Upper Skeena Fish Passage
Culvert Inspection

Ken Rabnett & Tim Wilson
Gitksan Watershed Authorities
April 2008

Summary

The purpose of this report is to present background information and survey results of fish passage inspections along the B.C. Rail grade located in the upper Skeena Watershed. In 2007, Gitksan Watershed Authorities (GWA) was retained by the Pacific Salmon Commission to conduct a Fish Passage and Culvert Inspection (FPCI) on all non-bridged B.C. Rail crossings of fish bearing streams in the upper Skeena Watershed. The upper Skeena Watershed fish passage assessment is the final component of a regional effort to investigate fish passage restrictions to high value fish habitat in the Skeena Basin by highways, secondary roads, and railway grades.

This fish passage inspection project focused on the BC Rail grade, which enters the Skeena Watershed a few kilometres south of Bear Lake, traverses Bear Lake and Bear River, passes down Sustut River on the north bank, and goes upstream on the Skeena River north bank passing into the Stikine drainage. The B.C. Rail grade is 195 km in length within the Skeena Watershed.

The primary objective of this project was to focus on the potential of increasing the abundance of fish stocks by opening freshwater habitat to salmon spawning and rearing. This project utilized the fish passage culvert inspection procedure developed to evaluate one of the most easily addressed fish habitat constraints: access to existing habitat. The methodology is based on the BC Government fish passage protocol outlined in *Fish Passage – Culvert Inspection Procedures*.

Sustut, Bear, and Skeena rivers are generally slightly entrenched into the valley bottoms with accompanying steep embankments ranging from 10 to 55 m in height. Therefore most tributary streams have steep lower reaches. There were 138 stream crossings examined in this Fish Passage Culvert Inspection project; of these 114 were determined to be fish bearing streams crossings. 24 crossings were determined to have no fish presence due to stream gradient or lack of suitable habitat. Approximately 47 first order stream crossings between Sustut and Kluatantan rivers on the Skeena River were not surveyed. Observations indicated that gradients were either too steep to accommodate anadromous and resident fish passage upstream to the rail grade or the stream was ephemeral in nature.

There are 33 stream crossings rated as full barriers to fish passage. Of these crossings, 3 are rated high priority for rehabilitation. One is rated as moderate and four are rated low priority for rehabilitation. Deactivation is recommended for 17 of these crossings. The other eight streams with full barriers are not rated for restoration or deactivation, due either to their geographical position — lying above a moderate to high gradient embankment above the main rivers — or to the lack of suitable fish habitat upstream from the stream crossing.

The seven partial barriers are of varying types and degrees; as there is variability in fish abundance and in quality of upstream fish habitat. Only two partial barriers are rated for rehabilitation, Azuklotz Creek and Garner Creek. Deactivation is recommended for 73 stream crossings, all of which are located from Garner Creek downstream to Kluatantan River.

Table of Contents

Acknowledgements

This project was funded by the Pacific Salmon Commission Northern Fund with in-kind funding contributed by Gitksan Watershed Authorities. The opinions expressed are those of the authors and do not necessarily reflect the funding agencies. Thanks to Lance Williams and Gordon Wilson for GIS analysis and mapping. Mark Beere, Jeff Lough, and Darren Fillier of B.C. Ministry of Environment provided background information and thoughtful discussions. Lana Miller of the Department of Fisheries and Oceans provided practical and timely advice. Thanks and appreciation to Rob Henderson and Craig Kendall from Canadian Helicopters and Evan McCallum from Sustut Air who provided fine flight services. Special thanks to Jeff Vermillion for his hospitality at Suskeena Lodge.

Introduction

The upper Skeena watershed fish passage assessment is the final component of a regional effort to investigate fish passage limited by highways, secondary roads, and railway grades to high value fish habitat in the Skeena Basin. In 2007, Gitksan Watershed Authorities (GWA) was retained by the Pacific Salmon Commission to conduct a Fish Passage and Culvert Inspection (FPCI) on all non-bridged B.C. Rail crossings of fish bearing streams in the upper Skeena Watershed. The purpose of this report is to present background information and survey results on fish passage inspections along the B.C. Rail grade located in the upper Skeena Watershed.

This fish passage inspection project focused on the BC Rail grade, which enters the Skeena Watershed a few kilometres south of Bear Lake, extends along Bear Lake and Bear River, passes down Sustut River on the north bank, and goes upstream on the Skeena River north bank to its northern limits and then passes into the Stikine drainage.

The connectivity of diverse fish habitats for various fish life stages is fundamental to supporting fish abundance in the upper Skeena Watershed's freshwater habitats. Tributary streams, lakes, off-channels, back channels, ponds, and sloughs all provide critical habitat. Ensuring that these components remain connected for the free migration of spawning adults and rearing juvenile fish is a critical component in maintaining healthy populations.

The maintenance of healthy fish populations requires that streams crossed by roads and non-open bottom structures such as culverts permit the free migration of spawning adult fish and rearing juveniles to upstream habitat. The purpose of this project is to serve as the assessment phase in a larger project to restore fish passage to diverse fish habitats disconnected in the past by culverts, which were installed primarily to facilitate rail transportation development.

Restoring access to additional upstream habitat through culvert rehabilitation is one of the most timely and cost-effective activities to benefit fish abundance and habitat productivity. The BC Rail grade was constructed 1967 to 1977 and abandoned in 1978 before completion. McKenzie et al. 1978 reported extensive damage to fish and wildlife habitat along the construction corridor. Along this rail grade there appears to be many kilometres of habitat that once supported salmonids that are now inaccessible due to improperly designed and installed fish passage structures. We assessed culvert stream crossings downstream of viable fish habitat to determine the degree of obstruction posed, followed by an evaluation of the feasibility and extent of restoration needed, and assigned priorities to each restoration activity.

Deliverables from this project include this narrative report, an updated database of all fish bearing streams crossed by culverts and bridges along the B.C Rail grade, and 1:50,000 TRIM based maps showing the streams, fish presence where known, topography, and culvert locations.

OBJECTIVES

The primary objectives of this project are to focus on increasing the abundance of fish stocks in a coordinated and planned manner by reopening freshwater habitat to salmon spawning and rearing while benefiting fish habitat and water quality. Objectives include:

- Conducting stream crossing assessments and prioritizing obstruction removal;
- Developing conceptual restoration prescriptions for prioritized obstructed stream crossings;
- Increasing the abundance of fish stocks, particularly coho, chinook, and steelhead, by restoring access to important fish habitat that is now disconnected;
- Developing partnerships that further habitat stewardship among DFO, BC Ministry of Environment (MoE), and Gitksan Watershed Authorities.

FISH PASSAGE

The movement of fish through culverts can be restricted by many factors including culvert length and gradient, stream levels and velocities, and inlet and outlet configurations. Improper culvert design and installation can block fish passage to spawning and rearing areas such as small streams, lakes, and wetlands. In some cases, depending on culvert location, large portions of sub-basins may be inaccessible due to full or partial obstruction at crossings. In some cases, bridges can form partial or full obstructions due to sediment deposition as shown in Figure 1.

Figure 1. Downstream side view across Azuklotz Creek Bridge showing 10 cm clearance between the bridge span and the stream surface.

When adult salmon enter freshwater, the maturing fish stop feeding and rely on energy reserves stored in body fat and protein to carry them through migration and spawning. The rate of sexual maturity is established by heredity and most often cannot adjust to delay (Powers and Orsborn 1985). Barriers that cause excessive delay and/or abnormal energy expenditures can result in pre-spawning mortality either during migration or in spawning areas.

The direction and length of migration vary with the fish species and life stage; consequently, the necessary timing, frequency, and duration for unimpeded access to required habitats also vary. On a finer scale, juvenile salmonids and resident freshwater species need to freely disperse to find optimal rearing conditions that ensure their survival, such as habitat with reduced competition, high quality and low velocity refuge habitat, and fewer predators.

Restoring fish passage increases the amount of available habitat within a stream system. If habitat abundance is the limiting factor, increased access to additional habitat will likely result in a rise in fish populations. However, the population response to habitat gain is also frequently dependent on numerous other factors, which may include the quality and quantity of new habitat, the nature and abundance of predators, and the presence of competitors.

Figure 2. A typical B.C. Rail triple culvert installation on a high fish value crossing. The high water velocity and outfall drops create a fish passage barrier.

When impassable culverts are replaced multiple reach changes frequently occur. These changes, can lead to both positive and negative effects, altering habitat preferences and affecting fish use and behavior. Restoring fish passage frequently alters the transport of sediments, woody debris, and other materials to downstream reaches. This could change the slope or elevations of upstream or downstream channel reaches, as elevation differences are reconciled. As in other areas, consideration of potential changes, especially by flood stage stream flows and sediment transport events is necessary in the upper Skeena Watershed.

Methods

Pre-field Planning

In order to generate a list of stream crossings to assess in the field portion of the project, an office-based overview was completed that identified all stream crossings. Data used included GIS analysis of Terrain Resource Inventory Maps (TRIM), a compilation of the existing fisheries information using the Fish Information Summary System (FISS), and GWA fish presence and habitat databases. Traditional fisheries knowledge and anecdotal material regarding important fish streams were also included in the review. Other general fisheries information is listed in the Reference section. A GIS-based 1:20,000 map series was created for the field work and included the following sheets: 94D/007, /017, /016, /025, /026, /033, /034, /035, /043, /052, /053, /062, /071, 104A/080, /089, /090, /098, /099, and 104H/007, /008, /017.

Field work

The fish passage culvert inspection methodology is based on the BC Government fish passage protocol outlined in Fish Passage – Culvert Inspection Procedures, (FPCI) (Parker 2000). Essentially, the FPCI fieldwork data collection includes: recording administrative information such as stream name, location coordinates, and watershed code; measuring stream and culvert characteristics; noting the fish habitat qualities and quantities; evaluating barriers, and photographing upstream and downstream features from the culvert inlet and outlet. Stream measurements were taken at distances of 25 m so as to avoid the influence of the culvert and road right-of-way on stream characteristics. Fieldwork was conducted from mid July to mid-September.

The objectives of this assessment were to:

- Identify all culvert and bridge crossing sites;
- Confirm that the channel upstream and downstream are viable fish habitat and determine the quality and quantity of that habitat;
- Identify to what degree the culvert blocks or impedes fish passage;

The following field gear was used to collect stream and culvert characteristic data:

- Culvert length was measured with a Leica Disto A5 laser range finder.
- Culvert and stream widths and depths were measured with a meter stick or tape.
- Stream velocities were measured with a Swoffer 2100 Current Meter.
- Stream and culvert gradients were measured with a Suunto clinometer.
- Location coordinates were recorded with a Garmin eTrex Summit.
- Digital photographs were taken with Olympus Stylus 730 and a Olympus SP-500 UZ.
- Stream lengths were measured with a hip chain.

Post-Field

Following completion of the fieldwork, calculations were prepared for each culvert barrier site evaluating the type and degree of obstruction, stream length upstream of the barrier as well as overall length, and an estimate of the hundred-year flood discharge (Q_{100}). These calculations were then scored using the criteria in the FPCI (Parker 2000) followed by assigning priority values to culvert site restoration. Three primary report sections were prepared to describe all stream crossings in text format, in a database, and on 1:50,000 scale maps.

Fish bearing streams receiving the fish passage culvert inspection were prioritized using the FPCI scoring matrix. The matrix considers fish species present, fish habitat values, barrier type, length of habitat upstream, proportion of stream habitat barred, and the presence of further upstream barriers. In short, prioritization is based on maximizing fish access to habitat segregated by a barrier culvert. The priorities do not take into account sediment movement or maintenance issues. The FPCI scoring matrix can be used to prioritize and to base restoration or rehabilitation efforts on funding availability or other considerations.

Fish species		**Habitat value**		**Barrier**		**Length of new habitat**		**Stream barred %**		**Limiting to upstream barrier**	
Multiple or significant	10	H	10	Full	10	≥1 km	10	>70%	10	Yes	5
Single	6	M	6	Partial	6	<1 km	6	51–70%	6	No	0
Other	3	L	3	Undet'md	3	<500 m	3	<50%	3		

Table 1. FPCI scoring matrix example.

Fish species are classed as single, multiple, or significant to note the degree of potential restorative benefits. Information in regard to fisheries values was generated through professional judgement by subjective analysis that included:

- Fish populations known to be conservation risks and their habitats and concerns;
- Fish species of provincial significance, including species that have been identified provincially as being particularly sensitive to development activities (Haas 1998). In this fish passage assessment, these species are bull trout (BT), Dolly Varden (DV), and/or cutthroat trout (CT);
- Fish populations and habitat identified by First Nations as being traditionally or contemporarily important.

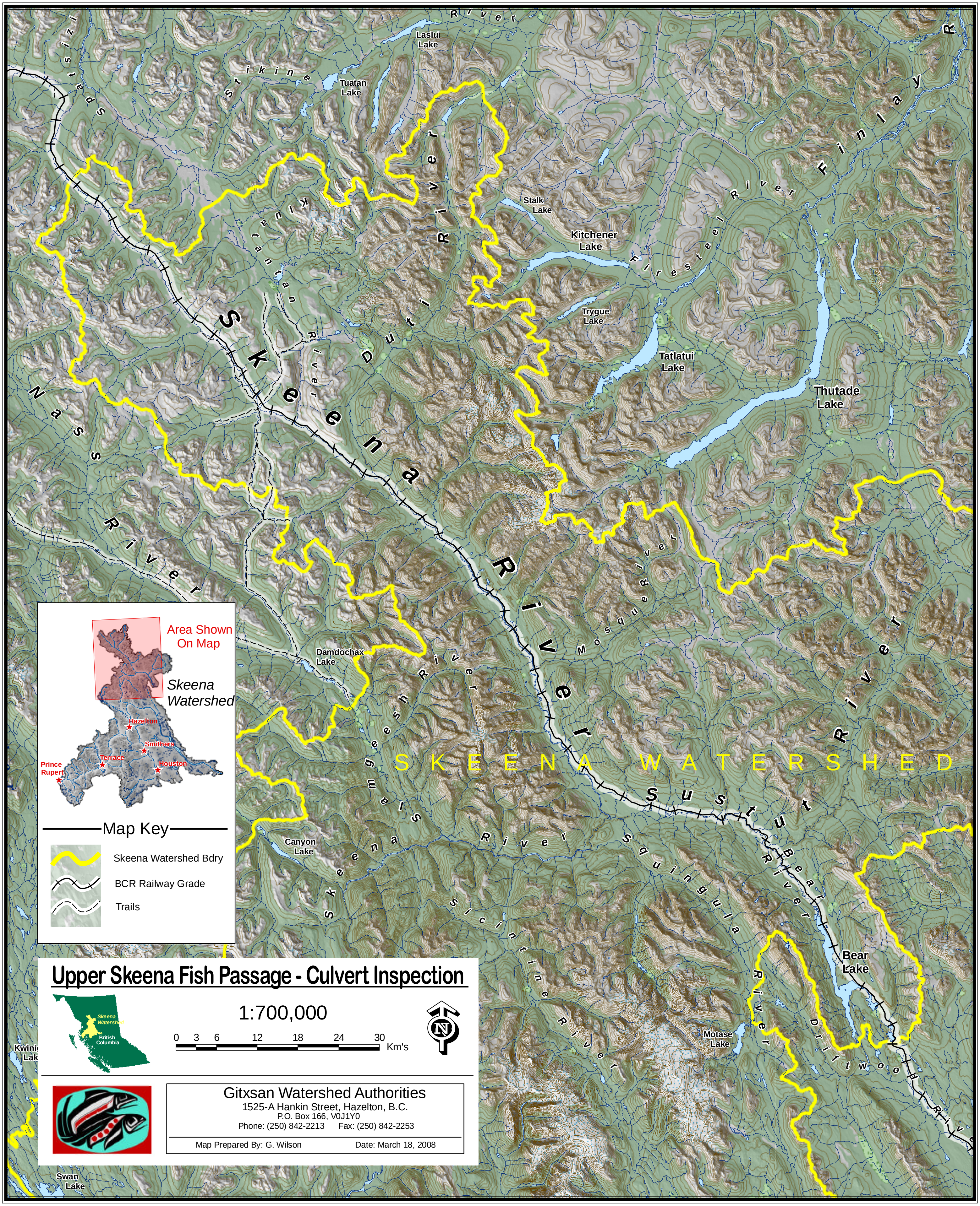
Habitat value is a subjective rating based on the known value of the stream habitat to be gained and is based on complexity, productivity, and limiting habitats. Different values for different habitat types are based on species preference and known distributions.

The barrier factor is used to give higher priority for sites with more severe obstructions to fish. Barriers are based on outfall drop, culvert water velocity, culvert gradient, and culvert length.

Length of new habitat is the length of potentially restored stream, measured on 1:20,000 scale maps or air photos, to the next known barrier, using gradient classes to differentiate the fisheries values of different habitat types. Stream barred percent is the length of new habitat divided by the total fish-bearing stream length. Limiting to upstream barrier is scored if there is another culvert upstream of the site assessed as a full, partial, or undetermined barrier (Parker 2000).

The relative numerical scores associated with each category are then summed. The ranking of high, moderate, or low is given based on the scoring classes listed below.

- High ranking score 39–55
- Moderate ranking score 26–38
- Low ranking score 15–25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Skeena Watershed
British Columbia
Gitxsan Watershed Authorities
1525-A Hankin Street, Hazelton, B.C.
P.O. Box 166, V0J1Y0
Phone: (250) 842-2213 Fax: (250) 842-2253
Map Prepared By: G. Wilson
Date: March 18, 2008
Map Key
Skeena Watershed Bdry
BCR Railway Grade
Trails
Area Shown On Map
Skeena Watershed
Hazelton
Smithers
Terrace
Houston
Prince Rupert
SKEENA WATERSHED
Skeena River
Nass River
Stikine River
Spatsizi
Finlay River
Firesteel River
Duti River
Kluatantan River
Mosque River
Sustut River
Bear River
Driftwood River
Squingula River
Sicintine River
Skeena River
Slamgeesh River
Laslui Lake
Tuatan Lake
Stalk Lake
Kitchener Lake
Trygue Lake
Tatlatui Lake
Thutade Lake
Damdochax Lake
Canyon Lake
Bear Lake
Motase Lake
Kwinia Lake
Swan Lake

Upper Skeena Watershed — Environmental Overview

The upper Skeena Watershed is defined for the purposes of this project as the drainage of the Sustut River and the Skeena upstream of the Sustut - Skeena confluence, located 466 km upstream of the mouth of Skeena River. The upper Skeena and the Sustut rivers are the major high interior headwater systems. The watershed is bounded in the north by the Stikine, to the east by Peace River tributaries, to the southeast by the Fraser system, and to the west by the Nass Basin.

HYDROLOGY

Most stream flood flows occur in May and June due to spring snowmelt throughout the upper Skeena Watershed. Water levels in the main river channels and back channels fluctuate seasonally; typically they are high from May to early July, drop for the summer months, rise to intermediate levels in the fall, and reach their annual low levels late in the winter season. There are no hydrometric stations located within the drainage.

The general climate of the watershed is transitional between the slightly temperate, maritime coastal climate and the dominant colder, continental climate of the interior of the province. Summers are warm and fairly moist with a short growing season. In the lower valleys, snowpacks are moderate (up to 2 m), and valley bottoms are prone to cold air ponding. There are no long-term weather records available.

Sustut River

The Sustut River is one of the major river systems in the high interior zone of the Skeena River Watershed. The Sustut River drainage is for the most part mountainous with high relief; elevations range from 580 m at the Skeena–Sustut River confluence to 2,469 m at Sustut Peak in the Hogem Range. The Sustut River flows in an irregular route that bisects the Hogem Range in a roughly southwest direction, discharging into the left bank of the Skeena River. The mainstem is approximately 97 km in length from the outlet of Sustut Lake to the mouth. The majority of the drainage is relatively high in elevation; the elevation at Sustut River/Moosevale Creek confluence is approximately 1,160 m. Major tributary streams within the drainage basin include Birdflat Creek, Bear River, Asitka River, Red Creek, Two Lake Creek, Willow Creek, Moosevale Creek, and Johanson Creek. Most of the small first and second-order tributaries flowing into the lower and middle reaches of Sustut River are short and steep.

Bear River

The Bear River is the largest tributary of the Sustut River. The watershed is a fifth-order system with a catchment area of approximately 452 km^2. Elevations range from Peteyaz Peak at 2241m to 690 m at the Bear–Sustut confluence. Tributaries flowing into Bear River are minor, with the exception of Patcha, Salix, and Azuklotz Creeks. Patcha Creek, the largest, is the only one that carries glacial silt. The dominant hydrological feature in the watershed is Bear Lake, which regulates river flows and levels. The lake lies at 779 m elevation, is 19 km in length, and averages 1 km in width, although it is 4.5 km in width at Tsaytut Bay. Two deep basins at either end of the lake are separated by a shallower mid-section.

Northern Skeena Headwaters

The Northern Skeena Headwaters is for the most part mountainous with high relief; elevations range from 580 m at the Skeena-Sustut River confluence to 2,375 m at Melanistic Peak in the Tatlatui Range. The Skeena River flows southeast bisecting the Skeena Mountains, which are relatively high in elevation. The Skeena River mainstem in this portion is approximately 133 km long.

Major north slope tributary streams within the drainage basin include Mosque River, Chipmunk Creek, Duti River, and Kluatantan River, which flow into the Skeena left bank. Major right bank tributaries include Foster, Cutfoot, Barker, Currier, and Beirnes Creeks. Most of the small first and second order tributaries flowing into Skeena River are short and steep. Streams originating from glaciers, particularly in the Kluatantan and the Duti Watersheds, produce moderate amounts of natural sediment that contribute to the downstream wash load.

The numerous ranges of the Skeena Mountains located within the watershed exert major hydrological influences, with tributary streamflows having a moderately high response from water input due to the high relief and steep channel gradients of the tributaries. Water storage in lakes is relatively small with the only notable lakes being North and South Duti Lakes, Kluayaz Lake, Kluatantan Lakes, and Tzahny Lake.

STREAM CHANNELS

Other than the channels that are entrenched in bedrock, stream channels of the major tributaries are erodible and generally occupy active floodplains with the channel location changing on a relatively steady basis. Many of the river and tributary creek sidewalls are steep, unstable when disturbed, and composed of fine, silty erodible soils.

Sustut Mainstem

The overall gradient of the Sustut mainstem from the Skeena River to Moosevale Creek confluence is 0.7%; however, there are short sections with gradients up to 3.8%. The Sustut River is commonly referred to as the lower Sustut River from the Skeena River confluence upstream to Bear River. From Bear River upstream to the canyon 500 m below Moosevale Creek, the river is referred to as the mid Sustut River. The upper Sustut River extends to Sustut Lake.

Figure 4. View downstream on lower Sustut River.

Sustut River, Reach 1 extends 18.5 km upstream of the Skeena River to the small canyon approximately 600 m downstream of Birdflat Creek. The channel has an average gradient of 0.1% and no obstructions to anadromous fish passage over its length (Resource Analysis Branch 1979). This reach of the Sustut River is a wandering gravel bed river, mostly with a single, dominant channel bordered mostly by terraces.

Reach 2 extends upstream 24.3 km to approximately 2.4 km upstream of Saiya Creek. In this reach, the channel is generally confined within the steep inner valley walls and is controlled by occasional bedrock outcrops or incised into the bedrock and till. The single channel is irregularly sinuous, rapids are common, and the gradient averages 0.7%. Reach 2 receives the flow from Birdflat and February creeks, and Bear River, as well as from many small first and second order tributary streams that are for the most part short and steep.

Figure 5. View downstream on Sustut River, Reach 2.

Reach 3 extends 10.5 km in length upstream to the mouth of Red Creek and receives the discharge from the Asitka River. The 0.5% gradient, single thread channel is confined by the valley walls, and a series of constrictions and rocks are found in the canyon below and above Asitka River. Reach 4 extends 29.5 km upstream to within 3.5 km of the Moosevale Creek confluence and receives the discharge of Willow and Two Lake Creeks. The reach is irregularly sinuous, entrenched, and confined by the valley walls except in the vicinity of the two major tributaries. Steelhead Canyon is about 8 km above Red Creek. The average gradient is 0.9%. Reach 5 extends 4.5 km in length with a steeper gradient of about 1.3%, especially at the series of cascades below the Moosevale confluence.

The upper Sustut and Moosevale valleys are both relatively wide with a complex of wetlands and eskers. Reach 6 is 3.9 km in length and extends upstream to the confluence of Johanson Creek. The reach is characterized by irregular meanders and a low gradient channel across a floodplain, which averages 500 m in width. Reach 7 is 5.4 km in length, with an average gradient of 1.0% and extends upstream to Mud Lake, which is a shallow, wide section of the mainstem. A further 0.8 km of low gradient channel surrounded by extensive wetland and seepage areas reaches Sustut Lake.

Bear River

The Bear River is 10 km in length and exhibits a single-thread channel with an irregular, sinuous channel pattern. It is generally low gradient; however, the lower portion of Reach 1 and the upper 1.6 km of the river are steeper in gradient (Shepherd 1975). The lower section of Reach 1 is steeper than the upper section, channelized with a boulder substrate and little cover other than overhanging streamside vegetation. The upper section of Reach 1 is characterized by slow and meandering, long, wide runs punctuated by relatively deep pools, with substrate composed primarily of gravel and some cobbles. In addition to numerous beaver ponds, side channels, oxbows, and pools, stream complexity is also provided by logjams, undercut banks, and abundant streamside vegetation (Williams *et al.* 1985). Reach 2 has less than 1% gradient overall and is channelized, with predominantly boulder substrate at its upper and lower ends. The middle 1.5 km of Reach 2 consists of wide slow runs with gravel substrate and minor amounts of log debris. Bear Lake, 18.5 km in length is considered Reach 3.

Figure 6. View downstream on Bear River to its confluence with the Sustut River. The Sustut River flows from the right to left (westward).

Skeena Mainstem & Major Tributaries

Skeena Mainstem

The overall gradient of the upper Skeena mainstem from the Sustut River confluence to the headwaters is 0.5%; however, there are limited sections with gradients up to 3.5%. Reach 12 of the Skeena River extends from Sustut–Skeena River confluence upstream 65.5 km to between Chipmunk Creek and Duti River. The channel has an average gradient of 0.5%; however, a partially eroded rock sill across the Skeena mainstem just north of Chipmunk Creek may be a partial barrier to fish at low water. This reach of the Skeena River is characterized as a single-thread, slightly sinuous channel, bounded by wide gravel terraces or by the valley walls; the floodplain varies in width from 0 to 0.5 km. Occasional islands and point bars characterize the channel with cobbles and gravels dominating the substrate.

Reach 13 extends 16.0 km in length upstream to Kluatantan River. In this reach, the valley is narrow, with the channel generally confined within the valley walls and controlled by occasional bedrock outcrops or incised into the bedrock or reworked till. The single channel is irregularly sinuous, with occasional rapids and an unknown gradient. Reach 13 receives the flow from many small first, second, and third-order tributary streams that are for the most part short and steep or possess steep gradients at the main valley slope break. A rock ledge across the Skeena mainstem 3.7 km downstream of Kluatantan River may be a partial barrier to fish at some flows.

Figure 7. Ledge drop on the Skeena where flow is concentrated to right bank. This is located 3.7 km downstream of Kluatantan River.

Reach 14 extends 29.3 km in length upstream to the mouth of Ethel Creek and the gradient is 0.1 to 0.5%. The channel is characterized as a wandering gravel bed river that is confined by the valley walls or high bench terraces. The floodplain varies in width from 0-500 m. The gradient averages less than 1%.

Figure 8. Skeena River, Reach 14, upstream of Currier Creek.

Reach 15 extends 22 km upstream to the headwaters and the Spatsizi River divide. The reach is irregularly sinuous, wandering across a floodplain that ranges from 0.1-1.5 km in width, and contains a few sidechannel and wetlands. The channel is noticeably smaller in width and depth upstream of Porky Creek.

Mosque River

The Mosque River extends 42.4 km upstream into the alpine, and is divided into five reaches. Reach 1 extends 7.0 km, is stepped in profile with many rapids, and is mostly entrenched between distinct glacial terraces. A canyon at 3.8 km extends approximately 0.5 km, and anadromous fish passage upstream is unknown. Reach 2 extends 11.3 km with a floodplain that is 0 to 0.5 km wide and constricted by the valley walls. Numerous bank and valley wall failures are scattered along the reach, as are debris accumulation zones and persistent beaver dam complexes.

Reach 3 extends 3.9 km and is characterized by a stepped profile that is entrenched in the valley walls. Reach 4 extends 4.1 km with a smooth gradient and a floodplain that averages 120 m in width and is controlled by steep mountain slopes.

Duti River

The Duti River mainstem extends 63 km to drain a large mountainous area and the headwater lakes, North and South Duti Lakes. The three major tributaries include: Chettleburgh Creek, 15 km in length; Tzahny Creek, 18 km in length draining Tzahny Lake; and Malloch Creek, 20 km in length.

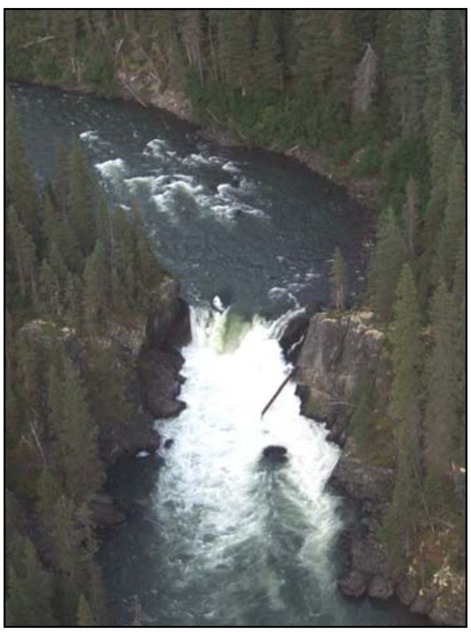

Figure 9. Duti River - Impassable falls 4.2 km upstream of the mouth.

Reach 1 of Duti Creek extends 14.5 km in a single-thread channel with a relatively moderate gradient bordered by gravel terraces or bedrock. An impassable falls is located 4.2 km upstream from the mouth. Reach 2 extends 8.5 km to the mouth of Tzahny Creek; the nearly straight channel lies in a floodplain that ranges from 0 to 600 m in width and contains substantial wetlands. Reach 2 receives the discharges from Chettleburgh and Tzahny Creeks. Reach 3 extends 6.8 km upstream of the mouth of Malloch Creek with a series of falls that is probably impassable to all fish species. The reach has a floodplain that is on average 1 km wide with sections controlled by the valley walls and ridges. The irregular stream course winds through extensive wetlands.

Kluatantan River

Kluatantan River extends 61.6 km upstream to drain a large mountainous area and approximately a dozen small ice fields in its headwaters. Historically, the Kluatantan was known as the Eastern Fork of the Skeena (Malloch 1912). The major tributaries include Tantan Creek, which drains the upper and lower Kluatantan Lakes; Kluayaz Creek, which drains Kluayaz Lake; and Campbell Johnston Creek.

Reach 1 of Kluatantan River extends 11.25 km upstream to the mouth of Lonesome Creek (1.75 km downstream of Tantan Creek). It has a slightly sinuous single-thread channel with a stepped profile and is entrenched within a narrow valley. A relatively long (3 km) canyon area culminates downstream with a 0.4 km series of chutes approximately 1 km upstream of the Skeena confluence. Tributary streams are mostly short and steep.

Figure 10. View of Kluatantan River lower reach downstream to the Skeena confluence.

Reach 2 extends 9.1 km in a single-thread channel receiving the discharge from the Tantan Creek drainage, which includes the Kluatantan Lakes. Reach 3 extends 7.6 km and receives the discharge from Kluayaz Creek. The valley bottom, which extends eastward into the Kluayaz drainage, is broad and flat with substantial wetlands.

Reach 4 extends 8.7 km with a gently sloping profile. The valley walls limit channel movement across a floodplain that averages 1 km wide. This reach has extensive wetlands and sidechannel amid open fens, black spruce bogs, and shrubby willows. Reach 5 extends 3.8 km past a series of rock falls that are most likely impassable to anadromous fish. The reach is characterized by multiple channels across a floodplain that averages 800 m in width and is composed of an extensive wetland complex.

Tantan Creek System

Tantan Creek extends 8.5 km into the subalpine and includes the Upper and Lower Kluatantan Lakes. The system usually has clear water. A third nearby lake, Beaverlodge Lake, drains into Tzahny Lake and then the Duti River. Reach 1 of Tantan Creek extends 1.5 km to the outlet of lower Kluatantan Lake; it has a slightly sinuous pattern with the channel inset in a floodplain that averages 150 m in width. The reach is susceptible to beaver dam activity, which at low flows can block fish passage. The reach possesses a wide variety of riffles, pools, and abundant cover (Bustard 1975).

Lower Kluatantan Lake comprises Reach 2. The shoreline is irregular and the lake is 1.5 km in length with an average width of 250 m. Mid-Tantan Creek is represented by Reach 3, which extends 1.75 km to the outlet of upper Kluatantan Lake. Reach 3 exhibits extensive wetlands, side channels, and sections of channel widening. Upper Kluatantan Lake represents Reach 4, which is 750 m long and averages 400 m in width with an irregular shoreline. Reach 5 extends 0.9 km, with the channel moving through a valley bottom wetland complex of swamps and ponds.

Kluayaz Creek System

Kluayaz Creek flows southwesterly 31.6 km from the alpine, where it drains several small ice fields resulting in frequent glacial colouring throughout the mainstem and Kluayaz Lake. Reach 1 extends 600 m upstream from Kluatantan River to Kluayaz Lake through a wetland and backchannel complex. The reach is low gradient and unconfined with good protective cover. Collingwood (1974) notes that the Kluayaz Lake outlet stays open virtually all year.

Reach 2 is represented by Kluayaz Lake, a high elevation (1,007 m) lake approximately 2.5 km in length and on average 550 m in width. Cold and mostly silt-laden streams feed the lake. Reach 3 extends 12.4 km and is unconfined, meandering across a floodplain with side channels, ponds, and wetlands. Reach 4 extends 7.9 km and is confined by the valley walls and plateau areas. A falls located 1.0 km above the reach break may be an obstruction to fish passage.

Figure 11. View down upper Kluayaz Creek to Kluayaz Lake.

WATER QUALITY

The Northern Skeena Headwaters and the Sustut River drainage generally have good water quality; however, during flood events or stream bank failures, water quality can be compromised in most of the tributary stream. In the mid 1970s, there were significant impacts on water quality due to the BC Rail Dease Lake Extension construction practices. In general, the valleys of the upper Sustut and Skeena Headwaters possess highly erodible soils with areas of glacio-lacustrine deposits, which can yield high suspended sediment loads when disturbed.

To date, there have not been any studies of surface water and groundwater resources. Since surface and ground water plays such significant roles and in so many ways influences stream habitats, understanding baseline characteristics and how they interact on ecosystem and habitat levels is important in relation to salmon conservation.

GEOGRAPHY

The fluvial and surficial geomorphology of the watershed is strongly influenced by its recent glacial history. Blankets and veneers of glacial till cover the main valley and mountain valleys, and extend up the valley sidewalls, though the surface expression generally conforms to the underlying bedrock surface. Thin soils, colluvium, and rock outcrops characterize the mountainsides sloping up from the Sustut River and tributaries. Bedrock is exposed along deeply incised streams and on steep-sided hillslopes (Holland 1976).

The majority of the soil is glacial till composed of a mixture of clay, silt, sand, gravel, and boulders. Pockets of glacial lacustrine deposits, located at many of the tributary stream mouths, can yield high sediment loads when disturbed. An example of this is the lower third of Mosque River, which has cut through the till and flows through steep, deep banks of clay. Most of the Skeena headwaters remain in a largely pristine state with probably the best water quality in the watershed.

During the last glacial period, ice flowed down from the north across the drainage, forcefully eroding the mountain slopes and basins, and leaving a legacy of glacial erosion and depositional features (Lord 1948). Pleistocene ice has overridden most of the drainage a number of times. Rounded summits generally lying below 1,800 m are the result of ice moving across the mountain ridges. Glaciers moving along the major valleys caused oversteepening of mountain slopes and contributed to the present-day U-shaped valley profiles. Above 1,500 m, alpine glacial activity of the Holocene significantly modified the high country, resulting in the knife-edged ridges, spires, abrupt crumbling slopes, and nearly vertical cliffs that characterize the rugged mountains. Tarns and hanging valleys are evident, with the mountains showing the erosional effects of valley and alpine glaciation.

Sustut Watershed Geography

The Sustut River and its tributaries divide the Swannell Ranges and further separate them from the Skeena Mountains to the west, as well as the McConnell and Osilinka Ranges to the east. The general elevations of both valley bottoms and peaks rise from the Sustut/Skeena confluence in the southwest corner of the drainage to a maximum in the upper Sustut Valley and Sustut Peak area. The lower Sustut valley (Skeena to Bear River) is relatively broad, with low to moderately steep mountain slopes. In addition, there are broad areas of gently to moderately sloping morainal blankets with organic deposits in depressions, often taking the form of bogs or wetlands.

The mid-Sustut valley possesses moderate to steep valley walls, and tributary valleys are generally narrow and steep. The rugged mountains are characterized by knife-edged ridges, spires, abrupt crumbling slopes, and nearly vertical cliffs. The upper Sustut valley and most of the upper tributary valleys open into large alpine grasslands and shrublands, meadows, swamps, and wetlands.

Bear Watershed Geography

The Bear Watershed is comprised of two mountain masses split by a trench-like fault valley. The valley is located along a major crustal break that separates the Stikine Terrane on the west from the Quesnell Terrane on the east. This fault zone extends for several hundred kilometres southward past Takla Lake and Stuart Lake. During deglaciation, stream flow was to the south into the Takla Lake basin, the Stuart River, and then the Nechako River.

Skeena Headwaters Geography

The Skeena Headwaters area is a varied assemblage of mountains and valleys. The Skeena River bisects the Skeena Mountains, composed of the Slamgeesh and Groundhog Ranges to the west and the Tatlatui Range to the east. The majority of the high peaks rise above 1,800 m elevation and the predominant vegetation cover is alpine. The elevation of the valley bottoms rise from the Sustut/Skeena confluence in the southeast corner of the drainage to a maximum at the upper Skeena-Spatsizi divide. The elevation difference between the valley bottoms and surrounding ranges is generally 800-1,000 m.

Figure 12. View eastward to the Thumb in the Bear Watershed.

The mountain ranges generally form northwest trending ridges or mountain masses that parallel the Skeena mainstem. Both broad and narrow tributary valleys intersect the ranges, forming a complex and sometimes parallel drainage pattern, as exhibited by the Kluatantan and Tzahny drainage systems. The mainstem and tributary valleys are typically U-shaped, rising rather abruptly with slopes to 50%, which frequently increase with elevation. The valleys generally have thick fills of glacial sediments in contrast to the mountains, which are rock with a veneer of till and colluvium. Upstream of the Duti River, the valleys are broad, while downstream the streams follow narrow steep valleys.

The Skeena valley is relatively broad, with low to moderately steep mountain slopes at lower elevations, often with broad areas of gently to moderately sloping morainal blankets and organic deposits in depressions that take the form of bogs or wetlands. In general, tributary streams possess higher gradients in their lower reaches, but above, many meander through marshy flats and wetlands to head in cirque-like basins. The upper Skeena and Kluatantan valleys open into large alpine shrublands, meadows, and wetlands. The broad and flat divide between the Spatsizi River, tributary to the Stikine River, and Skeena River is within a single valley at 1,372 m elevation.

Forests

Extensive alpine areas, snowfields, and rock dominate the higher elevation portions of the upper Skeena Watershed. The higher valleys are covered by willow and birch scrub tundra. The less extensive lower elevation part of the basin is covered with dense coniferous forests. There are small amounts of deciduous forests in the lower Sustut, in the major tributary valley bottoms, and some lower mountain slopes that were burnt. Many balsam stands have abundant snags due to endemic balsam bark beetle activity. Within the forested part of the drainage, two bio-geoclimatic ecosystem classification (BEC) zones are represented: the Sub-boreal Spruce (SBS) zone and the Engelmann Spruce-Subalpine Fir (ESSF) zone.

The lower elevation biogeoclimatic zone, the SBS zone, covers the lowland in the Sustut Valley below Bear River and a narrowing wedge of low elevation along the Sustut River as far as Two Lake Creek. Subalpine fir and hybrid spruce are the major tree species. Subalpine fir tends to dominate older, high elevation stands and moister sections of the zone. Non-forested wetlands occur in morainal landscape depressions, while dry grass/shrub meadows, though limited, are present on dry sites with favourable warm aspects.

Above the valley bottoms, the SBS zone merges into the ESSF zone at elevations ranging from 800 to 1000 m, depending on local topography, aspect, and climatic conditions. In the lower Sustut, the SBS-ESSF merge occurs at approximately 800 m elevation on the north facing slopes, and at 1000 m on the south facing slopes. The ESSF higher elevation forest zone has a longer, colder, and snowier winter and a shorter, cooler, and moister growing season. The forest is continuous forests at its lower and middle elevations; it then passes into subalpine parkland at higher elevations. Subalpine fir is the dominant tree species, with small numbers of lodgepole pine and white spruce hybrids in drier slope positions or fire-influenced areas.

Geology

Numerous faults and pervasive shearing prevail with a strong regional pattern at 340º. The geologic structure is dominated by complex block faulting which controls the location of the major mountain valley systems, as well as the many rock suites and mineral deposits (Richards 1975). Overall, metamorphism is light aside from the contact effects near intrusive bodies.

The geology of the Sustut Watershed is extremely complex. This watershed lies at the eastern edge of the Stikine Terrane and crosses into the Quesnell Terrane. In relation to older physiographic descriptions, these are the Intermontane Belt and the Omineca Crystalline Belt. The Sustut River transects through all of the different rock groups in the Stikine Terrane. The lower part of the Sustut is in sedimentary rocks of the Bowser Lake Group. The Sustut River then crosses the southern end of the Sustut Basin at Bear River. The Sustut Group are non-marine sediments of Cretaceous and Early Tertiary age, which are better exposed on the Stikine Plateau to the north.

From the Bear River upstream, the Sustut River passes deeper and deeper onto the rock sequence of the Stikine Terrane. The broad valleys occupied by Asitka Lake, Sustut Lake, and Moosevale are major fault zones related to the Pinchi Fault, which separate the Stikine Terrane from the Quesnell Terrane on the east (Monger 1976, Gabrielse *et al.* 1991). The Omineca Mountains in this portion of the Quesnell Terrane are formed by granites of the Hogem batholith intruded into a series of Triassic or older marine volcanic rocks.

The Bear Watershed is comprised of two mountain masses split by a trench-like fault valley. The mountains to the west, part of the Skeena Mountains, are composed of the middle Jurassic, Hazelton Group volcanic and sedimentary rocks. The Connelly Range to the east is comprised of upper Cretaceous Sustut Group sedimentary rocks presumably overlying Asitka Group Volcanic rocks at depth. The Thumb, a dramatic tower located at the north end of the Connelly Range, is formed by a Tertiary volcanic neck. Dispersed small stocks of Tertiary age Kastberg granitic intrusions are evident surrounding Bear Lake (Lord 1948) and are responsible for the mineralization on Tsaytut Spur to the west.

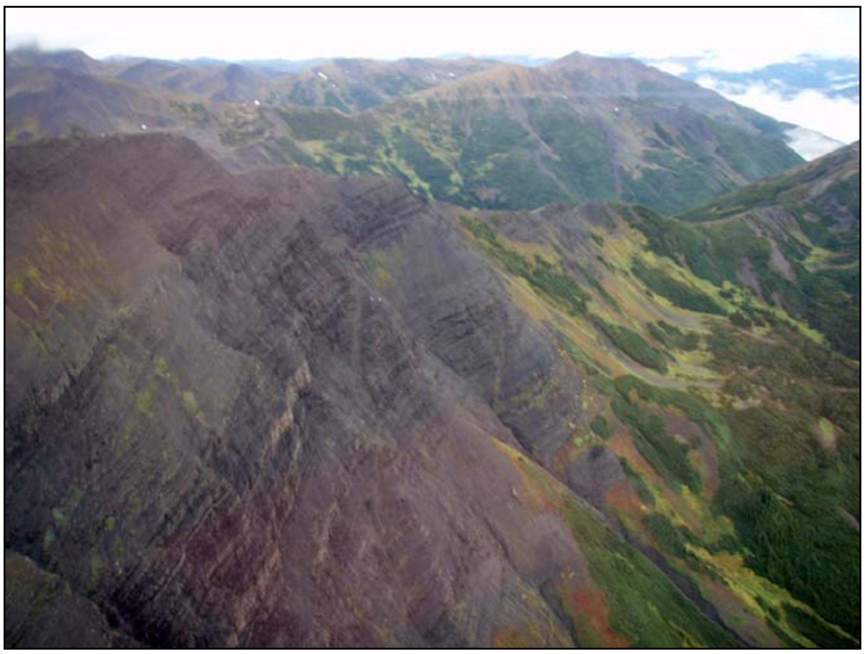

Figure 13. Photo shows typical Bowser Basin Strata in the Groundhog Range.

Sedimentary rocks of the Middle to Late Jurassic Bowser Lake Group underlie nearly all (98%) of the upper Skeena drainage. The Bowser Lake Group, formed approximately 157-136 ma ago in the middle to late Jurassic Period, is a series of marine and non-marine sedimentary rocks formed by massive and rapid erosion of land to the east. This deposit is made up of mudstones, sandstones, and conglomerate rock. During the course of massive deposition, the environment changed from offshore to nearshore, then to lowland fluvial sites. These rocks were folded, with the dominant fold trend to the northwest, and thrust faulted, showing extremely complex forms. In parts of the Groundhog Range and the Skeena valley, broad open folds predominate (Holland 1976). A strong pattern of north to northwest block faulting and occasional cross faults break up the mountains and form the wide valley systems.

Upper Skeena Watershed — Fish Values

The upper Skeena Watershed has high fish values and high value fish habitat. The drainage supports moderate levels of salmon abundance but significant populations of chinook, sockeye, pink, and coho salmon, as well as steelhead. Rainbow and lake trout, Dolly Varden, bull trout, mountain whitefish, burbot, longnose dace, prickly sculpins, and peamouth chub are also present in the drainage system (FISS 2005). In general, the most widely dispersed salmon species is coho, while Dolly Varden/bull trout and rainbow trout are located in most fish bearing waters. There are two resident freshwater fish species of conservation concern: Dolly Varden and bull trout.

Since 1992, one or two adult fences have been operated seasonally in the upper Sustut system. Presently, the mainstem fence is located 700 m upstream of the Moosevale Creek–Sustut River confluence and provides the most inclusive count (Holtby *et al.* 1999). The DFO and B.C. Ministry of Environment have conducted annual escapement programs for chinook, sockeye, and summer-run steelhead, along with occasionally sampling juveniles.

Chinook, coho, and steelhead rearing in the high elevation (>1000 m) upper Skeena watershed experience a short growing season and cold water temperatures. Consequently, the rearing period of these fish is generally a year longer than in warmer parts of the Skeena Watershed (Williamson 1998). Beyond a basic understanding of the migration timing and spawning, little is known about the biology of these high elevation populations.

CHINOOK SALMON

Sustut River Chinook

Sustut Watershed chinook escapement was carried out discontinuously from 1978 to the early 1990s, when considerable effort was put into adult enumerations at the counting fence located upstream of Moosevale Creek. Since 1994, the aggregate of upper Sustut chinook spawners recorded at the Sustut mainstem lower fence has ranged from 570 to 1,639 with an annual average of 993 chinook. Escapement numbers are unavailable for 1996 and 1997. In most years the chinook count through the fence peaks in mid-August. The Sustut fence is usually put into service at the first of August and thus misses the earliest (July) chinook.

In general, adult chinook spawn in approximately 10 km of habitat that extends from 0.5 km downstream of the Moosevale Creek-Sustut River confluence to 1.0 km upstream of the Johanson Creek–Sustut River confluence and in the lower portion of Johanson Creek.

The principal chinook juvenile abundance and habitat use studies in the upper Sustut were conducted by Williams *et al.* (1985), Shirvell and Anderson (1990, 1991a, 1991b), Bustard (1994b), and Williamson (1998) using a variety of locations and techniques. Based on their inclined plane trap sampling, Williams *et al.* (1985) concluded that the upper Sustut River was not important overwintering habitat for juvenile chinook salmon. Shirvell and Anderson (1990 and 1991b) censused chinook juveniles with a night-time drift diving technique they found more representative of actual abundance. Juvenile chinook salmon abundance was 1 fish/2.3 m of stream in 1990, while in 1991, they sampled 1 fish/1.0 m of stream close to the Johanson and Moosevale Creek–Sustut River confluences.

Williamson (1998) utilized a 1.5 m rotary trap and gee traps to determine relative abundance and movement of juvenile salmonids. Juvenile chinook density estimates for Moosevale Creek were $0.47/m^2$; for the Sustut mainstem they ranged between 0.48 and $2.78/m^2$. Williamson found considerable downstream migration of chinook fry in August and September. He suggested that the high juvenile chinook densities in the Sustut mainstem sites might be related to the substantial amounts of large and small woody debris present in those site reaches.

Bear River Chinook

Bear River chinook salmon are one of the largest chinook populations in the Skeena system. It is estimated that as much as 85% of the Sustut chinook stock spawn in the Bear River. Bear River has exceptionally high chinook spawning densities, which are probably the maximum achievable by this species (Shervill and Anderson 1990). Four field studies have documented chinook in the Bear River: the Skeena River Salmon Investigation conducted between 1944 and 1948 (Foskett 1948), a counting fence operation in 1972 (unknown reference), juvenile salmonid studies in 1984 (Williams *et al* 1985), and Shirvell and Anderson's (1990) chinook salmon and habitat study.

Chinook escapements appear to have been high in the 1950s (average 18,750) and considerably lower since, except for a recovery in the 1990s (average 11,300). More recent escapements (2000 to 2005) have averaged 5,820. Recent escapement in 2005 and 2006 were respectively 1,400 and 1,700, well below historical averages and a concern. In the 1950s the Bear River chinook escapement was the largest component in the Skeena Watershed. At present the Bear River is third or fourth in chinook abundance behind the Kalum and Morice and perhaps the Kispiox rivers.

Chinook salmon enter Bear River throughout August with peak spawning in early September. Concentrated spawning occurs from 2-3 km downstream of the lake outlet adjacent to the airstrip, which has excellent gravel and many dunes resulting from redd construction (Shepherd 1976, Williams *et al.* 1985). The remainder of chinook spawning takes place from this locality downstream to 2 km above the Sustut confluence. Shepherd (1975) reported that Bear River chinook spawners had smaller body size than fish from other similar age Skeena chinook runs, and that male fish were significantly smaller than females.

Peak emergence of chinook fry occurs during mid-June. Williams *et al.* (1985) trapped migrating fry with an inclined plane trap and found that most fry migrate downstream after July upon reaching a threshold size of 50 mm. Shervill and Anderson (1990) sampled one juvenile chinook per 1.4 m of stream in Bear River and suspected that the river is not an important chinook overwintering area. Their sampling methods utilized stream walk visual observations, daytime drift diving, electrofishing, night-time drift diving, and minnow trapping.

Skeena River Chinook

Early August usually marks the peak of chinook arrivals in the Skeena Headwaters. The majority of chinook spawning occurs in August; however, in upper Kluayaz Creek, chinook are known to spawn into late September. Chinook are present in the Kluatantan River at Tantan Creek, in Kluayaz Creek downstream of Kluayaz Lake, upstream of the lake in Kluayaz Creek, and upstream on Kluatantan River to Merry Creek. Chinook salmon are present in the Skeena mainstem, which is used for a migration route upstream to Kluakaz Creek. Chinook have been observed spawning on the lower 300 m of the alluvial fan. Recent observations indicate that the 2 km stretch of the Skeena downstream of Kluakaz Creek is a preferred spawning locale. Anecdotal observations indicate that small populations of chinook spawn on tributary alluvial fans in the Skeena mainstem. Overall chinook presence, numbers, timing, productivity, and preferred habitats are unknown due to the lack of observations.

PINK SALMON

Pink salmon only pass through the lower Sustut River to spawn in Bear River. Bear River pink salmon account for a few percent of the Skeena system total escapement. Odd-year escapement is the dominant cohort with an annual mean escapement of 46,600 with a range of 200 to 500,000. Even-year pink annual escapements have ranged from 700 to many years of no returns. Since 1990, there have only been two recorded pink escapement enumerations.

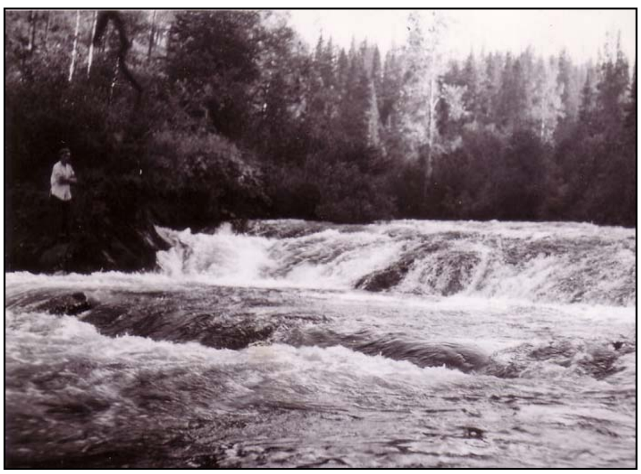

Figure 14. Bear River falls 3.5 km downstream of lake.
Fisheries Research Board of Canada, 1946.

Pink salmon generally enter the Bear River in mid-August with peak spawning typically occurring in late August to early September. The principal spawning grounds are scattered in the lower and middle river and pink salmon seldom seem to pass the falls 3.5 km downstream of the Bear Lake outlet. Emergence from gravels is coincident with ice break-up. Peak emergence levels occur in early May, followed by seaward migration (Williams *et al.* 1985).

COHO SALMON

Coho juveniles and adults are relatively widely dispersed throughout the accessible upper Skeena tributaries. In general, most upper Skeena tributary coho arrive in September and early October in a protracted run that peaks in mid-September (Holtby *et al*. 1999). Coho are usually the last salmon to spawn in the fall, with spawning from the end of September through December. Enumeration of coho spawners in streams is notoriously difficult, and true escapement numbers are commonly underestimated.

Sustut River Coho

There are few recorded coho spawning grounds in the lower and middle Sustut mainstem, but it is likely that coho spawn in the many accessible low-gradient tributaries situated on the Sustut River valley floor and in back channels of the lower Sustut. Bustard (1993a) reported several tributaries in the lower Sustut with coho presence including Teressa, Boyd, and Chelsea creeks. However, there are no recorded escapements for these creeks. Known spawning locations in the upper Sustut include the upper Asitka system, the upper Sustut mainstem, Moosevale Creek, and Johanson Creek.

Asitka Creek sustains known coho spawning in the upper reach, possibly in the section above Asitka Lake, and most likely in mid-reaches in the years that beaver dams obstruct fish passage. According to historic anecdotal Gitxsan and prospector reports, there are often large numbers of salmon spawning 15 km below Asitka Lake downstream of beaver dams. DFO (2005) reported two escapements records of 33 and 20 coho spawners, but spawner populations are essentially unknown.

Moosevale Creek has two coho escapement records of 20 and 50 fish. Coho adults have been observed to 17 km. A known spawning ground is located 3.5 km upstream of the abandoned airfield on an unnamed tributary (DFO 1991).

Johanson Creek escapement data show two records of 10 and 18 coho in the 1990s, with the coho spawning in unknown locations in the mainstem and in Solo Creek. The Sustut mainstem sustains known coho spawning from downstream of the Moosevale confluence to Sustut Lake. Escapement records show five enumerations starting in 1960, with a range from 5 to 300 fish (DFO 2005).

Aggregate escapement records from the Sustut mainstem fence underestimate coho abundance because the weir is removed before the coho migration is over. The 14 years of data in Table 4 show the annual average is 45 coho with no apparent trend. Taking into account the 37 km of stream habitat and at least 20 km of lake margin above the fence, the carrying capacity of the system ranges from 1,000-1,500 fish with 9-13 females/km (Holtby *et al.* 1999). Holtby *et al.* described the fence aggregate escapement as less than 10% of the carrying capacity, or at a level that is consistent with other areas of the depressed upper Skeena at that time.

Year	Sockeye	Coho	Steelhead	Chinook
1992	2590	30	487	100
1993	2169	18	476	199
1994	3737	118	598	956
1995	523	24	658	
1996	3368	33	515	
1997	965	5	701	
1998	2777	64	1252	570
1999	221	30	896	609
2000	476	12	377	1020
2001	1258	9	769	1639
2002	674	64	812	988
2003	4992	119	1104	1106
2004	1604	25	1042	483
2005	1175	88	271	383

Table 2. Sustut River fence counts 1992—2005.

Bear River Coho
Knowledge of Bear River coho spawning distribution and escapement is limited. Coho arrive in the Bear River generally throughout September and head to their spawning grounds. Scattered spawning occurs in the Bear River and in tributaries feeding Bear Lake, which include the lower reaches of Salix Creek, the un-named creek across the lake from Salix Creek, Azuklotz Creek, and the un-named tributary flowing into lower Azuklotz Creek (Finnegan 2002). There were serious conservation concerns with Bear system coho in the late 1990s, due to very few coho adult spawners. The aggregate escapements have steadily increased; since 2000 the average annual counts show 2,194 from a range of 851 to 4,636 returning adults. Williams (1985) reported that peak fry emergence was in mid-April followed by another larger peak in mid-June with the majority of coho smolts migrating down Bear River in May.

Skeena River Coho
Skeena River coho spawning distribution and escapement knowledge is limited. In general, most upper Skeena tributary coho arrive upriver in September. Coho juveniles and adults may be widely dispersed throughout the accessible upper Skeena tributary drainages. There are no known coho spawning grounds in the Skeena mainstem. It is likely that coho may spawn in the many accessible, low-gradient tributaries situated on the Skeena River valley floor.

Known locations with juvenile coho presence include: Chipmunk Creek and Duti River downstream of their impassable falls, Kluatantan River, Kluayaz Lake and Creek, Kluatantan Lake, Currier Creek (at 3.0 km), Beirnes Creek (2.5 km), and Otsi Creek (at 6.0 km), with most of these records showing presence in the lowest stream reach. Escapement records indicated 300 adults in Kluayaz Creek in 1970 (DFO 1991); for 2006, enumerations recorded 560 in Kluayaz Lake, 230 adults in Kluatantan Lake, and 180 in Chipmunk Creek (Finnegan 2007). Limited juvenile coho sampling has occurred upstream of Kluayaz Lake and in the lower Kluatantan mainstem close to the Skeena confluence.

SOCKEYE SALMON

Seven distinct sockeye stocks spawn and rear in the upper Skeena River drainage. All these populations are relatively small other than the Bear and Azuklotz lakes spawners.

Sustut River Sockeye
Sockeye rearing lakes include Asitka Lake, Sustut Lake, and the Johanson Watershed lakes: Spawning and Johanson. Escapements have been recorded since the Skeena River Investigations in the 1940s. Brett (1952) reported the average escapement to the Sustut Lakes in 1946 and 1947 at approximately 5,000 sockeye. Aggregate sockeye stock counts are discontinuous from 1950 to the early 1990s, and escapement trends are difficult to distinguish. Since 1992, counts have been made each year at the Sustut River counting fence. The 14-year annual average sockeye run size is 1,895 as shown in Table 2 above.

Bustard (1994b) reported that the majority (91.5%) of upper Sustut system sockeye smolts are age one fish, with the remainder (8.5%) age two. The average fork length of the sockeye smolts was 76.9 mm for age one, and 101.9 mm for age two. Rutherford *et al.* (1999) reported higher abundance of two-year freshwater resident sockeye in Johanson and Sustut Lakes. In 1993, catch estimates for sockeye smolts, using a 2.4 m rotary screw trap located upstream of the Moosevale–Sustut confluence, suggested that the peak of sockeye smolt downstream movement occurred during the period from May 24 to June 9 (Bustard 1994b).

Sustut Lake Sockeye: Sustut sockeye escapement records date back to the late 1940s and then are intermittent till the early 1960s. From the early 1960s to early 1990s, the annual average escapement was 606 sockeye. Escapement data from lower Sustut fence counts during the 1990s show the annual average to be at least double that number of spawners. The peak of the sockeye run passes through the fence in late August. Spawning is principally sustained in Sustut Lake in patchy sections along the southern shoreline. Foskett (1948) reported shallow water spawning along the eastern edge and at the southern end where Seepage Creek enters the lake through the gravel, as well as waters below 4.5 m in this region. Hancock *et al.* (1983) showed patchy spawning locations generally throughout both the east and west sides of the lake, except for the mid portion.

Figure 15. View south across Sustut Lake.

Asitka Lake Sockeye: The fence counts shown in Table 2 do not include Asitka Lake spawners, since Asitka River branches from the Sustut below the counting weir. The annual escapement from visual estimates (twenty years, recorded since 1950) averages approximately 300 sockeye, with a range of 1 to 700. Spawning locations noted by Hancock *et al.* (1983) are the three largest bays within the lake to the south, southwest, and to the west. DFO (1991) and Smith and Lucop (1966) also noted spawning grounds in the upper section of river below the lake outlet.

Johanson Lake Sockeye: Johanson Lake sockeye escapement records are fairly consistent since the late 1950s. Spawners have ranged from 2 to 800, ranging most years from 250 to 300. Since 1990, a fence has been operated discontinuously on Johanson Creek, but these data are not available. Spawning locations have been reported both in the lake and immediately downstream of the outlet (Foskett 1948, Hancock et al. 1983, DFO 1991).

Bear River Sockeye

Sockeye abundance in the Bear system was historically greater than shown by the last fifty years of escapement data. To facilitate estimation of the sockeye salmon run to Bear Lake, a fence was constructed across the head of Bear River during 1947 and 1948. Direct counts, combined with recaptures from a fence-tagging program, demonstrated that a high proportion of the returning sockeye salmon spawned in the lake (Fisheries Research Board 1947, 1948). Brett (1952) estimated the number of Bear Lake spawning sockeye at 42,000, with only Azuklotz Creek supporting >1,000 fish as a stream spawning population.

Bear Lake sockeye abundance decreased greatly in the 1950s and has not recovered. Since 1950, Azuklotz Creek has had variable escapement with no clear trends till the mid-1980s, when escapement increased to above pre-1950 levels. At least some of the Azuklotz fry rearing takes place in Azuklotz Lake, which is separated from Bear Lake by a low gradient stream channel a few hundred meters long. Annual average escapement from 2000 to 2005 was 2,012 sockeye, with a range from 486 to 3,630, representing a decreasing trend from the 1990s.

Sockeye adults typically return to Bear Lake in mid to late August, with peak spawning in mid-September. In the past, Bear Lake spawners used various beach and deep-water grounds scattered along the western lakeshore. Upper and lower Azuklotz Creek are now the principal spawning grounds, and Salix Creek supports minor numbers of spawners when flow conditions are high enough to permit entrance.

Figure 16. Lower Azuklotz Creek is a low gradient section between Bear and Azuklotz Lakes.

Fry emergence is followed by a one year lake residency (Rutherford *et al.* 1999). The 1995 juvenile sockeye sampling program found sockeye fry stomachs were 60% full and contained mostly *Daphnia* and *Heterocope*, both large and preferred food items. Although fry densities were relatively low with a mean of 132 fry/ha, mean late summer weight was 3.9 g, which is above average for sockeye nursery lake fry in the Skeena system (Shortreed *et al.* 1998).

Skeena River Sockeye

Two sockeye stocks spawn in the Kluatantan drainage, and the sockeye rearing lakes are the upper and lower Kluatantan lakes and Kluayaz Lake. Hancock *et al.* (1983) noted sockeye spawning grounds on the southern shore of lower Kluatantan Lake and in Kluayaz Lake along both longitudinal shorelines. Collingwood (1974) observed sockeye salmon arriving in mid-September in Kluayaz Lake in 1973 and 1974. The only escapement record is 1970, which showed 50 adults in lower Kluatantan Lake and 600 adults in Kluayaz Creek and Lake. The scant information available is insufficient to facilitate conservation planning and provide management objectives.

Figure 17. View west across Kluayaz Lake.

STEELHEAD

Sustut River Steelhead

The upper Sustut River drainage supports a summer-run steelhead population that is utilized as an index stock to monitor run strength of early migrating steelhead in the upper Skeena River (Parkin and Morton 1996). The upper Sustut steelhead are of particular concern to provincial fishery managers, due to this early timing which coincides with the large mixed stock fishery that harvests Skeena runs of sockeye and pink salmon.

Steelhead populations, run timing, and spawning locations in the Sustut Watershed are comparatively well known in relation to other Skeena sub-basins. The counting fence upstream of the Moosevale-Sustut confluence is primarily intended to enumerate these steelhead. The counting fence also provides data on the size and sex distribution of steelhead, and the effect of the stream stage and temperature on migration, which is reported by Parkin and Morton (1996). Diewert (2000) examined the number of gillnet marked fish and the regression relationship between the Sustut steelhead index and the Tyee test fishery index.

Figure 18. Sustut River counting weir.
M. Beere

Estimates of steelhead escapement are aggregates for the Sustut system above the counting fence. Escapement estimates have been continuous since 1992, with an annual average of 685 adult steelhead from a range of 377 to 1,252 fish.

Steelhead arrive in the upper Sustut from early August through to mid-October. They overwinter predominantly in Sustut and Johanson Lakes, particularly at their outlets (Chudyk 1972b, Spence *et al.* 1990, Bustard 1992b, Lough 1993). Lough reported that one radio tagged steelhead overwintered in the Sustut mainstem downstream of the Moosevale–Sustut confluence.

Steelhead spawn in May and June, coinciding with warming water temperatures and increasing streamflows. Bustard (1994b) indicated that spawning in the upper Sustut River upstream of the Johanson–Sustut confluence likely peaked in the week of May 21, and was completed with most fish off the redds and holding in deep water by June 15th.

The two principal spawning locations are the Sustut River below Sustut Lake and the mainstem of Johanson Creek (Bustard 1994a). Bustard noted that there is limited spawning in the mainstem below the Johanson–Sustut confluence, and that more spawning apparently occurs in upper Sustut River than in Johanson Creek. No other steelhead spawning locations are known on the Sustut mainstem. Bustard (1994a) suggested steelhead may spawn in side channels below the Bear River confluence and that suitable habitat exists on the north side of the Sustut River. However, north side tributaries may receive limited spawning activity due to fish passage concerns through BC Rail culverts and drainage structures. First Nation anecdotal reports note that steelhead spawn in Darb Creek and are present in Darb Lake during February and March.

Downstream fry migration appears to be widespread with sites along the mainstem and smaller tributaries offering suitable refuge. Bustard (1992b) noted relatively low fry densities adjacent to steelhead spawning locations, though fry densities were high in the mainstem near Moosevale Creek. Bustard (1992a, 1993b, 1994b) sampled steelhead fry and parr densities in the upper mainstem and tributaries. Johanson Creek had high densities in 1993, but most tributaries downstream to Two Lake Creek had low densities.

Timing and abundance of the downstream migration of steelhead parr and smolts have been studied by Williams *et al.* (1985), utilizing an inclined plane trap, as well as by Bustard (1994b), and Dubeau and Johannes (1996), who used a rotary screw trap. The large numbers of parr and fry moving downstream in the upper Sustut mainstem likely indicate that preferred downstream habitats are important for growth and survival in this high elevation nursery area. Scales collected over the last twenty years show that upper Sustut steelhead spend on average three years in freshwater prior to moving to the ocean (Baxter 1997a). Tautz *et al.* (1992) estimated the mean smolt age for upper Sustut steelhead to be 4.5 years, or about one year more than the direct scale estimates.

Bear River Steelhead

The Bear Watershed supports one of the large populations of summer-run steelhead in the Skeena Watershed. Once steelhead bound for the Bear River enter the lower Skeena River, it is estimated that it takes about one month to reach the Bear River (Lough 1980, 1981). Bear River steelhead and lower Sustut River steelhead are grouped into a distinct sub-population due to run timing and unique life-histories (Baxter 1997). Bear Lake is a known overwintering area (Chudyk 1972a), and it has been suggested that steelhead also overwinter in Sapolio Lake (Bustard 1993c), as well as in the mainstem Sustut River at the Bear confluence (Spence *et al.* 1990).

Figure 19. View across Sapolio Lake with Bear Lake in the background.

Bustard (1993c) estimated that steelhead started spawning in Bear River in mid-May, peaked in late May, and ended in early June. Chudyk (1972a) reported that 3,000 adult steelhead were spawning in the spring salmon spawning "ridge" on Bear River. Turnbull reported 700 steelhead spawners in late May 1989 in the mid-reach where chinook spawn (BC MoE files). Kelts are thought to migrate seaward immediately following spawning (Beere 2002).

Bustard (1993c) estimated that in Bear River, fry emergence was July 24 to August 5, with a peak around July 30. Williams *et al.* (1985) found that steelhead fry moved downstream into the lower Sustut River; he suggested that fry production in the Bear River was critical for seeding Sustut mainstem habitat. Steelhead smolt migration peaked at the beginning of May, before the onset of the freshet (Williams *et al.* 1985).

Skeena River Steelhead

The upper Skeena River drainage supports a summer-run steelhead population that likely enters the mouth of the Skeena early in comparison with other Skeena steelhead populations. There are no data from Floy tag recaptures in the TAGS database, so an estimation of timing through Area 4 cannot be directly made (Baxter 1997b). Information from angling records and the lone radio-tagged steelhead tracked to the Kluatantan system suggest that these steelhead move through the commercial fishery during the peak of commercial fishery effort.

Steelhead presence in the upper Skeena drainage has been noted in the Mosque River at 0.6 km and in the Kluatantan system in Kluayaz Lake (DFO 1991). There are no steelhead escapement estimates; though Whately (1975) suggested a total spawning population of 150 steelhead subsequent to reviewing angling guide records for Kluayaz Lake. Overwintering occurs in Kluayaz Lake (Lough 1979) and possibly in the Kluatantan Lakes, the Kluatantan River canyon, and the Skeena River mainstem. Steelhead spawn in May and June, coinciding with warming water temperatures and an increase in streamflows. It is thought that most spawning locations within the drainage are unknown.

In 1984, Tredger (1986) sampled four sites in the lower Kluatantan Watershed for juvenile steelhead; results showed that fry densities were highest downstream of the Tantan Creek confluence, with generally low densities in the lower Kluatantan mainstem and downstream of Kluayaz Lake. Parr densities were generally low at all sampled sites, though marginally higher downstream of Kluayaz Lake.

INDIGENOUS FRESHWATER FISH

With the exception of salmon and steelhead, information is scant in regard to fish in both river and lake habitats of the upper Skeena River drainage. Some of the drainage is poorly known and may contain populations of special interest or status that are presently unknown or undocumented. Ecological and life history information that would enable good conservation planning is not available.

Freshwater species and documented populations inhabiting the Sustut drainage include rainbow trout, kokanee, bull trout, lake trout, Dolly Varden, bull trout, lake and mountain whitefish, longnose dace, burbot, redside shiner, peamouth chub, and prickly sculpin (FISS 2005). Dolly Varden, and to a lesser extent rainbow trout, are the most widely dispersed species and are present in most fish bearing waters. Hatlevik (1999) reported a very large bull trout population in the Bear River.

FISHERIES

Aboriginal Fisheries

Anadromous chinook, coho, sockeye, pink, steelhead, and resident freshwater stocks were typically harvested and processed close by their spawning grounds by upper Skeena First Nations peoples. This large-scale utilization of the abundant salmon stocks formed the foundation of the economy. The predictable salmon runs provided the opportunity for people to harvest and preserve a high quality staple food in a few months of intensive effort.

Arrangements for management of the fishery were deeply interconnected and woven into the fabric of society. The harvest of surplus to conservation needs on a stock-by-stock basis allowed for optimal utilization of the salmon resource that was the core of the economy. Fundamental conservation elements were practiced; waste was forbidden. Processing capacity was limited by smokehouse infrastructure, particularly the amount of space available on the lower poles, where fish were hung in the first stages of the drying process, and by the number of fish that could be dressed in the available time.

At a few locations on the Skeena River mainstem, and on many its tributaries, salmon and steelhead were traditionally caught with fences or weirs, which were fitted with openings for a variety of large woven traps. These weirs were built either right across smaller streams, or on the mainstems out on an angle to guide the migrating fish into shore-side traps. The wide variety of weirs and contiguous traps used were matched to the species, environment, placement, and building materials available.

Skeena Watershed First Nations peoples managed the coho, sockeye, chinook, pink, chum salmon and steelhead fisheries of their territories up to the mid 1870s. At this point, the incursion of Euro-Canadians with their colonial social concepts and the establishment of coastal industrial fisheries at the mouth of the Skeena River initiated the pattern of fisheries we see today.

Sustut River Fisheries: Sustut River fisheries were concentrated at two main locations on the Sustut mainstem: Gaps Ganeex and Wilna Guuk. Dispersed fishery camps targeting anadromous and freshwater fish were located close to the outlets of Johanson and Sustut Lakes, at Asitka Lake and River, and at the mainstem canyon section downstream from Moosevale Creek–Sustut River confluence.

Gaps Ganeex is located approximately 1.75 km downstream of the Birdflat Creek–Sustut River confluence in the small canyon on the lower Sustut mainstem. This fishing and river-crossing site supported the ancient village of Anx Wil Djabas, which was located on the north bank of the Sustut River, west of Birdflat Creek. The canyon was crossed by a cantilevered suspension bridge that connected major aboriginal travel trails on the north and south sides of Sustut River.

The ancient bridge crossing was recorded by O'Dwyer (1901) and discussed by Buckham (1950). Anx Wil Djabas was unfortunately destroyed by Keene Industries when they bladed the site for a camp during construction of the BC Rail line (Helmer and Mitchell 1972). The fishing site is currently designated as BC Archaeological Site HbSs-01, while the pine cambium foraging site, with approximately 1,200 CMTs on the north bank of the Sustut River, is designated BC Archaeological Site HbSs-04 (Norcan 2000).

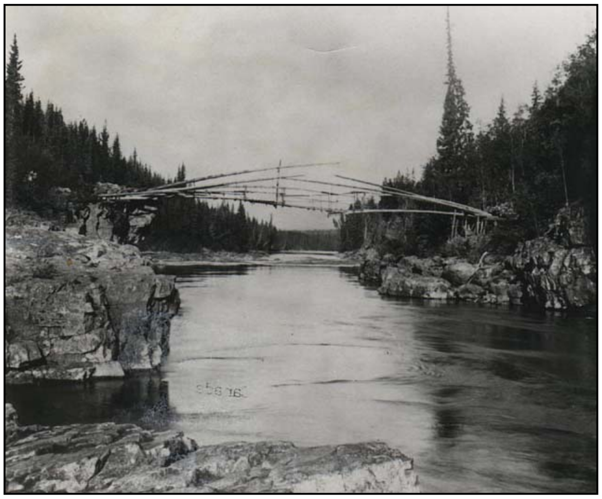

Figure 20. Bridge at Gap Ganeex, 1899.
O'Dwyer 1901

Steelhead Canyon on the Sustut River is located about 6.5 km downstream of the Two Lake Creek–Sustut confluence. This was an important salmon and steelhead fishing site. When families finished drying their groundhog meat in the late summer and fall, they fished at Steelhead Canyon and then dried fish for the winter. They also fished there while trapping in the winter (Abraham 1995). Abraham indicated that the mouth of Two Lake Creek is also a salmon fishing net site.

Gitmusundat, an ancient sockeye and steelhead fishing site, is located on the slough at the mouth of Willow Creek on the Sustut River. Abraham (1995) considered this site to be one of the best fishing spots on the river. The confluence of Johanson Creek and Sustut River is an important fishing place with two traditional camps mostly utilized in the fall to fish steelhead.

Subsequent to the Department of Fisheries forcing the abandonment of weir and trap fishing in 1906, the fishery was primarily with spears, and then later with gillnets. Essentially, the salmon stocks spawning in the upper Sustut formed the principal food resource enabling people to make this their home.

Dispersed traditional fishing sites in the upper Sustut drainage included the outlets of Johanson and Sustut Lakes, at Asitka Lake and River, and at the mainstem canyon section downstream of the Moosevale Creek–Sustut River confluence. Oral histories recount fishing at Johanson and Sustut Lakes. In the course of fieldwork on the upper Sustut sockeye nursery lakes, Foskett (1948) reported that a family of ten Indians took chiefly coho and steelhead with both spears and gillnets in Johanson Creek just below Johanson Lake.

They maintained a camp on the west bank at the outlet of Sustut Lake. This area has recently been the site of a mineral exploration camp. Foskett (1948) noted that Indians gillnetted steelhead during the winter at this site. He also noted that sockeye and coho were fished with spears by Indians in Asitka Lake and downstream in the Asitka River when beaver dams slowed fish passage. Foskett stated that shifting traplines and a decrease in sockeye runs to Asitka Lake largely account for the abandonment of fishing in this area.

Bear River Fisheries:
Traditionally, First Nations from Wil Dahl' Ax (Fort Connelly) used the Bear Watershed. The strong chinook run was the basis of a vigorous fishery as evidenced by the ten recorded fishing and processing sites (Rabnett *et al.* 2001). Rainbow trout, steelhead, lake trout, and Dolly Varden char were also fished in the lake.

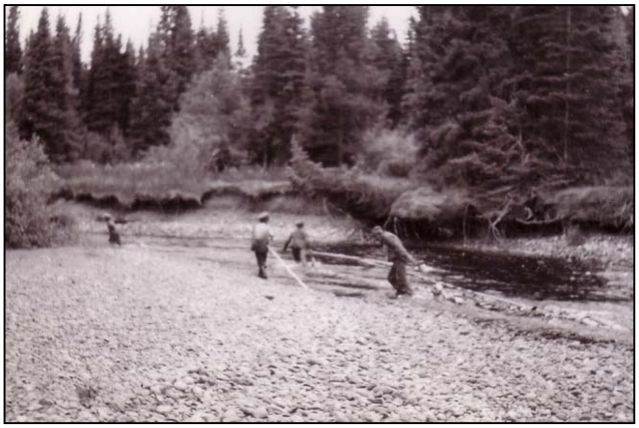

Figure 21. Bear Lake people pulling strings of chinook upstream for processing.
Fisheries Research Board, 1946.

Although various fisheries occurred at Bear River and Lake, a large fishing effort was expended at the weir immediately below Bear Lake Village, also known as Wil Dahl' Ax. Posts were pounded into the river bottom, and then overlaid with panels secured on the upstream side. These often supported a walkway across the top enabling access to barrel-type traps. These traps were fitted with a movable panel through which fish could be dipped, gaffed out, or released, depending on whether the species was desired. The other known weir location was at the shallows between Azuklotz and Bear Lakes. Patrick (2001) noted that one trap in both these fences provided enough fish for everybody. Wilna Guuk, an ancient fishing village, is located on the south bank close to the Bear River–Sustut River confluence. Bear River Indian Reserve No. 3 was laid out to retain the productive fisheries there.

Skeena River Fisheries: Aboriginal salmon fisheries within the upper Skeena River drainage were concentrated at six known locations on the Skeena mainstem. Fishing stations were located at the mouth of Alma and Currier creeks and at an unnamed creek upstream of Mosque River. Additionally, fishing sites were also located at the mouth of Kluatantan, Mosque, and Duti Rivers. Dispersed fishery camps that mainly targeted coho and steelhead were located upstream on Chipmunk Creek, Tantan Creek, Kluayaz Creek, and several unnamed creeks. Sockeye were harvested at Kluatantan and Kluayaz lakes. Chinook were harvested at Kluayaz, Tantan, and Kluakaz creeks. These known village and fishery sites were positioned mainly to exploit efficient capture sites.

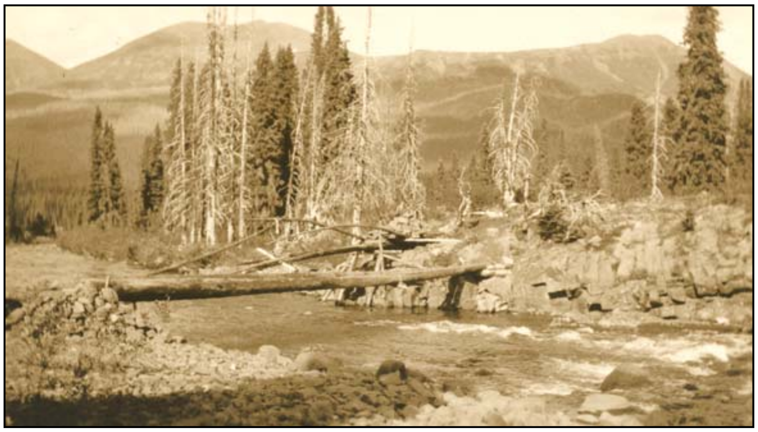

Figure 22. Photo shows log bridge in front of older aboriginal cantilever bridge across Kluatantan River. (Campbell-Johnston 1912)

RECREATIONAL FISHERIES

The high fisheries value in the lower Sustut, in combination with the high natural resource values – wildlife, remoteness, high water quality, and beautiful landscapes – results in uncrowded fishing conditions and exceptional fishing. Due to the remoteness and the necessity to access the area by air, the majority of anglers are guided clients.

Currently two angling lodges, Suskeena Lodge and Steelhead Valhalla Lodge, operate on the lower Sustut Rivers and occasionally on the Skeena River downstream of the Mosque. The majority of guided anglers are non-Canadians, and this trend is expected to continue. There is no fishing permitted on the Sustut River or its tributaries above the BC Rail Bridge at the mouth of Bear River. The Sustut River is designated Class 1 water September 1st to October 31st, and a Steelhead Stamp is mandatory during this period.

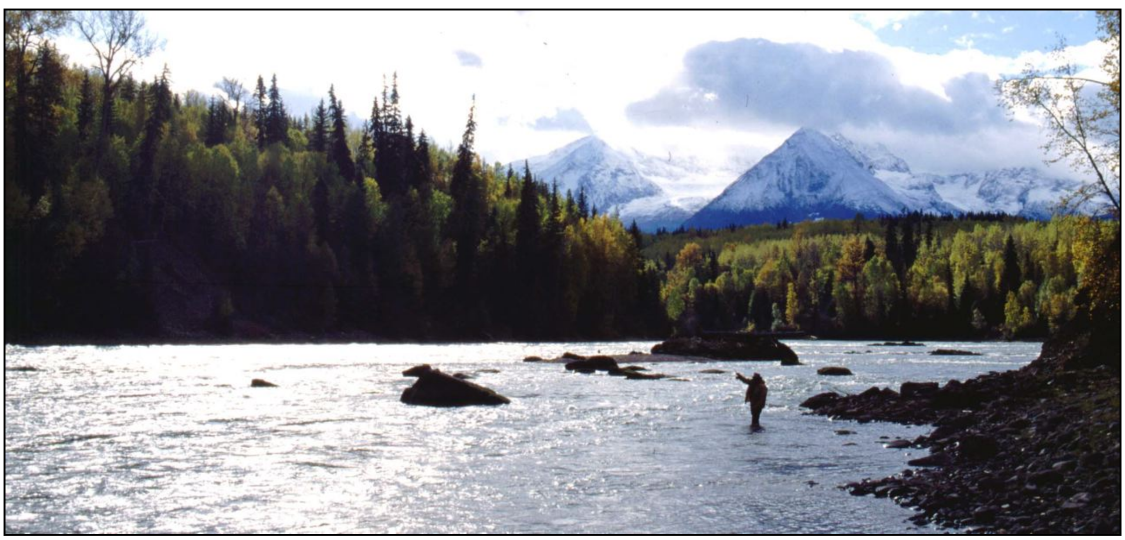

Figure 23. Fly angler on the lower Sustut River.

The recreational fishery in the Bear Watershed is limited by access, and a no fishing regulation applies to Bear River. A fishing lodge located near the northwest corner of the lake provides clients with game fish opportunities on Bear Lake and day trips to other nearby popular lakes, such as Babine Lake.

In the remote upper Skeena Headwaters, access is by air, and the majority of anglers are guided clients. Currently, there is one guide licensed to operate in the Kluatantan drainage with an allocation of fifty-five guided angler days. The angling days are based out of Kluayaz Lake where the main guiding lodge is located. The Kluatantan River is designated Class II water all year and a Steelhead Stamp is mandatory from September 1 to December 31; as well, a bait ban applies during this time.

Upstream of the Sustut Skeena confluence, regulations require mandatory release July 1 to December 31, and general restrictions include no fishing in the Upper Skeena drainage January 1 to June 15 (BC Fisheries 2005).

Land Use Development Activities

Currently, land use and development activities in the upper Skeena River drainage are logging in the lower portions of the Bear and Sustut drainages, small scale mineral exploration, coalbed methane development, and transportation that includes the B.C. Rail grade.

FOREST RESOURCE DEVELOPMENT

The Fort St. James Land and Resource Management Plan (LRMP) zones the Sustut River drainage as multi-value, which is essentially a pro-timber development policy. Large-scale forest exploitation did not occur until the early 1990s when the Sustut area forests were optioned off to various licensees to cut 900,00m^3/year on a twenty-year non-replaceable license condition. This forestry development was conceived to mitigate the effects of overcutting in the Prince George Forest District. Since the early 1990s, forest development has high-graded the economically valuable pine stands on the gently sloping, north and south sides of the lower Sustut River, with timber being shipped on the BC Rail line to Fort St. James and Prince George.

In 2007, logging was discontinued due to the end of easily accessible forest and the large-scale salvage efforts needed to cope with the mountain pine beetle epidemic close to Prince George. The logging camp at Minaret was removed and the road system was partially deactivated.

MINERAL DEVELOPMENT

Euro–Canadian explorations for base and precious minerals have been ongoing since the turn of the last century and were focused mainly on high-grade silver and gold veins. Mining exploration slowed down with the onset of the Depression. In the early 1960s, mineral exploration focused increasingly on porphyry copper-molybdenum deposits.

There are fifty-two mineral showings in the Sustut drainage, including two developed prospects: Sustut Copper and Sustut Coal. The greatest densities of mineral occurrences are located in the upper Sustut, upstream of Red Creek and Asitka River. These occurrences are largely silver, gold, and copper polymetallic vein-type deposits. Sustut Copper, west of Sustut Lake, owned by Doublestar Resources is a volcanic massive sulphide type deposit that has drill indicated reserves greater than 54.4 million tons at 1.25% copper (Doublestar 2001). The deposit geology is described by Harper (1977) and Wilton and Sinclair (1988).

Evaluation of metallic mineral potential for the watershed conducted by the BC Ministry of Mines and Petroleum Resources is relatively generalized. The area has been delineated into mineral tracts on the basis of geology and distribution of known mineral occurrences. Mineral assessments of the upper Sustut drainage show high metallic mineral values, though there is a narrow area of land extending from Moosevale Creek southward to Sustut Lake, where metallic mineral values are classed as low (Ministry of Energy and Mines 2002).

In the upper Skeena Headwaters, the most noteworthy mineral deposit is the Klappan-Groundhog coalfield, an oblong (roughly 30 by 80 kilometres) area extending southeast from the headwaters of the Klappan and Little Klappan rivers to Groundhog Mountain. The Groundhog coals are considered high grade anthracite. Early exploration efforts were intense before the onset of WW I. By 1913, approximately 1,813 km^2 were covered by over 460 claims in the Groundhog deposit area (Malloch 1913).

Figure 24. Beirnes Creek coal exploration camp. (Campbell-Johnston 1912)

In 1948, Buckham and Latour (1950) conducted a mapping and data collection program in the Groundhog coalfield wherein they documented 192 coal showings. Interest in the coal potential of the area was rekindled in 1966 and continued into the mid-1980s. Assessment of the Groundhog coalfield potential by a consortium of companies in 1970, conducted mapping, sampling, and diamond drilling programs, estimating upwards of 3.6 billion tonnes of speculative coal reserves in the southeastern Groundhog coalfield. The coal reserves in the Klappan, Groundhog, Jackson Flats, and Sustut deposits are estimated at more than 10 billion tonnes (Ryan 2000).

In 1981, Gulf Canada acquired the Mount Klappan coal licenses and annually conducted comprehensive activities until 1988, including maintenance as needed on the B.C. Rail grade. Gulf Canada also conducted exploration activities on the Groundhog coalfield. Gulf's measured economic reserves at Klappan are 64 million tonnes with total reserves of 630 million tonnes (Gulf 1986). In 2002, Fortune Minerals acquired the Mount Klappan property and since then has conducted periodic assessments mostly related to environmental applications and permitting for the B.C Environmental Assessment Office. In 2005, West Hawk Development Co, which holds coal tenures in the Groundhog area, conducted minor exploration activities consisting of clearing the B.C. Rail grade to the Kluatantan River.

COALBED METHANE DEVELOPMENT

The Bowser and Sustut basins potentially represent the largest petroleum exploration target area within the Intermontane region. This area has received renewed interest in the last few years as a result of new thermal maturation data indicating that large portions of these basins are within the oil and gas window (Evenchick *et al.* 2002). Prior to this, much of this area, particularly the Bowser Basin, was considered to be over mature with respect to oil and in the upper end of the gas window (Hannigan *et al.* 1995). This new data suggests the potential for hydrocarbon resources beyond those described by Hannigan *et al.* (1995). Further examination of catalogued surface and sub-surface samples and core, recognized more oil staining (Osadetz *et al.* 2004; Evenchick *et al.* 2004). These occurrences also confirmed the new thermal model generated for this area. Presently, this potential is based on a generally sparse data set, and additional work is needed to evaluate the thermal and diagenetic history of potential systems.

In 2004, the BC Ministry of Energy and Mines granted a lease to Shell Canada that enables coalbed methane exploration activities in the upper Klappan, upper Spatsizi, upper Nass, and upper Skeena areas. In 2004, Shell Canada utilized the Ealue Lake road and the BC Rail grade to access their lease, where they established and drilled three exploratory wells in the upper Klappan and Spatsizi drainages adjacent to the B.C. Rail grade. Shell Canada also conducted seismic testing in the upper Skeena headwaters upstream of Beirnes Creek.

Shell is expecting to do further work on their lease, but there are significant First Nation concerns related to the potential loss of healthy air, water, and soil; the potential loss of cultural interests and values; as well as the loss of future socio-economic opportunities.

TRANSPORTATION DEVELOPMENT — B.C. RAIL

Dease Lake Extension Overview

Transportation development in the Skeena Headwaters includes the logging road network in the lower Sustut area and the B.C. Rail - Dease Lake Extension. The extension was from Fort St. James to Dease Lake and was envisioned as a progressive building block approach to developing northern B.C. Construction commenced from Fort St. James in 1967, and by 1977 a rudimentary railroad grade was constructed 664 km north to Dease Lake. Steel rail was only laid to Chipmunk Creek with the subgrade in various stages of completion for the remaining 225 km to Dease Lake. In 1977, the track and grade was abandoned by BC Rail and the BC Government, due to significant environmental problems, unsuitable management approaches, and massive cost over runs. By 1977, the cost amounted to $168 million, well over double the original cost estimate.

By 1972 costs had escalated and claims were launched by various contractors against the railway. In December 1975, a change in government ushered in a different philosophical direction for the railway. A new board of directors was formed to operate the British Columbia Railway and this removed direct political influence from the day-to-day operation of the railway. The railway had become so deeply entwined with the ebb and low of provincial finances and policies that in December 1976, a royal commission was appointed to sort it out. Construction of the Dease Lake Extension was suspended in April, 1977.

The report from the Royal Commission on B.C. Railway in 1978 changed the structure of B.C. Rail (McKenzie *et al.* 1978). It recommended a new direction of operating on a commercial mandate rather than its previous role as an instrument of public policy and provincial development. Besides the cultural, social, and economic effects on Iskut, Takla/Bear Lake, and Stuart-Trembleur First Nations, the Commission revealed that extensive environmental damage had occurred, as well as large-scale harmful effects on fish and wildlife habitats and populations.

During the 1970-1977 period of construction, site investigations were conducted periodically by the federal Fisheries and Marine Service, by the provincial Fish and Wildlife Branch, and by B.C. Rail consultants. The results indicated significant environmental damage had occurred and continued to occur as a result of poor design related to right-of-way alignment, river diversions and encroachments, culvert installations, and unstable terrain conditions causing mass wasting. Some of these studies and reports include: Hourston (1972), Chislett ((1973, 1974), Bustard and Chudyk (1975), B.C. Fish and Wildlife Branch (1974), Taylor (1973), Galbraith (1975), and Walker (1977).

In April 1977, all construction on the B.C. Rail–Dease Lake Extension was terminated with instructions to permanently abandon the project. Extensive unstable earth works and cuts opened up since 1975 and older cuts that still had not stabilized were abandoned. Other large scale earth works, such as waste soil disposal areas and stream crossings that were in place and only partially completed, or cut and fills requiring slope stabilization work, were abandoned. These unstable sections were particularly prevalent upstream of the Kluatantan River on the Skeena, and through the Spatsizi, Klappan, Stikine, and Tanzilla valleys overlaid by the rail grade.

Not putting the rail grade "to bed" has exacerbated erosion and sediment problems from many of the significant unstable areas and caused approximately 28 culvert "wash-outs" in the upper Skeena drainage. Bustard's (1977) submission on behalf of the B.C. Fish and Wildlife Branch to the Royal Commission on B.C. Railway noted:

> "In conclusion, we wish to stress that we consider it irresponsible to simply abandon the B.C. Rail grade without a careful and detailed evaluation of the environmental problems this poses and the initiation of a program to undertake remedial action on those portions of the grade requiring further work".

In 1984, B.C. Ministry of Environment (BC MoE) undertook a reconnaissance level investigation of the abandoned B.C. Rail grade with the purpose of:

1) Determining the degree of natural repair to the environment along the right-of-way in the past decade;
2) Identifying areas where chronic environmental impacts continue;
3) Determining if there is a need for BC Rail in conjunction with BC Ministry of Environment to develop a program to correct damages and chronic impacts.

This investigation was reported on by Gates and Reid (1985). They concluded that it is impossible to determine the actual resource losses that resulted from short and long-term impacts caused by the B.C. Rail construction activities. Impacts were still occurring at some sites where sensitive environmental conditions were noted in 1974. Notwithstanding the above, BC MoE recommended BC Rail, in cooperation with the Ministry:

1) Undertake a program of periodic inspections of major culverts and fills along the right-of-way in order to ensure their continued safe operation;
2) Examine the cost effectiveness of providing fish passage into certain tributary streams presently obstructed by improperly functioning culverts;
3) Undertake a program to define and solve problems resulting from uncontrolled access into wilderness areas along the railway;
4) Undertake a program to reclaim abandoned construction camps and borrow pits by removing abandoned trailers, buildings, culverts, machinery, etc, and by reseeding disturbed land;
5) Take no action to replace those sections of railway washed out or damaged by culvert failure if the railway is not be reopened and if such measures are likely to cause further environmental impacts to water quality and fish resources.

No action has been taken on the first three recommendations, and only partial activities have occurred in relation to recommendation 4. In 2007, the rail tracks were removed from Chipmunk Creek down to Minaret and sold to Australian interests.

B.C. Rail Effects on Fish Habitat and Fish Passage

In summary, the construction of the B.C. Rail–Dease Lake Extension resulted in massive and severe environmental impacts to fish, wildlife, and water quality. These impacts are due to minimal and poor planning, a lack of pre-engineering and design work, and construction practices that were carried out with little concern for environmental values, particularly streams and rivers. These impacts are separate from erosion and failures resulting from natural lateral movement of stream channels.

Since construction began, but especially since 1977, the B.C. Rail grade has not been managed in compliance with and according to Federal and Provincial legislated land development regulations and guidelines in regard to riparian, sediment control, fish passage, and salmonid habitat issues. It is important to note that maintenance of drainage structures and monitoring of unstable areas has not occurred. The B.C. Rail grade issue clearly needs to be resolved.

B.C. Rail Effects in the Bear River

In 1970, construction of the BC Rail Dease Lake Extension reached the Bear River drainage and entered the Skeena Watershed. The railway follows the east bank of the Bear River, where glacial-lake deposits of plastic clay and silt underlie sand and gravel terraces; when the clay and silt are disturbed, they have low residual strength and move down the slope. This has usually involved relatively large masses of soil or slides. Portions of the rail grade were constructed relatively close to sections of the Bear River, which is a highly productive chinook, pink, and steelhead spawning stream.

The railway construction resulted in six major slides into the Bear River, which caused massive sediment deposition. The marginal rail grade drainage structures on tributary crossings, as well as deranged subsurface flows and seepage, caused more failures and sediment problems over a number of decades. Excessive sediment and siltation caused changes to the natural stream beds affecting both salmon spawning and rearing.

Figure 26. Chronic fill slope slide into Bear River, August 1974.

Figure 27. Sediment and waste earth into Bear River, August 1974.

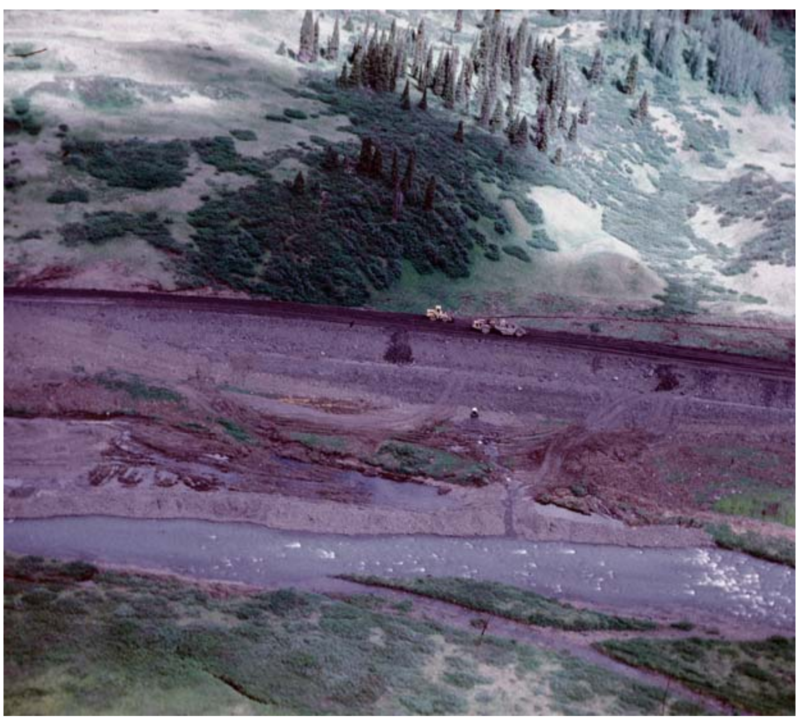

Figure 28. Photo shows Bear River with fill and waste soil encroaching on the channel, 1974.

Figure 29. Bear River tributary culvert installation, August 1974.

Figure 30. Slide into the Bear River, July 1977.

Figure 31. Bear River slide stabilized and revegetated, note the channel width is still reduced. (Same as Figure 30). July 2007

B.C. Rail Effects in the Sustut River

In 1971, construction of the BC Rail Dease Lake Extension reached the Sustut River. Downstream of Bear River to Birdflat Creek, the lower portion of the valley and Sustut River channel cuts through sedimentary bedrock with a thin mantle of glacial deposits. Most of the rail grade excavation was primarily granular soil material or bedrock. The predominant fisheries problems were unsuitable culvert placement that led to fish passage obstructions and large-scale cut and waste operations causing massive sedimentation into the mainstem. Downstream of Birdflat Creek, six B.C. Rail crossing culverts are impassable barriers to high value spawning and rearing habitat for steelhead, coho, bull trout, and Dolly Varden.

Figure 32. Extensive rock cut ~3 km upstream from Birdflat Creek, July 1977.

Figure 33. Sustut River with minor cutslope erosion 30 years later, 2007.

B.C. Rail Effects in the Skeena River

In 1972, construction of the BC Rail Dease Lake Extension reached the Skeena River upstream of the Sustut. Along the Skeena, the rail track was laid approximately one-half the distance in the south, while to the north the rudimentary rail grade ranges from 20-80% complete. Approximately one-half of the rail grade excavation was in outwash granular or bedrock material; north of Kluatantan River, the excavated material is predominantly silt and clay tills with tills depths ranging to greater than 15 m and low to medium plasticity.

The main fisheries problems were unsuitable culvert placement created fish passage obstructions and large-scale and unstable cut and fills caused massive sedimentation into tributaries and the mainstem. Large-scale cuts in close proximity to river meanders had waste material pushed into the mainstem. Some outside meanders in the mainstem had groins or rock push-outs to alleviate erosion at high water.

Figure 34. Cutslope upstream of Mosque River, 2007.

Figure 35. Skeena River upstream of Duti River. Outside meander groins, September 1974.

Figure 36. Cutslope between Alma and Fort creeks on the Skeena with chronic small slumps and erosion.

Figure 37. Cutslope showing limited recovery after 30 years .

Figure 38. Drainage ditch intercepts soil water movement and converts it to surface flow.

Upper Skeena Fish Passage Assessment Results

The Sustut, Bear, and Skeena Rivers are generally slightly entrenched into the valley bottoms with accompanying steep embankments ranging from 10 to 55 m in height. Therefore many streams have steep lower reaches in which fish passage is inherently difficult. In this Fish Passage Culvert Inspection project 138 stream crossings were examined. Of these 114 were determined to be fish bearing streams crossings and 24 crossings were determined to have no fish presence due to stream gradient or lack of suitable habitat.

Approximately 47 first order stream crossings between Sustut and Kluatantan rivers on the Skeena River were not surveyed. Observations indicated that gradients were either too steep to accommodate anadromous and resident fish passage upstream to the rail grade or the stream was ephemeral in nature.

There are 33 constructed stream crossings rated as full barriers to fish passage. Of these crossings, 3 are rated high and prioritized for rehabilitation. One is rated as moderate and 4 are rated low priority for rehabilitation. Deactivation is recommended for 17 of these crossings. The other 8 streams with full barriers are not rated for restoration or deactivation, due either to their geographical position — lying above a moderate to high gradient embankment above the main rivers — or to the lack of suitable fish habitat upstream from the stream crossing.

The seven partial barriers are of varying types and degrees; as there is variability in fish abundance and in quality of upstream fish habitat. Only two partial barriers are rated for rehabilitation, Azuklotz Creek and Garner Creek. From Garner Creek downstream to Kluatantan River deactivation is recommended for 73 stream crossings.

Due to the lack of presence/absence and species composition surveys, first to third order and larger streams at the 1:20,000 scale in the surveyed areas have an incomplete inventory of fish species presence. Fish presence in many first and second-order streams is inferred and has not been field-verified. Habitat quality and quantity were noted at and adjacent to the stream crossing sites, and where required were often verified from air observations.

Table 3, which follows, summarizes overall data presented in Appendix 1.

UPPER SKEENA FISH PASSAGE SITE SUMMARY

SITE I.D.	EAST	NORTH	STREAM NAME	CROSSING TYPE	FISH PRESENCE	BARRIER	RESTORE PRIORITY	DEACT REQ'D	MAINT REQ'D	COMMENT
1	643618	6214562	Azuklotz Creek		CO, SK, RB, CH, BT, DV	Partial	High		High	Large volumes of sediment deposition since 1969 and will continue to aggrade in the bridge area for several more decades.
2	642358	6216536	Unnamed	CMP	CO, MW, BT	No				Culvert good, flows to Azuklotz Lake
3	637176	6221388	Unnamed	MP	Inferred	Yes	High			Good fish habitat, flows to Tsaytut Bay. Outlet drop can be mitigated by building pool height with available nearby rocks.
4	636580	6222179	Unnamed	CMP	SK, CO	No				Dry, flows to Tsaytut Bay
5	635542	6223736	Salix Creek	Bridge	SK, CO	No				
6	633257	6228113	Unnamed	CMP	ST, CO, RB	No				Steep stream bed upstream of culvert
7	632296	6230920	Unnamed	CMP	ST, DB, RB	No				Seasonal stream, dry at survey
8	632111	6231212	Triple Creek	CMP	ST, RB	Yes	Moderate			1000, 1100, and 1200 mm culverts with outfall drops. Moderately steep upstream of the culvert.
9	631988	6231403	Unnamed	CMP	ST, RB	No				Seasonal stream, dry at survey
10	627913	6235690	Unnamed	CMP	Inferred	Yes	None			Steep embankment from Bear River limits fish presence.
11	627254	6236608	Kalliseks	MP	Inferred	Yes	None			Barrier falls 37 m upstream, 11 m outlet trough
12	626497	6238117	Unnamed	MP	CO, RB	Partial	None			Drains wetland. Steep embankment to Bear River.
13	625640	6239128	Sustut River	Bridge	CO, SK, CH, MW, RB, BT	No				
14	624315	6240860	Unnamed	CMP	CO, RB	No				Grade goes through wetland.
15	623287	6241542	Unnamed	CMP	Inferred	No				900 CMP dry
16	622998	6241871	Unnamed	MP	None	Yes	None			High Velocity. Slope up from the Sustut is 15%. Outfall drop mitigation is not worth the small amount of habitat gained.
17	622421	6241889	Unnamed	CMP	None	Yes	None			Culvert is 25 m up from Sustut R. Outfall drop mitigation is not worth the small amount of habitat gained.
18	621022	6243336	February Creek	Bridge	ST, DV	No				Impassable falls at 1.5 km.

SITE I.D.	EAST	NORTH	STREAM NAME	CROSSING TYPE	FISH PRESENCE	BARRIER	RESTORE PRIORITY	DEACT REQ'D	MAINT REQ'D	COMMENT
19	618018	6243896	Birdflat Creek	Bridge	CH, CO, ST, DV, RB	No				Impassable falls at 650 m with suitable rearing habitat below.
19A	616607	6243474	Unnamed	CMP	None	Yes	None			Difficult combination to mitigate in lower 30 m due to a steep embankment off river and 1.1 m outfall drop. Excellent potential for steelhead and coho spawning and rearing upstream for 1.8 km.
20	615943	6243895	Unnamed	CMP	None	Yes	Low			20 m off Sustut River with 1.5 m falls. May potentially provide passage at high water stage.
21	612871	6244107	Unnamed (Trib 7 Suskeena)	CMP	DV	Yes	High			Impassable to all species. 1.7 m outlet drop into Sustut R. Potentially excellent coho and steelhead stream with 2.5 km of moderate-high value spawning and rearing habitat.
22	610865	6244305	Chelsea Creek	MP	CO, DV	Yes	None			Impassable to all species. Steep embankment off the Sustut with low-moderate habitat values.
23	609195	6244134	Unnamed Creek	CMP	DV	No				Good habitat and culverts
24	609055	6244182	Islam Creek	MP	DV, BT	Yes	Low			3 culverts with outfall drops 0.6-0.8 m. This high-energy stream with predominantly cobble substrate has low-medium value habitat.
25	608237	6244452	Boyd Creek	CMP	CO, DV	Yes	High			5% culvert slope and 1.5 m outfall drop establish an impassable barrier. Coho spawning below indicates the 800 m of high value upstream of the rail grade is potential spawning and rearing habitat.
26	607153	6244796	Teressa Creek	CMP	CO, DV	No				Important coho producer, culvert good.
27	606614	6244914	Minaret Creek	MP	DV	No				High energy, moves large debris and bedload, culvert works. Stream banks up and downstream of the culvert are unstable.
28	603276	6245728	Unnamed	CMP	CO, CH, ST, RB, DV	No				Culvert good, drains wetland. High value habitat is below impassable falls at 800 m.
29	601465	6246661	Unnamed	CMP	Unknown	No				Culvert and outlet are good
30	598463	6248345	Unnamed	MP	Inferred	Yes	Low			Culvert and stream are relatively steep gradient. Habitat upstream is low-medium

SITE I.D.	EAST	NORTH	STREAM NAME	CROSSING TYPE	FISH PRESENCE	BARRIER	RESTORE PRIORITY	DEACT REQ'D	MAINT REQ'D	COMMENT
										gradient. Habitat upstream is low-medium value.
31	598244	6248653	Unnamed	MP	Inferred	Yes	Low			Culvert has outlet trough with 61 cm drop with low value habitat upstream.
32	597179	6249758	Unnamed	MP	Inferred	Partial	None			Culvert has 24 cm outfall drop into good pool. Steep embankment off the Skeena River.
33	596927	6249910	Unnamed	MP	CO, RB Inferred	Partial	None			Culvert good, nice habitat up and downstream, 8 cm outfall drop into deep pool. Creek is moderately steep off the Skeena River.
34	596045	6250420	Mohammed Creek	CMP	CO, RB Inferred	No				Culverts 3/4 filled, great habitat
35	594755	6252163	Unnamed	MP	CO Inferred	Partial	None			3000 mm culvert works, but 17 cm outfall drop. Steep embankment off the Skeena R.
36	594029	6252863	Picea Creek	MP	CO, (ST), BT	No				Culvert works, good outlet pool
37	592940	6253959	Unnamed	CMP	(CO, RB)	Yes	None			Deep fill (27m) culvert with 24 cm outfall drop. Low value habitat upstream.
38	591588	6257255	Unnamed	CMP	Unknown	No				1200 mm culvert works.
39	591265	6258132	Unnamed	MP	(CO, RB)	No				2400 mm good culvert with nice outlet pool.
40	588807	6264633	Mosque River	Bridge	ST, DV, BT, RB, (CO)	No				
41	585589	6269751	Fort Creek	Bridge	(CO, ST, BT, DV)	No				
42	582937	6274246	Unnamed	Bridge	(CO, ST, BT, DV)	No				
43	578127	6279614	Unnamed	CMP	Unknown	No				3 x 1200 mm culverts are good.
44	576998	6280869	Unnamed	CMP	Unknown	No				Culvert works
45	575769	6281944	Alma Creek	Bridge	(CO, ST, BT, DV)	No				
46	574583	6282532	Unnamed	CMP	Unknown	Partial	None		Yes	Culvert with nice 5 x 7 m outlet pool, 19 cm outfall drop with good habitat upstream. Gradient overly steep from Skeena River. Inlet needs cleaning.
47	573357	6284322	Chipmunk Creek	Bridge	CO, ST, BT, DV, CH, MW	No				

SITE I.D.	EAST	NORTH	STREAM NAME	CROSSING TYPE	FISH PRESENCE	BARRIER	RESTORE PRIORITY	DEACT REQ'D	MAINT REQ'D	COMMENT
			Creek		DV, CH, MW					
48	567473	6288572	Unnamed	CMP	Unknown	No				Culvert works
49	567068	6289219	Unnamed	CMP	Unknown	No				Good culvert and outlet
50	565418	6290875	Unnamed	MP	Unknown	Partial	None			Moderately steep creek off the Skeena River and culvert with high velocity. Habitat upstream does not warrant mitigating this fish passage problem.
51	564723	6291244	Duti River	Bridge	CO, DV, RB, ST	No				
52	552035	6298991	Kluatantan River	Bridge	CH, CO, SK, ST, BT, DV, MW	No				
53	550280	6299740	Skeena River		CH, CO, ST, DV, BT, MW, RB	N/A				Tote road into the Skeena River for 330 m
54	547525	6300678	Unnamed		Unknown	No	Deact	Yes		Culvert washed out
55	546917	6300915	Duke Creek		Unknown	No	Deact	Yes		Culvert washed out
56	546342	6302459	Telfer Creek		Unknown	No	Deact	Yes		Culvert washed out
57	546245	6302715	Telfer Creek-North Fork		Unknown	No		Deact		Culvert washed out
58	544669	6304482	Unnamed		Unknown	No	Deact	Yes		Culvert washed out (3 pole bridge)
59	543826	6306251	Langlois Creek		Unknown	No	Deact	Yes		Culvert washed out, impassable falls DS
60	542861	6307162	Unnamed		Unknown	No	Deact	Yes		Culvert washed out
61	542710	6307577	Unnamed		Unknown	No	Deact	Yes		Culvert washed out
62	542284	6308303	Unnamed		Unknown	No	Deact	Yes		Culvert washed out
63	541741	6309116	Unnamed		Unknown	No	Deact	Yes		Culvert washed out
64	541307	6309789	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert good
65	541014	6310091	Unnamed		Unknown	No	Deact	Yes		Culvert washed out
66	540210	6310780	Nannygoat Creek		Unknown	No	Deact	Yes		Culvert washed out
67	539570	6311110	Unnamed	CMP	Unknown	No	Deact	Yes		1000 culvert works
68	539291	6311354	Unnamed	CMP	Unknown	No	Deact	Yes		900 culvert works
69	539173	6311409	Unnamed		Unknown	No	Deact	Yes		Culvert washed out
70	538999	6311552	Unnamed	CMP	Unknown	No	Deact	Yes		900 culvert works

SITE I.D.	EAST	NORTH	STREAM NAME	CROSSING TYPE	FISH PRESENCE	BARRIER	RESTORE PRIORITY	DEACT REQ'D	MAINT REQ'D	COMMENT
71	538416	6311982	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culvert with 62 cm outfall drop, habitat upstream is moderately steep
72	537720	6312665	Unnamed		Unknown	No	Deact	Yes		Culvert washed out
73	537374	6312956	Unnamed	CMP	Unknown	No	Deact	Yes		Stream is eroding upstream side of road
74	536722	6313244	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culvert with 76 cm outfall drop, NFP
75	536635	6313361	Unnamed		Unknown	No	Deact	Yes		Culvert not visible, drainage across road, NFP
76	536392	6313494	Unnamed		Unknown	No	Deact	Yes		Culvert washed out
77	535938	6313935	Unnamed		Unknown	No	Deact	Yes		Culvert washed out, N & S drainage ditches discharge
78	535470	6314456	Unnamed		Unknown	No	Deact	Yes		Culvert washed out, N & S drainage ditches discharge
79	535144	6314809	Unnamed	CMP	Unknown	No	Deact	Yes		Drainage culvert
80	534974	6315044	Unnamed	CMP	Unknown	No	Deact	Yes		600, works, drainage
81	534743	6315181	Unnamed	CMP	Unknown	No	Deact	Yes		800, 27 cm outfall drop, drainage
82	534534	6315368	Unnamed		Unknown	No	Deact	Yes		Culvert washed out, drainage
83	534216	6315698	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culvert with 1.14 m outfall drop
84	533622	6316022	Unnamed	CMP	Unknown	Yes	Deact	Yes		900 with trough & outfall drop. Tote road ends & grade starts
85	533786	6315875	Unnamed		Unknown	No	Deact	Yes		Ditch drainage
86	533280	6316673	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culvert outlet eroded, 3 pipes segments in creek DS. 4
87	533154	6316895	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culvert works, trough, 86 cm outfall drop
88	533128	6317070	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culvert works, trough, 72 cm outfall drop
89	533003	6317322	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culvert works, trough, 31 cm outfall drop
90	532838	6317588	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert works, drainage
91	532743	6317860	Unnamed		Unknown	No	Deact	Yes		Culvert washed out
92	532108	6319719	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culvert inlet plugged
93	531989	6319979	Unnamed		Unknown	No	Deact	Yes		Culvert washed out
94	531410	6321005	Unnamed	CMP	Unknown	No	Deact	Yes		Culverts x 2 work
95	531067	6321619	Unnamed	CMP	Unknown	No	Deact	Yes		Culverts x 2 work, ditch drainage
96	530669	6322318	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culverts x 2, ditch and stream drainage, both with outfall drops
97	531230	6323553	Unnamed		Unknown	No	Deact	Yes		Slide to rail grade
98	530118	6322985	Unnamed	CMP	Unknown	No	Deact	Yes		Culverts x 2, work

SITE I.D.	EAST	NORTH	STREAM NAME	CROSSING TYPE	FISH PRESENCE	BARRIER	RESTORE PRIORITY	DEACT REQ'D	MAINT REQ'D	COMMENT
99	529480	6322855	Unnamed	CMP	Unknown	No	Deact	Yes		Culverts x 2, work
100	528187	6323221	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert with trough works, ditchline drainage
101	528298	6323240	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert with trough works, ditchline drainage
102	527835	6323311	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert with trough works, ditchline drainage
103	527736	6323326	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert with trough works, ditchline drainage
104	527432	6323446	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culverts x 2 with troughs & small outfall drops
105	527301	6323502	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert works
106	527152	6323553	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culvert, trough, 23 cm outfall drop
107	526477	6323925	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culvert, trough, 18 cm outfall drop
108	526025	6324304	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culvert with mod-high outlet erosion
109	526102	6325027	Unnamed		Unknown	Yes	Deact	Yes		No drainage structures along tote road through meadows
110	525757	6324706	Unnamed		Unknown	Yes	Deact	Yes		Creek flows down road to 111
111	524769	6325344	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culvert and trough, increased drainage has eroded DS right bank
112	524654	6325944	Unnamed	CMP	Unknown	No	Deact	Yes		Culverts x 2 work
113	524361	6326355	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert works, drainage
114	524085	6326972	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert works, drainage
115	524026	6327054	Unnamed	CMP	Unknown	No	Deact	Yes		Culverts x 2 work, drainage
116	523747	6327383	Unnamed		Unknown	No	Deact	Yes	Yes	Barrel and pipe coupler to be removed
117	523578	6327656	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert works
118	523363	6328322	Unnamed		Unknown	No	Deact	Yes		Drainage down the road
119	523225	6328434	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert works
120	523037	6328649	Unnamed		Unknown	No	Deact	Yes		Culvert washed out
121	522869	6328817	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert works
122	522733	6328940	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert works
123	522625	6329099	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert works, ditchline drainage
124	522469	6329413	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert works
125	522251	6329795	Unnamed		Unknown	No	Deact	Yes		Culverts on grade and tote road washed out. Photo 1 is the grade; photo 2 is the tote

SITE I.D.	EAST	NORTH	STREAM NAME	CROSSING TYPE	FISH PRESENCE	BARRIER	RESTORE PRIORITY	DEACT REQ'D	MAINT REQ'D	COMMENT
										road.
126	522069	6329985	Unnamed	CMP	Unknown	Yes	Deact	Yes		Culvert and trough
127	521886	6330143	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert on tote road
128	521312	6330424	Unnamed	CMP	Unknown	No	Deact	Yes		Culvert works
129	521386	6330249	Garner Creek	MP	Unknown	Partial	Mod-High			3500 culvert works, erosion at inlet, 73 cm outfall drop onto boulders. Build up outlet pool height with locally available rocks and logs.
130	520789	6330732	Unnamed	CMP	Unknown	No				Culvert works
131	520116	6331374	Unnamed	CMP	Unknown	No				Culvert works
132	519983	6331422	Unnamed	CMP	Unknown	No				Culvert works
133	519384	6331743	Unnamed	CMP	Unknown	No				Culvert, outlet trough with a 23 cm outfall drop. NFP
134	518978	6331916	Unnamed	CMP	Unknown					
135	518759	6332003	Unnamed	CMP	Unknown	No				Culvert works
136	518519	6332215	Unnamed	CMP	Unknown	No				Culvert works, dry
137	518398	6332310	Unnamed	CMP	Unknown	No				Culvert works
138	517342	6332870	Unnamed	CMP	Unknown	No				Culvert works

Table 3. Upper Skeena Fish Passage Site Summary

Site I.D.: refers to the site number in the text, in the table, and on the maps.
East: refers to the NAD 83, UTM east coordinate
North: refers to the NAD 83 UTM north coordinate
Stream Name: refers to the gazetted or locally known name
Crossing Type: refers to the type of culvert. CMP=corrugated metal pipe. MP=multi-plate pipe.
Fish Presence: refers to confirmed, inferred, or unknown presence.
Barrier: refers to velocity, outfall drop, and culvert length barriers.
Restore Priority: refers to restoration priority weighing feasibility, habitat value, fish species, and habitat gained factors.
Deact Req'd: refers to deactivation required to mitigate the hazard of significant erosion or landslides.
Maint Req'd: refers to maintenance required in the short-term or scheduled.

HIGH PRIORITY FISH PASSAGE SITES

UPPER SKEENA FISH PASSAGE — HIGH PRIORITY RESTORATION SITES

Site No.	Stream Name	Comment	Fish Species	Fish Passage Issue	Restoration Site Priority
1	Azuklotz Creek	Large volumes of sediment deposition since 1969 and will continue to aggrade in the bridge area for several more decades.	CO, ST, SK, DV, BT, RB	Stream channel has aggraded within 10 cm of main span.	High. Recommend raising the bridge structure or lowering the river bed by excavating.
3	Unnamed Creek	1.4 k m of high value habitat upstream. Fish presence unknown, but suspect CO, ST, DV, RB, BT.	Unknown (CO, ST, DV, RB, BT)	Culvert outlet has 56 cm outfall drop with a 48 cm deep pool.	High. Recommend building up outlet pool height with locally available material.
21	Unnamed Creek	Culvert has blocked fish access since the early 1970s. 2.9 km of potential high value spawning and 3.7 km of rearing habitat. Potentially excellent coho and steelhead stream.	DV	Two culverts with 1.7 m outfall drops. Impassable barrier at all flows constrain adult spawner movement upstream.	High. Recommend replacing culvert with a bridge or open bottom structure to allow adult and juvenile fish access.
25	Boyd Creek	Culvert installed in early 1970s is problematic for upstream fish access. Coho spawn below culvert. There is 800 m of valuable habitat upstream of the culvert.	CO, DV	900 mm culvert has 1.2 m outfall drop into a shallow (0.40 m) outlet pool, as well as a velocity barrier for juvenile salmonids.	High. Recommend replacing culvert with bridge or open bottom structure easing upstream fish passage to approx 3.8 km of high value habitat.

Table 4. Upper Skeena High Priority Fish Passage Sites

Four culverts are rated high priority for restoration: Azuklotz Creek, Site 3-Unnamed Creek, Site 21-Unnamed Creek, and Boyd Creek. Site 21 and Boyd Creek offer the highest potential benefit from re-opening excellent quality steelhead and coho habitat. Azuklotz Creek is a long-standing problem requiring either an enforceable monitoring and maintenance order or the bridge structure should be raised. Site 3 presents a low-cost fish passage mitigation opportunity relative to habitat gained.

HIGH PRIORITY FISH PASSAGE SITES

Site 1 Azuklotz Creek

Azuklotz Creek is located east of Bear Lake and drains a portion of the Hogem and Connelly Ranges. Azuklotz Creek is a moderate sized third-order watershed flowing into Pond Lake, prior to entering Azuklotz Lake and Bear Lake. The drainage is 66 km^2 with approximately 20 km of lake and mainstem reaches. The Azuklotz Creek Bridge was constructed in 1972 on the lower third of the alluvial fan. M. Miles and Associates (2003) report that lateral channel instability in upstream reaches produces valley wall erosion with these sediments transported downstream. The reduction of channel gradient has deposited enormous amounts of sediment and formed an extensive fan on Azuklotz Creek upstream of Pond Lake. The sediment has been deposited in the vicinity of the bridge crossing since 1969 and deposition will likely continue for several more decades.

The fish passage issue is created by significant sediment deposition in-filling the channel beneath the bridge structure. The large volumes of sediment deposited upstream, at, and downstream of the bridge build up to the point where there is zero clearance between the channel bed and the bridge span. The present channel width is approximately 110 m and tends to seasonally dewater and flow subsurface in segments of the channel. Potential channel instability is also a factor if Azuklotz Creek flows into and down one of the right bank distributary channels and washes out the rail grade to the northwest.

Fish presence in Azuklotz Creek includes coho, sockeye, chinook, rainbow trout, bull trout, with steelhead suspected. Fisheries values are rated high due to the spawning and rearing of the above species. The upper limit for anadromous and adfluvial fish migration is a waterfall barrier located approximately 3 km upstream of the bridge. The above species present complex and overlapping life histories and limit in-stream work opportunities from July 15 to September 1.

Figure 39. View across Azuklotz Creek fan.

Figure 40. Azuklotz Creek and the rail bridge.

Figure 41. View across downstream side of Azuklotz Creek Bridge showing 10 cm clearance between the bridge span and the stream surface, July 2007.

Azuklotz Creek Bridge was constructed in 1972 and the maintenance history until the early 1990s is unknown. The rail line was reactivated in 1991 to enable log hauling from Minaret. In 1992, the southern bridge approach was rebuilt and the creek was channelized upstream of the bridge. The sediment was excavated from the creek four to six times from 1992 to 1999. In 1999, a major excavation removed the bed material for several hundred meters upstream and downstream of the bridge. In 2003, the channel under the bridge was excavated to provide a 1.6 m depth (Triton 2004).

Azuklotz Creek Bridge crossing, sediment deposition and channel instability are rated High Priority in order to mitigate current conditions threatening fish passage and the integrity of the stream crossing. Options to improve current conditions include:

1. Raise the bridge structure and rail bed;
2. Excavate and lower the channel to centralize and convey higher velocity flows — this option would likely require on-going sediment removal;
3. A combination of options 1 and 2, which may be the most feasible and economically sensible given the long-term nature of the deposition;
4. Remove the bridge and deactivate the crossing.

Figure 42. View downstream to bridge structure.

Site 3 Unnamed Creek

Site 3 Unnamed Creek is a small second-order watershed draining into Tsaytut Bay, Bear Lake. The drainage area is 3.7 km2 with approximately 2.2 km of low-gradient mainstem and tributary channels before natural barriers limit upstream fish movement. A wetland 440 m in length is the primary feature of the drainage. The two 1100 mm multiplate culverts, 35 m in length, were installed in 1971 and have caused difficult fish passage since then.

Fish presence is unknown; however, coho, rainbow trout, and steelhead are suspected to be present. Habitat values are rated as high due to the channel substrate and structure, gradient, cover, wetland complex, and proximity to Bear Lake.

The fish passage issue is the 56 cm outfall drop from the main culvert into a relatively shallow outlet pool, 48 cm in depth. This culvert outlet combination impedes adult fish migration at most flows. There is no apparent beaver activity; however, there are signs indicating fairly recent machine activity.

Site 3 is rated high priority to rehabilitate due to its feasibility, simplicity, habitat value gained, and suspected use by coho, steelhead, and rainbow trout. Building up the heights on both outlet pools with locally available material such as rock, logs, and sediment will ease fish passage and provide a restoration option with future low maintenance requirements.

Figure 43. Site 3, view upstream of wetland complex.

Figure 43. Site 3, view upstream at culvert outlet.

Figure 44. Site 3, view downstream from culvert outlet.

Figure 45. Site 3, view upstream at culvert outlet.

Site 21 Unnamed Creek

Site 21, Unnamed Creek is a small second-order watershed draining into Sustut River (right bank) approximately 6 km downstream of Birdflat Creek. The drainage area is 8.3 km^2 with approximately 3.7 km of low-gradient mainstem and tributary channels before natural barriers limit fish presence. The lower portion of the watershed is gently rolling with low-gradient stream channels. The lower reaches of the two main tributaries are interspersed with occasional wetland complexes offering excellent rearing conditions.

Fish presence is limited to a resident Dolly Varden population. Bustard's (1993a) ground survey results indicate this stream has excellent potential for coho and steelhead with extensive sections of good habitat upstream of the rail grade crossing obstruction.

The fish passage issue is two 1100 mm multiplate culverts, 18 m in length, which were installed in the early 1970s and have blocked fish passage since then. The two culverts have 1.7 m outfall drops that establish impassable barriers at all flows and block adult spawner movement upstream.

Site 21 is rated high priority to restore fish passage due to its easy accessibility, feasibility, high-value habitat gained, and potential use by coho, steelhead, and other species. Replacing the culvert with a bridge or open-bottom structure will permit passage for juveniles and adults.

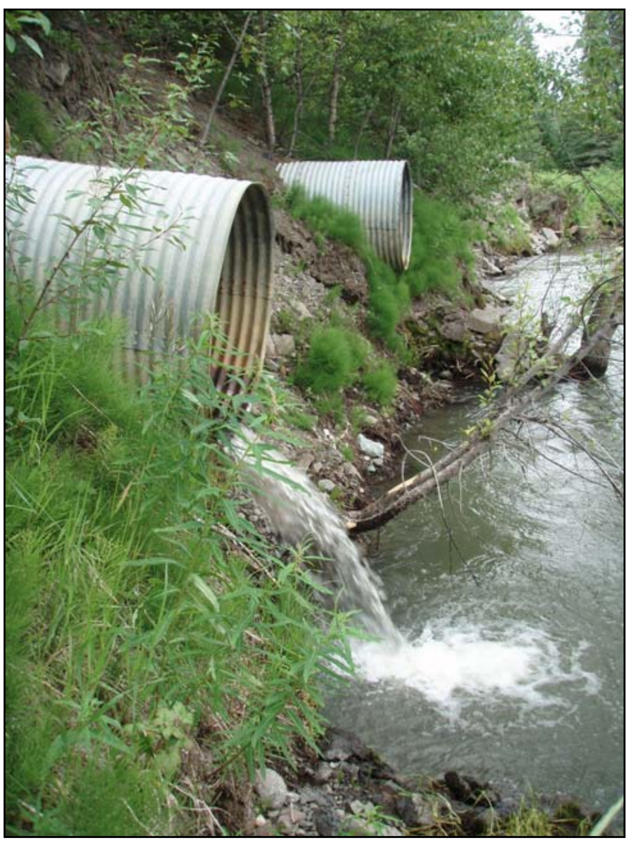

Figure 46. View of Site 21 culvert outlets and Sustut River.

Figure 47. Site 21, view downstream from culvert outlet.

Figure 48. Site 21, view upstream from inlet.

Figure 49. Site 21, view downstream at inlet.

Site 25 Boyd Creek

Site 25, Boyd Creek, is a small third-order watershed draining into Sustut River (right bank) approximately 7 km upstream of the Skeena River confluence. The drainage area is 10.7 km^2 with approximately 2.7 km of low-gradient mainstem and tributary channels, ponds and wetlands before natural barriers limit fish presence. The general topography in the lower portion of the watershed is flat to gently rolling with numerous wetlands. Upstream of the rail grade, two main tributaries are low-gradient and stable for 3.8 km in length. Fish presence is characterized by coho spawning and rearing and Dolly Varden use downstream of the rail grade.

The fish passage issue is a 900 mm culvert, 21 m in length, which was installed on the B.C. Rail in the early 1970s and has blocked fish passage since then. The culvert has a 1.2 m outfall drop and a 5% gradient that establishes an impassable barrier at all flows and blocks adult spawner and juvenile movement upstream.

Site 25 is rated high priority to restore fish passage due to its easy accessibility and feasibility, along with the 3.8 km of high-value habitat gained, as well as the potential use by coho and other species. Replacing the culvert with a bridge or open-bottom structure will permit passage for juveniles and adults.

Figure 50. Site 25, Boyd Creek. View upstream to culvert outlet.

Figure 51. Site 25, Boyd Creek. View downstream from culvert outlet.

Figure 52. Boyd Creek, view to culvert inlet.

Figure 53. View upstream from culvert inlet.

MEDIUM PRIORITY FISH PASSAGE REHABILITATION SITES

Two sites, Triple Creek and Garner Creek, are rated and prioritized as moderate for fish passage restoration; as well, 73 sites are rated moderate for deactivation. The ratings reflect culvert outlet configurations, fish presence and distribution, and habitat qualities and quantities.

Site 8 Triple Creek

Triple Creek is a small third-order watershed draining into Sapolio Lake approximately 1 km downstream of Bear Lake. The drainage area is 31 km^2 and has about 1 km^2 of water storage in the Triple Lakes. The rail grade is located approximately 300 m upstream from the mouth. The stream is high-energy and frequently transports debris and bed load material. The channel is moderately steep and confined upstream of the rail grade for approximately 600 m, then steepens for 1100 m before the 3 m barrier falls that limits upstream fish passage. In 1993, Bustard (1993a) reported fish presence characterized by steelhead spawning and rearing upstream of the rail grade. Bustard considered the culverts passable at high spring flows for steelhead, which subsequently spawn in isolated gravel pockets in the mainstem. It is suspected that bull trout utilize Triple Creek.

The fish passage issue is three culverts (1000, 1100, and 1200 mm), 26 m in length, which were installed on the B.C. Rail in the early 1970s. Currently, the three culverts have outfall drops of 34, 94, and 76 cm respectively, and a 2.5% gradient that establishes an impassable barrier at all flows and blocks adult spawner and juvenile movement upstream.

Triple Creek is rated moderate priority to restore fish passage due to the pattern of the culvert inlets and outlets, the outfall drops, the velocity barriers, and its use by steelhead. Replacing the culverts with a bridge or an open-bottom structure will permit easy passage for juveniles and adults.

Figure 54. View downstream from culvert outlet.

Figure 55. View upstream to culvert outlets.

Figure 56. View upstream of partially blocked south culvert inlet.

Site 129 Garner Creek

Garner Creek is a small third-order watershed draining into the upper Skeena River (left bank) approximately 5.8 km downstream of the Spatsizi divide. The drainage area is 37.4 km^2 with approximately 1.3 km of low-gradient mainstem. The rail grade is located approximately 1.3 km upstream from the mouth. The stream is high-energy and frequently transports debris and bed load material. The channel is moderately steep with no barrier falls limiting upstream fish passage. A good assortment of spawning gravels and conditions exist upstream of the crossing. Fish presence is characterized by chinook, Dolly Varden, and mountain whitefish. It is unknown if adult chinook can migrate past the B.C. Rail crossing, though they have been observed downstream of the outlet.

The fish passage problem is a single 3500 mm culvert, 35 m in length, with a 5% gradient installed at the B.C. Rail crossing in the early or mid-1970s. The culvert has a 73 cm outfall drop onto boulders, which establishes an impassable barrier at most flows and is believed to block adult spawner and juvenile movement upstream.

Garner Creek is rated moderate priority to restore fish passage due to the arrangement of the culvert outlet and outfall drop, the velocity barrier, and its use by salmonids. Replacing the culvert with a bridge or an open-bottom structure will permit easy passage for juveniles and adults. A further mitigating option would be to establish a two-step pool configuration utilizing locally available logs and rock. The upstream bank of the crossing is currently eroding and needs fill and armoring to maintain its structure; these materials are available adjacent to the site.

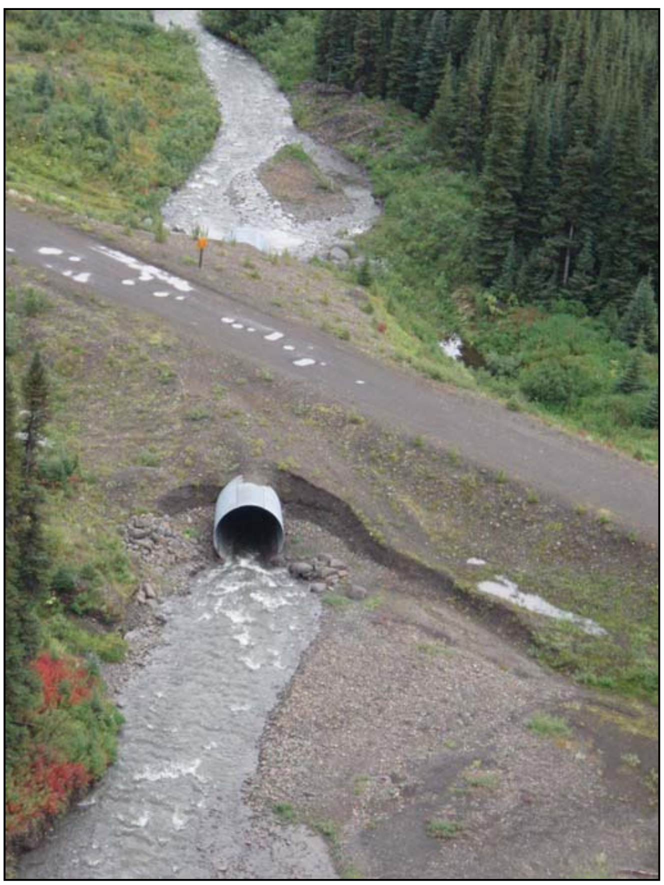

Figure 57. View downstream of Garner Creek crossing.

Figure 58. View downstream of the Garner Creek culvert inlet.
Note the erosion of the grade fill.

Figure 59. View downstream from the Garner Creek culvert outlet.

Figure 60. View upstream to culvert outlet.

MEDIUM PRIORITY FISH PASSAGE DEACTIVATION SITES

The 73 stream crossings prioritized for deactivation are located upstream of Kluatantan River and extend to Garner Creek. These crossings are for the most part located on the uncompleted segment of the B.C. Rail grade. Shortfalls in construction practices, along with the failure to deactivate drainage structures when the rail grade was abandoned in 1977, and the lack of maintenance activities to ensure the stability of the rail grade since then, have caused large-scale frequently chronic sediment erosion and sediment transport downstream.

Currently, of the 73 culverts at stream crossings, 37% or 27 are washed-out or plugged from in-filling. This recommendation to deactivate the 73 stream crossings over approximately 40 km of the rail grade upstream of Kluatantan River is based on the need to restore and/or maintain natural stream conditions, provide for fish passage, minimize sedimentation, and conserve riparian vegetation.

A management framework focused on water and sediment is needed to control erosion. The recommended approach is to remove the remaining culvert structures and re-establish the stream channels. The goal is to limit risks to, and restore fish habitats, improve and maintain water quality, and limit future risk and liability issues.

The conceptual objectives include:

1. Removing culverts with the least amount of disturbance to the stream and surrounding environment;
2. Re-establishing the stream channel as close to the natural gradient as possible;
3. Establishing stable stream banks following culvert removal;
4. Seeding to limit sediment mobilization and transport.

Developing deactivation prescriptions for the 73 stream crossings is beyond the scope of this project. Nonetheless, the next step forward is to conduct a detailed deactivation study that includes the following key objectives:

1. Complete a field assessment of road stability, hillslope hydrology, and geomorphology;
2. Assess the hazard, consequence, and risk;
3. Formulate deactivation prescriptions;
4. Document on the ground and in a text, table and map report what work must be conducted.

Photographs follow showing current conditions at various sites prioritized for deactivation.

Figure 61. Site 56, Telfer Creek and washed out culvert.

Figure 62. Site 59, view east across Langlois Creek and washed out culvert.

Figure 63. Site 59, view west across Langlois Creek and washed out culvert.

Figure 64. Site 59, view downstream of crossing on Langlois Creek showing section of washed out culvert.

Figure 65. View shows Site 62 Unnamed Creek and washed out crossing.

Figure 66. Site 66, view north on Nannygoat Creek and washed out culvert.

Figure 67. Site 69, view shows washed out culvert.

Figure 68. Site 76, view west on Unnamed Creek and washed out culvert.

Figure 69. Site 86, Unnamed Creek. View shows washed out culvert outlet.

Figure 70. Site 91, view shows washed out culverts.

Figure 71. Site 120, washed out culvert on Unnamed Creek.

Discussion

The task of restoring fish passage and upstream habitat at stream crossings involves establishing priorities based on measurable benefits. With limited resources, a focused approach providing the greatest short and long-term benefits to our fish and fish habitat resources is required. This report presents fish passage issues on the B.C. Rail grade in the upper Skeena Watershed that need to be addressed with restoration, deactivation, or maintenance action. Our findings indicate the need for restoration or rehabilitation on 79 stream crossings. Of these culvert crossings, four are rated as high priority for restoration, two are rated as moderate for restoration, and 73 are rated moderate for deactivation.

The four culverts rated high priority for restoration are: Azuklotz Creek, Site 3-Unnamed Creek, Site 21-Unnamed Creek, and Boyd Creek. Site 21 and Boyd Creek offer the highest potential benefit from re-opening excellent quality steelhead and coho habitat. Azuklotz Creek is a long-standing problem requiring either an enforceable monitoring and maintenance order or the bridge structure should be raised. Site 3 presents a low-cost fish passage mitigation opportunity relative to habitat gained. The amount of potential habitat gained and probable coho and steelhead production are thought to be significant.

Only two partial barriers are rated for rehabilitation, Azuklotz Creek and Garner Creek. Deactivation is recommended for 73 stream crossings, all of which are located from Garner Creek downstream to Kluatantan River.

Support for moving forward with restoration efforts is currently slow due to B.C. Rail and the B.C. Government debating which party is liable for the rail grade. The next steps include a meeting of partners and stakeholders to discuss and consider survey results and conceptual restoration plans, then development of a consensus work plan that outlines information gaps and assumptions in regard to:

- Restoration cost, liabilities, funding sources, and risks to investment if any,
- Fish species life histories and limiting habitat factors,
- Engineering assumptions and alternatives,
- Further site assessments needed.

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Appendix 1 Photographs and Data Tables

Photographs and Data Tables submitted under separate cover.

Appendix 2 Financial Statement of Expenditures

Financial Statement submitted under separate cover.

Appendix 3 Maps

Four 1:50,000 maps in pockets.