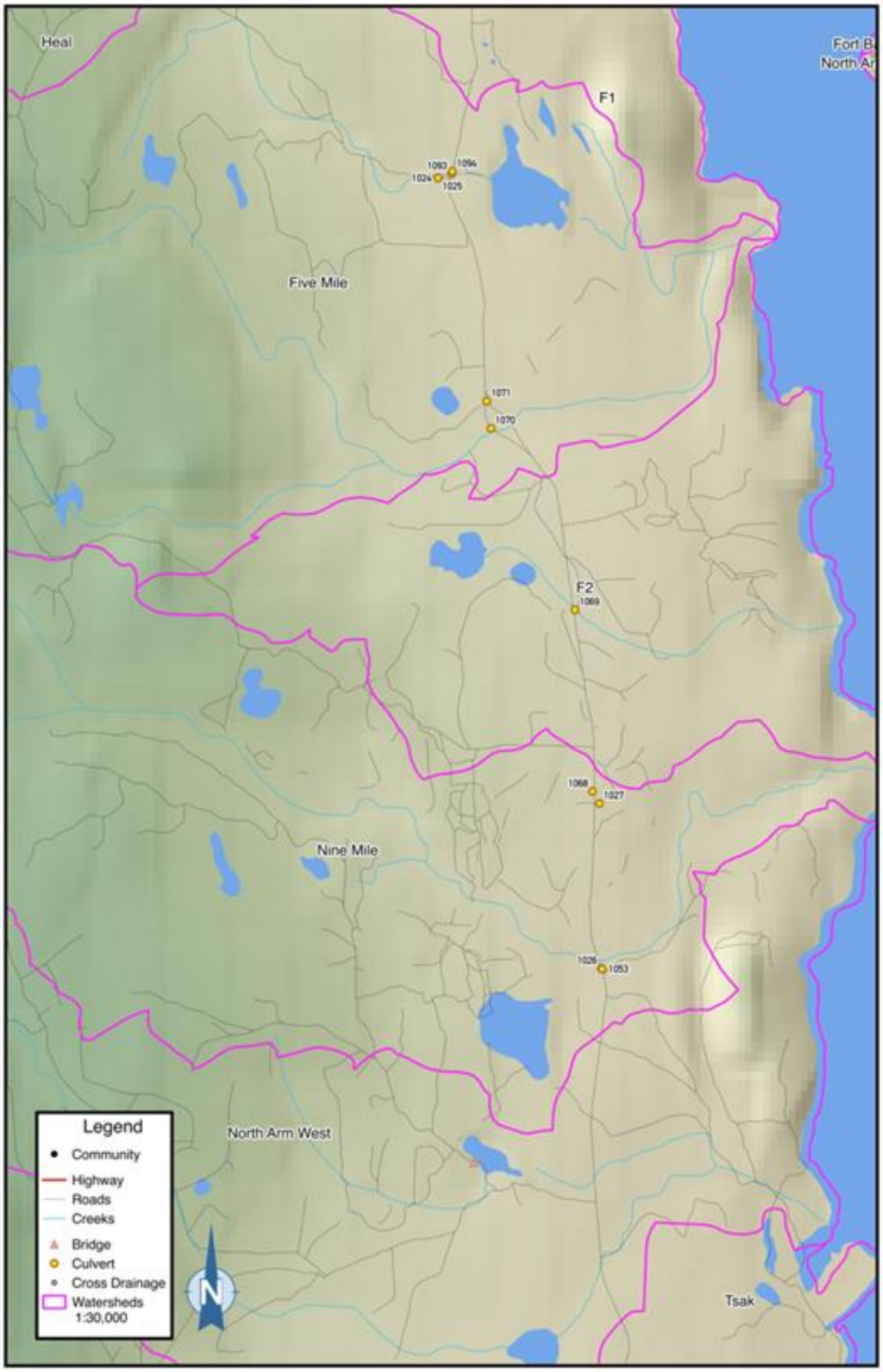


Figure 16. Stream crossings assessed in the Five-Mile and Nine-Mile Creek sub-watersheds.

Table 15. Five-Mile Creek system, culvert 1093 assessment.

Stream crossing codes, type and date visited	1093, Culvert, 12/10/16
Sub-basin and stream name	5-Mile Creek
Road System	Nilkitkwa FSR (4000 Rd)
Culvert type and size (mm)	CMP, 1100
UTM (Zone, Northing, Easting)	9U 6126360 649443
Fish Presence, species	
Fish Habitat	Fish habitat – observed
Crossing Responsibility	
Maintenance issue	Large amount of debris built up at inlet. Fence broken.
Recommendations	*Revisit site to assess possibilities for debris management and prescribe management actions.*


(1) Downstream and (2) upstream at the inlet.


(3) Upstream and (4) downstream at the outlet.

* *Culverts 1093 and 1094 both drain 5-mile Creek, an alternate crossing should be assessed for this location.*

Table 16. Five-Mile Creek system, culvert 1094 assessment.

Stream crossing codes, type and date visited	1094, Culvert, 12/10/16
Sub-basin and stream name	5-Mile Creek
Road System	Nilkitkwa FSR (4000 Rd)
Culvert type and size (mm)	CMP, 1100
UTM (Zone, Northing, Easting)	9U 6126383 649449
Fish Presence, species	
Fish Habitat	Fish habitat – observed
Crossing Responsibility	
Maintenance issue	Inlet blocked and slightly damaged, little to no water flow within culvert.
Recommendations	Revisit site to assess possibilities for debris management and prescribe management actions.




(1) Upstream and (2) downstream at the inlet. (3) Upstream and (4) downstream at the outlet.

** Culverts 1093 and 1094 both drain 5-mile Creek, an alternate crossing should be assessed for this location.*

4.2.4 Nine-Mile Creek

Nine-Mile Creek, 23.2km in length, located on the west side of the North Arm of Babine Lake, is a sockeye bearing tributary as shown in Figure 16. The annual sockeye escapement over the past decade averaged 1,152 spawners (LBNF, unpublished data). Sockeye spawn in the lower 2200m reach with their upstream migration blocked by an impassable waterfall. Logging has continued to occur in the mid and upper portions of the watershed with impacts being reflected in the GIS analysis results. High thresholds have been reached in the Nine-Mile Creek sub-basin for the riparian disturbance, road density, and human development footprint indicators; however, the stream crossing density indicator remains low as shown by Table 17. Remediation action needs to be considered.

Table 17. Nine-Mile Creek sub-basin GIS analysis summary.

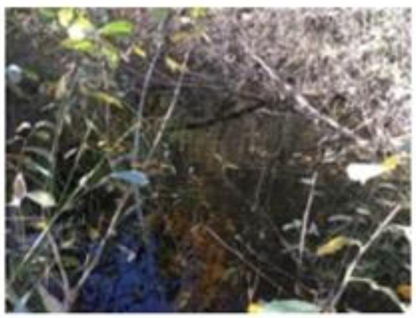
Measure	Score
Accessible Stream Length (km)	25.75%
Riparian Disturbance (%)	15.66%
Road Density (km/km^2)	1.32
Stream Crossing Density (crossings per km^2)	0.12
Human Development Footprint (% of sub watershed effected by anthropogenic disturbances)	24.18%

4.2.4.1 Nine Mile Stream Crossing Assessments

Three culverts in the Nine-Mile sub-basin were assessed in the field; however, two were rated as low priority, and the third, culvert 1027, was rated as medium priority for remediation (Table 18).

Table 18. Nine-Mile Creek, culvert 1027 stream crossing assessment results.

Stream crossing codes, type and date visited	1027, Culvert, 20/09/16
Sub-basin and stream name	9-Mile Creek, unknown
Road System	Nilkitkwa Forest Service Road (4000 Rd)
Culvert type and size (mm)	CMP, 450
UTM (Zone, Northing, Easting)	9U 6120577 651075
Fish Presence, species	
Fish Habitat	unknown
Crossing Responsibility	
Maintenance issue	Vegetation growing at inlet.
Recommendations	Remove vegetation that is blocking water flow.




(1) Upstream and (2) downstream at the inlet

(3) Upstream and (4) downstream at the outlet

4.2.5 Tsezakwa Creek

Tsezakwa Creek drains into the Nilkitkwa Lake south basin and extends 21km upstream to Suskwa Pass. This allows Skeena-based weather systems to drop relatively heavier precipitation and, as a result, Tsezakwa Creeks tends to flood after heavy rainfall events. Many eroding bank slopes contribute to relatively large sediment transport to the alluvial fan where Tsezakwa Creek confluences with the Babine River. The alluvial fan provides good to very good spawning habitat for sockeye salmon. Other fish species that occur in Tsezakwa Creek include Chinook (*O.tshawytscha*), coho and pink salmon (*O. gorbuscha*) Dolly Varden char, rainbow trout/steelhead and cutthroat trout. The annual average sockeye escapement between 2010 and 2016 was 1,573 fish (LBNF, unpublished data).

Figure 17. Stream crossings assessed in the Tsezakwa Creek sub-watershed.

The Tsezakwa Creek sub-basin GIS analysis results indicate there are moderate levels of riparian disturbance, road density and human development footprint, and a low level of stream crossing density as shown in Table 19.

Table 19. Summary of GIS analysis of the Tsezakwa Creek sub watershed.

Measure	Score
Accessible Stream Length (km)	8.33%
Riparian Disturbance (%)	7.94%
Road Density (km/km^2)	0.45
Stream Crossing Density (crossings per km^2)	0.04
Human Development Footprint (% of sub watershed effected by anthropogenic disturbances)	10.24%

4.2.5.1 Tsezakwa Stream Crossing Assessments

Eight culverts within the Tsezakwa Creek sub-watershed were field-assessed and included in the prioritization matrix. One culvert, 1029, was designated high priority; five crossings were designated medium, and two crossings were rated as low priority. Culverts 1031, 1033, 1034, and 1035 were identified as needing maintenance attention (Tables 20 to 23). Two of these culverts were wooden box culverts that had been left on deactivated roads, which suggests that other deactivated roads in the area should be examined for deteriorating road crossings that have the potential to obstruct stream flow or contribute sediment.

Culvert 1029 was designated high priority based on its potential to create a barrier and its inferred fish habitat as shown Figure 18. The stream crossings assessed on the ground make up a very small proportion of the total number of stream crossings. Stream crossings in the upper watershed were assessed via helicopter. Stream crossings along the north side and in a cutblock on the south side of Tsezakwa Creek were assessed, and appeared to be functional with the exception of two stream crossings that showed water pooling on the road as depicted in Figure 19.

Figure 18. Culvert 1029 Looking downstream towards the inlet (left panel) and looking upstream to the outlet (right panel).

Figure 19. Stream crossings on north side of Tsezakwa Creek with water pooling on road.

Table 20. Tsezakwa Creek, culvert 1031 stream crossing assessment results.

Stream crossing codes, type and date visited	1031, Culvert, 20/09/16
Sub-basin and stream name	Tsezakwa Creek, unknown
Road System	Road down to lake at 44.5
Culvert type and size (mm)	CMP, 300
UTM (Zone, Northing, Easting)	9U 6134556 648288
Fish Presence, species	
Fish Habitat	Fish habitat - inferred
Crossing Responsibility	
Maintenance issue	Inlet buried. Water pooling upstream.
Recommendations	Excavate inlet.

(1 and 2) Pooled water above road crossing. (3) Upstream and (4) downstream at the outlet.

Table 21. Tsezakwa Creek, culvert 1033 stream crossing assessment results.

Stream crossing codes, type and date visited	1033, Culvert, 20/09/16
Sub-basin and stream name	Tsezakwa Creek, unknown
Road System	Road down to lake at about 44.5?
Culvert type and size (mm)	CMP, 500
UTM (Zone, Northing, Easting)	9U 6133647 648493
Fish Presence, species	
Fish Habitat	Fish habitat inferred
Crossing Responsibility	
Maintenance issue	Some vegetation and debris in culvert
Recommendations	




(1) Upstream and (2) downstream at the inlet

(3) Upstream and (4) downstream at the outlet

Table 22. Tsezakwa Creek, culvert 1034 stream crossing assessment results.

Stream crossing codes, type and date visited	1034, Culvert, 20/09/16
Sub-basin and stream name	Tsezakwa creek, unknown
Road System	441-1.5, R09511 441-1.5
Culvert type and size (mm)	Wood box, 350x500
UTM (Zone, Northing, Easting)	9U 6131658 646712
Fish Presence, species	
Fish Habitat	No fish habitat
Crossing Responsibility	
Maintenance issue	Wooden box culvert deteriorating. Culvert inflow blocked by woody debris. Road deactivated.
Recommendations	Remove culvert

(1) Downstream at the (1) inlet and (2) outlet. Note debris and collapsed logs at inlet. (3) Inside culvert, (4) Alongside of culvert. Note water leaking out of edges.

Table 23. Tsezakwa Creek, culvert 1035 stream crossing assessment results.

Stream crossing codes, type and date visited	1035, Culvert, 20/09/16
Sub-basin and stream name	Tzesakwa Creek, unknown
Road System	
Culvert type and size (mm)	Wood box, 450x680
UTM (Zone, Northing, Easting)	9U 6131658 646712
Fish Presence, species	
Fish Habitat	Fish habitat – inferred
Crossing Responsibility	
Maintenance issue	Wooden box culvert deteriorating. Culvert inflow blocked by woody debris. Road deactivated.
Recommendations	Remove culvert.

(1) Upstream and (2) downstream at the inlet.

(3) Upstream and (4) downstream at the outlet.

4.2.6 Tachek Creek

Tachek Creek drains into west side of Babine Lake south of Topley Landing and the Lake Babine Nation Tachet Reserve as shown in Figure 20. The average annual sockeye escapement between 2010 and 2016 was 3,035 (LBNF, unpublished data). Tachek Creek supports coho, kokanee, rainbow trout, and prickly sculpin upstream to the impassable falls. Upstream of the falls, a resident population of rainbow trout are also supported. A relatively large number of naturally occurring streambank failures contribute to lateral instability and sediment accumulation on the alluvial fan. The fan sediment deposition contributes to drying of the surface flows, which impedes sockeye access to upstream spawning areas. Reconnaissance focused on potential groundwater augmentation was conducted on the Tachek Creek alluvial fan in 2015, but no suitable sites were located.

The Tachek Creek sub-basin GIS analysis results determined low levels of riparian disturbance and overall human development and moderate levels of road density and stream crossing density as shown in Table 24 below.

Table 24. Summary of GIS analysis of the Tachek Creek sub watershed.

Measure	Score
Accessible Stream Length (km)	67.81%
Riparian Disturbance (%)	1.93%
Road Density (km/km^2)	0.74
Stream Crossing Density (crossings per km^2)	0.35
Human Development Footprint (% of sub watershed effected by anthropogenic disturbances)	5.03%

4.2.6.1 Tachek Creek Stream Crossing Assessments

Five stream crossings were assessed in the Tachek Creek sub basin (Figure 20) and two in the adjacent Port Arthur Creek drainage (1036 and 1037). Two of these crossings, 1037 and 1041, were determined to be high priority, four were determined to be of medium priority and three of low priority (Figures 21 and 22). Culvert 1037 showed an outfall drop of 30 cm and unidentified fry were observed in the outlet pool. Culverts 1036 and 1038 require further assessment and maintenance as noted in Tables 25 and 26.

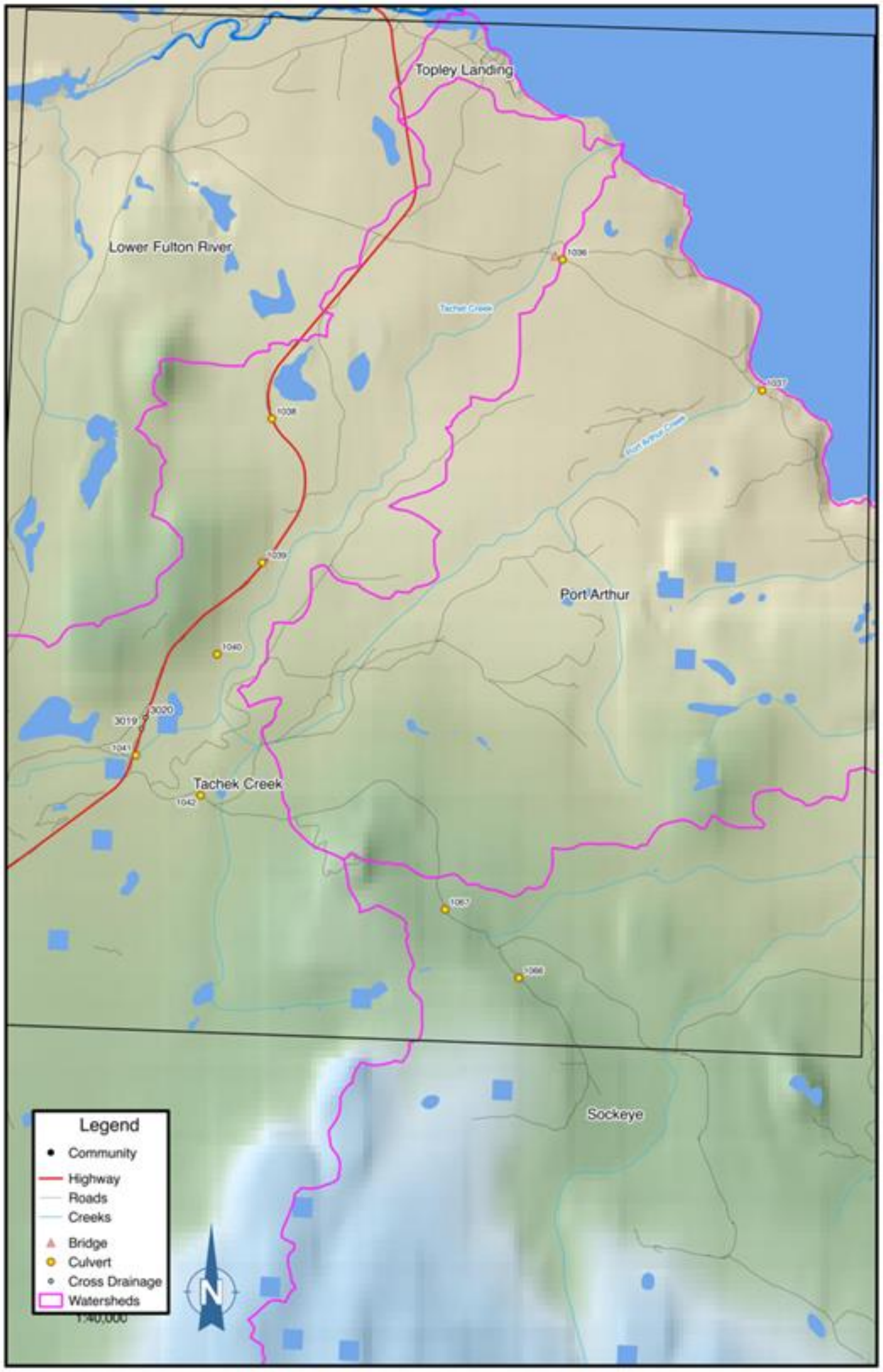


Figure 20. Stream crossings assessed in the Tachek and Sockeye sub-basins.

Figure 21. Port Arthur Creek Culvert 1037 looking downstream towards the inlet (left panel) and looking upstream to the outlet (right panel).

Figure 22. Tachek Creek mainstem culvert 1041, Granisle Highway crossing looking downstream at the inlet (left panel) and looking upstream into the outlet.

Table 25. Tachek Creek, culvert 1036 stream crossing assessment results.

Stream crossing codes, type and date visited	1036, culvert, 23/08/16
Sub-basin and stream name	Tachek Creek, unknown
Road System	
Culvert type and size (mm)	CMP, 900
UTM (Zone, Northing, Easting)	9U 6074842 684731
Fish Presence, species	
Fish Habitat	Fish habitat – inferred
Crossing Responsibility	
Maintenance issue	Rise out of outlet.
Recommendations	Revisit site at higher flow, assess impact of outlet rise.


(1) Upstream and (2) downstream at the inlet.


(3) Upstream and (4) downstream at the outlet.

Table 26. Tachek Creek, culvert 1038 stream crossing assessment results.

Stream crossing codes, type and date visited	1038, culvert, 23/08/16
Sub-basin and stream name	Tachek Creek, unknown
Road System	Granisle Highway (HWY 118)
Culvert type and size (mm)	CMP
UTM (Zone, Northing, Easting)	9U 6072718 681193
Fish Presence, species	
Fish Habitat	Fish habitat – inferred
Crossing Responsibility	
Maintenance issue	Water pooled about 9m upstream of culvert inlet.
Recommendations	Excavate 9.25m (0.75m depth) to connect pooled water to culvert inlet.



(1) Pool above inlet, note the disconnect. (2) Downstream at the inlet. (3) Culvert outlet.

4.2.7 Sockeye Creek

The Sockeye Creek is directly south of the Tachek Creek sub-basin (Figure 31). Sockeye creek has had an annual average sockeye escapement of 2,900 over the past 5 years (LBNF, unpublished data). However, this creek has dried up within 1km of the mouth at least twice in the recent past. In 2014, the creek channel was dry at 350 m prior to the arrival of the sockeye spawners, and in 2002 the creek dried up at 800 m from the mouth. During an overflight in October 2016, new logging activities were observed in the upper watershed of Sockeye Creek.

The GIS analysis of the Sockeye Creek sub-basin was found to have medium to low risk threshold for all indicators except road density, which had a moderate risk level (Table 27). The new logging activities observed in 2016 may increase levels of riparian disturbance, road and stream crossing density, and human development footprint.

Table 27. Sockeye Creek sub-basin GIS analysis results.

Measure	Score
Accessible Stream Length (km)	20.92%
Riparian Disturbance (%)	3.01%
Road Density (km/km^2)	0.33
Stream Crossing Density (crossings per km^2)	0.12
Human Development Footprint (% of sub watershed effected by anthropogenic disturbances)	4.70%

4.2.7.1 Sockeye Creek Stream Crossing Assessments

Two culverts field-assessed in the Sockeye Creek watershed were found to be low priority. It is recommended that stream crossings in this sub basin are revisited in summer, as snow cover made assessment and access difficult. The road was waterlogged at culvert 3010 and should be re-assessed with no snow cover (Table 28). Further stream crossings on Sockeye Creek were assessed via helicopter in October 2016. Nine additional crossings were assessed this way, and appeared to be functioning well.

Table 28. Sockeye Creek, culvert 3010 stream crossing assessment results.

Stream crossing codes, type and date visited	3010, ditch drainage culvert, 20/09/16
Sub-basin and stream name	Sockeye Creek
Road System	TOPLEY - R11213 7
Culvert type and size (mm)	CMP, 400
UTM (Zone, Northing, Easting)	9U 6064310 686994
Fish Presence, species	
Fish Habitat	No fish habitat
Crossing Responsibility	
Maintenance issue	Road surrounding culvert waterlogged for about 100m on either side.
Recommendations	Revisit site when snow melts to assess culvert effectiveness and placement.

(1) Downstream at inlet and (2) upstream at outlet

4.2.8 Boucher Creek

Boucher Creek joins the north end of Nilkitkwa Lake, close to where it drains into the Babine River (Figure 24). This 40.8 km in length stream has its headwaters in the southern Bait Range and drains through wetlands in it mid-reaches. The average annual sockeye escapement was 265 between 2010 and 2016 (LBNF, unpublished data). Boucher Creek also supports coho and chinook salmon, steelhead, rainbow trout, Dolly Varden, red side shiners (*Richardsonius balteatus*) and prickly sculpins (Triton, 1997). The GIS analysis of the Boucher Creek sub-basin found that there were low levels of riparian disturbance and stream crossing density but moderate levels of riparian disturbance and human development as shown in Table 29.

Table 29: Boucher Creek sub-basin GIS analysis results.

Measure	Score
Accessible Stream Length (km)	59.76%
Riparian Disturbance (%)	2.18%
Road Density (km/km^2)	0.78
Stream Crossing Density (crossings per km^2)	0.17
Human Development Footprint (% of sub watershed effected by anthropogenic disturbances)	12.11%

4.2.8.1 Boucher Creek Stream Crossing Assessments

Of the six Boucher Creek sub-basin crossings assessed and prioritized, one (1048) was found to be high priority (Figure 23). The remaining culverts were found to be low (3) and medium (2) priority. Two culverts were crushed at the outlet, and are recommended to be repaired (Tables 30 and 31).

Figure 23. Road Crossing 1048 looking downstream to the inlet (left panel) and looking upstream to the outlet (right panel).

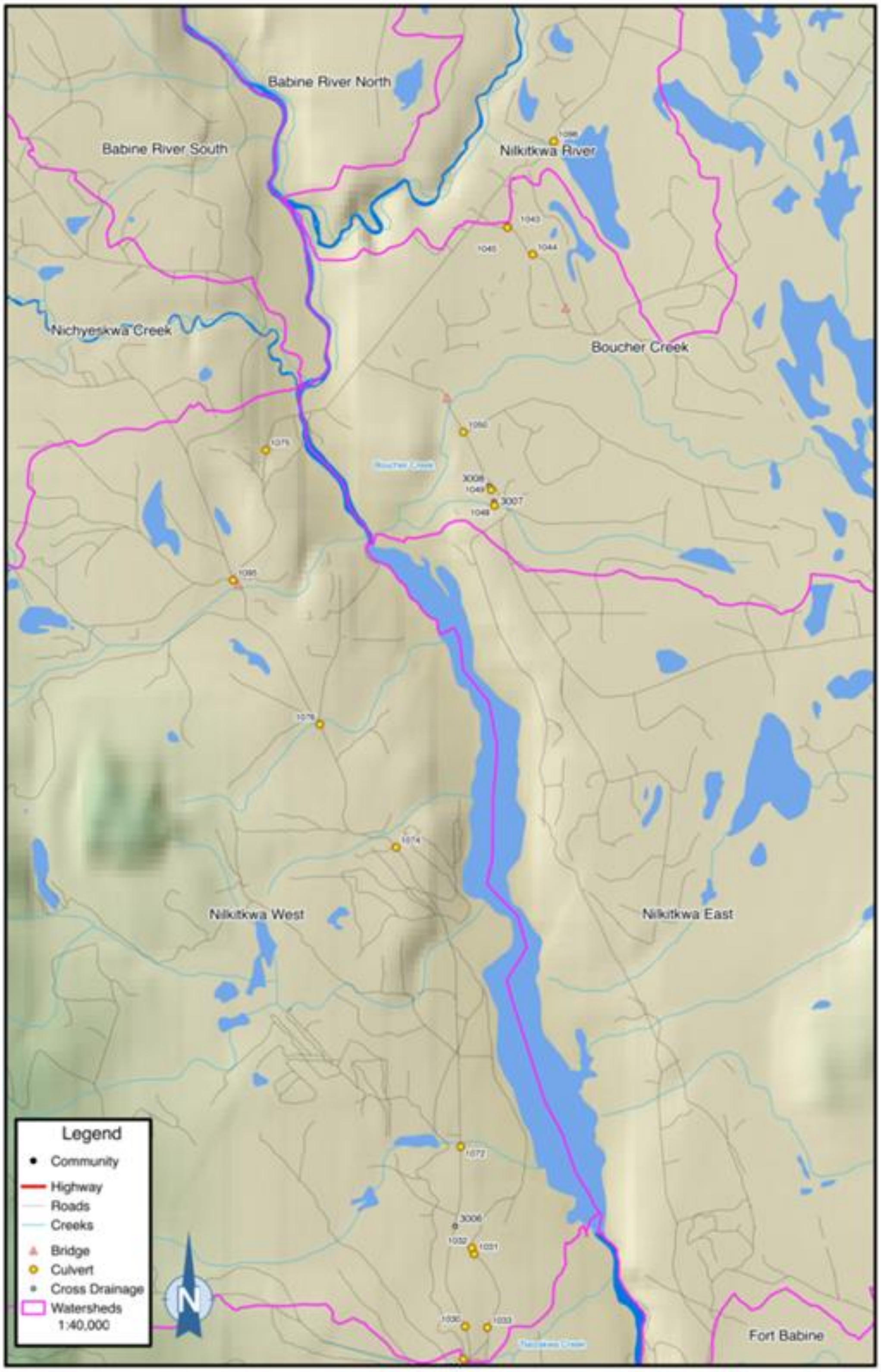


Figure 24. Stream crossings assessed in the Boucher Creek sub-watershed.

Table 30. Boucher Creek, culvert 1043 stream crossing assessment results.

Stream crossing codes, type and date visited	1043, Culvert, 21/09/16
Sub-basin and stream name	Boucher Creek, unknown
Road System	61KM Nilkitkwa, R09511 461
Culvert type and size (mm)	CMP, 250x480
UTM (Zone, Northing, Easting)	9U 6147365 648157
Fish Presence, species	
Fish Habitat	unknown
Crossing Responsibility	
Maintenance issue	Pipe is slightly bent at outlet
Recommendations	Mend outlet


(1) Downstream at inlet


(2) Upstream at outlet

Table 31. Boucher Creek, culvert 1044 stream crossing assessment results.

Stream crossing codes, type and date visited	1044, Culvert, 10/08/16
Sub-basin and stream name	Boucher Creek, unknown
Road System	61KM Nilkitkwa, R09511 461
Culvert type and size (mm)	CMP, 600
UTM (Zone, Northing, Easting)	9U 6147041 648487
Fish Presence, species	
Fish Habitat	Fish habitat – inferred
Crossing Responsibility	
Maintenance issue	Pipe is bent
Recommendations	Mend outlet

(1) Downstream at inlet

(2) Upstream at outlet

4.2.9 Bairnsfather Creek

Bairnsfather Creek flows into Nilkitkwa Lake on the west side, opposite to the mouth of Boucher Creek. This system is 12.3km long and contains sockeye, Dolly Varden, and rainbow trout (Triton 1997). Bairnsfather Creek is not a core stock assessment stream counted by Lake Babine Nation Fisheries crews. Bairnsfather Creek is positioned in the of Nilkitkwa West sub-watershed. This watershed was determined to have high levels of riparian disturbance, road density, and human development footprint, and moderate levels of stream crossing density as shown in Table 32.

Table 32. Nilkitkwa West sub-basin GIS analysis results.

Measure	Score
Accessible Stream Length (km)	60.01%
Riparian Disturbance (%)	28.09%
Road Density (km/km^2)	1.66
Stream Crossing Density (crossings per km^2)	0.47
Human Development Footprint (% of sub watershed effected by anthropogenic disturbances)	42.68%

4.2.9.1 Bairnsfather Stream Crossing Assessments

Only one stream crossing in the Bairnsfather sub-basin was assessed and prioritized due to deactivated roads limiting access to older crossings. Culvert 1095 was designated as a medium remediation priority stream crossing based on its inferred fish presence and potential for creating a fish barrier. An additional cross drainage culvert, 3017, was identified as requiring maintenance as noted in Table 30.

Table 33. Bairnsfather Creek, culvert 3017 stream crossing assessment results.

Stream crossing codes, type and date visited	3017, 12/10/16
Sub-basin and stream name	Bairnsfather Creek, unknown
Road System	Access to CP581-1, R09511 454-4
Culvert type and size (mm)	CMP, 400
UTM (Zone, Northing, Easting)	9U 6142299 643933
Fish Presence, species	
Fish Habitat	Fish habitat – inferred
Crossing Responsibility	
Maintenance issue	Damage to culvert inlet and debris blocking the outlet.
Recommendations	Mend inlet, remove debris, and revisit site to assess further maintenance or replacement.

(1) Damaged inlet

(2) Outlet is blocked by debris and vegetation.

4.2.10 Morrison Creek

The Morrison sub-basin is a lake headed system that enters Babine Lake at the northern end of Morrison Arm as shown in Figure 25. In addition to sockeye salmon, the Morrison watershed provides habitat for spawning kokanee, and coho as well as a variety of resident fish species (Bustard 2004). Morrison Creek is the lowest portion of a relatively large drainage that encompasses almost 500km^2 as noted by Bustard (2004).

The watershed drains from the Bait Range through both upper and lower Tahlo Creeks, and Tahlo Lake, all of which also provide habitat for spawning sockeye. Lakeshore sockeye spawning has been observed in Morrison Lake, and Morrison and Tahlo Lakes provide rearing habitat for juvenile sockeye salmon. Extensive forestry activities have also occurred with proposed development focused on the Tahlo system. Pacific Booker Minerals has proposed an open pit gold and copper mine, which is located 80 m from the lakeshore and prime sockeye spawning sites. Morrison Creek had the largest escapement of all sockeye spawning streams monitored by Lake Babine Nation Fisheries, with an annual average between 2010 and 2016 of 26,935 sockeye (LBNF, unpublished data).

GIS Analysis of the Morrison Creek sub basin found that the indicator high risk thresholds had been passed for both riparian disturbance and human development footprint, and moderate risk level thresholds had been passed for road density and stream crossing density indicators as shown in Table 34.

Table 34. Summary of GIS analysis of the Morrison Creek sub watershed.

Measure	Score
Accessible Stream Length (km)	65.27%
Riparian Disturbance (%)	18.28%
Road Density (km/km^2)	1.02
Stream Crossing Density (crossings per km^2)	0.34
Human Development Footprint (% of sub watershed effected by anthropogenic disturbances)	26.09%

4.2.10.1 Morrison Creek Subwatershed Stream Crossing Assessments

Six stream crossings were included in the field assessment and prioritization of Morrison Creek stream crossings. Two crossings were found to be of medium remediation priority and four were found to be of low priority. Two stream crossings, 1046 and 1047, require maintenance as noted in Tables 35 and 36.

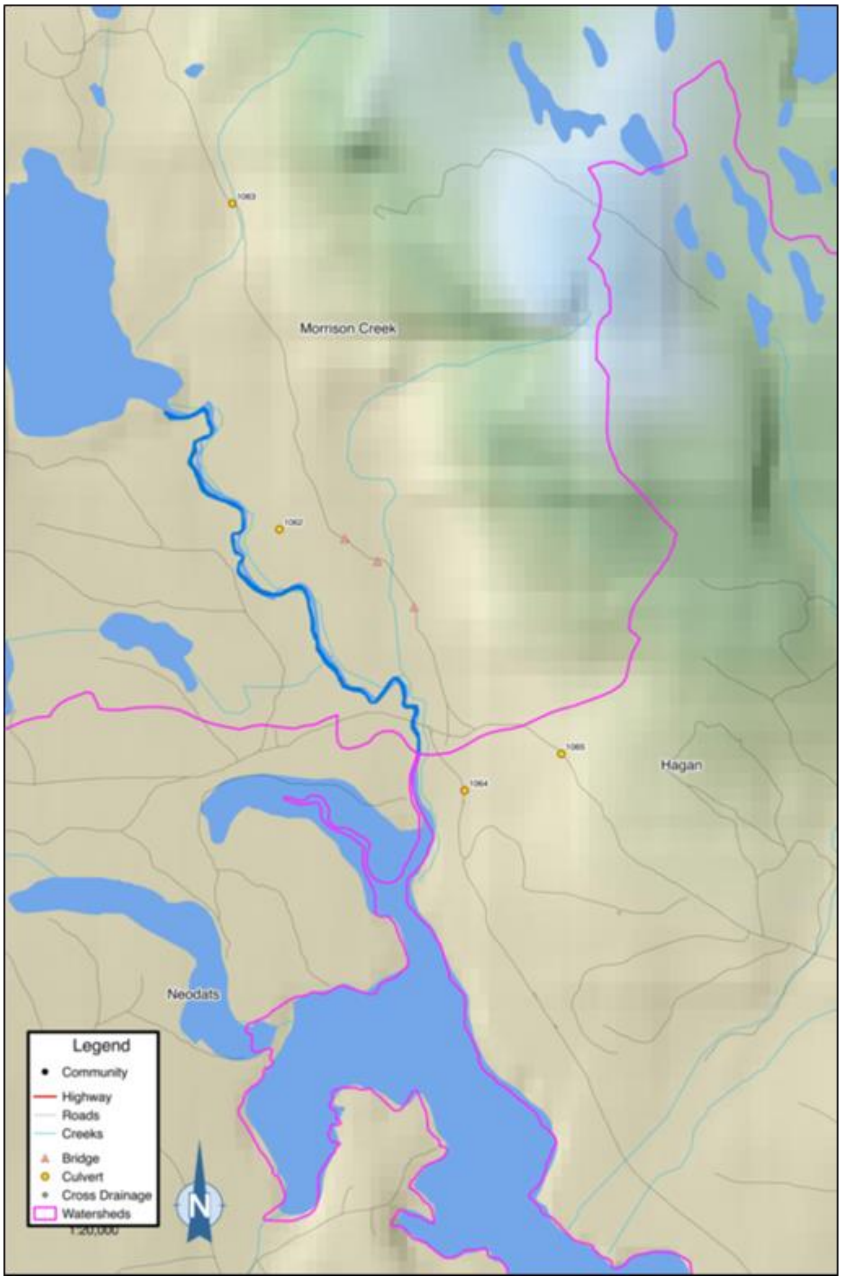


Figure 25. Stream crossings assessed in the Morrison Creek sub-watershed.

Table 35. Morrison Creek, culvert 1046 stream crossing assessment results.

Stream crossing codes, type and date visited	1046, Culvert, 10/08/16
Sub-basin and stream name	Morrison Creek, unknown
Road System	
Culvert type and size (mm)	CMP, 850
UTM (Zone, Northing, Easting)	9U 6115692 667979
Fish Presence, species	
Fish Habitat	unknown
Crossing Responsibility	
Maintenance issue	Fence upstream of culvert has accumulated a lot of debris.
Recommendations	




(1) Fence at inlet, and (2) pooled water upstream of inlet. (3) Upstream and (4) downstream at the outlet.

Table 36. Morrison Creek, culvert 1047 stream crossing assessment results.

Stream crossing codes, type and date visited	1047, Culvert, 10/08/16
Sub-basin and stream name	Morrison Creek, unknown
Road System	5000 Road
Culvert type and size (mm)	CMP, 500
UTM (Zone, Northing, Easting)	9U 6117708 668070
Fish Presence, species	
Fish Habitat	Fish habitat – inferred
Crossing Responsibility	
Maintenance issue	Culvert is damaged, water is pooled at both ends but low flow in the pipe. Debris has also built up at inlet and outlet.
Recommendations	Culvert should be replaced.

(1) Downstream and (2) upstream at the inlet. (3) Outlet damage. (4) Downstream at the outlet.

4.2.11 Four-Mile Creek

Four-Mile Creek flows northward and joins the south end of Babine Lake and drains 51km^2 (Figure 26). This creek had an average annual escapement of 4,777 sockeye between 2010 and 2016 (LBNF, unpublished data). Four-Mile Creek also supports coho, kokanee and rainbow trout (FINS Consulting Ltd. 1998a). Upstream fish passage is barred at approximately 1.79km from the mouth. Stream crossing assessments were conducted in October, when there was already snow cover. It is recommended that further assessment, especially regarding sediment input from stream crossings, be conducted in seasons without snow cover.

The mainstem is characterized by a relatively small and quiescent alluvial fan, a cascades and canyon section, no lake storage, small amount of headwater wetlands, and a stable channel. Occasional low discharge can create increased water temperatures and reduced dissolved oxygen concentrations that cause sockeye and kokanee to hold spawning until cooler temperatures and or precipitation facilitates reasonable spawning activity. The majority of sockeye spawning occurs in the lower 800m. The Four-Mile Creek sub-watershed GIS analysis results indicated all habitat indicators were at moderate levels as shown in Table 37.

Table 37. Four-Mile Creek sub watershed GIS analysis results.

Measure	Score
Accessible Stream Length (km)	34.66%
Riparian Disturbance (%)	9.88%
Road Density (km/km^2)	0.97
Stream Crossing Density (crossings per km^2)	0.32
Human Development Footprint (% of sub watershed effected by anthropogenic disturbances)	13.74%

4.2.11.1 Four-Mile Creek Stream Crossing Assessments

Sixteen road crossing were assessed for the Four-Mile sub-basin. Nine crossings were identified as low priority, four crossings as medium priority and three crossings as high priority for remediation. Culverts 1081, 1085, and 1086 were determined to be of high priority for restoration as shown in Figures 27 to 29. In addition, five culverts were identified as needing further assessment and maintenance as noted in Tables 38 to 42.

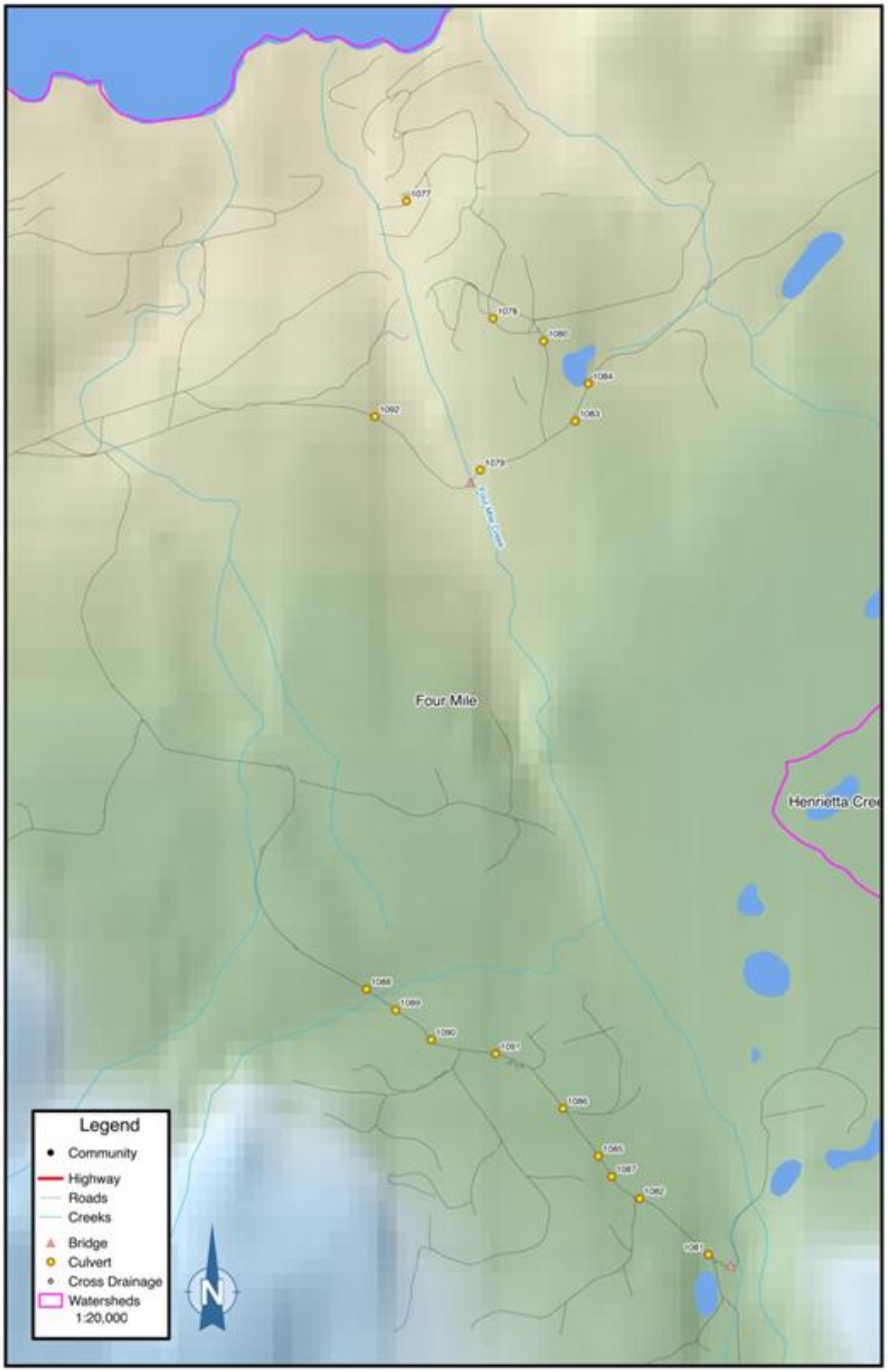


Figure 26. Stream crossings assessed in the Four-Mile Creek sub watershed.

Figure 27. Culvert 1081 looking downstream towards the inlet (left panel) and looking upstream towards the outlet (right panel).

Figure 28. Culvert 1085 looking downstream towards the inlet (left panel) and looking upstream towards the outlet (right panel).

Figure 29. Culvert 1086 looking downstream towards the inlet (left panel) and looking upstream towards the outlet (right panel).

Table 38. Four-Mile Creek, culvert 1077 stream crossing assessment results.

Stream crossing codes, type and date visited	1077, Culvert, 13/10/16
Sub-basin and stream name	4-Mile Creek, unknown
Road System	
Culvert type and size (mm)	CMP, 500
UTM (Zone, Northing, Easting)	9U 6036347 350593
Fish Presence, species	
Fish Habitat	Fish habitat inferred
Crossing Responsibility	
Maintenance issue	Inlet could not be found; culvert is likely blocked. Water is pooled upstream. On deactivated road.
Recommendations	Remove culvert.

(1-2) Pooled water at inlet

(3) Downstream and (4) upstream at outlet

Table 39. Four-Mile Creek, culvert 1078 stream crossing assessment results

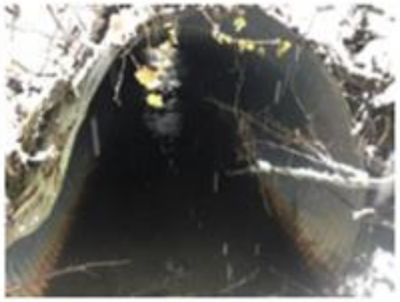
Stream crossing codes, type and date visited	1078, Culvert, 13/10/16
Sub-basin and stream name	4-Mile Creek, unknown
Road System	R16589 154
Culvert type and size (mm)	CMP, 500
UTM (Zone, Northing, Easting)	10U 6035598 351098
Fish Presence, species	
Fish Habitat	unknown
Crossing Responsibility	
Maintenance issue	Vegetation growing in inlet. Outlet crushed.
Recommendations	Remove vegetation, mend outlet. Assess further maintenance as snow was covering ground at time of assessment and culvert is very embedded.

(1) Downstream at the inlet and (2) upstream at the outlet.

Table 40. Four-Mile Creek, culvert 1080 stream crossing assessment results

Stream crossing codes, type and date visited	1080, Culvert, 13/10/16
Sub-basin and stream name	4-Mile Creek, unknown
Road System	R16589 154
Culvert type and size (mm)	CMP, 1600
UTM (Zone, Northing, Easting)	10U 6035445 351406
Fish Presence, species	
Fish Habitat	Fish habitat – inferred
Crossing Responsibility	
Maintenance issue	Middle of culvert (1600mm) was slightly crushed, some segments were separating.
Recommendations	Revisit site to assess impacts of damage and feasibility of replacement.






(1) Upstream and (2) downstream at inlet. Note cracks inside.

(3) Upstream and (4) downstream at outlet.

Table 41. Four-Mile Creek, culvert 1084 stream crossing assessment results.

Stream crossing codes, type and date visited	1084, Culvert, 13/10/16
Sub-basin and stream name	4-Mile Creek, unknown
Road System	R16589 187
Culvert type and size (mm)	CMP, 450
UTM (Zone, Northing, Easting)	10U 6035170 351671
Fish Presence, species	
Fish Habitat	Fish habitat – inferred
Crossing Responsibility	
Maintenance issue	Large build-up of sediment fulling about 50% of outlet.
Recommendations	

(1) Downstream at the inlet and (2) upstream at the outlet.

Table 42. Four-Mile Creek, culvert 1089 stream crossing assessment results.

Stream crossing codes, type and date visited	1089, Culvert, 14/10/16
Sub-basin and stream name	4-Mile Creek, unknown
Road System	R16589 188
Culvert type and size (mm)	CMP, 500
UTM (Zone, Northing, Easting)	10U 6031347 350313
Fish Presence, species	
Fish Habitat	unknown
Crossing Responsibility	
Maintenance issue	Rise out of outlet, no water flowing through culvert.
Recommendations	Revisit site when there is no snow to reassess. Consider removing buildup of vegetation at outlet

(1) Downstream at inlet and (2) upstream at outlet.

4.2.12 Deep Creek

Deep Creek is located at the south end of Babine Lake and joins the lake on the northern shore (Figure 30). Between 2010 and 2016, Deep Creek had an average sockeye escapement of 450, which is lower than the previous five years, which comprised an annual average escapement of 695 sockeye (LBNF, unpublished data). Access issues at the mouth of Deep Creek are noted as a potential problem for spawning salmon, a consistent issue throughout the watershed during years of low flows. Other Deep Creek fish species include coho salmon, rainbow trout, prickly sculpins and longnose suckers (*Catostomus catostomus*) (FINS Consulting Ltd. 1998b).

Deep Creek was included in the Boiling sub-watershed for the GIS analysis of habitat indicators. The Boiling sub-watershed has moderate levels of riparian disturbance, road density, and stream crossing density, and high levels of overall human development as shown in Table 43.

Table 43. Boiling sub-basin GIS analysis results.

Measure	Score
Accessible Stream Length (km)	49.49%
Riparian Disturbance (%)	10.79%
Road Density (km/km^2)	1.18
Stream Crossing Density (crossings per km^2)	0.38
Human Development Footprint (% of sub watershed effected by anthropogenic disturbances)	20.54%

4.2.12.1 Deep Creek Stream Crossing Assessment

Seven crossings from the Deep Creek sub basin were included in the field assessment and prioritization matrix. All crossings were ranked as low priority due to the absence of observed or inferred fish habitat.

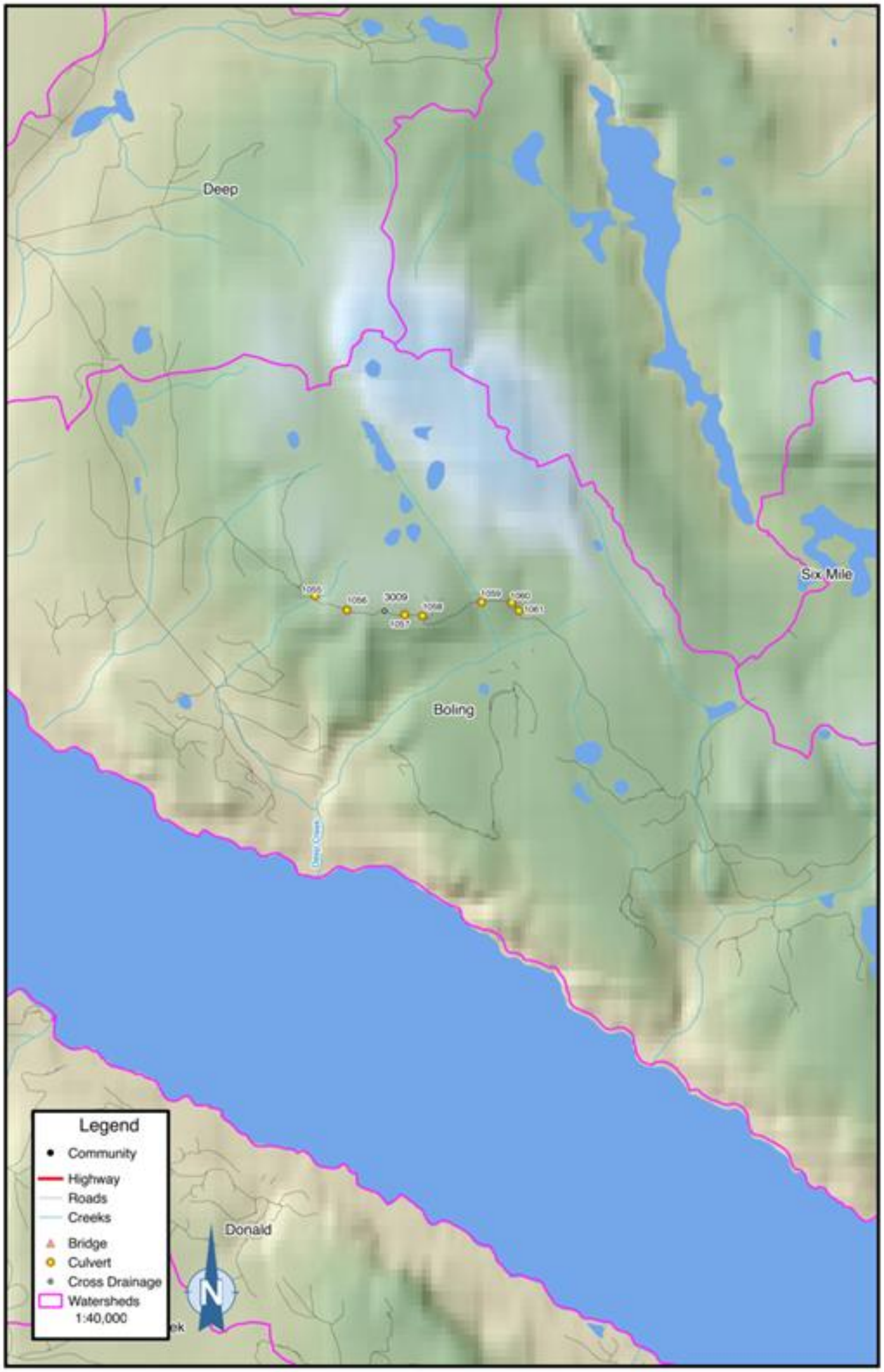


Figure 30. Stream crossings assessed in the Deep Creek sub watershed.

4.2.13 Hazelwood Creek

Hazelwood Creek sub-basin is located on the on the east side of Morrison Arm. This stream typically has a small annual return of sockeye salmon that are not routinely inspected by Lake Babine Nation Fisheries. In October 2016, stream crossings on this system were inspected via helicopter. During this assessment, two bridges were inspected and appeared to be functioning well as shown by Figure 31. The remaining stream crossings looked to be deactivated, and were not observed to have any negative influence on the stream channels as shown in Figure 32. Reassessment of these crossings to determine sediment input is recommended.

Figure 31. View of bridges crossing Hazelwood Creek.

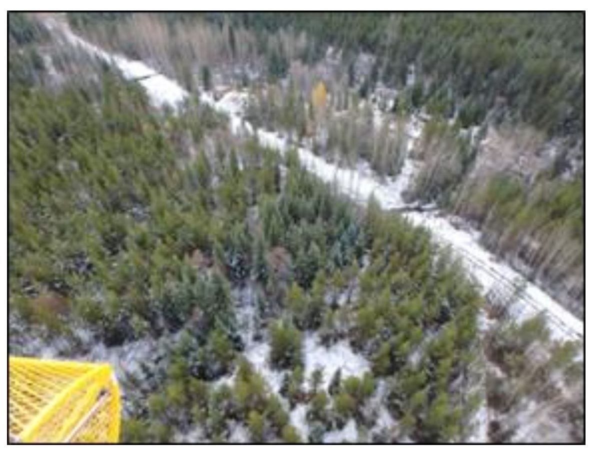


Figure 32. Deactivated stream crossings on Hazelwood Creek tributaries.

4.2.14 4000 Road Stream Crossing Assessment

Several stream crossings along the 4000 Road, also known as the Nilkitkwa Forest Service Road, were assessed and the results indicated that maintenance is required as noted in Tables 44 to 47.

Table 44. 4000 Road, culvert 1096 stream crossing assessment results.

Stream crossing codes, type and date visited	1096, cross drainage culvert, 12/10/16
Sub-basin and stream name	
Road System	Nilkitkwa FSR (4000 Rd)
Culvert type and size (mm)	CMP
UTM (Zone, Northing, Easting)	9U 6148461 648690
Fish Presence, species	
Fish Habitat	unknown
Crossing Responsibility	
Maintenance issue	Culvert slightly crushed at outlet. Culvert is not embedded; water does not reach inlet at current level.
Recommendations	Revisit site to assess site rehabilitation.

Culvert (1) inlet and (2) outlet. Note: culvert level is above that of the pooled water.

Table 45. 4000 Road, culvert 1097 stream crossing assessment results.

Stream crossing codes, type and date visited	1097, cross drainage culvert, 12/10/16
Sub-basin and stream name	
Road System	Nilkitkwa FSR (4000 Rd)
Culvert type and size (mm)	CMP, 400
UTM (Zone, Northing, Easting)	9U 6150460 649612
Fish Presence, species	
Fish Habitat	Unknown
Crossing Responsibility	
Maintenance issue	Culvert inlet crushed and filled in with sediment. Some water pooled at inlet and not reaching culvert.
Recommendations	Revisit site to assess rehabilitation.

Culvert (1) inlet and (2) outlet. Note: Inlet condition and water level below culvert level at both ends.

Table 46. 4000 Road, culvert 1099 stream crossing assessment results.

Stream crossing codes, type and date visited	1099, Culvert, 21/09/16
Sub-basin and stream name	
Road System	Nilkitkwa FSR (4000 Rd)
Culvert type and size (mm)	CMP, 450
UTM (Zone, Northing, Easting)	9U 6163269 646943
Fish Presence, species	
Fish Habitat	Fish habitat – inferred
Crossing Responsibility	
Maintenance issue	Inlet is overgrown and has too large of a rise for water to reach. No water flow in pipe at time of assessment
Recommendations	Revisit site to assess rehabilitation.


(1) Inlet, overgrown and filled in with organic material, (2) Culvert outlet, perched, no flow.

Table 47. 4000 Road, culvert 1100 stream crossing assessment results.

Stream crossing codes, type and date visited	1100, Culvert, 21/09/16
Sub-basin and stream name	
Road System	Nilkitkwa FSR (4000 Rd)
Culvert type and size (mm)	CMP, 700
UTM (Zone, Northing, Easting)	9U 6163206 647036
Fish Presence, species	
Fish Habitat	Fish habitat inferred, fry observed
Crossing Responsibility	
Maintenance issue	Large pool forming at inlet.
Recommendations	Revisit site to assess feasibility and effectiveness of installing a larger culvert.




(1) Downstream at inlet (2) Upstream at outlet Pool to the (3) left and (4) right at the inlet.

4.2.15 Sediment

Forest service roads are a known source of sediment input into streams (Reid and Dunne, 1983). In the Babine Watershed, the anthropogenic input of sediment into fish bearing creeks exacerbates the existing high rate of sediment delivery from upper watersheds to the lower reaches, where salmon spawning occurs.

Observations on sediment input and transport were recorded at each stream crossing. Moderate or high input of sediment from the road and ditch lines was noted for 22% of the culverts assessed. These observations were made between August and October 2016, suggesting that there is further potential for sediment input during the fall to spring months as a result of snowmelt and higher rainfall events. Reducing fine sediments from road crossings has been previously noted as a possible area of improvement within the Lake Babine Nation SOI boundary (FLNRO, unpublished data). More detailed inspections of road crossings identified as potential sources of sediment input using the Forest and Range Evaluation Program Water Quality Effectiveness Evaluation is recommended.

The draft Lake Babine Nation Multiple Resource Value Assessment compiled by FLNRO (2015) discussed Grading Practices. Our 2016 stream crossing assessment investigative study noted grading practices over bridge decks throughout the area could see improvement. Berms of sediment were observed on bridge decks on Bairnsfather, Boucher, Twain, Nine-Mile and Tsezakwa Creeks (Figure 33). Several crossings were revisited in April 2017, one of which was the Boucher Creek mainstem crossing, which had a large build up if sediment on the still frozen creek (Figure 34).

Figure 33. Sediment berm from grader on the Augier Road/Twain Creek road crossing (left panel) and the Nine-Mile Creek/4000 Road crossing (right panel).

Figure 34. Graded sediment on the Boucher Creek crossing, April 2017.

4.2.16 Deactivated Roads

Several crossings were assessed along deactivated forest service roads. These crossings were found in varied states. Box culverts found in the Tsezakwa Creek sub basin appeared to be decomposing and showed the potential to block or obstruct stream flow if they collapsed. With the potential for high or peak flow issues in the upper Babine Watershed, it is recommended that culverts with the ability to block stream flow are removed. Culvert 1014 in the Twain Creek sub basin had been abandoned in the road, but was completely blocked at the outlet. It is recommended that standard best management practices for culvert removal during road deactivation be developed and/or enforced in the upper Babine Watershed.

5.0 Cost-benefit analysis of Habitat Rehabilitation Projects-

5.1 Water Augmentation

No suitable sources of surface or ground water to augment Tachek Creek, Lower Tahlo Creek, Morrison River or Nine Mile Creek flows were located from ground surveys. It was realized that ground surveys, implemented in both 2015 and 2016, were inefficient in locating potential sources of water that could be diverted into sockeye-bearing tributaries and that a considerable amount of resources would be needed to conduct ground surveys on the scale required. An Unmanned Aerial Vehicle (UAV), described in the following section, showed some potential promise for locating water sources and could be used in future efforts to locate potential sources for tributary flow augmentation purposes. Generalized cost items and feasibility considerations that should be evaluated before conducting a water augmentation project are as follows:

1. Environmental Impact Assessment
2. Plant and wildlife surveys
3. Engineered design and implementation of water conveyance structures
4. Permits to convey water and alter or remove forest and/or wetland habitat
5. Archaeological surveys if drainage ditches, drilling and/or excavation are to be conducted.
6. Maintenance of water conveyance structures
7. Performance (cost-benefit) evaluation

The removal of water from wetlands to augment a stream may have negative impacts on wetland/riparian and upland plant and animal species which should be assessed by a qualified professional hydrologist, wildlife biologist and botanist. Any federally or provincially listed plant or animal species that may be negatively affected by the project would need proper impact prevention or mitigation measures implemented as required by the relevant regulatory agency. Tree removal and road construction that may be required for a water augmentation project should be assessed by a qualified professional forester and engineer. It is anticipated that a water augmentation project on a scale that would have a measurable benefit to sockeye spawning habitat would be expensive and require considerable expertise to execute.

The value of wetlands in recharging ground water aquafers, which may potentially supply cool water to sockeye tributaries through upwelling, needs to be considered. Augmenting a sockeye stream with surface water drawn from a wetland may have a net negative effect depending on the surface water quality of the wetland and any subsequent reduction in cool water upwelling from ground water sources that are derived from wetlands. The groundwater recharge function of wetlands is well known (e.g. van der Kamp and Hayashi, 1998). The restoration or construction of wetlands for the purpose of increasing ground water recharge has been proposed elsewhere to address both water quality and quantity issues (e.g. Hamilton, 1994) and may be a feasible option in some situations within the Babine Lake watershed for improving water supply to Babine sockeye streams and rivers.

5.2 Sediment Berm Removal and Sediment Management at the mouths of Four Mile Creek and Six Mile Creek, and soft channelization for improving access to tributary spawning habitat.

The total estimated cost of installing two 110ft log boom break-water structures at the mouths of Four Mile Creek and Six Mile Creek, in effort to prevent wave action from piling sand, gravel and cobble at these tributary mouths, which can form berms that block fish access, was $18,887. The cost breakdown of installing the log boom break water structures is provided below in Appendix A, Table A1. The average sockeye escapement to Four Mile and Six Mile Creeks is 3,183 and 634 sockeye spawners/year respectively. The cost-to benefit was considered high for Four Mile Creek and moderate for Six Mile Creek, assuming the log boom break water proved effective. A significant consideration is maintenance requirements and longevity of the log booms. Logs, galvanized chain and related attachment fixtures will deteriorate over time and will eventually need to be replaced (Babine Lodge, personal communication).

The estimated cost of removing berm-forming beach sediment at the mouths of Four Mile Creek and 6 Mile Creek by an excavator, transported to site by barge, including two legally required archaeological surveys by a professional archaeologist, is $21,200 (Appendix A, Table A2). This cost does not include liability insurance which is recommended in the event of a boat colliding with the log boom structure. The benefit-to-cost was considered high for Four Mile Creek and moderate for Six Mile Creek given that the average sockeye escapement to Four Mile and Six Mile Creeks is 3,183 and 634 sockeye spawners/year respectively. A significant unknown is how frequent subsequent excavations will be required as sediment deposited by both streams and waves will eventually again accumulate at the mouths of Four Mile and Six Mile Creek to the extent where access to upstream spawning habitat will again be impeded.

The estimated cost of removing accumulated beach sediment using hand tools such as shovels and pick axes on an as-needed basis at Four Mile Creek, Six Mile Creek and Sockeye was $1,350.00/annum (two-person hours X 3 times per year for three creeks) (Appendix A, Table A3). Excavation of beach sediment by hand is by far the most cost-effective technique of the three methods considered for beach sediment removal to ensure spawner access to tributary spawning habitat. The technique has been used successfully in the past by LBNF stream enumeration staff, particularly in low water years. The cost-benefit of applying this technique was ranked as high for each of Four Mile Creek, Six Mile Creek and Sockeye Creek. The cost of applying this technique assumes continued Aboriginal Fisheries Strategy (AFS) funding for LBNF escapement enumeration throughout the Babine Lake watershed. AFS funding currently covers boat and fuel costs and travel and per diem costs.

The disadvantage of excavation by hand tools is that excavation must be re-applied whenever a berm re-form s at a tributary mouth or whenever access is impeded, typically in low water years. However, this technique has numerous advantages: (i)) not limited by road or barge accessibility, it can be applied anywhere on any tributary; (ii) lower risk of mechanical break-down; (iii) without the use of heavy machinery, there is lower risk to crew and public safety; (iv) without the need for heavy machinery there is a lower risk to the environment given the lower risk of fossil fuel leaks and/or spills associated with heavy machinery use; (v) the carbon footprint impact associated with fossil fuel combustion is lower; (vi) little training is required and (vii) there are no additional costs associated with maintenance inspections and repairs.

Soft channelization in the context of this project is the narrowing of a channel using wooden structures (Figure 35) or riparian vegetation to concentrate stream energy to scour and maintain a channel through beach sediment and provide access to upstream spawning habitat.

The estimated cost of constructing three soft channel timber structures in each of Four Mile Creek, Six Mile Creek and Sockeye Creek, 9 timber structures in total, and not including periodic maintenance costs, was $6,119, or approximately $2,000/creek (Appendix A, Table A4). Owing to relatively low cost, the cost-benefit of implementing soft channelization involving the installation of 6X6 untreated timbers or logs found on site and secured with ½ inch rebar, was considered high for Four Mile Creek, Six Mile Creek and Sockeye Creek. Mean annual escapement for Sockeye Creek is 2,900 sockeye/year. The technique can be applied to any creek where low water discharge and aggradation of stream and/or beach sediment and bed materials impedes upstream salmon migration. The angles of the structures are easily adjustable to create the desired velocity, depth and scouring effect. The height of the structures to create more depth upstream can be adjusted by adding more timbers, one on top of the other.

Figure 35. Timber structures secured with rebar concentrating stream flow energy to improve fish access to upstream habitats.

The cost of soft channelization using riparian vegetation planting in Four Mile Creek, Six Mile Creek and Sockeye Creek was $6,900 (Appendix A, Table A5) for the three creeks combined, or approximately $2,300/creek. Due to a low probability of success, the planting with willow, cottonwood or red osier cuttings in unstable beach habitat and/or within riparian zones was ranked as low for Four Mile Creek, Six Mile Creek and Sockeye Creek. The riparian zones for each of these three tributaries are dominated by intact and properly functioning mature forest. The dense root networks and dense canopy provides high stream bank stability for the large majority of their lower reaches where the majority of sockeye spawning occurs. The dense canopy and over story vegetation in each of these creeks would limit the amount of light that reaches any cuttings planted upstream of the Babine Lake high water mark and prevent cuttings from developing or surviving. Cuttings planted in unstable beach habitat are also not likely to survive over the long term due to drowning as a result of prolonged inundation during high lake water levels in the spring and mechanical damage and uprooting from wave energy and winter ice flows. However, revegetation of unstable banks exposed to sunlight upstream of the lake high elevation level and within road-side drainage ditches may be effective in reducing channel braiding and sedimentation for streams such at Tachek Creek and Nine Mile Creek where sedimentation upstream of the high lake level mark has occurred in areas exposed to sunlight.

Table 48 summarizes the results of the cost-benefit analysis discussed above. Soft channelization using a combination of timbers and riparian planting, depending on site-specific conditions, and channel excavation by hand tools within beach habitat, is recommended based on this cost-benefit analysis. These techniques should be implemented, monitored and assessed and refined over time. If these recommended techniques do not meet management objectives or expectations, the more expensive log-boom structure and excavation of beach materials by barge and excavator options can be re-visited. Where sedimentation issues are impeding upstream migrating salmon, or is suspected of having a general negative impact to receiving streams, a number of cost-effective and easy-to-implement erosion prevention and sediment management techniques, such as the construction of water bars, diversion ditches, sediment fencing, check dams and small settling ponds, which, under appropriate conditions, could be converted to small wetlands, should be considered.

Table 48. Cost-Benefit Analysis for Sediment Berm Removal and/or Sediment Control techniques at indicated tributary mouths to ensure access of migrating sockeye salmon to tributary spawning habitat.

Habitat Improvement Technique	Creek	Average Sockeye Salmon Escapement	Estimated Combined Total Cost ($)	Anticipated Benefit	Benefit to Cost Rank
Water Augmentation	Tachek	1,133	Unknown	Fish Access	Not feasible
Log Breakwaters	Four Mile	3,183		Fish Access	High
	Six Mile	634	18,887	Fish Access	Moderate
Channelization - beach sediment removal by barge and excavator	Four Mile	3,183		Fish Access	High
	Six Mile	634	21,200	Fish Access	Moderate
Channelization - Hand excavation	Four Mile	3,183		Fish Access	High
	Six Mile	634		Fish Access	High
	Sockeye	2,662	1,350	Fish Access	High
Soft channelization - 6"X 6" timbers, LWD	Four Mile	3,183		Fish Access	High
	Six Mile	634		Fish Access	High
	Sockeye	2,662	6,119	Fish Access	High
Soft channelization - Riparian planting	Four Mile	3,183		Fish Access	Low
	Six Mile	634		Fish Access	Low
	Sockeye	2,662	6,900	Fish Access	Low

Combined total cost is the total cost of implementing the technique at all indicated creeks.

8.0 Salmon Habitat in Relation to Land Use in Babine Lake Watershed Tributaries

The GIS results summarizing (i) the number of road-stream crossings and drainage structures; (ii) road density; (ii) riparian disturbance and (iv) overall habitat disturbance in relation to key salmon habitats, are provided in the appended document as Appendix B titled Salmon Habitat in Relation to Land Use in Babine Lake Watershed Tributaries. May 2017

7.0 Nine Mile Creek Unmanned Aerial Vehicle (UAV) Survey

An Unmanned Aerial Vehicle (UAV), also referred to as a drone, was used to survey Nine Mile Creek to gain an understanding of topography surrounding the creek and in-stream habitat for spawning salmonids. The results from data processing, completed by LM Forest Resource

Solutions, included (1) a high resolution orthomosaic of in-stream habitat attributes as well as riparian habitat, and (2) a digital elevation model of the whole surveyed area both of which are included in appended document as Appendix C titled Nine Mile Creek May 2017 UAV Processing Report. June 10, 2017.

8.0 Babine Sockeye Habitat Rehabilitation Workshops

The meeting notes and summaries of discussions for the two workshops involving staff from LBNF, the DFO, the World Wildlife Fund and private contractors, held on May 23, 2017 and June 12, 2017, are provided in the attached document as Appendix D titled Babine Lake Wild Sockeye Rehabilitation: Sockeye Habitat Workshops

9.0 Acknowledgements

Thank you to Johanna Pfalz and Eclipse Geomatics, Larry McCulloch and LM Forest Resource Solutions, Brenda Donnas and project lead Kenny Rabnett (Suskwa Research) for their contributions to this project. Mark Tiley and Emily Mason completed the Cost-Benefit Analysis.

10.0 Literature Cited

B.C. Ministry of Forests, Lands and Natural Resource Operations, B.C. Ministry of Environment, and Fisheries and Oceans Canada. 2012. Fish-stream crossing guidebook. Rev. ed. For. Prac. Invest. Br. Victoria, B.C.

Bellehumeur, S. (Cliff Manning Forestry Services LTD). 1998. Watershed restoration program Babine west drainages overview assessment, FRBC Contract #CSK3079. Babine Forest Products.

Bustard and Associates Ltd. 2004. Fisheries background studies Morrison Watershed 2004.

Cox-Rogers, S. and Spilsted, B. 2012. Update assessment of sockeye salmon production from Babine Lake, British Columbia. Canadian Technical Report of Fisheries and Aquatic Sciences 2956.

Fisheries and Oceans Canada (FOC). 1993. Land development guidelines for the protection of aquatic habitat. September, 1993.

FINS Consulting Ltd. 2000. Reconnaissance (1:20,000) Fish and fish abitat nventory, Pierre and Twain sub-units fish inventory-1999.

FINS Consulting Ltd. 1998a. Reconnaissance (1:20,000) Fish and fish habitat inventory, inventory in the Babine Lake Watershed – Four Mile Creek (WSC 480-964000).

FINS Consulting Ltd. 1998b. Reconnaissance (1:20,000) Fish and fish habitat inventory, inventory in the Babine Lake Watershed – Deep Creek (ILP 53001) (WSC 480-886700).

Forests, Land and Natural Resource Operations (FLNRO). 2015. Multiple resource value assessment 2 report (MRVA2) Lake Babine Nation Asserted Territory.

Ginetz, R.M.J., A Review of the Babine Lake Development Project 1961-1967. 1997. Technical Report Series No. PAC/T-77-6. North Coast Branch, Pacific Region, Department of Fisheries and Oceans.

Gottesfeld, A.S., K.A. Rabnett, and P.E. Hall. 2002. Conserving Skeena fish populations and their habitat. Skeena Fisheries Commission. Hazelton, BC.

Hamilton, J. 1994. Planning and investigations for groundwater recharge using wetland-treated sewage effluent. Future Groundwater Resources at Risk (Proceedings of the Helsinki Conference, June 1994). AHS Publ. no. 222,

Johnson, W.E., 1956. On the distribution of young sockeye salmon (*Oncorhynchus nerka*) in Babine and Nilkitkwa Lakes, B.C. Journal of the Fisheries Research Board of Canada 13: 695-708. In Ginetz, R.M.J., A Review of the Babine Lake Development Project 1961-1967. 1997. Technical Report Series No. PAC/T-77-6. North Coast Branch, Pacific Region, Department of Fisheries and Oceans.

Johnson, W.E., 1958. Density and distribution of young sockeye salmon (*Oncorhynchus nerka*) throughout a multibasin lake system. Journal of the Fisheries Research Board Canada 15: 961-982. In Ginetz, R.M.J., A Review of the Babine Lake Development Project 1961-1967. 1997. Technical Report Series No. PAC/T-77-6. North Coast Branch, Pacific Region, Department of Fisheries and Oceans.

Johnson, W.E., 1961. Aspects of the ecology of a pelagic, zooplankton-eating fish. Verhandlugen des Internationalen Verein Limnologie.

Government of Alberta Transportation. 2011. Erosion and Sediment Control Manual. June 2011.

Lake Babine Nation Fisheries Program. 2005. Overview of Twain Creek (WSC 480-816400) Channel Avulsion.

Levson, V.M. 2002. Quaternary geology and till geochemistry of the Babine Porphyry Copper Belt, British Columbia (NTS 93 L/9,16, M/1, 2, 7, 8). Bulletin 110. British Columbia Ministry of Energy and Mines.

Levy. D.A. and Hall, K.J. 1985. A review of the limnology and sockeye salmon ecology of Babine Lake. Westwater Research Centre. Westwater Technical Report No 27

Ministry of Environment (MOE). 2005. Order- fisheries sensitive watersheds- Skeena Region. Available at: http://www.env.gov.bc.ca/wld/frpa/fsw/order/f-6-001_f-6-005.pdf accessed: 07/14/2017.

Packer, P.E. 1967. Criteria for designing and locating roads to control sediment. Forest Science. 13: 2 -18.

Parker, M.A. 2000. Fish passage – Culvert inspection procedures. Watershed Restoration Technical Circular No. 11. Ministry of Environment, Lands and Parks.

Rabnett, K. and Wilson, T. 2008. Upper Skeena fish passage culvert inspection. Gitksan Watershed Authorities.

Reid, L.M.; Dunne, T. Sediment production from forest road surfaces. Water Resour. Res. 1984, 20, 1753–1761.

Rothwell, R.L. 1983. Erosion and Sediment Control At Road-Stream Crossings. The Forest Chronicle. April, 1983.

Triton Environmental Consultants Ltd. 1997. Boucher Creek reconnaissance. 2488/WP7803.

Water Air and Land Protection (WALP). 2004. Standards and Best Practices for Instream Works. Province of British Columbia Ecosystem Standards and Planning. Biodiversity Branch.

van der Kamp, G. and M. Hayashi. 1998. The groundwater recharge function of small wetlands in the semi-arid northern prairies. Great Plains Research. 8:39-56

Appendix A Costs of considered techniques for berm and sediment removal and control at Four Mile Creek, Six Mile Creek and Sockeye Creek.

Table A 1. Itemized costs of installing two 110 foot log-boom structures to prevent beach sediment berm development at the mouths of Four Mile Creek and Six Mile Creek.

Equipment/ Supplies	Unit Cost ($)	# of units or person days Per Trib	Estimated Total Cost ($)	Comments
Navigable Waters Permit	500/day	2	1000.00	
Tree Harvesting Permit	500/day	2	1000.00	
LBNF Project Coordination	500/day	2	2000.00	LBNF staff to hire and coordinate contractors
Faller: Logs collected on site	500/day	4	1000.00	Cost of professional faller for 2 days
Galvanized Chain	150/15ft	12	2070.00	Includes 15% tax
4000lb Concrete Blocks	180/block	12	2484.00	Includes 15% tax
Safety lights, reflectors	100/log	6	600.00	
Micellaneous equipment	200/day	3	600.00	Rope, shackles, First Aid,
LBNF Enviromental monitor	500/day	3	1500.00	
LBN Per Diem	66.65/day	8	533.20	Includes faller, barge operator, two LBNF staff
LBNF boat/truck rental	500/day	3	1500.00	
Contractor Mileage	0.65/km	0	0.00	Assumes a local faller will be hired.
Barge + Operator	275/hr	16	4400.00	Owner/operator of Babine Barge is experienced at deploying log booms.
Post completion monitoring	50/hr	8	200.00	Detailed above water assessment and inspection four times per year.
Estimated Total Cost			***18,887.20***	Total cost for log boom structures at both creeks
Cost-Benefit	***Moderate benefit to cost for Four Mile Creek, High benefit to cost for Six Mile Creek***			

Table A 2. Itemized costs an extensive excavation beach sediment by an excavator to prevent berm formation at the mouths of 4 Mile Creel and 6 Mile Creek.

Equipment/ Supplies	Unit Cost ($)	# of units or person days Per Trib	Estimated Total Cost ($)	Comments
Permits from BC Archaeology Branch	500/day	2	1000.00	
Archaeological Surveys	1000/day	6	6000.00	Includes travel and per diem costs for one professioanl archaeologist
Barge + Operator	275/hr	24	6600.00	
Excavator+Operator	275/hr	24	6600.00	
LBNF Environmental monitor	500/day	2	1000.00	
***Estimated Total Cost* ($)**			***21,200.00***	Total cost of removing beach sediment by excavator at both creeks
Cost-Benefit	***Moderate benefit to cost for Four Mile Creek, High benefit to Cost for Six Mile Creek***			

Table A 3. Cost per annum beach sediment removal by LBNF stream Crew using hand tools, three times per year per creek, from July 03 to October 15, in Four Mile Creek, Six Mile Creek and Sockeye Creek.

Equipment/ Supplies	Unit Cost ($)	# of units or person days Per Trib	Estimated Total Cost ($)	Comments
Shovel/pick axe rental	50/day		450	
LBNF labour - total person/hr	50/hr	26	900	Assumes 1hr of gravel removal/2 person hours/trib 3 times/year.
Travel and boat rental			0	Assuming these costs are covered by AFS stream enumeration budget.
***Estimated Total Cost* ($)**			***1,350.00***	
Cost-Benefit	***High benefit to cost for Four Mile Creek, Six Mile Creek and Sockeye Creek***			

Table A 4. Itemized Cost of Soft Channelization using Timbers and Rebar at Four Mile Creek, Six Mile Creek and Sockeye Creek

Equipment/ Supplies	Unit Cost ($)	# of units or person days Per Trib	Estimated Total Cost ($)	Comments
Permit Application for instream work	500/day	1	500.00	
LBNF staff	500/day	6	3000.00	
LBN Per Diem	66.65/day	6	399.90	
LBNF boat/truck rental	500/day	3	1500.00	
6 inch X 6 inch X 12 ft timbers	30.00/8ft	18	621.00	Includes 15% tax
1/2" rebar	0.59/ft	144	97.70	Includes 15% tax
Estimated Total Cost ($)			***6,118.60***	
Cost-Benefit	***High benefit to cost for both Four Mile Creek, Six Mile Creek and Sockeye Creek***			

Table A 5. Itemized Cost of Soft Channelization by planting riparian vegetation along and within the stream banks to stabilize tributary channels and concentrate stream energy to create scour to maintain access to sockeye spawning habitat in Four Mile Creek, Six Mile Creek and Sockeye Creek

Equipment/ Supplies	Unit Cost ($)	# of units or person days Per Trib	Estimated Total Cost ($)	Comments
LBNF staff	500/day	10	5000.00	3 days for collecting dormant willow, cottonwood and red osier cuttings
LBN Per Diem	66.65/day	6	399.90	
LBNF boat/truck rental	500/day	3	1500.00	
Hand tools	100/day	3	300.00	Hand saws, clippers, hammers, string, pole bar planter
Estimated Total Cost ($)			***6,899.90***	
Cost-Benefit	***Low benefit to cost for Four Mile Creek, Six Mile Creek and Sockeye Creek***			

Appendix B Salmon Habitat in Relation to Land Use in Babine Lake Watershed Tributaries

See appended document titled. Salmon Habitat in Relation to Land Use in Babine Lake Watershed Tributaries. May 2017

Appendix C Nine Mile Creek Unmanned Aerial Vehicle (UAV) Feasibility Pilot Study

See appended document titled: Nine Mile Creek May 2017 UAV Processing Report. June 10, 2017.

Appendix D Sockeye Rehabilitation Workshops held on May 23, 2017 and June 12, 2017

See appended document titled: Babine Lake Wild Sockeye Rehabilitation: Sockeye Habitat Workshops

Salmon Habitat in Relation to Land Use in Babine Lake Watershed Tributaries

May 2017

Prepared for
Lake Babine Nation and
SkeenaWild Conservation Trust

Prepared by
Eclipse Geomatics, Smithers BC
under the auspices of Suskwa Research

Purpose

- A sub-watershed level assessment of select pressures on salmon habitat within the Lake Babine Watershed.
- This type of sub-watershed assessment is useful for establishing a common understanding of the current pressures on freshwater salmon habitats, informing land-use planning decisions, and developing strategies that mitigate risks to freshwater salmon habitat.

Project consisted of a series of spatial analyses based on five pressure indicators specific to wild salmon (based on Wild Salmon Policy)

1. Road density
2. Stream crossing density
3. Riparian disturbance
4. Key salmon habitat
5. Total Land Cover Alteration

Road Density Interim Thresholds

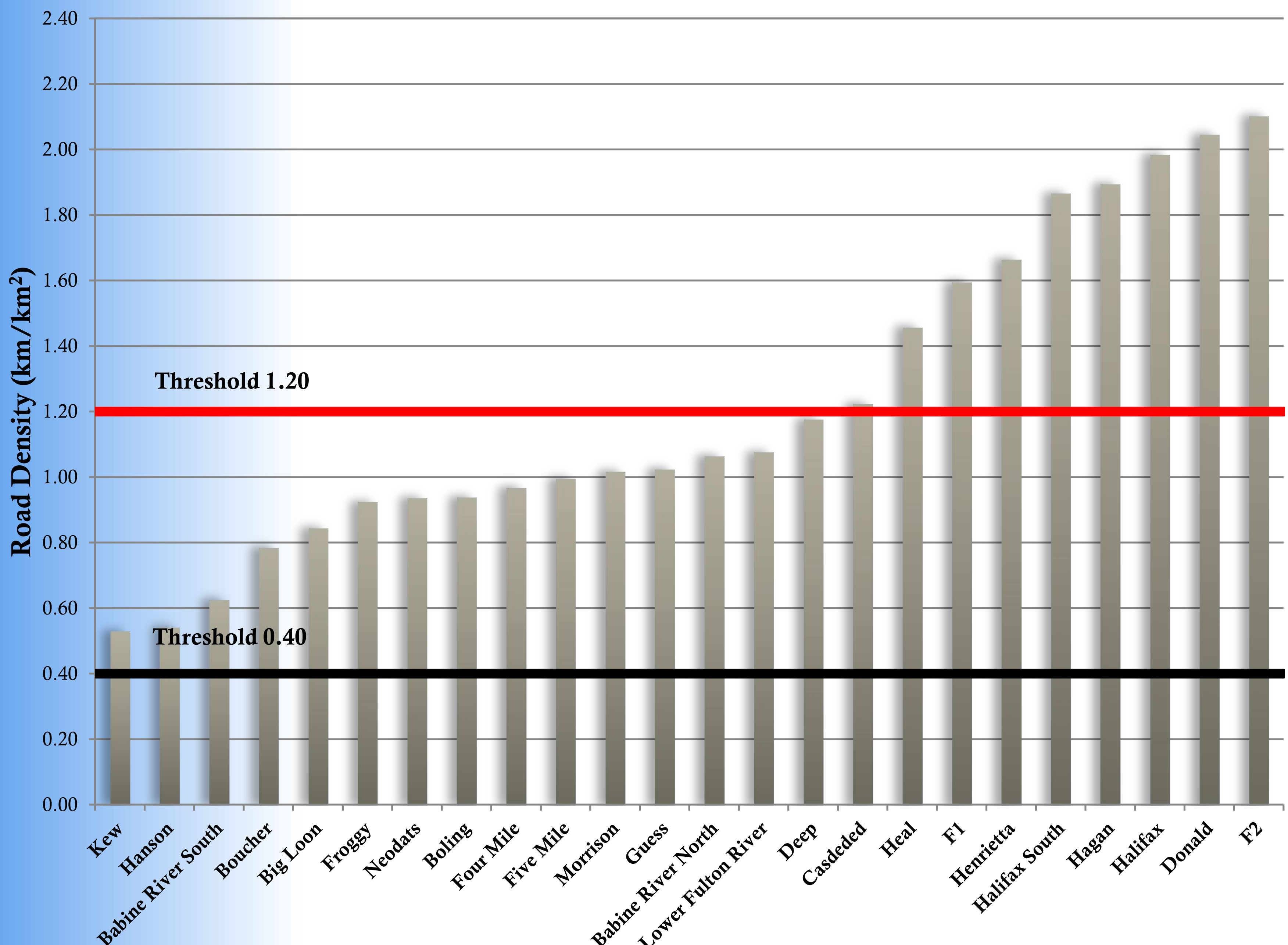
Interim thresholds used in this analysis follow the recommendations put forth by the Wild Salmon Policy.

- Low risk: road density < 0.40 km/km^2
- Moderate risk: road density >= 0.40 km/km^2
- High risk: density >=1.2 km/km^2

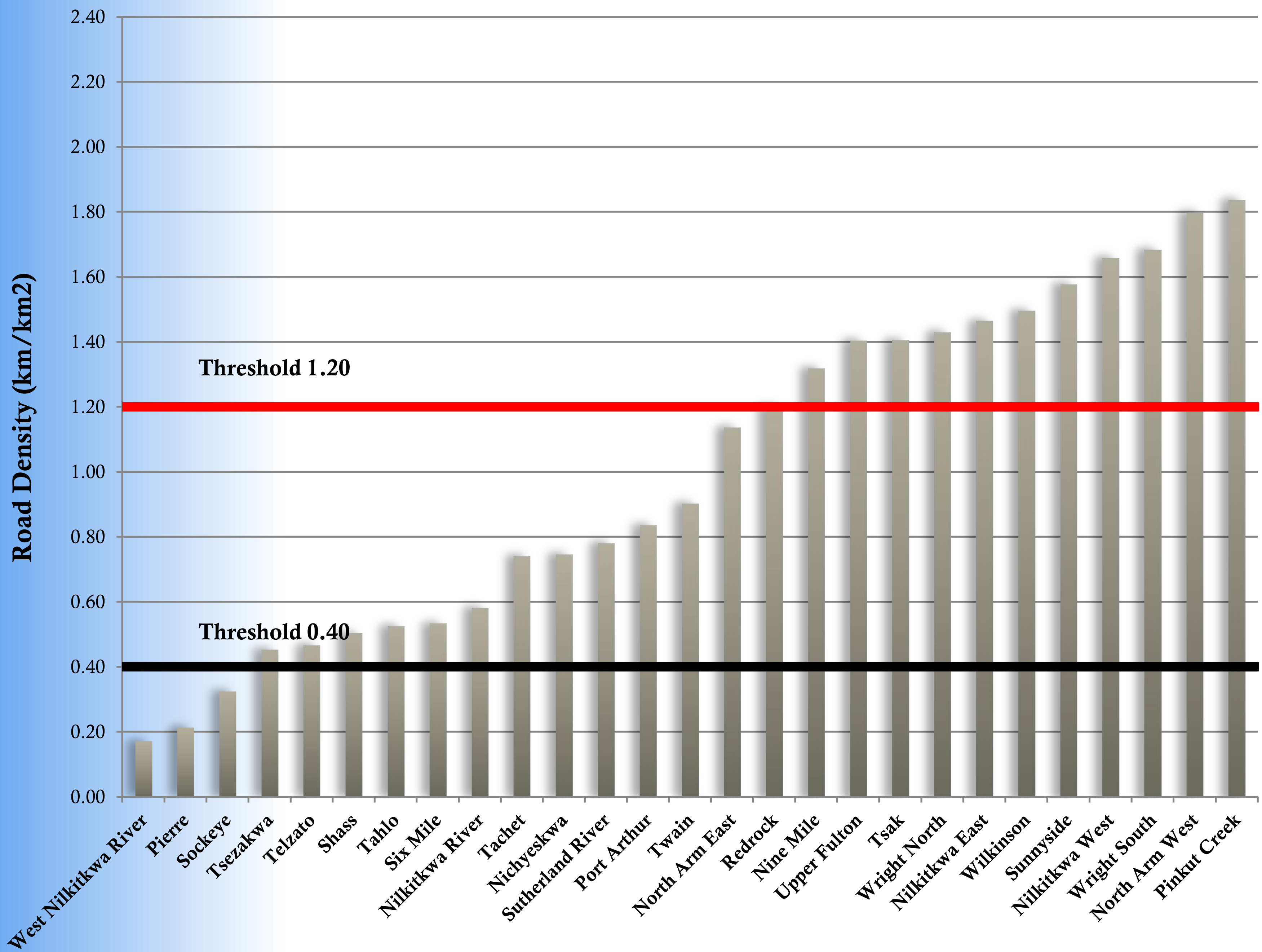
Road Density Summary

Babine Lake Watershed	1.07 km/km^2	moderate
Lake Babine Territory	0.80 km.km^2	moderate
WSP Conservation Units	0.70 km/km^2	moderate

Three sub-watersheds, West Nilkitkwa River, Pierre, and Sockeye fall within the low risk category. Twenty-seven sub-watersheds fall within the moderate risk category, and the remaining twenty-one sub-watersheds fall within the high risk category.

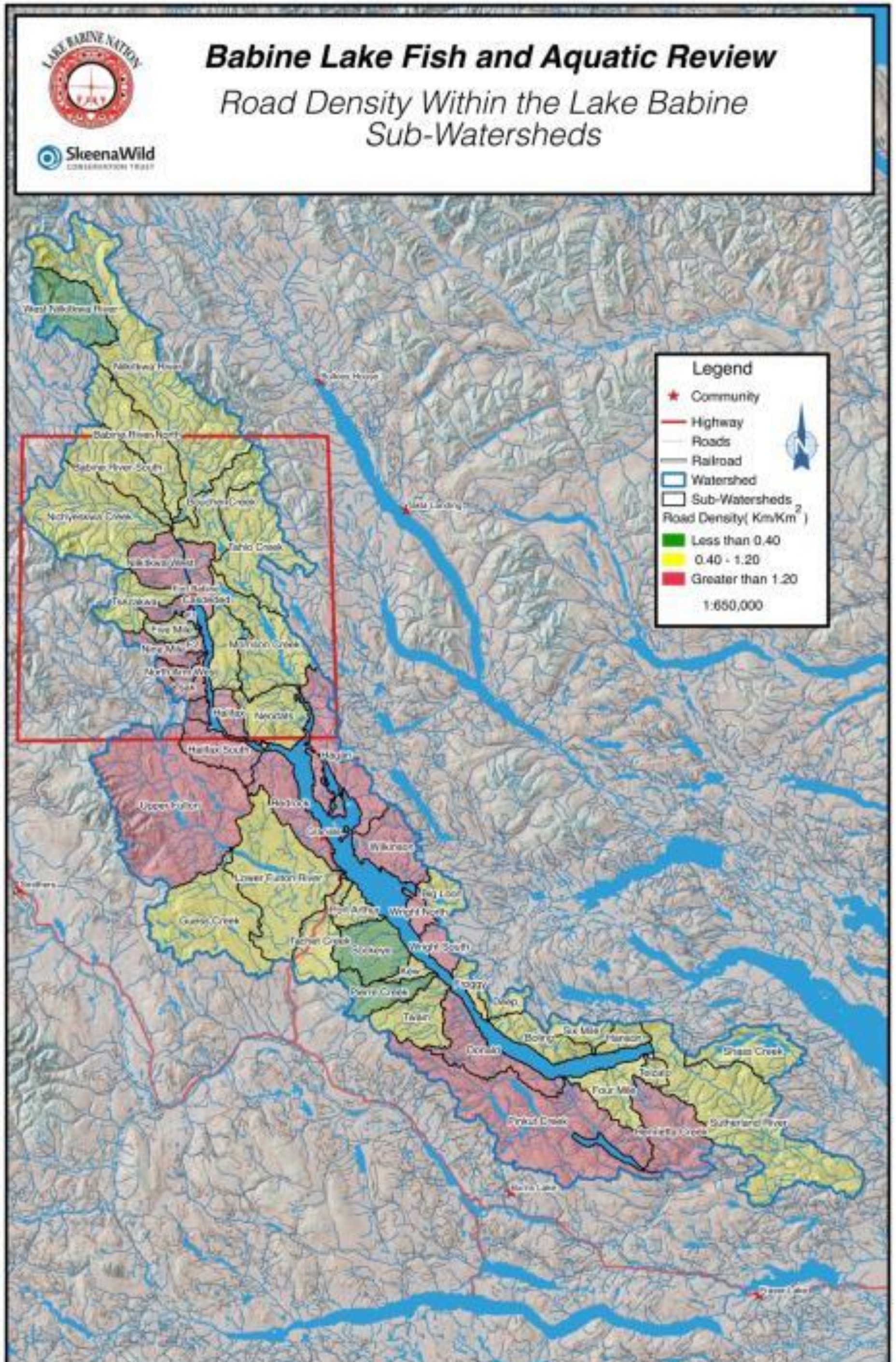


Road Density (km/km²)
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Threshold 1.20
Threshold 0.40
Kew
Hanson
Babine River South
Boucher
Big Loon
Froggy
Neodats
Boling
Four Mile
Five Mile
Morrison
Guess
Babine River North
Lower Fulton River
Deep
Casdeded
Heal
F1
Henrietta
Halifax South
Hagan
Halifax
Donald
F2

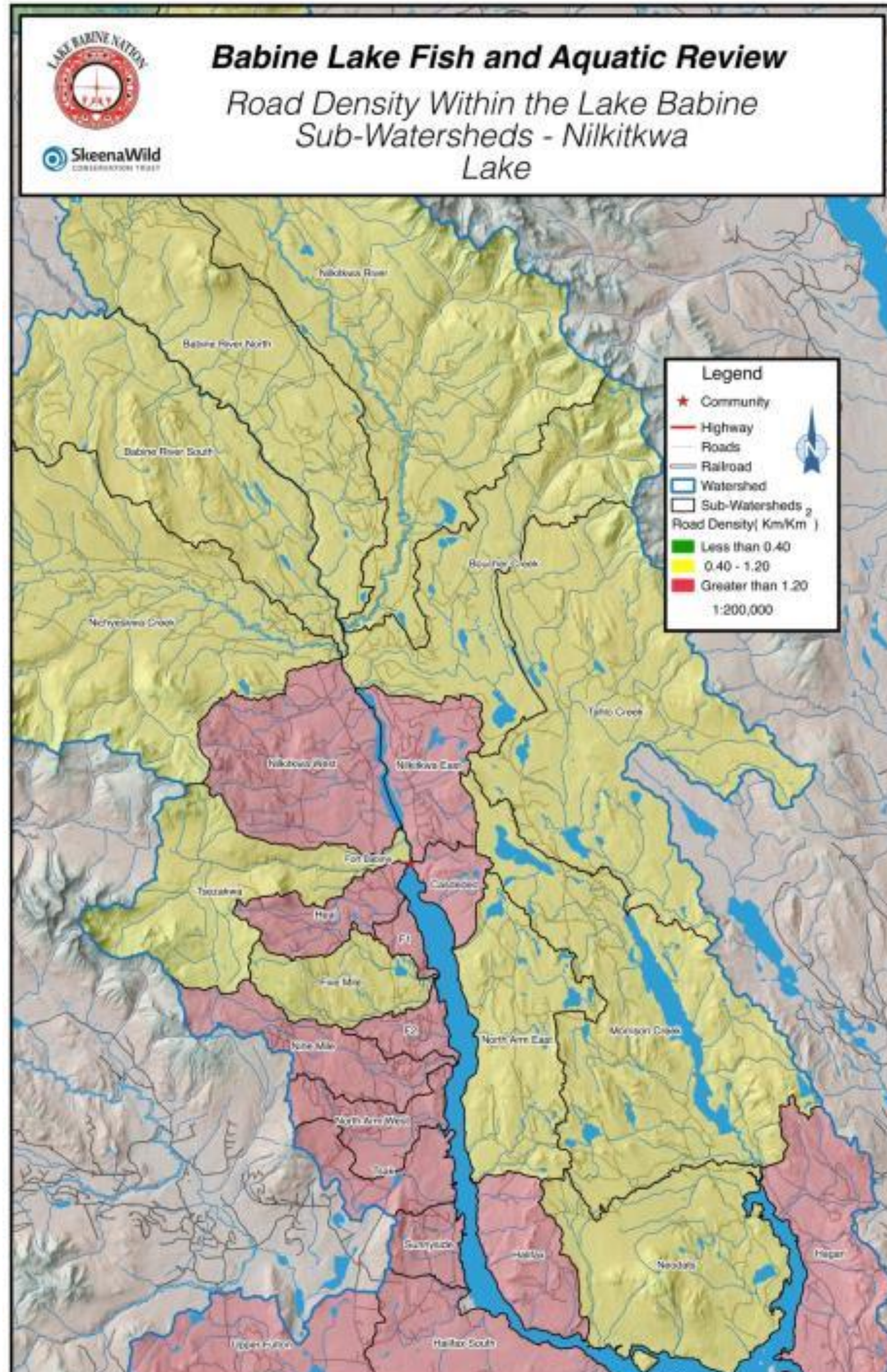

Road Density (km/km2)
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Threshold 1.20
Threshold 0.40
West Nilkitkwa River
Pierre
Sockeye
Tsezakwa
Telzato
Shass
Tahlo
Six Mile
Nilkitkwa River
Tachet
Nichyeskwa
Sutherland River
Port Arthur
Twain
North Arm East
Redrock
Nine Mile
Upper Fulton
Tsak
Wright North
Nilkitkwa East
Wilkinson
Sunnyside
Nilkitkwa West
Wright South
North Arm West
Pinkut Creek

Sub-watershed Units	Area (km^2)	Road Length (km)	Density (km/km^2)
Babine River North	203.95	216.94	1.06
Babine River South	179.22	112.07	0.63
Big Loon	60.03	50.66	0.84
Boling	95.99	90.01	0.94
Boucher	147.61	115.73	0.78
Casdeded	18.03	22.04	1.22
Deep	39.84	46.83	1.18
Donald	169.29	346.25	2.05
F1	7.63	12.17	1.59
F2	15.22	32.00	2.10
Five Mile	43.44	43.24	1.00
Four Mile	107.86	104.32	0.97
Froggy	32.64	30.17	0.92
Guess	333.38	341.25	1.02
Hagan	214.80	406.92	1.89
Halifax	44.71	88.73	1.98
Halifax South	110.04	205.33	1.87
Hanson	41.34	22.38	0.54
Heal	32.00	46.63	1.46
Henrietta	199.79	332.57	1.66
Kew	24.17	12.79	0.53
Lower Fulton River	407.14	438.05	1.08
Morrison	234.09	238.06	1.02
Neodats	138.17	129.42	0.94
Sub-total	**2,900.38**	**3,484.57**	**1.20**

Sub-watershed Units	Area (km^2)	Road Length (km)	Density (km/km^2)
Nichyeskwa	361.55	269.88	0.75
Nilkitkwa East	51.17	74.98	1.47
Nilkitkwa River	655.97	382.02	0.58
Nilkitkwa West	104.20	172.83	1.66
Nine Mile	48.76	64.29	1.32
North Arm East	101.01	114.87	1.14
North Arm West	32.03	57.60	1.80
Pierre	93.33	19.97	0.21
Pinkut	600.89	1104.18	1.84
Port Arthur	46.87	39.17	0.84
Redrock	151.74	182.17	1.20
Shass	152.57	76.92	0.50
Six Mile	53.17	28.40	0.53
Sockeye	144.01	46.85	0.33
Sunnyside	18.83	29.72	1.58
Sutherland River	537.49	420.07	0.78
Tachet	123.97	91.92	0.74
Tahlo	263.20	138.34	0.53
Telzato	26.98	12.61	0.47
Tsak	31.89	44.83	1.41
Tsezakwa	104.28	47.24	0.45
Twain	133.85	120.86	0.90
Upper Fulton	685.15	962.66	1.41
West Nilkitkwa River	170.36	29.13	0.17
Wilkinson	140.12	209.70	1.50
Wright North	33.15	47.44	1.43
Wright South	44.19	74.41	1.68
Sub-total	**4,910.74**	**4,863.08**	**0.99**
Total	**7,811.12**	**8,347.65**	**1.07**



LAKE BABINE NATION
SkeenaWild
CONSERVATION TRUST
Babine Lake Fish and Aquatic Review
Road Density Within the Lake Babine Sub-Watersheds
Legend
Community
Highway
Roads
Railroad
Watershed
Sub-Watersheds
Road Density(Km/Km^2)
Less than 0.40
0.40 - 1.20
Greater than 1.20
1:650,000
West Nilkitkwa River
Nilkitkwa River
Babine River North
Babine River South
Nichyeskwa Creek
Boucher Creek
Tahlo Creek
Nilkitkwa West
Tsezakwa
Five Mile
Nine Mile
North Arm West
Morrison Creek
Halifax
Nesdalis
Halifax South
Hagan
Upper Fulton
Wilkinson
Lower Fulton River
Guess Creek
Wright North
Wright South
Pierre Creek
Twain
Donald
Boling
Six Mile
Hanson
Four Mile
Pinkut Creek
Sutherland River
Shass Creek



LAKE BABINE NATION
SkeenaWild
CONSERVATION TRUST
Babine Lake Fish and Aquatic Review
Road Density Within the Lake Babine Sub-Watersheds - Nilkitkwa Lake
Legend
Community
Highway
Roads
Railroad
Watershed
Sub-Watersheds
Road Density(Km/Km^2)
Less than 0.40
0.40 - 1.20
Greater than 1.20
1:200,000
Nilkitkwa River
Babine River North
Babine River South
Boucher Creek
Nichyeskwa Creek
Tahlo Creek
Nilkitkwa West
Nilkitkwa East
Fort Babine
Tsezakwa
Cascaded
Five Mile
Nine Mile
North Arm East
Morrison Creek
North Arm West
Halifax
Nesdalis
Hagan
Upper Fulton
Halifax South

Stream Crossing Density
Fish Habitat Data

The stream crossing data is a derived product from the BC Environment Provincial Stream Crossing Information System (PSCIS).

The PSCIS model ties stream crossings to a fish habitat model (version 2.0). The fish habitat model assigns three general fish habitat classes to streams.

- Fish Habitat – Observed
- Fish Habitat – Inferred
- No Fish Habitat – Inferred

These three categories are further broken down by gradient (0-10, 15, 20, 25, 30, > 30%)

Stream Crossing Density Interim Thresholds

Interim thresholds used in this analysis follow the recommendations put forth by the Wild Salmon Policy.

- Low risk: < 0.20 crossings/km^2
- Moderate risk: $>= 0.20$ crossings/km^2
- High risk: $>= 0.58$ crossings/km^2

Stream Crossing Density Results

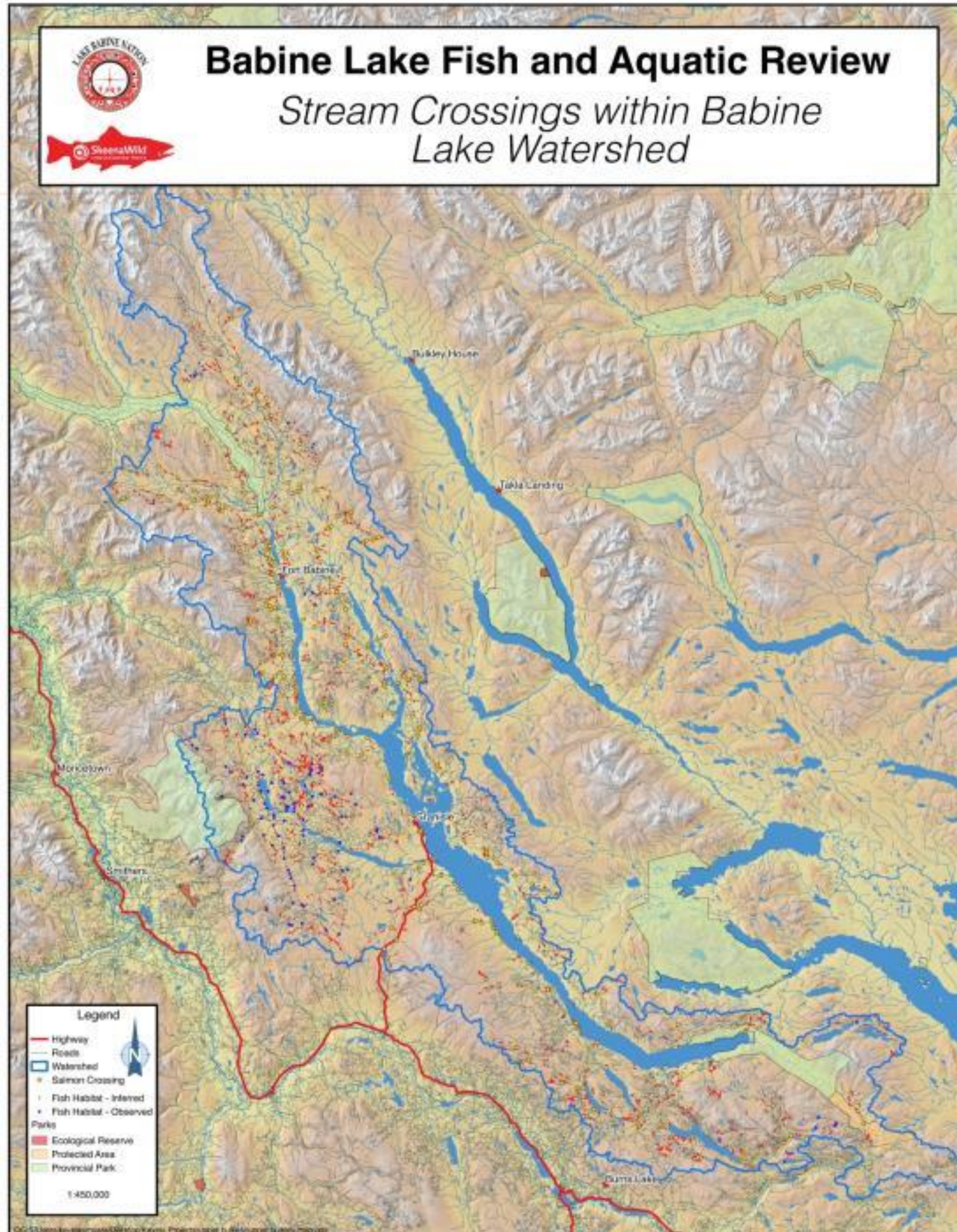
Babine Lake Watershed	0.31 crossings/km^2	moderate
Lake Babine Territory	0.24 crossings/km^2	moderate
WSP Conservation Units	0.26 crossings/km^2	moderate

Three sub-watersheds, F1, Halifax South, and Sunnyside fall within the high risk category. 31 sub-watersheds fall within the moderate risk category, and the remaining 17 sub-watersheds fall within the low risk category.

The Babine Lake Watershed contains a potential 2,403 stream crossings.

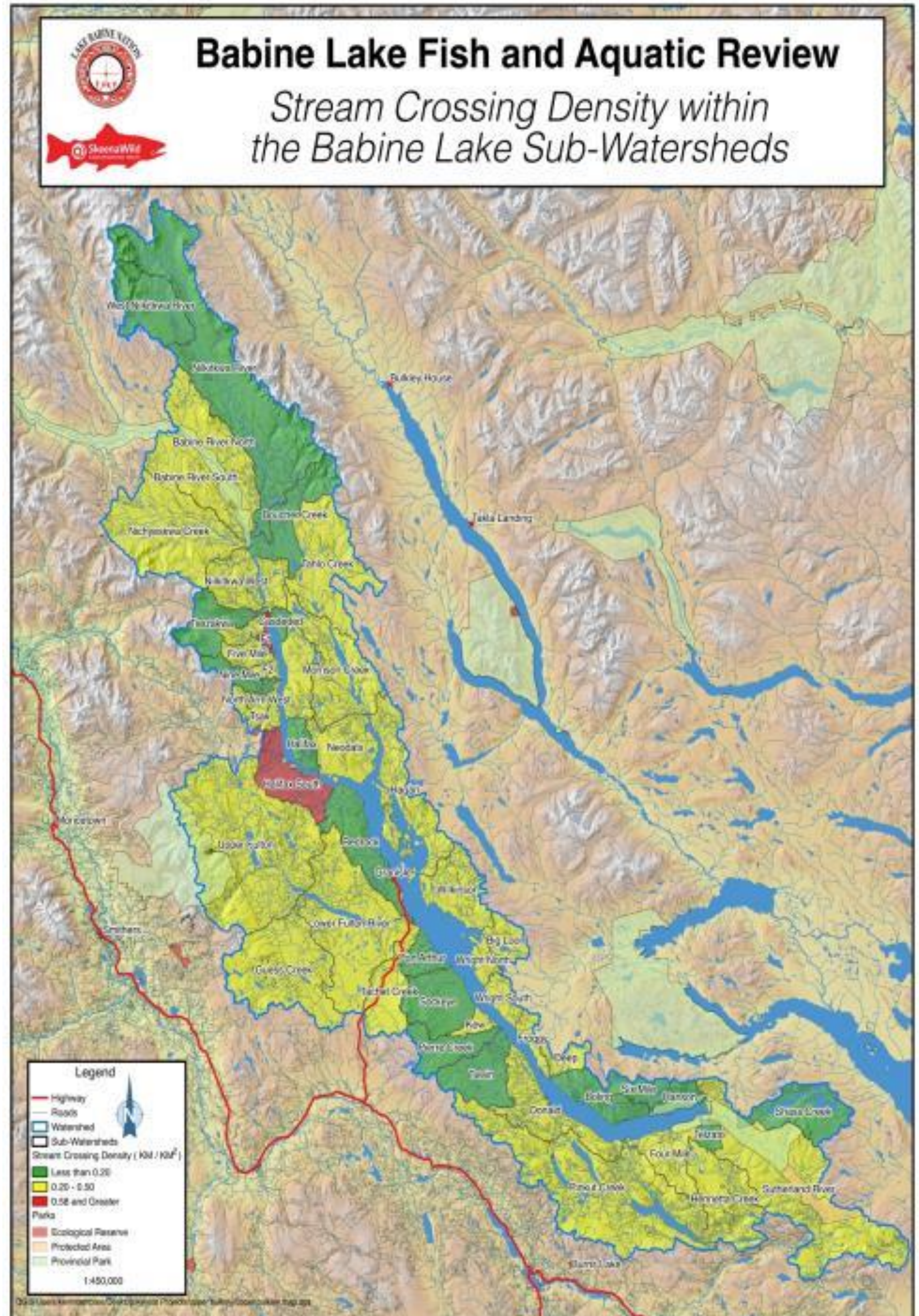
13.9 % (334) of these crossings have confirmed fish presence and 86.1% (2,069) are classified as inferred fish presence.

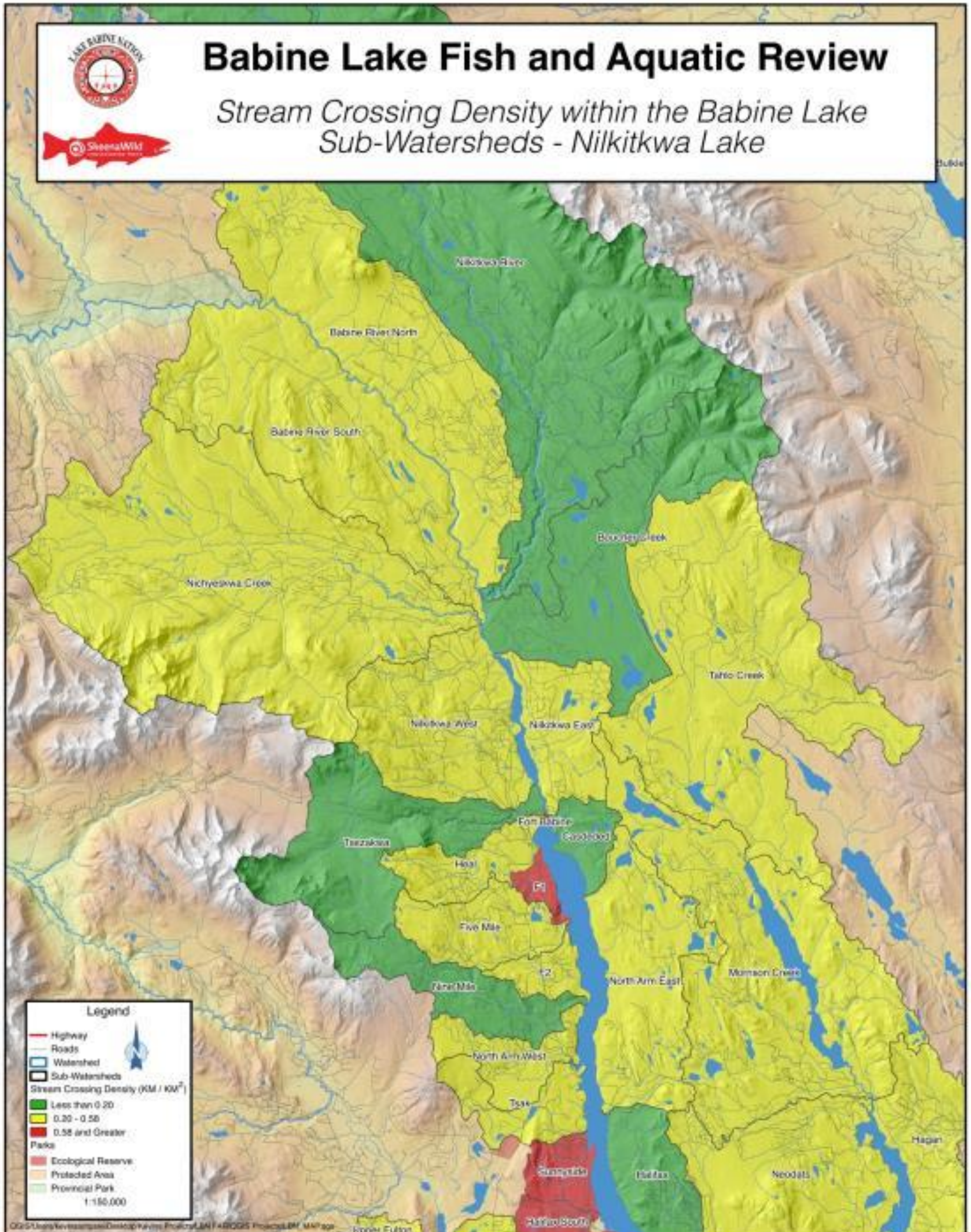
The total stream crossing density falls within the moderate category at 0.31 crossings/km^2.



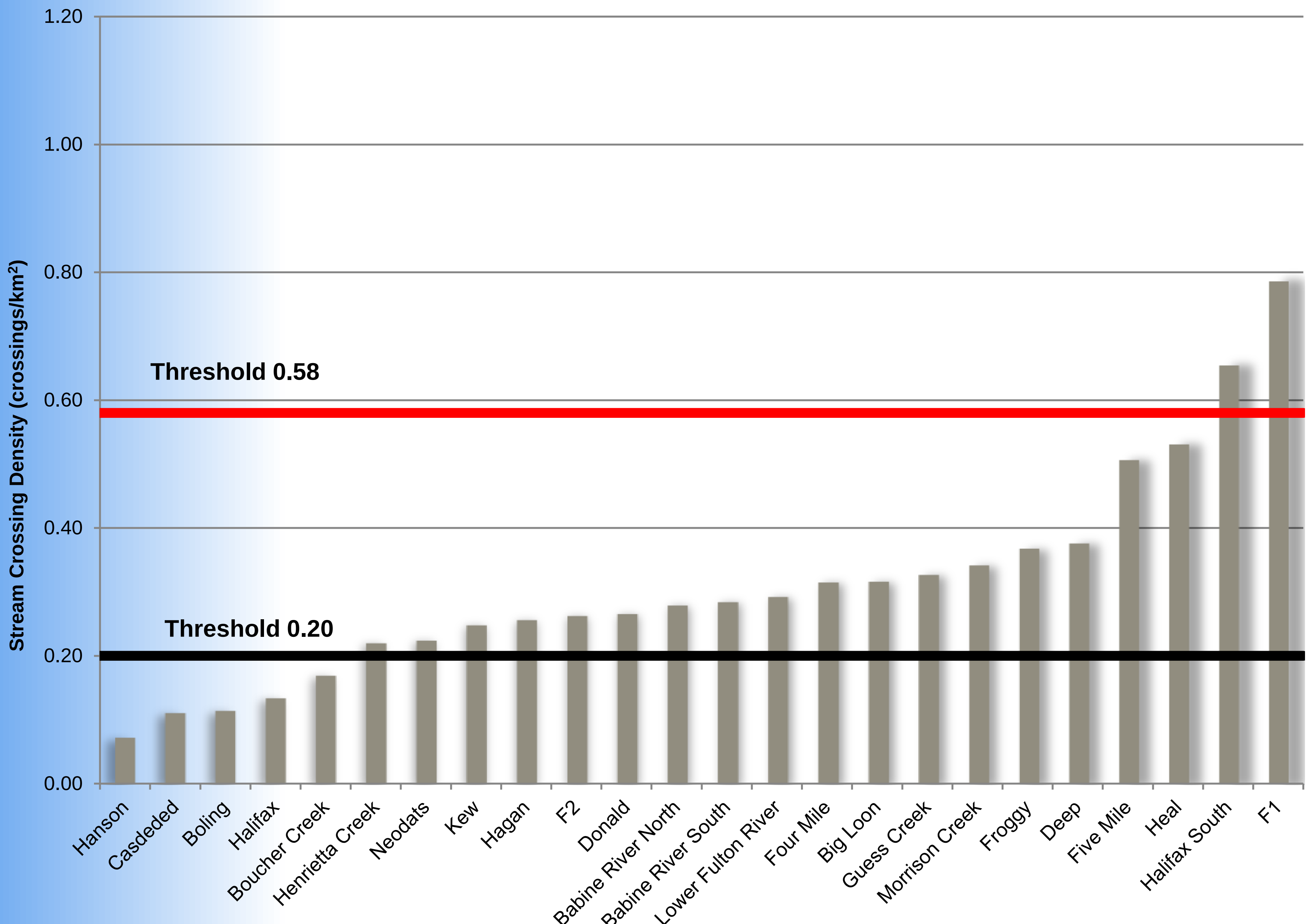
The stream crossing densities in the sub-watersheds range from 0.0 crossings/km^2 in the Telzato sub-watershed to 1.01 crossings/km^2 in the Sunnyside sub-watershed.

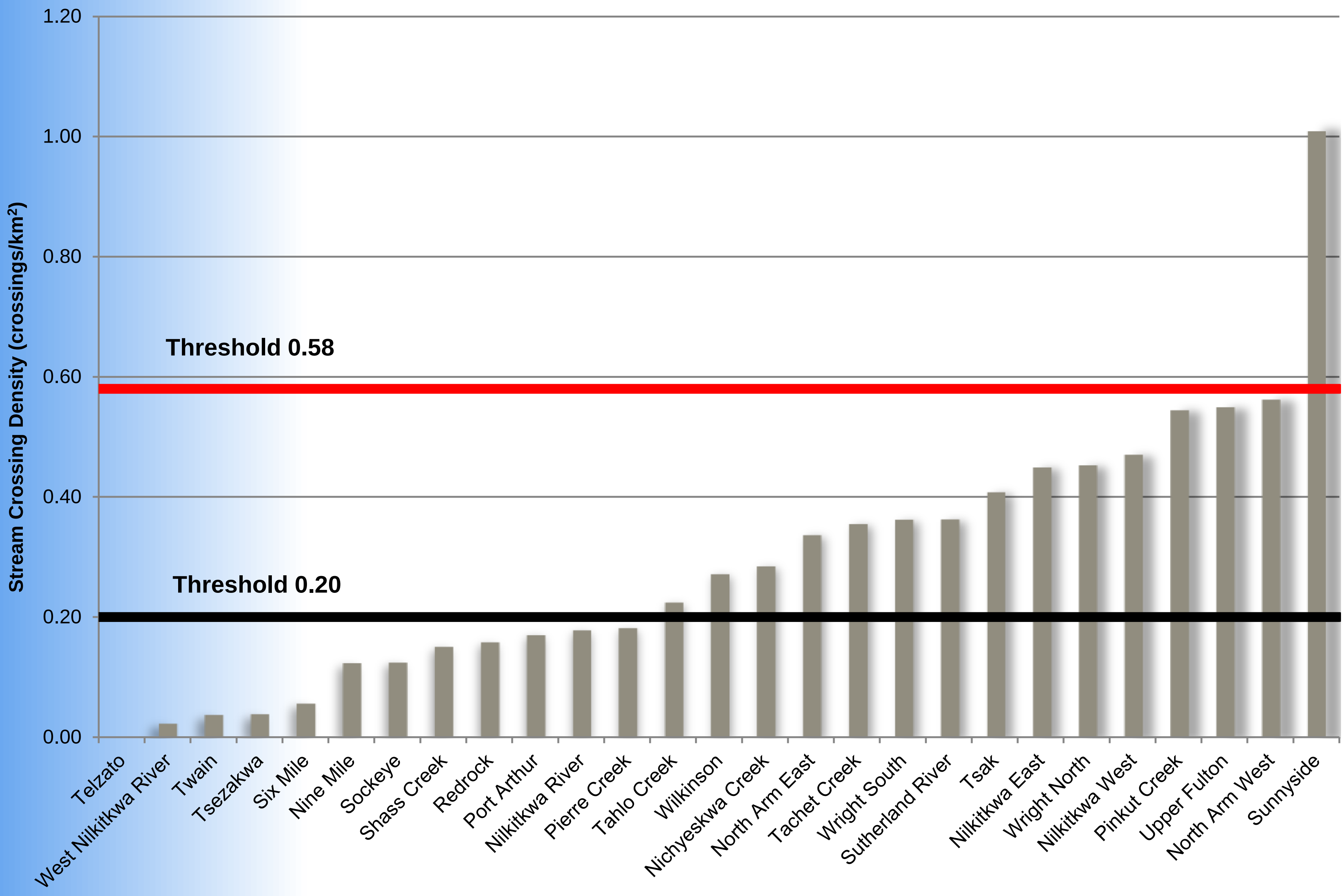
17 sub-watersheds = low
31 sub-watersheds = moderate
3 sub-watersheds = high
(F1, Halifax South, Sunnyside)





Babine Lake Fish and Aquatic Review
Stream Crossing Density within the Babine Lake Sub-Watersheds - Nilkitkwa Lake
Nilkitkwa River
Babine River North
Babine River South
Nichyeskwa Creek
Boucher Creek
Tahlo Creek
Nilkitkwa West
Nilkitkwa East
Fort Babine
Tsezakwa
Heal
Five Mile
Nine Mile
North Arm East
Morrison Creek
North Arm West
Tsak
Hagan
Halifax
Neodats
Halifax South
Upper Fulton
Legend
Highway
Roads
Watershed
Sub-Watersheds
Stream Crossing Density (KM / KM^2)
Less than 0.20
0.20 - 0.58
0.58 and Greater
Parks
Ecological Reserve
Protected Area
Provincial Park
1:150,000


Stream Crossing Density (crossings/km²)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Threshold 0.58
Threshold 0.20
Hanson
Casdeded
Boling
Halifax
Boucher Creek
Henrietta Creek
Neodats
Kew
Hagan
F2
Donald
Babine River North
Babine River South
Lower Fulton River
Four Mile
Big Loon
Guess Creek
Morrison Creek
Froggy
Deep
Five Mile
Heal
Halifax South
F1


Stream Crossing Density (crossings/km²)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Threshold 0.58
Threshold 0.20
Telzato
West Nilkitkwa River
Twain
Tsezakwa
Six Mile
Nine Mile
Sockeye
Shass Creek
Redrock
Port Arthur
Nilkitkwa River
Pierre Creek
Tahlo Creek
Wilkinson
Nichyeskwa Creek
North Arm East
Tachet Creek
Wright South
Sutherland River
Tsak
Nilkitkwa East
Wright North
Nilkitkwa West
Pinkut Creek
Upper Fulton
North Arm West
Sunnyside

Riparian Disturbance

The riparian corridors are calculated as a 30m buffer around all streams. The corridors are intersected with the various linear development features as well as cut blocks.

Feature	Corridor width (m)
Stream	60
Road – main/mainline	30
Road – operational/in-block	18
Railway ROW	30
Pipeline – existing	75

Riparian Disturbance Interim Thresholds

Interim thresholds used in this analysis follow the recommendations put forth by the Wild Salmon Policy.

- Low level disturbance: < 5%
- Moderate level: 5 to 15%
- High level of disturbance: > 15%

Riparian Disturbance Results

Babine Lake Watershed	14.9 %	moderate
Lake Babine Territory	13.0 %	moderate

Within the Babine Lake watershed:

10 sub-watersheds indicate a low riparian disturbance
18 sub-watersheds indicate a moderate riparian disturbance,
24 sub-watersheds rank within the high riparian disturbance category.

The Hagan sub-watershed has the highest riparian disturbance detected where 47.97% of the riparian area has been altered by development.

Riparian disturbance due to pipeline development is only situated within the Nilkitkwa East, Nilkitkwa River, Nilkitkwa West, Tahlo Creek, and Tsezakwa sub-watersheds.

Babine Lake Sub-watersheds

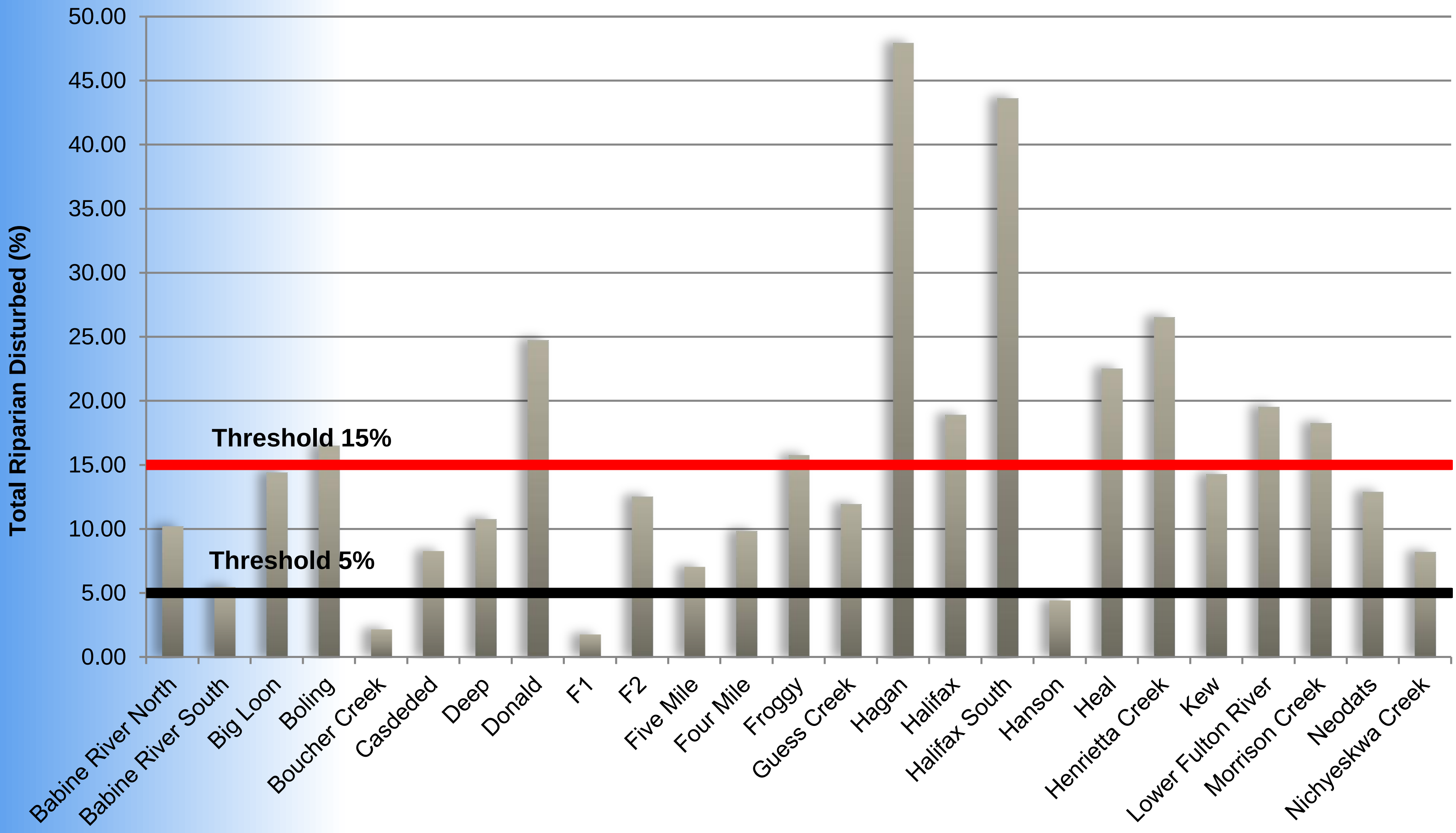
The fifty-one sub-watersheds within the Babine Lake watershed contain 929.50 km^2 (11.90%) of streamside riparian.

15.7% of the riparian is situated along creeks with observed fish presence

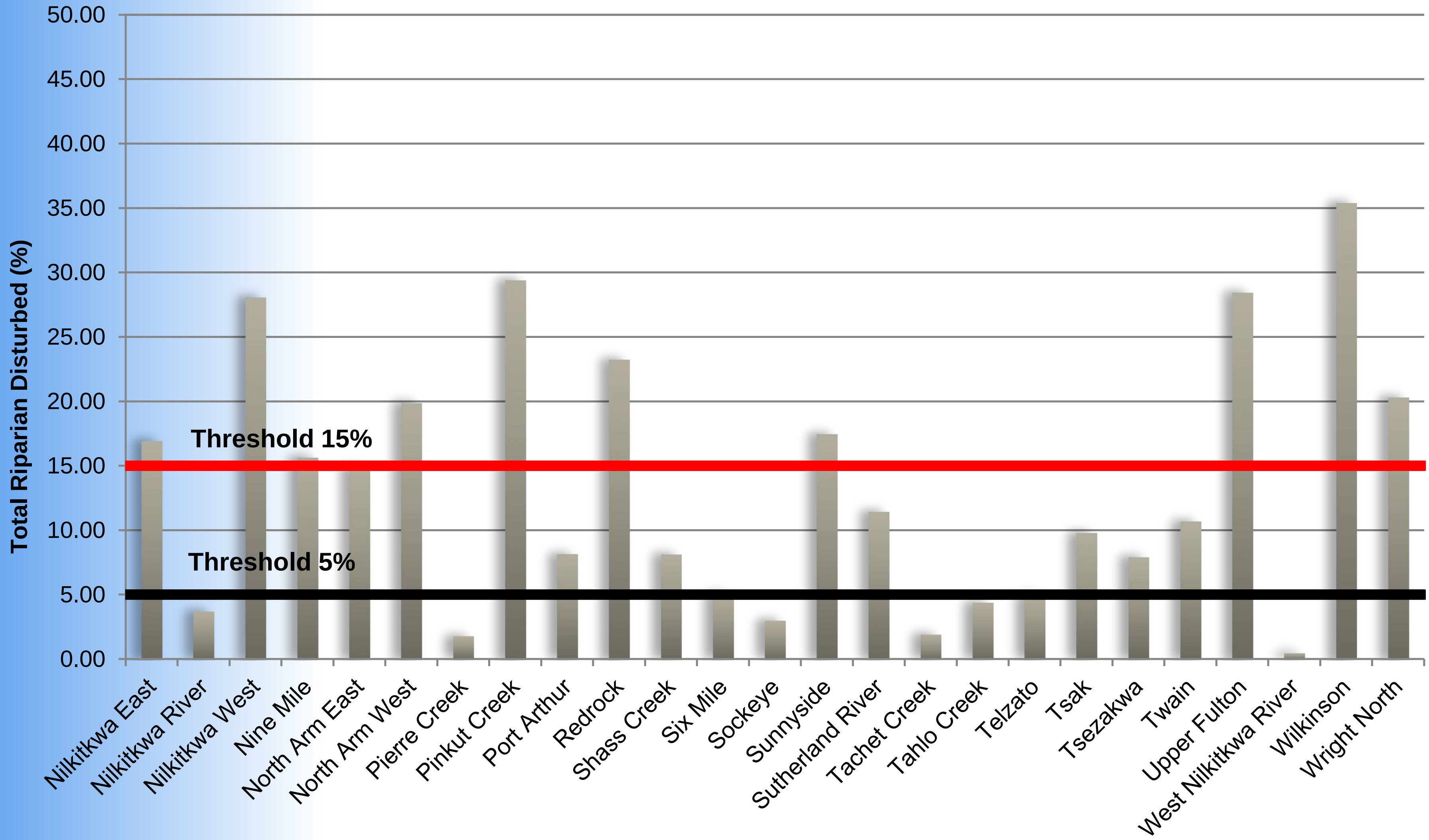
37.3% of the riparian areas are situated along creeks with inferred fish presence

47.0 % of the riparian is situated along creeks classified with no fish presence (inferred).

Riparian Disturbance Thresholds Applied to the Babine Lake Sub-watersheds.



Riparian Disturbance Thresholds Applied to the Babine Lake Sub-watersheds



Summary of Riparian Disturbance (km^2) by Type of Development

Sub-Watershed	Total Riparian (km^2)	Roads	Harvesting	Pipelines	Total Riparian Disturbed	% Riparian Disturbed
Babine River North	23.51	0.25	2.16	0.00	2.40	10.23%
Babine River South	24.83	0.21	1.15	0.00	1.36	5.48%
Big Loon	5.77	0.04	0.79	0.00	0.83	14.44%
Boling	12.68	0.20	1.90	0.00	2.10	16.54%
Boucher Creek	18.58	0.09	0.32	0.00	0.40	2.18%
Casdeded	1.82	0.01	0.14	0.00	0.15	8.29%
Deep	4.13	0.04	0.40	0.00	0.45	10.79%
Donald	18.57	0.37	4.22	0.00	4.60	24.76%
F1	0.86	0.02	0.00	0.00	0.02	1.78%
F2	1.34	0.02	0.15	0.00	0.17	12.55%
Five Mile	5.71	0.07	0.33	0.00	0.40	7.05%
Four Mile	12.46	0.15	1.08	0.00	1.23	9.88%
Froggy	2.36	0.03	0.34	0.00	0.37	15.79%
Guess Creek	38.85	0.42	4.23	0.00	4.65	11.97%
Hagan	18.61	0.44	8.49	0.00	8.92	47.97%
Halifax	4.00	0.08	0.68	0.00	0.76	18.93%
Halifax South	12.66	0.26	5.26	0.00	5.53	43.64%
Hanson	3.74	0.02	0.14	0.00	0.17	4.42%
Heal	3.55	0.06	0.74	0.00	0.80	22.56%
Henrietta Creek	21.69	0.32	5.44	0.00	5.76	26.55%
Kew	3.25	0.04	0.43	0.00	0.47	14.32%
Lower Fulton River	40.13	0.42	7.43	0.00	7.85	19.55%
Morrison Creek	26.64	0.30	4.57	0.00	4.87	18.28%
Neodats	15.25	0.15	1.82	0.00	1.97	12.92%
Nichyeskwa Creek	50.73	0.34	3.83	0.00	4.17	8.22%
Subtotal	**371.74**	**4.34**	**56.05**	**0.00**	**60.39**	**16.25%**

Summary of Riparian Disturbance (km^2) by Type of Development Cont'd.

Sub-Watershed	Total Riparian (km^2)	Roads	Harvesting	Pipelines	Total Riparian Disturbed	% Riparian Disturbed
Nilkitkwa East	4.59	0.09	0.63	0.06	0.78	16.98%
Nilkitkwa River	98.18	0.47	3.07	0.11	3.66	3.72%
Nilkitkwa West	11.89	0.17	3.02	0.15	3.34	28.09%
Nine Mile	5.86	0.06	0.86	0.00	0.92	15.66%
North Arm East	11.63	0.12	1.61	0.00	1.73	14.92%
North Arm West	3.63	0.07	0.65	0.00	0.72	19.89%
Pierre Creek	15.48	0.03	0.25	0.00	0.28	1.78%
Pinkut Creek	68.37	1.64	18.48	0.00	20.12	29.42%
Port Arthur	5.58	0.04	0.41	0.00	0.46	8.16%
Redrock	14.59	0.19	3.20	0.00	3.40	23.27%
Shass Creek	13.06	0.09	0.97	0.00	1.06	8.14%
Six Mile	6.75	0.04	0.30	0.00	0.34	5.05%
Sockeye	20.28	0.07	0.54	0.00	0.61	3.01%
Sunnyside	1.56	0.04	0.23	0.00	0.27	17.49%
Sutherland River	79.82	0.84	8.31	0.00	9.15	11.46%
Tachet Creek	15.63	0.11	0.19	0.00	0.30	1.93%
Tahlo Creek	34.94	0.19	1.26	0.09	1.54	4.41%
Telzato	2.62	0.01	0.12	0.00	0.13	4.92%
Tsak	2.63	0.05	0.20	0.00	0.26	9.80%
Tsezakwa	12.93	0.09	0.92	0.02	1.03	7.94%
Twain	14.05	0.10	1.41	0.00	1.50	10.70%
Upper Fulton	73.62	1.31	19.66	0.00	20.97	28.48%
West Nilkitkwa River	25.01	0.02	0.10	0.00	0.12	0.49%
Wilkinson	11.55	0.17	3.92	0.00	4.09	35.43%
Wright North	0.70	0.01	0.13	0.00	0.14	20.34%
Wright South	2.79	0.06	1.05	0.00	1.11	39.65%
Subtotal	**557.75**	**6.07**	**71.51**	**0.44**	**78.02**	**13.99%**
Total	**929.48**	**10.41**	**127.56**	**0.44**	**138.41**	**14.89%**

Total Accessible Stream Length (Fish Presence)
Total Key Salmon Habitat (Stream Length)

- Total accessible stream length (ASL) consists of streams (or portions of) where resident and anadromous fish presence has been observed or is inferred based on gradient and fish passage. The analysis results are broken down by ASL – observed (fish presence) and ASL – inferred (fish presence).

- Total key salmon habitat consists of streams (or portions of) where salmon presence has been observed and recorded by provincial, federal, and local resource professionals.

- **Thresholds – To be determined**

Breakdown of Total Accessible Stream Length within the Lake Babine Watershed

4.1. Babine Lake Watershed

52.6 % of the total stream length (13,601.67 km) is accessible by fish within the Babine Lake Watershed. The total accessible stream length consists of 2,107.17 (29.4%) km of observed presence and 5,049.17 km (70.6 %) of inferred presence.

Table 4.1.1 Total Accessible Stream Length (ASL) for Resident and Anadromous Fish (km)

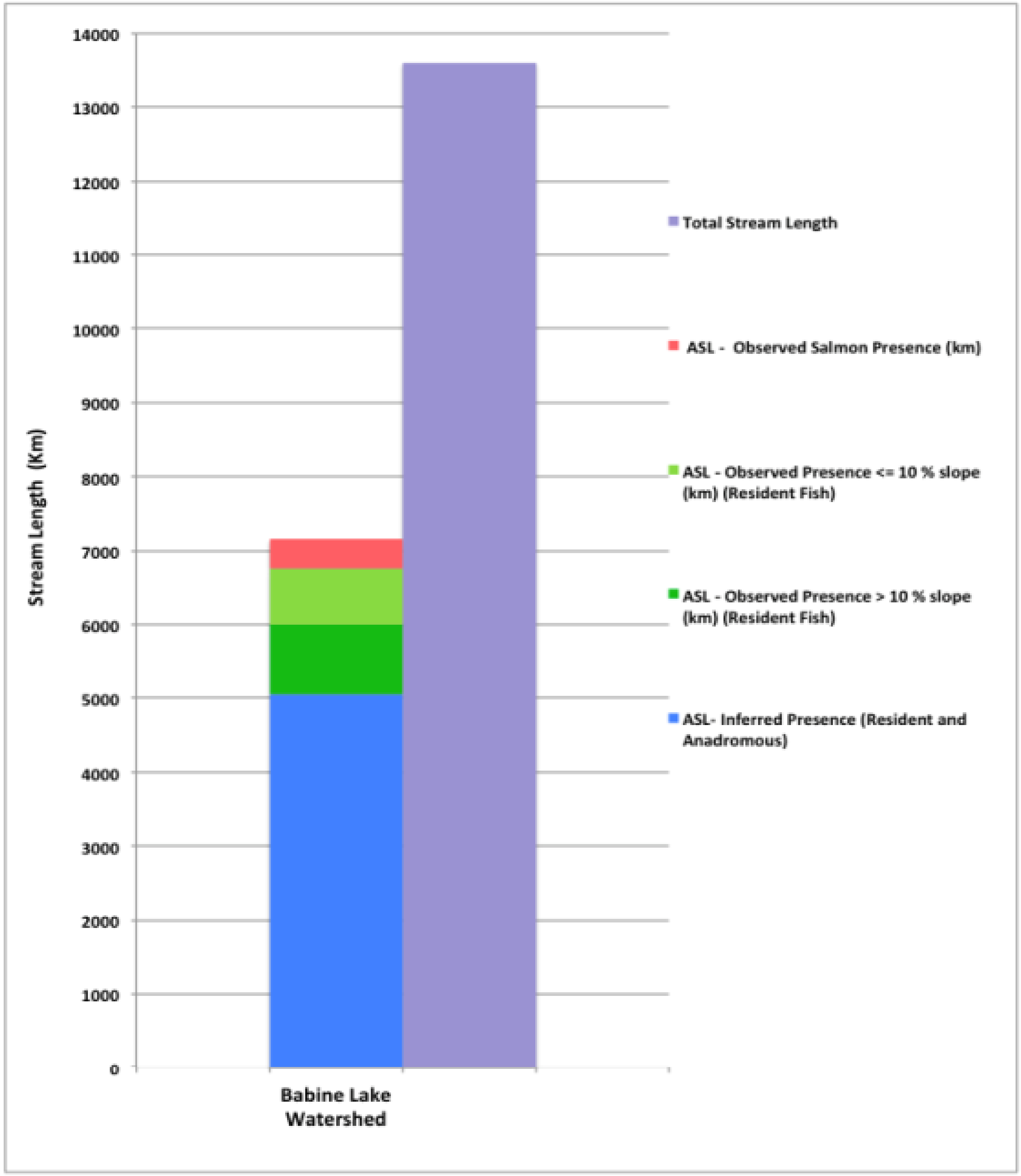
Total Stream Length (km)	Observed Presence (km)	Observed as % of Total ASL	Inferred Presence (km)	Inferred as % of Total ASL	Total ASL (km)	ASL as % of Total Stream Length
13,601.67	2,107.17	29.44%	5,049.17	70.56%	7,156.34	52.61%

Of the 7,156.34 km of observed accessible stream length, 409.10 km (5.7%) is identified key salmon habitat.

Table 4.1.1 Observed Salmon Presence (km)

Total ASL	Observed Presence > 10 % slope (km)	Observed Presence > 10% slope as % of Total ASL	Observed Presence <= 10 % slope (km)	Observed Presence <= 10 % slope as % of Total ASL	Salmon Observed (km)	Total Salmon as % of Total ASL
7,156.34	961.08	13.43%	736.99	10.30%	409.10	5.72%

Figure 4.1.1 Breakdown of Total Stream Length by Fish Habitat within Babine Lake Watershed



Total Land Cover Alteration

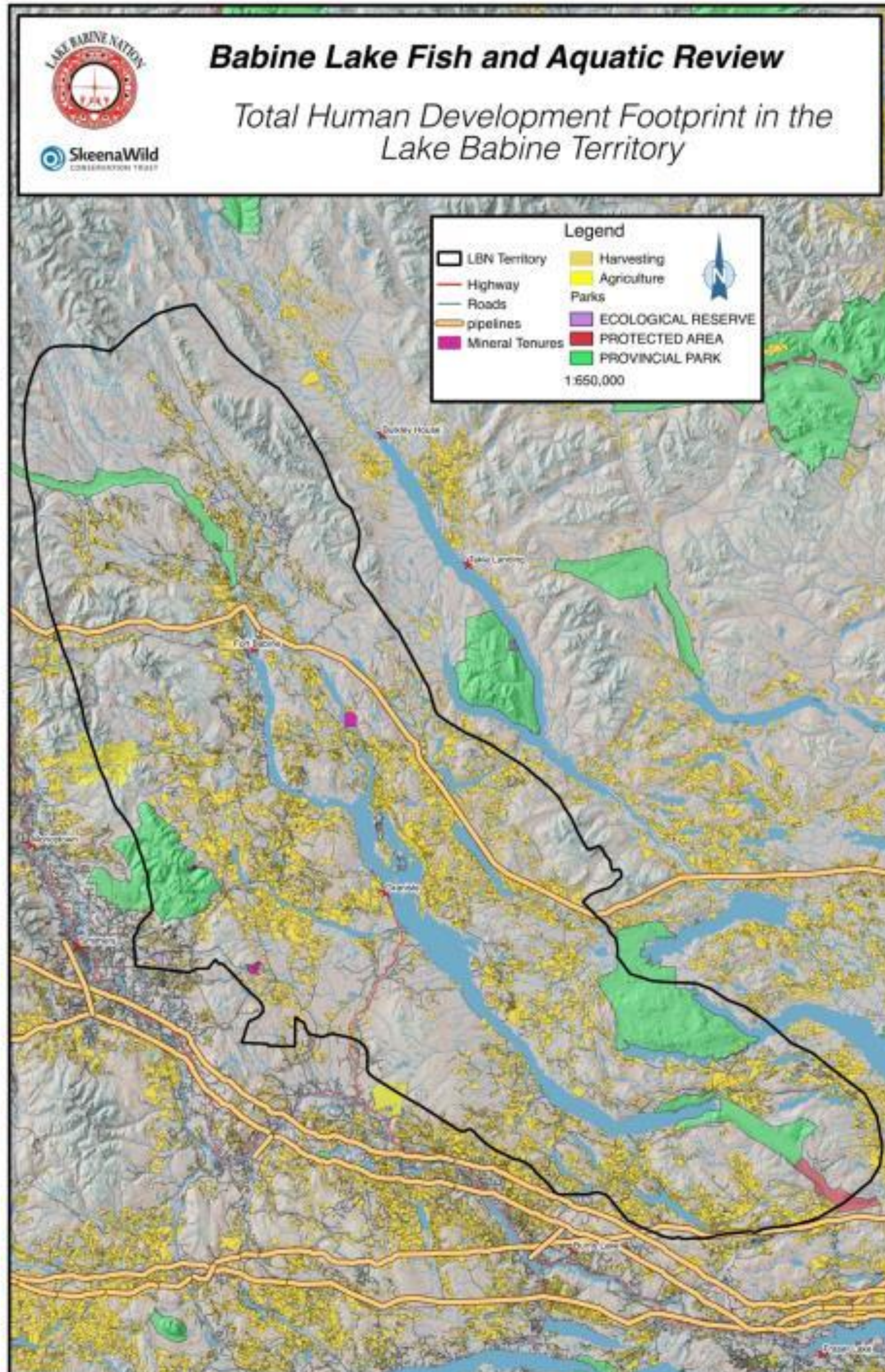
The following spatial information was utilized in the analyses:
Consolidated Skeena roads (DRA, FTEN database, Bing imagery)
Railway, natural gas pipeline, and transmission lines (NTS 1:50,000)
Provincial Harvest Depletion Layer 2015 (consolidated cutblock data from BC Gov't)
Crown Tenures (Agriculture, Industrial, Utility, Transportation, Commercial, Quarrying, Residential, Community)
Mineral Tenures/Advanced Exploration Sites
Bing Maps Aerial photos
Fire History data (BC Wildfire Service)

Low risk: < 6.4%
Moderate risk: >= 6.4%
High risk: >= 22%

Total Land Cover Alteration

Babine Lake Watershed	22.8 %	high
Lake Babine Territory	19.7 %	moderate

A disturbance value of 19.7 % in the Lake Babine Territory indicates a moderate human development footprint.



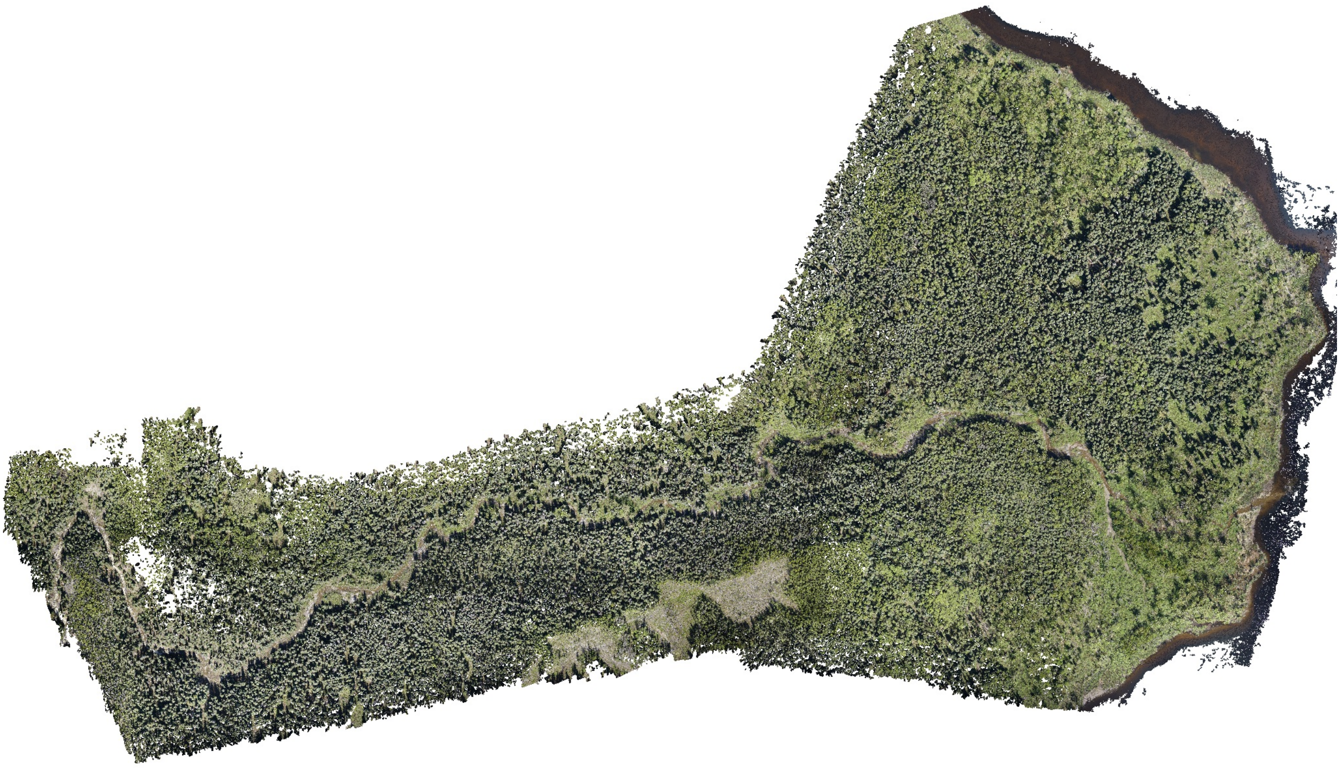
Extension Activities

- Scripts developed to automate the GIS analysis for the road density, stream density, and riparian disturbance indicators.
- Ongoing conversations with Emily and Kenny regarding stream crossing data and possible linkages with the PSCIS program.
- Lake Babine Fish and Aquatic Review reports included in the Lake Babine Fisheries section of the Salmon Data Centre
- Skeena Maps portal for further data visualization and mapping tools.

NineMileCreekMay2017

Processing Report

10 June 2017



Survey Data

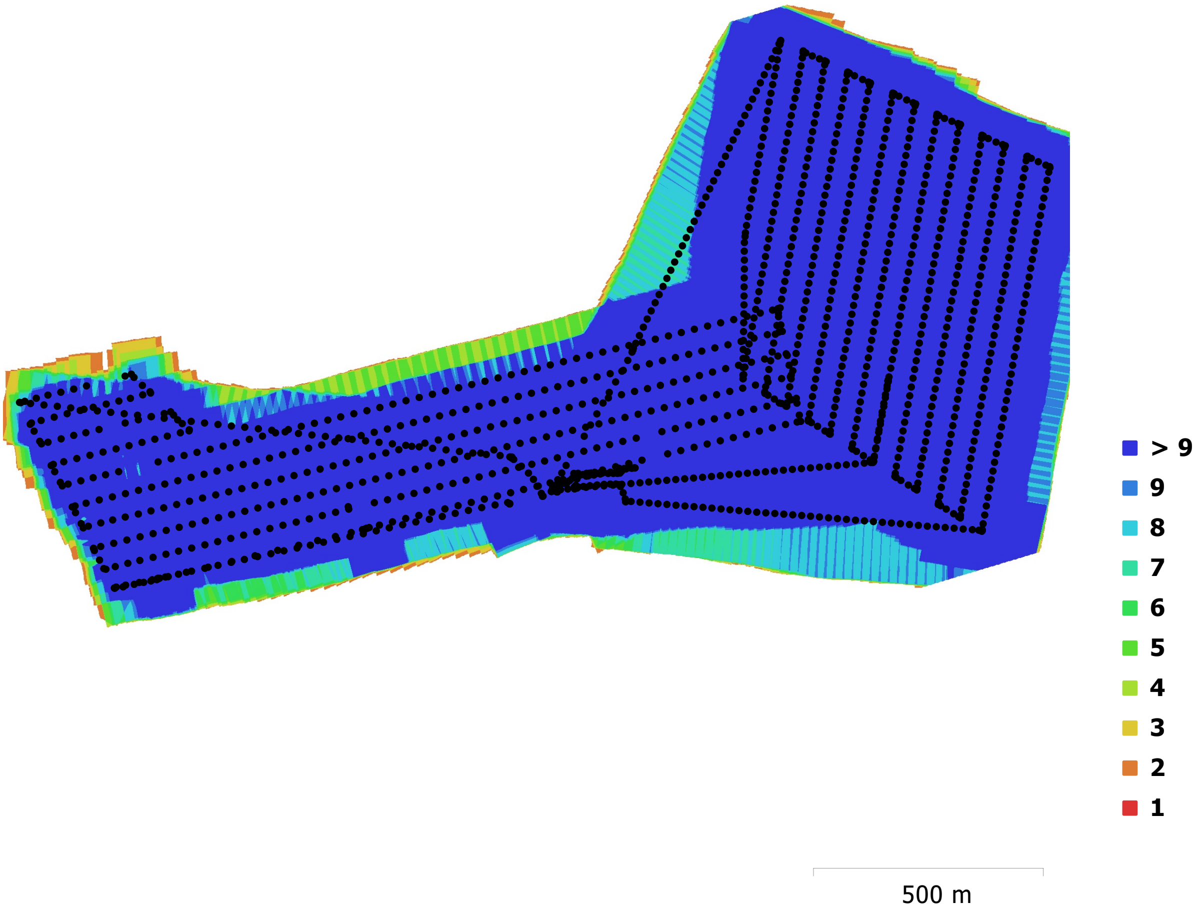


Fig. 1. Camera locations and image overlap.

Number of images:	1,431	Camera stations:	1,422
Flying altitude:	218 m	Tie points:	903,058
Ground resolution:	2.71 cm/pix	Projections:	3,062,889
Coverage area:	1.67 km²	Reprojection error:	1.8 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
ILCE-7R (35 mm)	7360 x 4912	35 mm	4.89 x 4.89 µm	No

Table 1. Cameras.

Camera Calibration

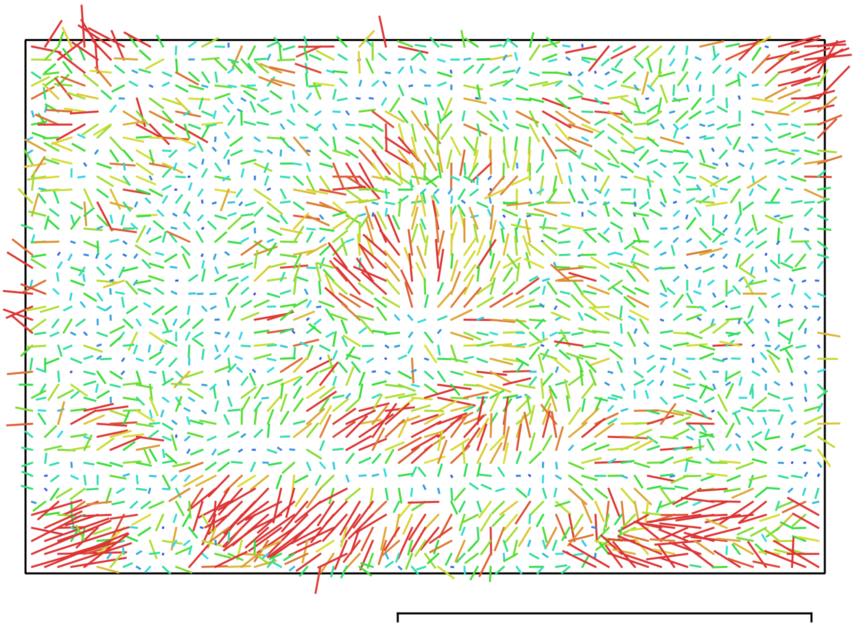


Fig. 2. Image residuals for ILCE-7R (35 mm).

ILCE-7R (35 mm)

1431 images

Type	Resolution	Focal Length	Pixel Size
Frame	**7360 x 4912**	**35 mm**	**4.89 x 4.89 µm**

	Value	Error	F	Cx	Cy	B1	B2	K1	K2	P1	P2
F	**7469.62**	0.93	1.00	-0.15	0.53	-0.03	0.03	0.60	-0.88	0.06	0.10
Cx	**4.38493**	0.074		1.00	-0.02	0.02	0.02	-0.10	0.16	0.78	0.03
Cy	**12.0542**	0.092			1.00	-0.07	0.08	0.26	-0.44	0.08	0.62
B1	**-0.894953**	0.018				1.00	-0.01	-0.02	0.02	-0.01	-0.01
B2	**0.0588253**	0.019					1.00	0.01	-0.02	0.00	0.04
K1	**0.0549291**	6.1e-05						1.00	-0.79	-0.05	0.22
K2	**-0.239265**	0.00014							1.00	-0.02	-0.11
P1	**0.000439942**	2.9e-06								1.00	0.03
P2	**1.10418e-05**	3.2e-06									1.00

Table 2. Calibration coefficients and correlation matrix.

Ground Control Points

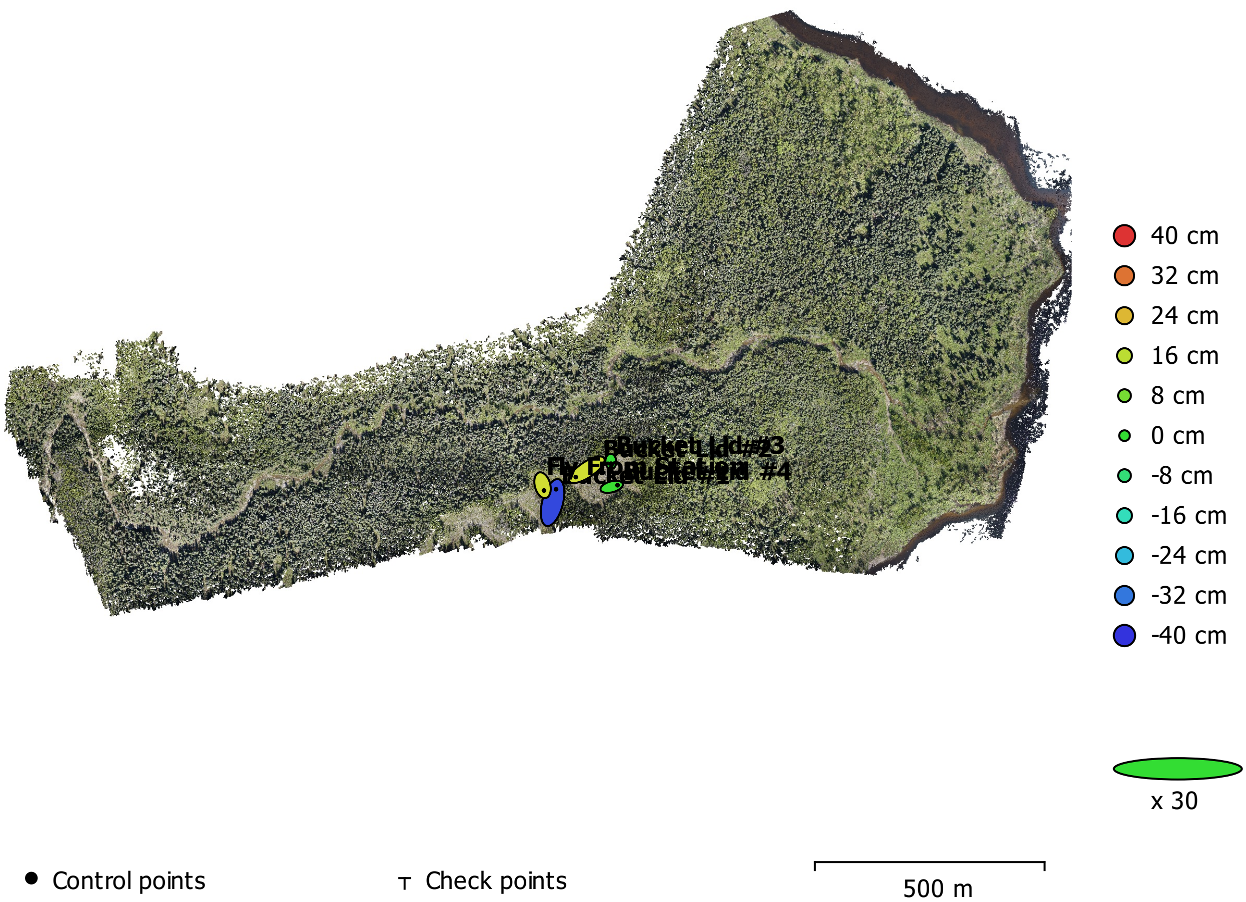


Fig. 3. GCP locations and error estimates.
Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.
Estimated GCP locations are marked with a dot or crossing.

Count	X error (m)	Y error (m)	Z error (m)	XY error (m)	Total (m)
5	0.840966	1.06059	0.205365	1.35354	1.36903

Table 3. Control points RMSE.
X - Longitude, Y - Latitude, Z - Altitude.

Label	X error (m)	Y error (m)	Z error (m)	Total (m)	Image (pix)
Bucket Lid #1	0.506861	1.9337	-0.379402	2.03471	0.078 (2)
Bucket Lid #2	-1.58544	-1.06377	0.184784	1.91817	0.098 (16)
Bucket Lid #3	0.0208793	-0.329104	-0.00729985	0.329846	0.133 (14)
Bucket Lid #4	0.850006	0.230202	0.00954087	0.880678	0.151 (21)
Fly From Station	0.206516	-0.769481	0.18066	0.816938	0.221 (13)
Total	**0.840966**	**1.06059**	**0.205365**	**1.36903**	**0.152**

Table 4. Control points.

X - Longitude, Y - Latitude, Z - Altitude.

Digital Elevation Model

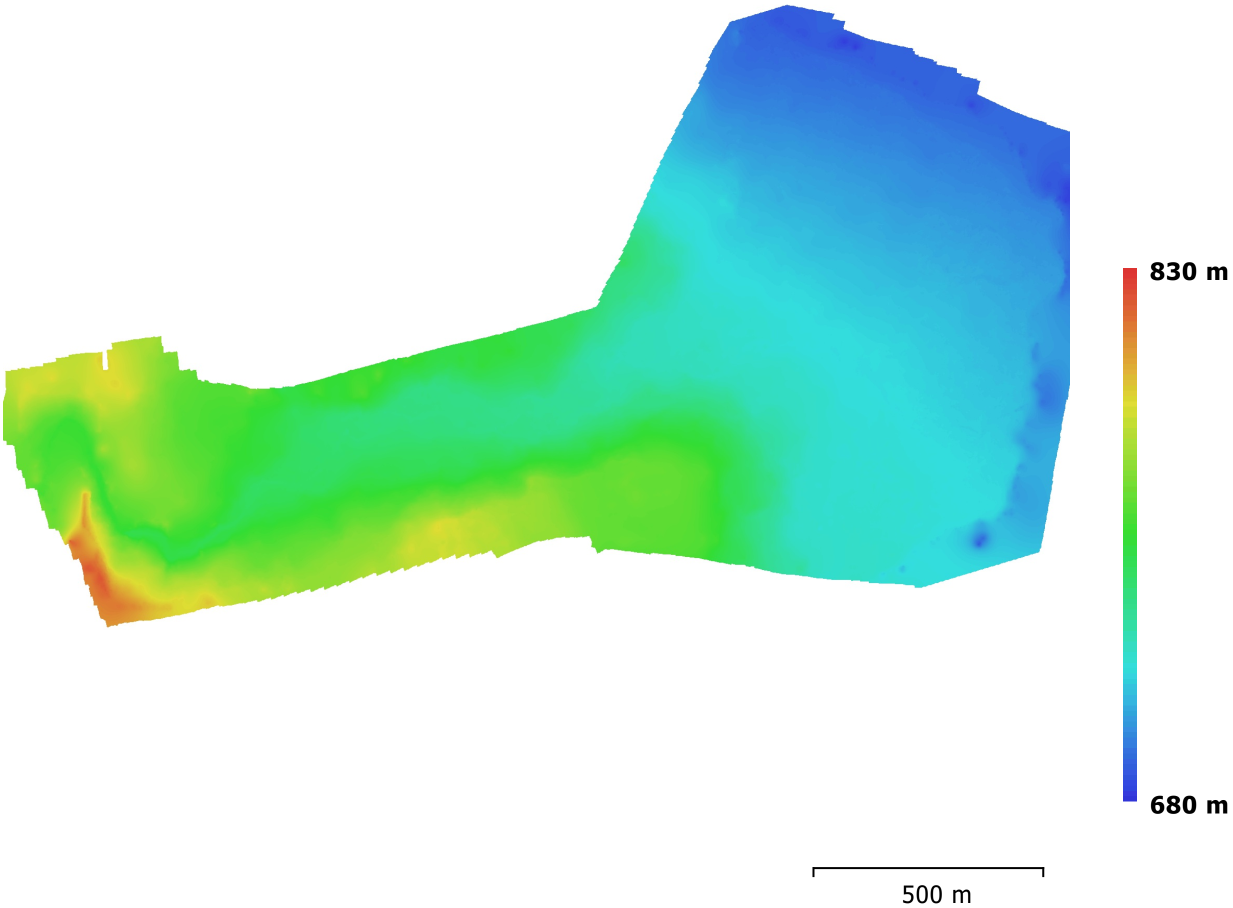


Fig. 4. Reconstructed digital elevation model.

Resolution:	10.8 cm/pix
Point density:	85.2 points/m²

Processing Parameters

General	
Cameras	1431
Aligned cameras	1422
Markers	5
Coordinate system	WGS 84 (EPSG::4326)
Rotation angles	Yaw, Pitch, Roll
Point Cloud	
Points	903,058 of 1,006,504
RMS reprojection error	0.116774 (1.79662 pix)
Max reprojection error	1.0776 (66.3404 pix)
Mean key point size	10.0712 pix
Effective overlap	4.08947
Alignment parameters	
Accuracy	Medium
Generic preselection	Yes
Key point limit	40,000
Tie point limit	4,000
Adaptive camera model fitting	Yes
Matching time	43 minutes 19 seconds
Alignment time	17 minutes 14 seconds
Optimization parameters	
Parameters	f, b1, b2, cx, cy, k1, k2, p1, p2
Fit rolling shutter	No
Optimization time	28 seconds
Depth Maps	
Count	1422
Reconstruction parameters	
Quality	Medium
Filtering mode	Mild
Processing time	1 hours 27 minutes
Dense Point Cloud	
Points	256,698,922
Reconstruction parameters	
Quality	Medium
Depth filtering	Mild
Depth maps generation time	1 hours 27 minutes
Dense cloud generation time	6 hours 0 minutes
DEM	
Size	25,007 x 17,994
Coordinate system	WGS 84 (EPSG::4326)
Reconstruction parameters	
Source data	Dense cloud
Interpolation	Enabled
Processing time	6 minutes 9 seconds
Software	
Version	1.3.2 build 4205
Platform	Windows 64

BABINE LAKE WILD SOCKEYE HABITAT REHABILITATION:

MAY 23, 2017 AND JUNE 12, 2017 SOCKEYE HABITAT WORKSHOPS

SUMMARIES AND MEETING MINUTES

Lake Babine Nation Fisheries Program
June 2017

Table of Contents

Introduction

Lake Babine Nation has conducted sockeye stock assessment and habitat assessments and monitoring over the last several years. The information collected is pertinent to the design and implementation of a Babine Wild Sockeye Recovery Plan. The goal of a recovery plan is to stop and reverse the decline of Babine sockeye salmon and ensure the natural bio-diversity and genetic integrity of wild Babine sockeye stocks is maintained in perpetuity.

The Lake Babine Nations Fisheries Program has implemented stock and habitat monitoring and assessment projects that focus on determining threats to wild Babine sockeye populations. Identification of factors that contribute to stock declines and/or to reductions in habitat productivity and integrity is a precursor to recovery planning.

Stock monitoring to date has included:

- Annual operation of the Babine counting weir
- Annual stream escapement monitoring in the lower Babine River and tributaries and Babine Lake tributaries
- Babine River sockeye smolt enumeration
- Smolt: spawner ratios for brood years 2011 - 2014
- Installation of a fry fishway at the Babine counting weir to assist fry migrating upstream to Nilkitkwa and Babine lakes
- Participation in research studies conducted by Fisheries and Oceans Canada research scientists (Dr. Dan Selbie et al) regarding nutrient loads (N vs P) in Babine Lake, phytoplankton population composition, monitoring of smolt weight and decline in smolt production in Babine Lake, , Babine Lake water temperature profiles, Babine Lake sediment core samples

Habitat monitoring has included:

- Babine Lake tributary water level, discharge and water quality monitoring which includes continuous temperature monitoring at numerous sites
- Monitoring water quality and habitat conditions of the lower Babine River and Babine Lake tributaries
- Beaver dam management – to create access for spawners into Babine Lake tributaries
- Babine Lake tributary access management to ensure access for sockeye spawners
- Annual stream survey measurements in Babine Lake tributaries to monitor changes in habitat and to look for potential habitat restoration projects
- Helicopter over-flights to determine upstream impacts (e.g. Twain Creek failing banks contributing to sediment transport and access issues) that assist in determining feasibility and viability of conducting downstream habitat projects (2015-2016)
- Winter helicopter over-flight to look for areas of groundwater influence (potential to use groundwater to augment low summer flows, water levels and higher water temperatures)

- GIS project to develop a shared understanding of current freshwater habitat impacts. Land use impacts in the Babine watershed were compared to recommended threshold levels from the Wild Salmon Policy. Habitat indicators included road density, stream crossing density, riparian disturbance, key salmon habitat and total land cover alteration. GIS results assist with collaborative land use planning that aims to reduce negative impacts to salmon habitat.

Suskwa Research conducted a literature search and information summary to assist with creating a shared understanding of the status of Babine watershed habitat.

Babine Lake Wild Sockeye Habitat Rehabilitation Workshops

Two workshops were held with the following objectives:
- Gather multi-discipline experts together to present and discuss research and monitoring activities in the Babine watershed that are pertinent to wild Babine sockeye
- Using information from the multi-discipline experts and from the literature search and summary of state of Babine watershed habitat, facilitate a group discussion to determine current impacts and threats to wild Babine sockeye production and sustainability
- Discuss gaps in information and requirements for collection of missing information
- Facilitate discussion regarding developing approaches to restoring wild sockeye recruitment in the Babine system
- Form partnerships with multi-discipline experts and stakeholders in the Babine watershed, with clearly defined roles and responsibilities, to design and implement small scale habitat rehabilitation projects

This document provides the objectives and summaries of the presentations and discussions that occurred during the May 23, 2017 and June 12, 2017 workshops.

Workshop 1: May 23'rd, 2017

Objectives:
- Gather multi-discipline experts together to present and discuss research and monitoring activities in the Babine watershed that are pertinent to wild Babine sockeye
- Discuss gaps in information and requirements for collection of missing information

Results

An information gathering workshop was held on May 23'rd, 2017 in Smithers, BC.

Experts invited to attend the workshop included:
- Dr. Kim Hyatt – Department of Fisheries and Oceans Canada (DFO)
- Dr. Dan Selbie – DFO

- Andy Rosenberger, Fisheries Management and Research Biologist, Lake Babine Nation (LBN)
- Mark Tiley, Senior Biologist, LBN
- Kenny Rabnett, Suskwa Research
- Emily Mason, Biologist, LBN
- Jeff Anderson, Senior Manager – Freshwater Skeena Region, World Wildlife Fund
- Vanessa Foord, Research Climatologist, North Area, Forests Lands and Natural Resource Operations
- Johanna Pfalz – Eclipse Geomatics
- Lana Miller, Resource Restoration Biologist, DFO
- Natalie Newman, Community Advisor, DFO
- Sandra Devcic, Resource Restoration P. Eng, DFO
- James Powell, Resource Restoration, Engineering Tech, DFO
- Dave Peacock, Stock Assessment Biologist, DFO
- Brenda Donas, Biologist and meeting facilitator

Presentations provided information on Babine wild sockeye stock status and Pinkut and Fulton spawning channel production trends. Dr. Dan Selbie was unable to attend the workshop but a synopsis of the research being conducted was given by Mark Tiley, Senior Biologist, LBN. The final results from the research were not made available however, Dr. Selbie agreed to conduct a presentation on the Babine Lake research project results in July 2017.

Vanessa Foord presented information on climate change impacts specific to the Babine watershed and models that can be used as predictive tools in determining annual impacts of climate change on salmon habitat. For example, impacts of climate change may lead to changes in hydrology that negatively impact Babine sockeye. Modelling data needs to be considered when determining feasibility of potential habitat projects. There was discussion on climate monitoring data gaps and an agreement to discuss how LBN could install monitoring stations to assist with information collection.

GIS information (Johanna Pfalz, Eclipse Geomatics) was provided and Babine watershed results were compared to the recommended threshold levels in the Wild Salmon Policy.

A review of and highlights from the habitat reconnaissance flights and stream walks was presented by Lana Miller, Resource Restoration Biologist, DFO.

Keynote Information from the May 23, 2017 Workshop

- Wild sockeye populations are in decline
- In some years the ratio of spawners to recruits is barely 1:1 i.e. spawning and resultant returns are not enough to sustain population levels in some years

- After the Babine Lake Development Project (Fulton and Pinkut spawning channels) began producing fry, smolt weights decreased for a period of time (1970's to late 1980's). In the early 1990's and from 2013 to 2016 smolt weights had increased.
- Harvest rates in Alaskan fisheries may be unsustainable for wild Babine sockeye which are harvested in Alaskan pink salmon fisheries (Pacific Salmon Treaty issue)
- State of the habitat is changing with lower water levels, higher water temperatures
- Spawner access to Babine tributaries is an issue and as climate change advances, access up the mainstem Babine River, due to reduced summer flows and/or high temperatures, may become impeded
- Babine watershed is a snow melt dependent system. Recent climate change patterns show that winter precipitation is decreasing, winter atmospheric temperatures are increasing and number of frost free days is decreasing
- Climate change predictions point to increasing temperatures during winter with less precipitation as snow and, warmer summer temperatures with more precipitation. Evaporation rates may be increasing partially negating an increase in precipitation.
- Historically, sediment has been transported to mouths of creeks restricting access to spawners in some years. This process continues today but may be exacerbated by land use activities, climate change and changes to hydrological processes
- Changes in water flows, levels and increasing temperatures may create physiological stress that inhibits successful spawning and reduces incubation survival.
- Nutrient levels in Babine Lake have increased as a result of the Babine Lake Development Project spawning channels and this may have resulted in changes to the food web structure
- Changes in plankton communities are being monitored and the research from 2013 appears to point to a shift in plankton production away from the preferred species, such as *Daphnia spp.*, to less palatable plankton that have lower nutritional value
- GIS analysis compared land use impacts in the Babine watershed to the recommended threshold levels stated in the Wild Salmon Policy. The majority of the Babine watershed falls within the moderate to high risk categories for road density. Stream crossing density is classed as moderate. The Babine watershed has 14.9% riparian disturbance and 24 sub-watersheds are classified as having a high level of riparian disturbance. Total land cover alteration is classified as high to moderate.
- There are upslope (higher elevation) impacts that are very large in some areas of the watershed (e.g. Twain Creek)
- There is some ground water influence in areas of the watershed. There is potential for groundwater augmentation during low flow/water level, which may improve the temperatures of streams such as the Upper and Lower Tahlo Rivers and the Morrison River which experience periods of high water temperatures, sometimes exceeding 20^{o}C, during parts of July and August.

Notes from the May 23'rd, 2017 workshop are included as Appendix 1.

Workshop 2: June 12’th, 2017

<u>Objectives:</u>

- Using information from the multi-discipline experts and from a literature search, facilitate a group discussion to determine current impacts and threats to wild Babine sockeye production and sustainability
- Discuss gaps in information and requirements for collection of missing information
- Facilitate discussion regarding developing approaches to restoring wild sockeye recruitment in the Babine system
- Form partnerships with multi-discipline experts and stakeholders in the Babine watershed, with clearly defined roles and responsibilities, to design and implement small scale habitat rehabilitation projects

<u>Results:</u>

A habitat planning group workshop was held on June 12’th, 2017 in Smithers, BC.

Experts invited to attend the workshop included:

- Dr. Dan Selbie – DFO
- Andy Rosenberger, Fisheries Management and Research Biologist, Lake Babine Nation (LBN)
- Mark Tiley, Senior Biologist, LBN
- Kenny Rabnett, Suskwa Research
- Emily Mason, Biologist, LBN
- Jeff Anderson, Senior Manager, Freshwater – Skeena Region, World Wildlife Fund
- Lana Miller, Resource Restoration Biologist, DFO
- Natalie Newman, Community Advisor, DFO
- Sandra Devcic, Resource Restoration P. Eng, DFO
- James Powell, Resource Restoration, Engineering Tech, DFO
- Brenda Donas, Biologist and meeting facilitator

<u>Keynote information from the June 12’th, 2017 Workshop:</u>

- Photo presentation showing state of the habitat of 12 Lake Babine tributaries and respective escapement data
- Photo presentation showing 4 small scale habitat projects on streams similar to Lake Babine tributaries. Two projects were installed by hand and two projects required excavators.
- Discussion on habitat project evaluation criteria. Criteria to evaluate and prioritize habitat projects could include escapement history, types of upstream impacts, discharge

trends, water temperature trends, stream access condition, sediment transport issues, locations of impassable barriers.

- Discussion on projects required to address data gaps
- Discussion on potential partnerships
- Discussion on small scale pilot projects for summer 2017
- Discussion on future funding opportunities

Notes from the June 12'th, 2017 workshop are included as Appendix 2.

Conclusions and Recommendations:

The Babine Lake Wild Sockeye Habitat Rehabilitation Workshops provided an opportunity for multi-discipline experts, interested in wild Babine sockeye, to provide and gather information. The workshops created a shared understanding of current stock and habitat status and highlighted areas for concern.

Data gaps were identified and areas where additional work is required were discussed.

Stock and habitat status monitoring on wild Babine sockeye streams will continue in 2017. It is important that LBN and multi-discipline experts continue to communicate on status of Babine sockeye and on results from various research and monitoring studies.

Recommendations:

LBN continue to facilitate semi annual or annual workshops to bring multi-discipline experts together to discuss research and monitoring results. (Collaborative planning for future initiatives).

LBN facilitate partnerships with Non-Government agencies that specialize in assisting with acquiring sensitive stream designation for selected Babine streams.

LBN engage in an internal post season review to highlight linkages between LBN Fisheries Program components, define and discuss stock and habitat concerns and priorities. Information could assist in annual work plans and with determining funding required from outside sources.

APPENDIX 1. Babine Sockeye Habitat Rehabilitation Project Introductory Synopsis of the Babine Watershed Pertaining to Sockeye Salmon and Their Habitat: May 23, 2017 Meeting Minutes:

Meeting Attendees

Andy Rosenberger – Fisheries Management and Research Biologist, LBN
Emily Mason – Biologist, Lake Babine Nation
Brenda Donas – Biologist, Meeting Facilitator
Jeff Anderson – Biologist, World Wildlife Fund
Kenny Rabnett – Suskwa Research
Lana Miller – Resource Restoration Biologist, Fisheries and Oceans Canada
Natalie Newman – Community Advisor, Fisheries and Oceans Canada
Vanessa Foord – Climatologist, North Area, Ministry of Forests, Lands and Natural Resource Operations
Johanna Pfalz – Eclipse Geomatics
Mark Tiley – Senior Biologist, Lake Babine Nation

Introduction

Babine River Sockeye are a primary food source for the Lake Babine Nation and for other First Nations peoples from the confluence of the Skeena River upstream to Lake Babine Nation territory. Approximately 90% of Skeena River sockeye return to the Babine watershed and 75% of those returns are from the Pinkut and Fulton systems.

Babine sockeye are harvested in Alaskan commercial fisheries, Canadian fisheries, in-river Food, Social and Ceremonial (FSC) fisheries, Excess Salmon to Spawning Requirements (ESSR) fisheries in Babine Lake and recreational fisheries. Sockeye are harvested at the Babine River counting fence and in Babine Lake as part of FSC fisheries.

There are three distinct run timings of wild Babine sockeye:

- early (peak through Tyee around July 10'th) – Babine Lake tributary stocks
- mid (peak through Tyee around July 22'nd) - Tahlo/Morrison
- late (peak through Tyee around July 29'th) – Nilkitkwa (upper and lower Babine River populations)

Sockeye produced in the spawning channels at Pinkut and Fulton have similar timing to the wild, mid-timed Tahlo/Morrison and late-timed Babine River sockeye.

The Fulton spawning channels were constructed in 1965 (channel 1) and 1971 (channel 2) and the Pinkut spawning channel was constructed in 1968. The purpose of the channels was to produce additional sockeye fry to better use the rearing capability of Babine Lake. Additional fry production contributes additional harvestable fish to commercial, recreational and FSC fisheries. Since the 1970's Babine sockeye production has been dominated by production from the spawning channels. Skeena sockeye abundance has been monitored since the early 1900's. Catch, escapement and exploitation rates have been affected by the presence of enhanced fish from the spawning channels.

There are approximately 30 sockeye escapement counting sites on the Babine system and a total of 14 indicator streams/sites including:

- 7 early timing wild indicator streams (Babine Lake tributaries)
- 2 mid timing wild indicator streams (Tahlo/Morrison)
- 2 late wild timing indicator areas (2 sections of the Babine River)
- Pinkut and Fulton spawning channels (both have counting fences)
- Babine weir (counting fence)

Habitat monitoring is occurring throughout the watershed to assist with determining status of the fish habitat. Monitoring includes:

- Water temperature – continuous monitoring
- Water quality parameters such as dissolved oxygen, pH, conductivity, hardness, alkalinity, carbon dioxide (CO_2)
- Water discharge and levels
- Limnological studies (water quality including nutrient concentrations, phytoplankton, zooplankton, bacteria,
- Stream surveys – measure physical characteristics of selected streams
- Spawner access surveys
- Sediment transport
- Level of substrate embeddedness (cobble and gravel embeddedness)
- Snow pack
- Precipitation
- Road density
- Stream crossing density
- Riparian disturbance
- Total land cover alteration

Multi-agency monitoring of stock strength and habitat status is providing results that are of concern to Lake Babine Nation. The Babine Sockeye Habitat Rehabilitation Project was developed to determine prescriptions for returning health of the watershed to a level that will sustain sockeye salmon production in perpetuity.

This report provides a summary of information that was gathered at a meeting hosted by Lake Babine Nation on May 23, 2017. The information gathering meeting included participants from government agencies, NGO's and Fisheries program staff from Lake Babine Nation.

Information gathered at the meeting can be categorized as follows:

- Stock status
- State of the Babine habitat
- Current research and monitoring

- Climate change impacts

Wild Babine Sockeye Stock Status

Data on stock status was presented by Andy Rosenberger, Fisheries Management and Research Biologist, Lake Babine Nation Fisheries Program. Data included information provided by Steve Cox-Rogers, DFO Fish Management Biologist, Josh Korman, Ecometric Research Inc. and PSF, Carrie Holt and others from the DFO and from stock assessment information collected by Lake Babine Nation.
The run timings of all Babine stocks overlap therefore the timing of harvest is important. When enhanced Babine Sockeye are exploited at high levels (historical exploitation rates were as high as 80% in some years) *(Cox-Rogers and Spilsted 2012, other DFO publications, older Skeena publications and PSF run reconstructions)* wild Babine Sockeye are subjected to the same exploitation rates which in many years are unsustainable. Recent data points to a trend where ratio of spawners to recruits is less than 1. (Connors et al. 2013 PSF Skeena CU snapshots: Nilkitkwa for example). Such a low spawner:recruit ratio is cause for concern as wild sockeye salmon stocks cannot be sustained at current exploitation rates.

Incidentally captured Babine sockeye are present in Alaskan pink salmon fisheries. Pink fishery harvest can be in the tens of millions of pieces and much of this production is a result of ocean ranching. Since 2005, Alaskan fisheries regularly harvest more Babine sockeye than are harvested in Canadian fisheries. Late timing stocks are intercepted in Alaskan fisheries at higher harvest rates than earlier timing stocks. Babine wild stocks harvested in Alaskan fisheries as bycatch may not be appropriately protected during Pacific Salmon Treaty negotiations. Protection of wild Babine sockeye in Alaskan fisheries is a concern for Lake Babine Nation as wild Babine stocks decline.

Data gaps and trends were discussed. There are some creeks that historically were sporadically monitored for sockeye escapement and they should be monitored again (e.g. Hazelwood and Bairnsfather Creeks).

Although wild stock escapement looks somewhat stable, escapements are variable over time i.e. there is no clear pattern of escapement. Overall abundance is trending down to the point where the escapement is not replacing the population in some years. Babine River total abundance has seen a dramatic decline from estimates around 1 million in the 1880s to 1920s. In recent years high escapement has not led to an equivalent increase in recruits.

Morrison and Tahlo systems are counted visually which can be challenging in years when visibility is poor. Counting techniques are being discussed with DFO Stock Assessment Division to improve reliability of escapement numbers. Counting methods such as DIDSON sonar, drone monitoring or mark-recapture in the Morrison/Tahlo system may prove useful in the future.

Production from the spawning channels was discussed. Initially there was a dramatic increase in production as a result of the channels. In recent years the Pinkut channel is not producing at target levels and this is cause for concern.

Discussion points and concerns:

- May be able to use fat content of sockeye (using a fat content meter) to distinguish wild sockeye from channel sockeye

- Will try using drones to count redds
- Late timing wild sockeye are declining and proportion of late wild sockeye in the total sockeye run has decreased since the spawning channels came into production
- Historically 40-50% of the run was late-run wild sockeye and now 10% or less of the run is late-run wild Sockeye
- The Lower Babine River population has exhibited a large decline in escapement
- Studies are being done to determine if fry are able to swim upstream across the Babine weir (velocity concern)
- Data is showing that high returns of wild spawners does not necessarily equate to an increase in smolt production
- Section 35 harvests are decreasing as a result of declining sockeye returns

To review the power point presentation prepared by Andy Rosenberger, follow the link below.

https://drive.google.com/open?id=0B2omTbjjYXSQZlJ1UHVZU0JrY3M

Status of Wild Sockeye Habitat in the Babine Lake Watershed

Kenny Rabnett, Suskwa Research, provided a verbal presentation on status of Babine habitat based on his literature search, helicopter flights over the watershed and ground truthing and recon field trips.

- The Babine watershed is situated on the Nechako Plateau
- Snow melt fed system with limited capacity for water storage
- Sub-basins with water storage include Pinkut, Fulton, Morrison, and Sutherland
- Regulated flow coming out of Pinkut and Fulton could be very important as water sources due to climate change impacts
- Due to climate change and land use, water storage areas are absorbing more heat than they did historically
- Additional heat absorption contributes to increasing water temperatures
- Most of the lake tributaries drop down through canyon areas towards gravel fans at the confluences with Babine Lake
- There is sediment transport occurring to the confluences and this is a historical process
- Land use such as logging appears to have contributed to an increase in peak flows, stream bank failures and sediment transport and decreased water retention which exacerbates low summer water levels and flows
- The elevation gain from the Skeena-Bulkley confluence to Babine Lake is the same as the elevation gain from the ocean to the Skeena-Bulkley confluence, but it occurs over about 1/3rd of the distance.
- With lower flows during upstream migration and higher water temperatures, it is increasingly more challenging for sockeye spawners to make the elevation rise from the confluence with the Skeena River to the lake and then from the lake to the lake tributary systems
- Spawner access in future years, due to lower flows and water levels, may become a serious concern
- Discussed the need for physiological studies on Babine sockeye as they migrate upstream

- Forests, Lands and Natural Resource Operations are doing a watershed study – contact person is Don Morgan.
- Note – drought monitoring will be done summer 2017 by Water Stewardship Branch – could recommend that some Babine streams be included as index sites.
- LBN crews will continue monitoring habitat and water quality and quantity at some sites

  Note: LBN will be conducting a pilot project to use drones to look for areas of groundwater influence starting in late May 2017

ACTION – invite Don Morgan to the June 12'th meeting to give a presentation on his study.

ACTION – contact Water Stewardship Branch re: drought monitoring index sites in the Babine watershed

Babine Lake Limnology Assessment

The Babine Lake Limnology Assessment is a research and monitoring program being led by Dr. Dan Selbie, Dept. of Fisheries and Oceans Canada (DFO). Mark Tiley, Lake Babine Nation (LBN) Senior Fisheries Biologist, has assisted with some components of the study and provided a description of the project. Dr. Dan Selbie was not able to present information from the study at this meeting so no results have been reported here.

- Nutrient analysis done – includes phosphorous and nitrogen levels
- Annual phosphorous (P) loading is higher compared to P levels observed since limnological surveys began. There is some concern whether P levels in Babine Lake are increasing which could lead to concerns about lake eutrophication and changes in food web structure.
- Salmon carcasses in the spawning channels have resulted in increased nutrient loading into Babine Lake (information from Shortreed and Morton, 2000). Logging also increases nutrient loading (citations within Shortreed and Morton, 2000)
- Looked at plankton populations –there has been a shift in plankton production away from preferred species (*Daphnia*) to less palatable plankton that have lower nutritional value
- After the spawning channels began producing fry, smolt weights decreased for some time (late 1970's to late 1980's) and in the early 1990's and from 2013 to 2016, smolt weights have increased.
- Nutrient levels in the lake have increased as a result of the Babine Lake Development Project spawning channels and this may have resulted in changes to the food web structure
- Stomach content in terms of stomach fullness observed in 2013 appeared to be lower than historic levels
- Changes in ice cover – in most years ice is on the lake later and off earlier, which may change lake turn-over rates and nutrients cycling into the water column from the lake bottom
- Hydrological conditions are monitored but there are limitations to monitoring such that they don't produce the quality of predictive models that would be most beneficial
- Throughout the Babine watershed there can be a high level of variability in egg to fry survival within the same year

- Discussed width:depth ratio in Babine tributary streams – with climate change streams appear to be wider and shallower which limits access to spawning grounds. A simple habitat rehabilitation technique may be to channel flow (i.e. adjust the width:depth ratio in-season to create and maintain access for spawners). Some of this work is already being done by LBNF crews during spawner enumeration.
- Riparian planting helps keep a narrower channel width and may also be a successful technique when applied in the right conditions.

ACTION – discuss width:depth ratio and riparian planting at June 12'th meeting.

Climate Change Monitoring and Results

Vanessa Foord, Climate Change Biologist with Forests, Lands and Natural Resource Operations gave a presentation on climate change specific to the Babine watershed.

Summary

- Recently global Carbon dioxide levels have been measured at 400 ppm. This is the tipping point for accelerated climate change.
- Atmosphere is trapping more heat as compared to the past
- Year 2016 was the hottest year on record followed by years 2015 and 2014 respectively
- In Northern BC mean annual atmospheric temperature has increased by 3°C
- Significant decrease in winter precipitation
- Projected that maximum and minimum annual mean temperatures will increase by as much as 4 to 5°C
- Large decreases in snow as precipitation but increases in summer precipitation
- Greater precipitation doesn't necessarily equate to more water on the ground as greater evaporation rates may be occurring due to increased atmospheric (air) temperatures
- In Babine watershed – was 60.8 mm less of snow (expressed as water equivalents)
- In Babine, number of frost free days will increase by 49 days
- Mean winter air temp will increase by 3.1 °C and mean summer air temp will increase by 3.7 °C
- Babine is a snowmelt dominated system therefore less snow with a shorter snow season will be detrimental to the watershed
- With less snow pack and less rain – groundwater recharge may decrease
- With less snow pack but more summer rain – groundwater recharge rates may be acceptable
- Predictions are for temperatures to continue to warm – this is based on behaviour of the Pacific Decadal Oscillation
- More and better data is needed to have more accurate climate change modelling
- Monitoring snow levels in the Babine watershed would be valuable as water levels and flows depend on snow melt
- Discussed if setting up three or four monitoring stations in the Babine would be feasible – stations cost between $5K and $10k and that does not include snow monitoring. Manual snow surveys could be done at index sites but should be done once per month. Require snow monitoring stations at low, mid and high elevation. (concerns with access and safety).

- Manual snow monitoring requires a high amount of data analysis
- May be able to use snow depth sensors (cost of about $1000 each)
- Snow data collected in the field could be compared to the snow model outputs
- Discussed putting one climate change monitoring station in each of the 4 sub-basin watersheds of the Babine ($20K each?)

ACTION: Vanessa offered to assist with determining where climate change monitoring stations should go and assist with organizing/implementing the stations.

ACTION: bring this item forward to the June 12'th meeting

Babine Lake Fish and Aquatic Review

Johanna Pfalz, Eclipse Geomatics, gave a presentation on current pressures on freshwater salmon habitats. Information included a series of spatial analyses based on pressure indicators i.e. road density, stream crossing density, riparian disturbance, key salmon habitat and total land cover alteration.

<u>Summary</u>

- Road density thresholds follow Wild Salmon Policy recommendations
- 21 Babine sub-watersheds fall within the high risk category for road density
- 27 Babine sub-watersheds fall within the moderate risk category and this category includes streams such as Babine River, lower Fulton River, Morrison, Sutherland, Tachet, Tahlo and Twain which are wild Babine Sockeye spawning streams
- Stream crossing data has gaps and issues
- Note that in general when identifying fish habitat 20% is observed and 80% is inferred. There is a data gap in that there is more observed data but fish inventory systems are not properly being populated with that data
- Threshold levels for stream crossing density are based on Wild Salmon Policy recommendations
- For the Babine watershed, total stream crossing density falls within the moderate category
- Riparian disturbance thresholds are based on the Wild Salmon Policy recommendations
- Babine watershed has 14.9% riparian disturbance and 24 sub-watersheds rank within the high level of disturbance

  Total accessible stream length consists of streams or portions of streams where there are resident and/or anadromous fish present. There are currently no thresholds developed for this indicator.
- 5.7% of the total accessible stream length is identified as key salmon habitat
- Total land cover alteration has a disturbance value of 22.8% which is rated as high
- Data gaps were discussed – old fish inventory data has been used, need better input of recent fish inventory data into databases
- Need access to data that consultants are collecting – discussed getting data from reports generated as part of Scientific Licence/Permit process
- GIS model is based on data that goes back about 20 years – look at indicator trends over time?
- LBN data should be incorporated into this process (field data collected in 2016)

ACTION: Johanna would like to give this group a presentation on other data systems such as the Salmon Data Centre and data sharing.

Community Economic Development Program: Habitat Monitoring

Natalie Newman, DFO Community Advisor gave a presentation on habitat monitoring work in partnership with LBN.

Summary

- Have done stream surveys to assess fish presence/absence and measure fish habitat
- Continuous water temperature monitoring using temperature loggers
- In-field water quality measurements such as dissolved oxygen, pH, conductivity, hardness, carbon dioxide and alkalinity
- Discharge measurements at select streams
- Using field information and observations to recommend potential habitat restoration opportunities

Babine Lake – Selected Creeks for Habitat Restoration Investigation

Lana Miller, DFO Resource Restoration Biologist gave a presentation that provided an overview of the Pacific Salmon Commission (PSC) funding provided for Babine Sockeye Habitat Rehabilitation.

Summary

- In 2015 LBN received PSC funding for a phased plan (3 years)
- Funding amount was to be $47K each year of the three year program
- Year 1 – recon flights, ground truthing of observations made on flights, do GIS work, conduct a literature review
- Year 2 – design and implement pilot projects – thought about using a paired stream design where one stream would receive a habitat treatment and the other stream would be the control
- Year 3 – monitor projects
- In year 1 meetings were held with DFO and LBN to determine criteria that could be used to prioritize creeks for habitat work
- Criteria included looking at historical Sockeye escapement levels, ease of access, duration that streams could be accessed (year round, summer only), upslope impacts, cost of monitoring
- 2 helicopter flights were done in year 1 and during flights ground water areas were identified.
- Photo logs from flights showed areas of impact, where old stream channels used to flow and where new stream channels entered the lake
- Areas for possible water storage were searched out
- Some areas were visited on foot so it could be better determined if ground water supplies were useable
- In 2016/2017 – PSC funding was discontinued for this project

ACTION: review the paired stream idea, determine if some low cost, simple habitat projects could be designed then find funding to implement. NOTE: project concepts for PSC funding have to be submitted by end of August 2017.

APPENDIX 2. Lake Babine Nation Babine Sockeye Habitat Rehabilitation Project Planning Workshop: June 12, 2017 Meeting Minutes

Attending

Andy Rosenberger – Fisheries Management and Research Biologist, LBN
Emily Mason – Biologist, Lake Babine Nation
Brenda Donas – Biologist, Meeting Facilitator
Jeff Anderson – Biologist, World Wildlife Fund
Kenny Rabnett – Suskwa Research
Lana Miller – Resource Restoration Biologist, Fisheries and Oceans Canada
Natalie Newman – Community Advisor, Fisheries and Oceans Canada
Sandra Devcic – Resource Restoration P. Eng, Fisheries and Oceans Canada
Mark Tiley – Senior Biologist, Lake Babine Nation

Introduction

On May 23'rd, 2017 an information gathering meeting provided the habitat project planning group with information about Babine sockeye stock and habitat status. Current and emerging impacts such as climate change impacts and land use impacts were identified. Limiting factors or "pinch points" were noted as important information to include in discussions regarding potential habitat rehabilitation projects.

A habitat project planning meeting held on June 12'th, 2017 brought a habitat project planning group together to review stream and stock status information and to determine potential habitat projects in the Babine watershed.

Planning workshop presentations and discussions included:

- Photo presentation showing state of the habitat of 12 Lake Babine tributaries and respective escapement data
- Photo presentation showing 4 small scale habitat projects on streams similar to Lake Babine tributaries. Two projects were installed by hand and two projects required excavators.
- Discussion on habitat project evaluation criteria. Criteria to evaluate and prioritize habitat projects could include escapement history, types of upstream impacts, discharge trends, water temperature trends, stream access condition, sediment transport issues, locations of impassable barriers.
- Discussion on projects required to address data gaps
- Discussion on potential partnerships
- Discussion on small scale pilot projects for summer 2017
- Discussion on future funding opportunities

Habitat Status of Selected Babine Lake Tributaries – Stream Survey Measurements, Photo Journal and Escapement Data

Brenda Donas and Lana Miller provided presentations to show current habitat snap shots of Babine Lake tributaries. The streams reviewed were:

- Morrison/Tahlo
- Tsezakwa Cr.
- 5 Mile (Williams) Cr
- 9 Mile Cr
- Tachek Cr
- Sockeye Cr
- Pierre Cr
- Twain Cr.
- Cross/Pendleton Cr
- 4 Mile Cr
- 6 Mile Cr

Stream survey data and photographs were provided by Lake Babine Nation stream escapement counting crews (Aboriginal Fishery Strategy Program - DFO) and other habitat data was provided by stream crews conducting water quality measurements and spawner access management (Community Economic Development Program – DFO). Stream surveys, stream measurements, water quality measurements and spawner access management occurs annually which has produced a consistent record of stock numbers and habitat conditions.

Common habitat impacts included:

- Gravel/sediment accumulation at stream confluences - during low water times of the year impede or inhibit upstream access to spawning grounds (5 Mile, 9 Mile, Tachek, Sockeye, 4 Mile, 6 Mile)
- Upstream eroding banks that are not feasible to repair (Twain Cr) – continued high levels of sediment transport
- Gravel accumulation areas that cause flow sub surface flow and create barriers to upstream migration
- Sediment transport to confluences by wave action – impedes or inhibits access to spawning grounds (4 Mile, 6 Mile)
- Sub-surface flow during low water times of year – impedes or inhibits access to spawning grounds, spawners more vulnerable to predation (Sockeye Cr, Tachek Cr, 6 Mile Cr, Cross/Pendleton Cr, Twain Cr)
- Beaver dams and beaver dam complexes, some extremely large, inhibiting upstream migration to spawning grounds and making spawners more vulnerable to predation just downstream of dams
- Low flows and water levels during summer months – impedes or inhibits access to spawning grounds, spawners more vulnerable to predation, facilitates dam building by beavers
- Precipitation events that contribute to sudden increases in stream water level – spawning activity during higher water appears to result in some redds becoming dewatered after

precipitation event when water levels return to low levels (Sockeye Cr, Tachek Cr). Observations of sockeye redd locations during and after high water events. (Alana Dickson, CEDP Project 2014).

- High water temperatures during summer months when spawners are migrating upstream to spawning areas – affects energy resources required for successful spawning, impacts to gametes, fish health impacts, pre-spawn mortality
- Deforestation throughout the watershed for roads, logging, mining (GIS results)

Habitat reconnaissance work located areas with groundwater influence (Tachek Cr).

Discussions occurred about locations where lake spawning occurs and potential to increase lake spawning areas.

Small Scale Habitat Rehabilitation Projects: Examples of Projects In Other Watersheds

Brenda Donas and Lana Miller provided presentations to show small scale habitat rehabilitation projects on Comeau Creek, Waterfall Creek, Mission Creek, Scully Creek and Williams Creek.

Projects addressed limiting factors such as available spawning habitat, access to spawning areas due to stream sections with high velocity and access to spawning areas through beaver dam complexes. An artificial cutbank was constructed on Scully Creek to provide cover for upstream migrating sockeye spawners.

Off-channel spawning habitat was constructed on Williams Creek (tributary to Lakelse Lake near Terrace, BC) as a component of the Lakelse Lake Sockeye Recovery Plan. The channel has a surface water intake as well as groundwater influence and was built for coho juvenile rearing and to increase spawning habitat for Lakelse sockeye.

Techniques used on these projects are transferable to Babine Lake tributaries. There are engineered drawings available for the Mission Creek, Scully Creek and Williams Cr projects.

Habitat Project Evaluation Criteria

Given limited resources to address habitat issues in the Babine watershed, there was some discussion on the value or need for creating a list of evaluation criteria for prioritizing potential habitat projects.

In the past, the DFO Resource Restoration Division tried to design a checklist of criteria that would assist in determining a prioritized list of proposed habitat restoration projects.

In September 2015, DFO Resource Restoration and LBN Fisheries Program staff developed a preliminary list of evaluation criteria. Criteria included a consideration of the following factors:

- Is there a serious decline in escapement

- Consider exploitation rates – is that the reason for decline
- Sedimentation increase
- Barriers to migration
- Mean annual discharge
- Water quality
- Water temperature regime
- Access for machinery
- Access for people to monitor pre project and post project
- Stability of the area of the proposed project (upslope impacts)
- Groundwater influence
- Cost/benefit – project cost vs number of fish produced, number of square metres of stream restored
- Expected life span of the project
- Requirement for maintenance (ongoing, none?)

By the end of the discussion there was no decision regarding the need for evaluation criteria at this time.

Projects to Address Data Gaps and Creation of New Partnerships

Several data gaps and requirements for improved monitoring were identified:

- Nilkitkwa Lake – information is lacking on Nilkitkwa Lake as a sockeye rearing area, need information on nutrients in the water and in the sediments. Build on recent hydro-acoustic data (started by Janvier Doire).
- Decline in lower Babine River sockeye escapement – 100K down to 1700 (serious decline)
- Fry fishway – trying to facilitate getting fish into the lake – past the velocity issue at the weir. Do some marking of fry through fry fishway to determine if they are in Nilkitkwa Lake
- Monitoring – zoo plankton population composition on a regular basis.
- Look at the impact and importance of the regulated supply of water from Pinkut and Fulton (may be very important to Babine Lake in the future)

Planning components to address Babine watershed impacts that deal with regulating land use activities were discussed:

- Need conversations with forest companies (in the very near future) to protect existing habitat and stocks
- Logging in Pierre Cr watershed is just about to start and that is the most productive wild sockeye stream in Babine. LBN is trying to get Pierre designated as fisheries sensitive habitat
- Engage in the temperature sensitive stream designation process by applying to have some Babine streams designated as temperature sensitive

Climate change impacts are measurable in the Babine watershed. Vanessa Foord (FLNRO) highlighted the need for fuller monitoring programs aimed at collecting data from additional monitoring stations. LBN and Vanessa Foord are interested into entering into a partnership to install up to 4 additional monitoring stations, in the four main sub-basins of the Babine watershed, to assist with collection of climate change data.

GIS analysis has measured land use impacts on freshwater habitats in the Babine watershed. There are data gaps that if filled, would give a more accurate measurement of road density, stream crossing density, riparian disturbance and land alteration. Johanna Pfalz (Eclipse Geomatics) would like to schedule a workshop to further discuss data gaps and how to fill those gaps. The workshop would include a presentation on data systems such as the Salmon Data Centre and how data could be shared.

Jeff Anderson, World Wildlife Fund (WWF), offered assistance to LBN in facilitating engagement in the following:

- Response to the upcoming Forest Practices Board report on fish and fish habitat in logging areas. Use report results to encourage local forestry companies to engage in discussions that will address land use factors contributing to the decline of wild Babine sockeye
- Assist LBN with applying for sensitive stream designations
- Monitoring of Froude number (ratio of depth to velocity) and sharing of data input sheets. Data can assist in determining how to encourage groundwater upwelling in streams.

DFO Resource Restoration staff offered their extra temperature loggers for installation into Morrison/Tahlo system, in Morrison and Tahlo wetland areas and in lower Babine tributaries to have better continuous temperature monitoring.

Small Scale Habitat Projects for 2017

AFS and CEDP stream crews conduct monitoring in the Babine watershed throughout the summer and fall months. Crews will continue to conduct access management to ensure sockeye have access to spawning grounds. Access management will include breaching of beaver dams when adults are present, concentrating/channelizing flow using small pieces of woody debris and rock from the stream area and digging trenches through gravel fans to create access into streams.

Riparian planting of willows to stabilize eroding banks will be tried at a few locations to determine if plantings can establish.

Drone flights with infrared capability, will be used to search for groundwater sources. Drones will also be used to determine locations of sockeye redds. Redds will be monitored for survival rates with an interest in monitoring redds that become dewatered due to decreases in water levels.

Funding Opportunities

Costs of small scale habitat projects suggested for summer 2017 can be included within AFS and CEDP budgets.

Funding for larger scale monitoring projects, such as the drone flights and future access management projects will be required. LBN will investigate the Fish Habitat Initiative funding program by talking to the local program biologist, Jeff Guerin.