LAKELSE SOCKEYE SPAWNING HABITAT REHABILITATION FEASIBILITY PROJECT 2007—08

REVIEW DRAFT

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SUMMARY

After more than a century of adverse impacts from settlement and resource development activities in the Lakelse Lake Basin, there is clear recognition of the need to restore stream processes and habitat. In recent years, sockeye recruitment in the Lakelse system has fallen dramatically and currently fluctuates at low levels of abundance relative to historic levels. Limited sockeye recruitment is mostly due to human-caused disturbance of key watershed processes. Adequate high quality spawning habitat is an important key to conserving and rebuilding sockeye populations in the Lakelse system.

The purpose of this report is to present background information and preliminary project results identifying sockeye habitat rehabilitation that will improve sockeye fry production and recruitment into Lakelse Lake. The project goal is to increase understanding of the direction and approach to restoring juvenile sockeye recruitment in the Lakelse Basin.

Two important concepts, watershed-scale and reach-scale processes, need to be understood if Lakelse stream and aquatic restoration activities are to be considered successful. Reach-scale processes that supported sockeye have been broken to various degrees and need to be fixed. There needs to be private land protocols and resources dedicated to rehabilitating these extremely dynamic and complex processes.

In Lakelse Lake basin, protection and conservation of ecosystem processes and fish habitat are a significantly higher priority than habitat rehabilitation. This is because protecting habitat costs substantially less than rehabilitating it. Habitat protection also has predictable results.

The biological goals, objectives, and approaches for recovery of Lakelse Lake sockeye are realistic and feasible. As Lakelse Lake is fry-recruitment limited and is producing sockeye well below capacity, the most immediate biological need is to reverse this trend by improving natural production.

The Lakelse Sockeye Recovery Plan has successfully completed a large number of high priority rehabilitation projects in the Williams, Sockeye, Scully, Granite, Hatchery, and Salmon drainages. It is uplifting to consider the problems that have been addressed to date, as well as the increased understanding gained of Lakelse sockeye and their habitats. Further investment is scheduled for rehabilitating spawning habitat and generally includes planning, implementing pilot projects, moving forward on larger projects if the pilot results are promising, and monitoring and evaluating results. Various programs are ongoing, such as beaver management, annual spawner enumeration, annual fry density monitoring, and annual egg incubation and survival assessments.

Over the course of this project, recommendations were developed focused on rehabilitating sockeye spawning habitat and improving sockeye fry recruitment. These have were based on: reviews of historical and current data; observations by enumeration crews, field workers, and biologists; as well as the recommendations that came out of the 2007 Lakelse Recovery Workshop. The recommendations are presented by sub-basins and will need to be discussed and prioritized by the recovery team.

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ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

1.1 PROJECT PURPOSE

After more than a century of adverse impacts from a multitude of settlement and economic activities in the Lakelse Lake Basin, there is clear recognition of the need to restore stream processes and habitat. In recent years, sockeye recruitment in the Lakelse system has fallen dramatically and currently fluctuates at low levels of abundance relative to historic levels. Limited sockeye recruitment is mostly due to human-caused disturbance of key watershed processes. Decline of salmon abundance is the most conspicuous sign of the watershed-wide decline of ecosystem integrity. The restoration of Lakelse sockeye populations and critical habitats is highly compelling, given that Lakelse was considered the most productive salmon ecosystem in the Skeena watershed.

The purpose of this report is to present background information and preliminary project results identifying and prioritizing sockeye habitat rehabilitation that will improve sockeye fry production and recruitment into Lakelse Lake. The project goal is to improve understanding of the direction and approach to restoring juvenile sockeye recruitment in the Lakelse Basin. The major objectives of this project are:

1. to improve the understanding of quantitative and qualitative attributes of past and current sockeye spawning;
2. to determine the locations and extents of key sockeye spawning areas in several Lakelse Lake tributaries;
3. to identify and prioritize distinct sites or reaches exhibiting the greatest potential circumstances for rebuilding spawning habitat;
4. to provide feasibility recommendations and conceptual plans that will assist in directing the rehabilitation of spawning habitat conditions and processes;
5. to understand the level of investment needed and the value and quality of resources to rehabilitate critical Lakelse sockeye spawning habitat;
6. to improve public and agency awareness of adverse impacts to wild salmon habitat and the externalized costs of restoration.

1.2 CONTEXT

Lakelse Lake sockeye are one of approximately 28 wild sockeye salmon stocks in the Skeena River drainage. Lakelse Lake is located in northwestern British Columbia, 20 km south of Terrace. The lake basin drains via the 18 km-long Lakelse River into the Skeena River southwest of Terrace.

What is know from a biological perspective about Lakelse Lake sockeye is relatively extensive compared to other lakes in the Skeena River watershed. Enhancement activities preceded formal assessments, with hatcheries operating on Coldwater Creek from 1901-1920 and at Granite Creek from 1920-1936. From the late 1940s through the mid 1960s, extensive research was conducted on basic sockeye life history, migrant survival, and production trends in the lake and in key spawning tributaries (Foerster 1968). As well, fish fences were operated on Lakelse River and Williams Creek from 1944-1965 to assess adult escapements and fry and smolt migrations. At Scully Creek, a hatchery and counting fence was operated from the mid-50s through 1965 to facilitate egg to smolt survival and to assess escapement.

Significant human activity in the Lakelse Lake watershed began in the 1950s. These activities included logging, highway construction, channel modifications and diversions, and lake side residential developments. The cumulative affects of human activity have affected fish, in particular sockeye, in the watershed (Skeena Fisheries Commission 2003).

Over the past 30 years, there have been numerous assessments of Lakelse Lake water quality and tributary habitats. These have included impact assessment studies of watershed hydrology, sediment transport and deposition, status of tributary channels, lake trophic status, sockeye productive capacity, and the factors limiting sockeye production. Increased sedimentation is also thought to provide favourable habitat conditions for the recent near-shore growth of the macrophyte *Elodea canadensis*. Human-caused disturbances of pivotal watershed processes have negatively affected, and continue to affect, productive sockeye spawning stream reaches. More recently, the focus has shifted to implementing a broad yet concise sockeye recovery strategy.

Exploitation rates for Lakelse sockeye have been low to modest; this is primarily due to the early run timing of this stock, which allows unimpeded access through the mixed-stock fisheries targeting enhanced Babine Lake sockeye. Fisheries exploitation is believed to be a minor factor affecting Lakelse sockeye aggregate escapement and subsequent production; however, this may require additional evaluation.

1.3 Spawning Habitat Rehabilitation Concepts

The major sockeye spawning stream reaches in Lakelse Watershed that once sustained healthy and robust sockeye salmon populations are now, for the most part, impacted by channelization, flood control diversions, or channel instability across their alluvial fans.

It is important to note that ecological restoration — restoring ecosystems and habitats which existed prior to Euro-Canadian settlement — is very difficult, and in the case of Lakelse sockeye, highly unlikely. Conceptually, stream habitat rehabilitation is a more accurate, definable, and achievable approach.

In western North America, spawning habitat rehabilitation has been a component of salmon stream restoration for approximately three decades. Many projects lack science-based designs and are based on local knowledge and/or an ad-hoc implementation (Wheaton *et al.* 2004). Two important concepts, watershed-scale and reach-scale processes, need to be understood if Lakelse stream and aquatic restoration activities are to be considered successful.

1.3.1 Watershed-scale Processes

Watershed-scale processes are characterized by physical and biological components. Physical and biological processes create stream channel and floodplain structure, in which habitat functions for fish occur (Saldi-Caromile *et al.* 2004). Physical or geomorphic processes include the interaction of water, sediment, and wood, which create channels, alluvial fans, and floodplains. To be more specific, stream-related geomorphic processes encompass hydrologic response, sediment transport, wood influences, erosion and deposition, fire, and channel evolution and migration. Changes in the quantity, quality, timing, and/or routing of water results in geomorphic process change in stream systems.

Ecological or biological processes, such as salmon returning to spawn, interact in complex pathways with geomorphic activities that include nutrient cycling, riparian and upland vegetation dynamics, soil building, and habitat-forming processes such as beaver impoundments (Saldi-Caromile *et al.* 2004). Sockeye salmon have co-evolved and adapted on a fine scale to exploit the habitats created by these ecosystem developments. Most processes that create fish habitat operate on time scales of decades or longer. Sustaining wild sockeye salmon populations in the Lakelse Basin means sustaining watershed-wide geomorphic and biological processes. A broad-scale quantitative watershed-level approach is essential for predicting a site or reach-specific restoration project's limitations, risks, and potential.

1.3.2 Reach-scale Processes

Channel reaches are typically many channel widths in length and exhibit similar geomorphic characteristics throughout, such as channel pattern, slope, confinement, or sediment size. Reach scale processes are characterized by physical and biological components that operate on the reach level. Common processes that determine the abundance, diversity, form, and quality of stream reach-scale habitats are water flow, supply and transport of sediment, organic matter inputs ranging from LWD to detritus and nutrients, and light and heat.

Reach assessments can identify, quantify, and evaluate the abundance and quality of habitat contained within (Saldi-Caromile *et al.* 2004). They can also describe the habitat forming processes, the existing habitat conditions, species present, and the relationships between species inhabiting the reach. Assessments can identify restoration or rehabilitation constraints and opportunities that exist in the reach. These assessments can then be used to develop a realistic rehabilitation plan that incorporates and sequences the constraints and opportunities. A remaining challenge is the uncertainty regarding the level and extent of rehabilitation needed at the reach level to effect change at the watershed level.

1.3.3 Spawning Habitat Rehabilitation Investment

Fish and fish habitat are the common property of the public and regulated through various federal and provincial jurisdictions. Historic and current legislation states that production, protection, and enhancement of fish are in the public interest, with regulation and policies to ensure a sustainable and productive salmonid resource. Society as a whole bears responsibility for the impacts to Lakelse sockeye spawning habitat. Results from previous watershed restoration assessments indicate that impacts have diminished ecological processes and resources and also future economic opportunity-based assets.

The cost of impacts to fish and fish habitat could be weighed against the economic development and growth, which includes forestry, roads, gas and hydro distribution lines, agricultural, residential, and flood control structures. The nature of the impacts is relatively large-scale and complex. Cause and effect relationships in stream environments are typically extremely complex and are often difficult to define with any certainty.

In Lakelse Lake basin, protection and conservation of ecosystem processes and fish habitat are a significantly higher priority than habitat rehabilitation. This is because protecting habitat costs substantially less than rehabilitating it. Habitat protection also has predictable results.

Figure 1. Aerial view of the Hotsprings area showing the modified Scully south, center, and north creek channels at Lakelse Lake and Highway 37S in the top right.

2.0 LAKELSE LAKE SOCKEYE RECOVERY PLAN

In the fall of 2003, the Lakelse Watershed Society, the Kitselas First Nation, the federal Department of Fisheries and Oceans, Terrace Salmonid Enhancement Society, and the provincial Ministry of Environment formed a steering committee to begin reviewing available information, evaluating options, and identifying activities for recovering Lakelse Lake sockeye. In 2004, the steering committee formally established the Lakelse Lake Sockeye Recovery Plan (LLSRP); at that time, B.C. Timber Sales joined as a stakeholder participant.

2.1 RECOVERY PLAN FEASIBILITY

The Lakelse Lake sockeye population is depressed, but recovery appears to be both biologically and technically feasible if certain threats to its viability can be addressed. The intent of recovery is to bring this population back to viable status by targeting the threats that have contributed to sockeye recruitment decline.

The available watershed and reach level assessment data for the Lakelse Lake basin indicate that channelized or degraded stream channels, which affect spawning habitat, are a major threat to maintaining or restoring sockeye recruitment into the lake. Therefore, recovery efforts that focus on diminishing spawning habitat have been prioritized. Other threats, such as *Elodea* infestation, juvenile predation, and juvenile competition for food may also have the potential to limit production over short time spans, and may require further evaluation. Fisheries exploitation, although believed low for Lakelse sockeye, may also require additional evaluation. The lists of threats potentially affecting recovery of Lakelse Lake sockeye are summarized by life stage as follows:

Life Stage: Egg to Alevin

- Random loss of genetic variation due to low spawning abundance in the Lakelse Lake spawning tributaries (known threat, high risk).
- Past, current, and continued human activity, development, and encroachment in and around the Lakelse Lake spawning tributaries (known threat, high risk).
- Animal activity (beavers) and habitat alteration in and around the Lakelse Lake spawning tributaries (presumed threat, moderate risk).

Life Stage: Fry/Parr

- In-lake predation (presumed threat, low risk).
- In-lake food competition (presumed threat, low risk).
- In-lake macrophyte infestation (potential threat, unknown risk).
- Altered lake water quality due to human activity, development, and encroachment in and around the Lakelse Lake (known threat, moderate risk).
- Altered lake productivity, including that resulting from climate change (potential threat, unknown risk).

Life Stage: Smolt

- In-river predation (presumed threat, low risk).
- Estuarine predation (presumed threat, low risk).
- Estuarine development (potential threat, unknown risk).

Life Stage: Marine Growth

- Altered ocean productivity, including that resulting from climate change (potential threat, unknown risk).
- Finfish aquaculture (potential threat, unknown risk).
- Predation (presumed threat, low risk).
- Fisheries mortality (known threat, moderate risk).

Life Stage: Spawner

- Reduced access to Lakelse Lake spawning tributaries due to tributary fan dynamics (known threat, moderate risk).
- Elevated water temperatures in Lakelse Lake spawning tributaries during low water years (presumed threat, moderate risk).
- Flood or slide events in Lakelse Lake spawning tributaries with loss of spawning habitat and subsequent tributary production (known threat, high risk).
- Bear predation (presumed threat, low risk).
- Disease (presumed threat, low risk).
- Beaver activity reducing access to spawning grounds (known threat, low-moderate risk).

2.2 GOALS AND OBJECTIVES

The biological goals, objectives, and approaches for recovery of Lakelse Lake sockeye are realistic and feasible. As Lakelse Lake is fry-recruitment limited and is producing sockeye well below capacity, the most immediate biological need is to reverse this trend by improving natural production. The goals of Lakelse Lake sockeye recovery are to:

1) Stop and reverse the decline of Lakelse Lake sockeye salmon.

2) Ensure that the natural bio-diversity and genetic integrity of this population is maintained.

To meet these goals the objectives of the recovery plan must consider the nature of the various threats affecting sockeye production in Lakelse Lake, as well as the watershed's current and future capacity to support increased salmon production. An additional consideration is the time frame for recovery, given that some threats can be addressed in the short-term and some may require further assessment. The short-term is defined as one sockeye life cycle or four years; the long-term is defined as three sockeye life cycles or twelve years.

As such, the short-term objectives of Lakelse Lake sockeye recovery are to:

1) reduce the biological risk to the Lakelse Lake sockeye population by improving fry-recruitment into Lakelse Lake as quickly as possible, while maintaining the diversity of production among spawning tributaries.

2) halt further loss of critical (major) sockeye spawning habitat in Lakelse Lake spawning tributaries.

3) identify and, where feasible, begin restoring lost critical (major) sockeye spawning habitat in Lakelse Lake spawning tributaries.

The long-term objectives of Lakelse Lake sockeye recovery are to:

1) examine and, where feasible, reduce potential threats to sockeye recruitment into Lakelse Lake caused by other factors (macrophyte loading, juvenile predation, food competition, fisheries exploitation, etc).

2) achieve upward and sustained growth in annual sockeye fry-recruitment into Lakelse Lake relative to the lake-rearing capacity.

3) achieve upward and sustained growth in annual adult sockeye returns into Lakelse Lake relative to spawning capacity.

4) monitor, and where feasible, reduce potential threats to critical rearing habitat for Lakelse Lake sockeye outside of the Lakelse Lake watershed.

2.3 Recovery Approaches

Recovery of Lakelse Lake sockeye will focus on four coincident recovery approaches to achieve the above objectives:

1) maintenance and restoration of critical spawning habitat.
2) strategic enhancement or fry outplanting in key spawning tributaries.
3) assessments of juvenile and adult stock status coupled with population viability analysis (PVA).
4) assessments of other factors affecting Lakelse Lake sockeye production.

For each recovery approach, a list of specific projects is presented and prioritized from high to low to ensure resources are directed to where they are needed most. Some of the projects associated with each recovery approach could provide results rather quickly, such as fry outplanting, and will be important for enhancing remaining habitats and stabilizing the population. Other projects will produce results that will support population recovery over the long term such as habitat rehabilitation. It is important to establish priorities, as resources may be limited and substantial time and effort may be needed to implement some projects.

To date, technical evaluations by federal and provincial agencies have determined which protection and restoration projects have the greatest potential to contribute to recovery of Lakelse Lake sockeye. Priorities have been assigned based on the information contained and referenced in the plan, as well as on the success or failure of similar conservation efforts in other watersheds.

2.4 Project Implementation, Priorities and Status

Recovery of Lakelse Lake sockeye will utilize a feed-back learning process starting with the smaller, logistically tractable projects and moving towards the larger and costlier, logistically difficult projects.

As recovery proceeds, the scope of future projects will need to remain flexible to changing priorities as project results and new information become available. For example, habitat degradation of Williams Creek is known to be severe and it may prove difficult to reverse past or future disturbances without substantial cost, effort, additional resources, and/or different approaches. Tables 1 through 3 outline the prioritized habitat, stock assessment, and enhancement projects that are designed to recover Lakelse Lake sockeye salmon.

Lakelse Sockeye Recovery - Habitat Rehabilitation Projects		
Project	**Priority**	**Status**
Williams and Sockeye Creeks Fish Passage Improvement - Provide spawner passage through beaver dams and prepare a long-term beaver management plan.	High	Underway
Scully South Fish Passage Improvement - Provide spawner passage through beaver dams and prepare a long-term beaver management plan.	High	Underway
Williams Creek Sediment Source Assessment - Provide sediment source mapping and basic budgeting for the watershed.	High	Completed
Williams Creek Fan Channel Mapping - Provide detailed channel assessment of the alluvial fan reaches.	High	Completed
Williams/Sockeye/Blackwater/ Creeks Fan Assessments - Provide habitat restoration feasibility.	High	Partial Completion
Hatchery Creek Spawning Restoration - Design and installation of gravel placement and LWD.	High	Completed
Salmon Creek Spawning Habitat Restoration - Culvert replacement.	High	Completed
Salmon Creek Spawning Habitat Restoration - Gravel nourishment, SWD removal, and LWD placement and possible channel extension to increase flows.	High	Feasibility Stage
Scully Creek Flow Augmentation/Off-channel Spawning Habitat - Construct groundwater channel. Currently exploring feasibility.	High	Ongoing
Scully Creek Sediment Study - Prescribe upslope stabilization for roads and potential sediment sources.	High	Proposed
Williams Creek Off-channel Spawning Habitat - Reconnaissance and feasibility study.	High	Underway
Community Consultation and Awareness - Communicate Sockeye Recovery Plan activities to the community.	High	Ongoing
Scully Creek South – Fishway installation to ensure access upstream of Highway 37S culvert.	High	Completed
Salmon Creek Habitat Improvement - Reduce the number of bridges, culverts, and retaining walls.	Moderate	Proposed
Scully South Gravel Nourishment - Improve spawning substrate in the lower reach.	Moderate	Proposed
Scully South Fish Passage Improvement and Habitat Restoration - Replace highway culvert with an open bottom structure.	Moderate	Proposed
Scully South Riparian Assessment and prescription - Facilitate accelerated conifer growth.	Lower	Proposed
Scully North, Center, and Parallel Channels - Improve spawning habitat with gravel and LWD placements, stabilize stream banks, and plant riparian conifers.	Lower	Proposed
Furlong Creek Groundwater Channel - Develop groundwater channel.	Lower	Underway
Granite Creek Groundwater Channel - Develop groundwater channel. Currently-test pit monitoring.	Lower	Monitoring Underway
Andalas Creek Fish Passage Improvement - Conduct beaver management.	Lower	Proposed

Table 1. Lakelse habitat rehabilitation projects.

The majority of the high-priority habitat rehabilitation projects have been completed or are underway. Beaver management remains an unresolved issue that requires funding on an annual basis. Volunteers and DFO staff currently manage beaver dams on Scully Creek during the spawning season. Most current habitat condition assessments have been completed, other than the complex Williams-Sockeye-Blackwater fan and the Scully Creek Sediment Study.

Lakelse Sockeye Recovery - Stock Assessment Rehabilitation Projects		
Project	**Priority**	**Status**
Annual Juvenile Fry Density Monitoring in Lakelse Lake - Hydro acoustic survey for estimating fall-fry abundance.	High	Completed Annually
Annual Adult Escapement Counts and Mapping - AUC stream walk escapement surveys of Lakelse sockeye tributaries.	High	Completed Annually
Annual Egg Incubation and Survival Assessments - Conducted in Williams, Scully, and Sockeye Creeks.	High	Completed Annually
Lake juvenile trawls or trapping to assess marked vs unmarked ratios.	Moderate to High	Proposed
Lakelse Lake Sockeye Shore Spawner Surveys - Survey and mapping of potential lakeshore spawning areas.	Moderate	Proposed
Lakelse Lake Sockeye Food Competition - Survey and evaluation of fish and zooplankton communities and potential food competition.	Moderate	Proposed
Lakelse Lake Sockeye Predation Monitoring - Assessment of juvenile sockeye predation rates in Lakelse Lake.	Moderate	Proposed
Lakelse Lake Sockeye Exploitation Rate Assessment - Historic review and updated modelling of recent fisheries exploitation rates.	Moderate	Underway
Lakelse Lake Sockeye Smolt Program - Spring smolt out-migration surveys on Lakelse River or one of the major sockeye spawning tributaries.	Lower	Proposed
Adult Sockeye counting Fence Feasibility Study - Assessment of establishing an adult counting fence on Lakelse River or one of the major sockeye spawning tributaries.	Lower	Proposed

Table 2. Lakelse stock assessment rehabilitation projects.

Lakelse Sockeye Recovery - Enhancement Rehabilitation Projects		
Project	**Priority**	**Status**
Pilot Satellite Sockeye Fry Outplanting - Incubate and rear sockeye fry and outplant into Williams and Scully Creeks.	High	Completed/ongoing
Pilot Sockeye Fry Outplanting - Incubate and rear sockeye fry in a local enhanced site and in groundwater-fed sites.	Moderate	Proposed
Establish Formal Spawning Channels - Assess control of water flows and fish density in formal spawning channels.	Lower	Proposed

Table 3. Lakelse sockeye recovery – enhancement rehabilitation projects.

The high priority stock assessment and enhancement project components have been completed or are ongoing. A final but important component of recovery implementation is informing and educating the local community and other stakeholders about the recovery planning process and encouraging them to become involved. The Lakelse Watershed Society continues to play a role in this regard.

2.5 MONITORING AND EVALUATION

Monitoring is critical for detecting and evaluating the response of Lakelse Lake sockeye to recovery activities. The success of this recovery strategy will be dependent upon the measures implemented, and a review will be conducted every subsequent 5-year period. Monitoring and evaluation will incorporate, where appropriate, the following components into the projects listed above in Tables 1-3.

- statistical designs for gathering data,
- specific indicators of recovery that can be measured over time,
- standardized sampling protocols,
- logistic procedures for data collection that are consistent (quality control),
- generation of data that is accessible and can be shared,
- stable and appropriate funding,
- summary analyses that will help integrate monitoring information into the recovery process,
- inclusion of the public through stewardship initiatives that help protect critical habitats and restore impacted habitats,
- community awareness through information programs developed with local stakeholder and community groups,
- partnerships with public and industry for specific stewardship projects.

3.0 LAKELSE LAKE SOCKEYE SALMON

The bulk of Section 3 was originally presented in the Lakelse Lake Sockeye Recovery Plan (Lakelse Watershed Society *et al.* 2005).

3.1 SOCKEYE STOCK STATUS

3.1.1 Species Biology

Lakelse Lake sockeye spawn from late August through October in tributary creeks to Lakelse Lake. Thirteen tributaries feed into Lakelse Lake with the three largest — Williams, Hatchery, and Schulbuckhand creeks — being the principal sockeye spawning tributaries. Unlike some other Skeena River sockeye lakes, lakeshore spawning does not appear to be significant in Lakelse Lake.

Like other sockeye salmon, Lakelse sockeye die soon after spawning. Fry emerge from the gravels in early spring and subsequently school into deeper lake waters soon after. After one year of lake rearing, the smolts migrate to sea in late April and move northward from the Skeena River estuary along the coast and offshore into the North Pacific Ocean. Most Lakelse River sockeye mature at age 4 or 5, although immature males commonly called jacks mature at age 3. The maturing fish return from offshore waters of the North Pacific Ocean through Southeast Alaska and northern British Columbia and enter the Skeena terminal fishing areas from mid-June through early July. Based on tagging data (Aro and McDonald 1966) and recent DNA analyses from the Tyee Test fishery on the lower Skeena River (Cox-Rogers *et al.* 2004, Beacham *et al.* 2005), the return typically peaks in Canadian waters during the last week of June.

3.1.2 Fisheries

Lakelse Lake sockeye migrate through a complex array of mixed-stock fishing areas in southern southeast Alaska, northern British Columbia (Statistical Areas 1 through 5), and in First Nations food, social, and ceremonial fisheries (FSC) within the lower Skeena River itself (Wood 1999).

Lakelse Lake sockeye migrate homeward through Southeast Alaska, and a proportion of the total run is harvested in Alaska gillnet and seine fisheries. Given the early run-timing of this stock, Alaskan commercial fisheries are not believed to be exerting high exploitation rates on Lakelse Lake sockeye. The Pacific Salmon Treaty limits catch in some Alaskan fisheries directed at Skeena sockeye salmon, but other interceptions occur as incidental harvests in Alaskan pink and chum fisheries.

The Kitselas Band of the Tsimshian First Nation harvest Lakelse sockeye in food, social, and ceremonial fisheries in the Skeena River mainstem below the confluence of the Lakelse and Skeena Rivers. First Nations exploitation of Lakelse Lake sockeye is believed to be quite low as the stock migrates into the Skeena River when river levels are high and when First Nations fishing is minimal. Terminal sockeye fishing by First Nations has not occurred on the Lakelse River or at Lakelse Lake for many years (Wilfred McKenzie, Kitselas Band, Pers. Comm.), although historic terminal fisheries are well documented (Skeena Fisheries Commission 2003).

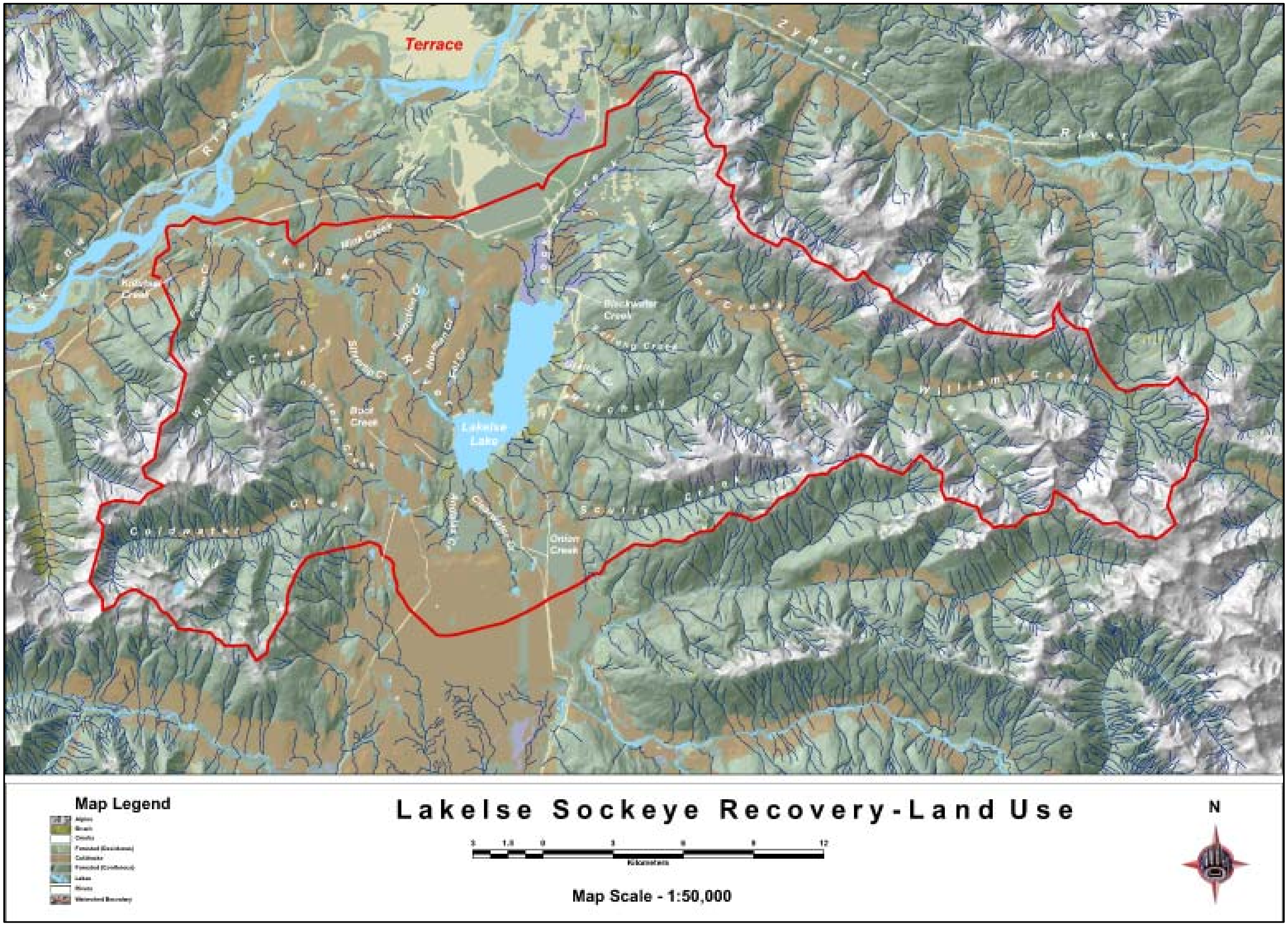

Figure 2. Lakelse Watershed.

The commercial fishery on Skeena River sockeye began with the first cannery operations in 1877 (Wood 1999, 2001). Sockeye salmon were harvested predominantly by gillnets in the Skeena River until the 1930s when powered vessels moved out to ocean fishing areas. A seine fishery was introduced in the 1950s and grew rapidly through the next two decades. The fishery typically ran from late-June through mid-August, but in recent years the fishery has been confined to the mid-July to early August time period to reduce incidental catches of coho, steelhead, and earlier migrating non-Babine sockeye. Effort levels in recent years, from gillnet and seine boat-days, are substantially reduced compared to historic levels. As with fisheries in Southeast Alaska, commercial fishing in Canada is not believed to exert high exploitation rates on Lakelse Lake sockeye because of the early run-timing of this stock.

3.1.3 Enhancement Activities

Skeena River Hatchery was located at the Coldwater Creek-Lakelse River confluence. The hatchery was constructed in 1901 and operated until 1920. Fish were trapped for the egg take at the mouth of Sockeye River (presently Williams Creek) and taken to the hatchery, which had capacity for 4,000,000 fry. Coldwater Creek was dammed for a water supply, with the dam failing on an annual basis as recorded in 1902, 1903, 1904, and 1905, with subsequent flooding of the hatchery (Sword 1903, Whitwell 1906).

Due to cold water and flooding, the hatchery moved in 1920 to Hatchery Creek. This hatchery had a capacity of about 15,000,000 fry handling primarily sockeye; but occasionally pink, coho, and trout eggs were collected and hatched out. Aro and Broadhead (1950) note that the mean egg content of Lakelse sockeye is 3,815 from a range of 3,699 to 3,888 eggs. Apparently, the majority of sockeye eggs were collected from Williams and Scully creeks spawners. Foerster (1968) indicates that annual egg takes from 1920 to 1932 averaged 7,900,000 eggs. Estimated annual natural egg deposition for the Lakelse system from the 1920-1932 period is 778,000,000; therefore, mean annual eggs collected represent 1%.

Figure 3. Skeena River Hatchery ca. 1940s.

From 1924 to 1926, large numbers of Lakelse sockeye eggs were shipped to Stuart Lake Hatchery and also planted in the Nadina, Stuart, Bowron, and Quesnel systems. The intent was to rehabilitate upper Fraser sockeye stocks that were adversely affected by the Hells Gate slides. In compensation for supporting the upper Fraser sockeye stocks, the Skeena River Hatchery received eggs from Birkenhead River, and juvenile sockeye from Pemberton Hatchery were outplanted in numerous Lakelse streams that are shown in Figure 4. Skeena River Hatchery also received Atlantic salmon, cutthroat trout, and Kamloops trout eggs. In 1921 and 1923, Atlantic salmon eggs were received from Miramichi Hatchery, hatched out, and distributed into Lakelse streams and lake. In 1933, cutthroat trout eggs received from Cranbrook Hatchery were hatched and released into Granite Creek.

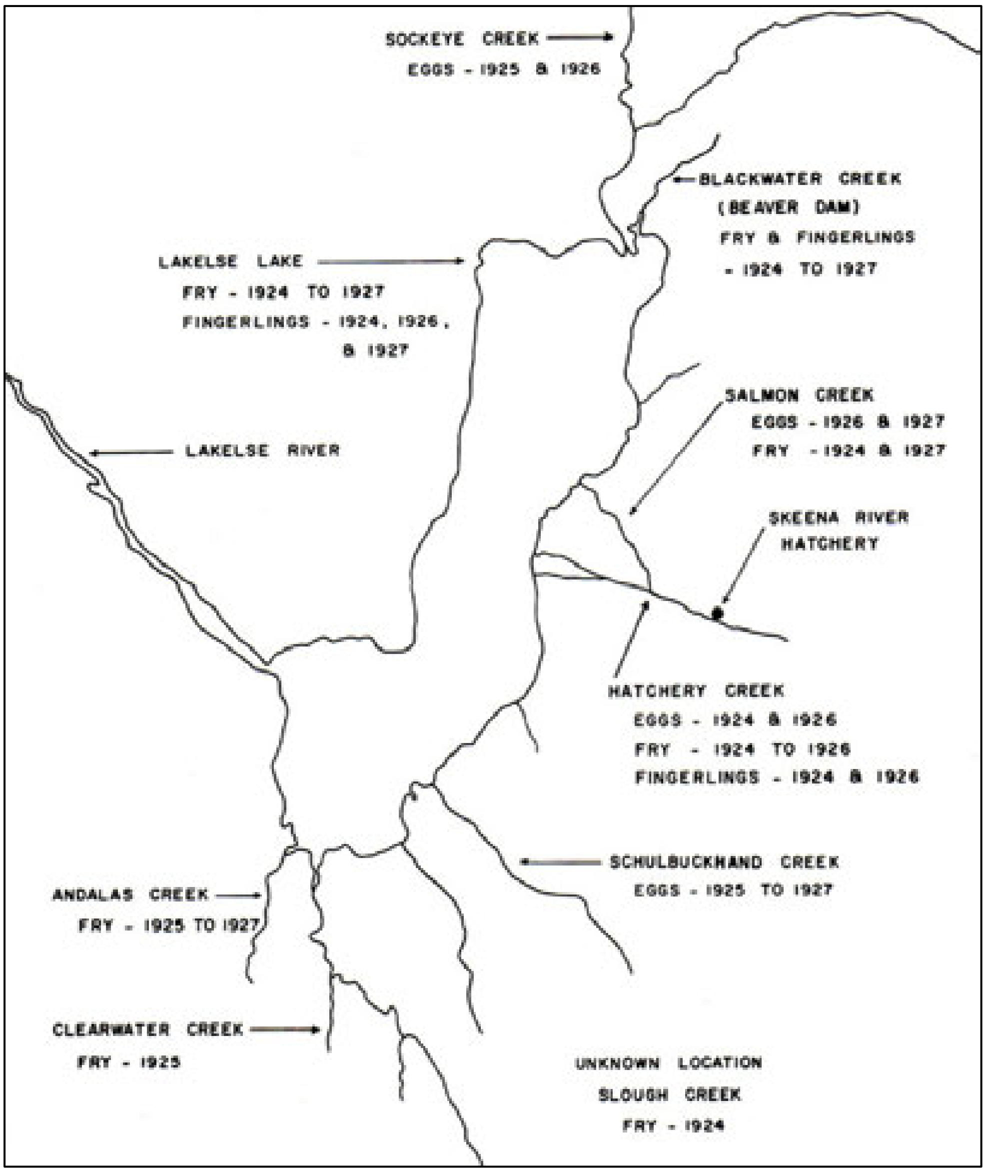

Figure 4. Sockeye egg and juvenile transplants from Birkenhead River to Lakelse Lake and streams in the 1920s.

Skeena River Hatchery operated until the fall flood in November 1935, when it was closed due to flood damage and policy changes (Fisheries Research Board 1948). Foerster (1968) sums up the B.C. sockeye hatchery approach:

> To what extent differing conditions in other areas would alter the relative efficiencies of natural and artificial propagation was a matter of conjecture. Acting, however, on the fact that (1) artificial propagation involved such a small percentage of the eggs contained in the spawning escapements to any area and that (2) no clear evidence was available that hatcheries had achieved any beneficial results in any of the areas where they were located, the Federal Department of Fisheries closed down all hatcheries at the end of the 1935 season.

The Scully Creek Hatchery operation, designed for a capacity of 15 million sockeye eggs, functioned from 1960-66 in conjunction with counting fences and ancillary facilities located on Williams and Scully creeks. The hatchery program was coincident with lake sampling aimed at monitoring mortality and growth rates of the artificially propagated sockeye population. Comparing the same rates in the natural population in Lakelse Lake over a number of years would disclose hatchery-induced differences, if any. In 1966, the hatchery and counting fences were dismantled. From 1964 to 1966, 12,520,000 eyed pink salmon eggs were shipped to Newfoundland for planting in the North Harbour River.

Since the early 1900s, remedial work has been implemented periodically on lower Williams Creek to improve fish passage by countering aggradation effects on the alluvial fan. Sockeye Creek received channel improvements as well as logging debris cleanup in the mid-sixties. Various studies for enhancement opportunities were undertaken under the auspices of SEP, particularly in regard to reconnaissance for sites with good groundwater flow (Brown 1980). In the 1980s, a small volunteer facility at Howe Creek in Terrace, called Eby Street Hatchery, began enhancing many of the small streams flowing into the east shore of Lakelse Lake. This group consistently produced coho fry from broodstock collected on Clearwater Creek for at least eight years. In the late 1980s, Deep Creek Hatchery conducted chinook enhancement on Coldwater Creek.

3.1.4 Stock Assessment Status

3.14.1 Lakelse Lake Abundance and Exploitation

Annual catch data for Lakelse Lake sockeye are not available, and annual escapement records are incomplete. As such, exploitation rates on this stock cannot be directly calculated. Instead, exploitation rates are modeled using weekly sockeye harvest rates in Canadian fisheries, run-timing curves for the wild stocks, and add-on exploitation for U.S. and in-river First Nations fisheries (Cox-Rogers *et al.* 2003).

Decadal mean exploitation is estimated to have been 0.262 from 1970-79, 0.245 from 1980-89, 0.338 from 1990-99, and 0.279 from 2000 through 2002. These exploitation rates are considered maximums and may be biased high because: a) exploitation rates for the Skeena River aggregate stock caught in Southeast Alaska have been used as a surrogate for the earlier-timed Lakelse Lake sockeye stock, and b) FSC exploitation rates within the Skeena River are for the aggregate stock captured below Terrace, which may not apply to the earlier-timed Lakelse Lake sockeye stock. Future DNA-based stock identification analyses of commercial and FSC fisheries may help to quantify exploitation rates on Lakelse Lake sockeye.

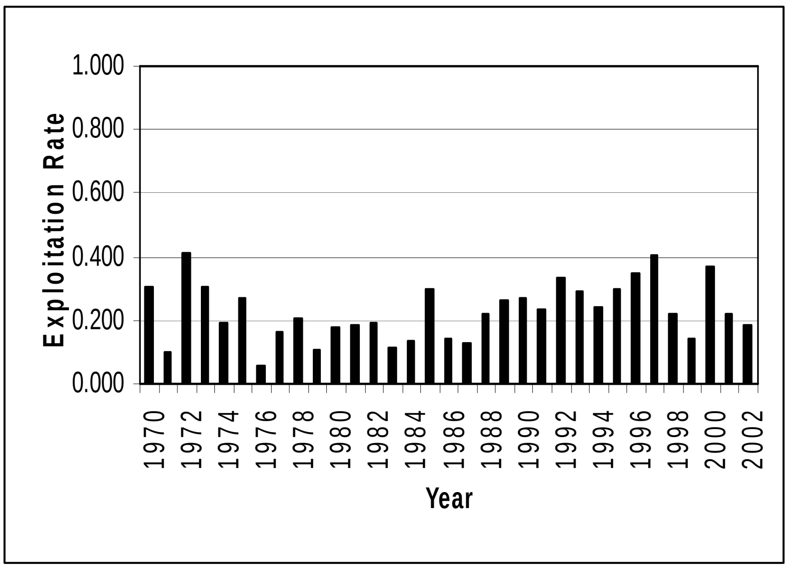

Figure 5. Estimated total fisheries exploitation rates on Lakelse Lake sockeye salmon: 1970-2002.

3.1.4.2 Spawning Escapements

Exploitation to achieve maximum sustained yield (MSY) has been estimated at 0.432 for Lakelse Lake sockeye based on adjusted (for Mysid competition) lake trophic status assessments. However, this calculation assumes that lake rearing capacity alone limits sockeye production (Cox-Rogers *et al*. 2004). Sustainable exploitation may actually be reduced for this stock if spawning habitat limitation is occurring.

Escapement trends for Lakelse Lake sockeye are somewhat difficult to assess because the counts represent data from a diverse series of surveys with decreasing coverage over time. Between the late 1990s and 2003, stream walks have been sporadic, but those conducted have indicated lower escapements to key tributary streams than in past years (Mitch Drewes, DFO, Pers. Comm.).

Figure 6 shows estimated sockeye escapements into Lakelse Lake based on the available data from 1934 to 2007. The records indicate that Lakelse Lake sockeye escapements were generally above 5,000 fish in most years (range 1,000-57,000). Years of peak abundance appear in the 1940s, the 1960s, early 1980s, and mid 1990s, and very low abundance in recent years. Note that the visual escapement records are considered under-estimates of actual escapement except for the 1950s to the mid-1960s time period, when fence counts and calibrated visual estimates were used to derive the annual escapements (Forester 1968).

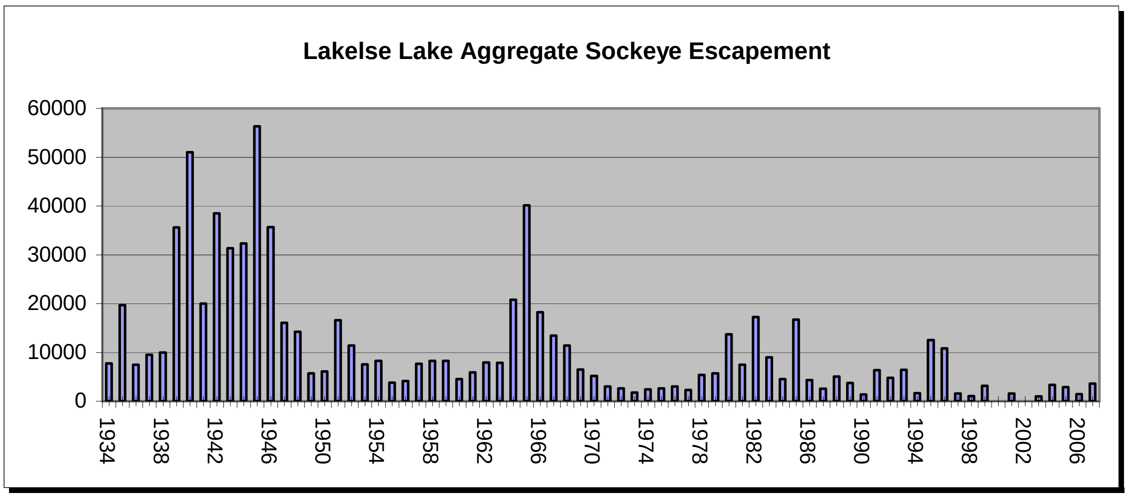

Figure 6. Estimated sockeye escapements to Lakelse Lake 1934-2007.

3.1.4.3 Limnological and juvenile surveys

Ongoing analyses of limnological and juvenile acoustic data for Lakelse Lake sockeye indicate that spawning escapements are much too low to fully utilize lake rearing habitat and maximize smolt production (Shortreed *et al.* 1998, 2001). Highlights of lake trophic and acoustic surveys conducted in 2003 are summarized below:

- The lake was thermally stratified from June to September, and thermocline depths were unusually deep (usually greater than 20 m) for a relatively small lake. This is no doubt due to the frequent winds. The lake is relatively clear, with an average 8.2 m euphotic zone depth (the depth to which plants can grow).

- Lakelse Lake water has a near-neutral pH averaging 7.1, a relatively low average conductivity of 54 µS/cm, and a total alkalinity of 22.5 mg $CaCO_3$/L. These values are near the middle of the range seen for a number of other lakes in the Skeena River system.

- Total phosphorus concentrations averaged 5.4 µg/L. Spring nitrate concentrations were approximately 50 µg N/L, and although epilimnetic nitrate did not become completely depleted, it was <6 µg N/L from June to September. Bacteria numbers averaged 1.5 million/mL, and average chlorophyll concentrations 1.4 µg/L. Photosynthetic rates averaged 144 mg $C \cdot m^{-2} \cdot d^{-1}$.

- These data all indicate that Lakelse is a relatively unproductive lake and is in the middle of the oligotrophic range.

- The data indicate that for much of the growing season, lake productivity is limited by the availability of both nitrogen and phosphorus. In other words, an increased supply of both nitrogen and phosphorus would stimulate lake productivity.

- Lakelse Lake has a somewhat unusual zooplankton community in that the preferred food item (*Daphnia*) of juvenile sockeye is abundant only in July. The rapid decline of *Daphnia* numbers from July to August is likely due to the high numbers of the mysid shrimp *N. mercedis*, which was most abundant (360/m^2) in August.

- In the fall of 1994 it was estimated there were 450,000 sockeye juveniles in the lake, but the fall 2003 estimate found only 100,000 sockeye fry. It would require approximately 750 sockeye spawners in the previous year to produce this number of fry in the fall of 2003.

- Every sockeye nursery lake has a rearing capacity for juvenile sockeye that is controlled by a number of factors, some of which are surface area, nutrient loading, productivity, and presence of competitors. The large mysid population in Lakelse Lake reduces its sockeye rearing capacity by 40%. Taking this into account, Lakelse Lake has the capacity to effectively rear the sockeye fry from 29,000 spawning adults. Data collected in 2003 and 2004 showed that just 9% and 20% of the lake's sockeye rearing capacity were being utilized in each year respectively.

- Increasing fry recruitment by increasing escapements, escapement success (recruits per spawner), and/or fry stocking may be the best way to enhance this population.

3.1.5 Stock Status Outlook

Based on the last 12 years (1992-2003) of available visual escapement data for Lakelse Lake, and assuming these data are representative, the Lakelse Lake sockeye stock has declined by 92% over the last three cycles. Figure 7 shows the estimated 3 generation or the last 12 years, escapement decline rate for Lakelse Lake sockeye salmon in a solid line. Also shown are the smoothed escapement data with curved line and the COSEWIC conservation criteria thresholds corresponding to decline rates of 0%, 30%, 50%, and 80% with the dashed lines. Note the y-axis is plotted on a logarithmic scale.

Although the accuracy of the escapement data is not known, recent juvenile surveys in the lake confirm low escapement levels. Escapement surveys since the late 1990s indicate reduced escapements in the major spawning tributaries relative to historic levels. If low escapements continue and if fry recruitment into the lake is not improved, preliminary analyses suggest the Lakelse Lake sockeye could be at biological risk even at currently low levels of exploitation (Cox-Rogers *et al*. 2004).

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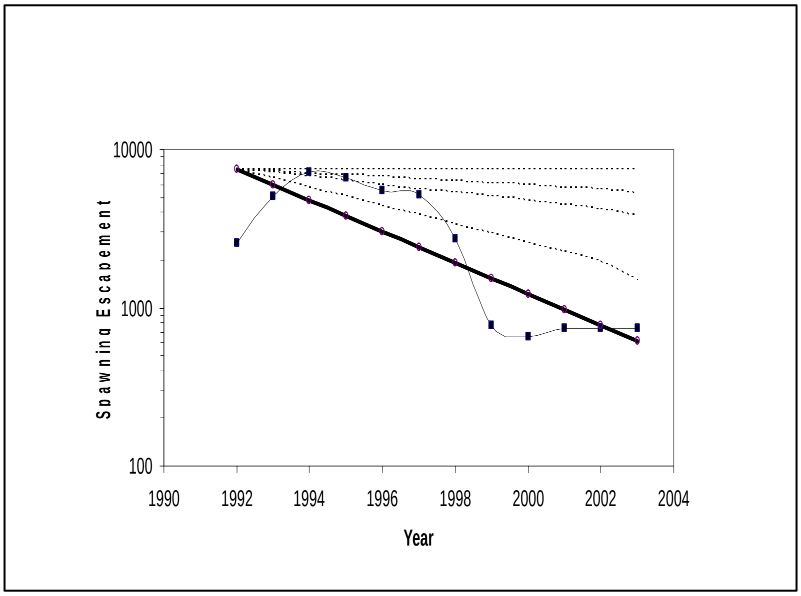

Figure 7. Estimated 3 generation escapement decline rate for Lakelse Lake sockeye salmon.

3.2 HABITAT STATUS

3.2.1 Habitat Setting

The Lakelse watershed lies in a basin with mountains to the east and west that rise to 1845 m, presenting considerable relief. The basin floor is low-gradient, but the watershed as a whole has a moderately high response from water input due to the steep topography of the major tributaries. Coastal weather systems have easy access to the watershed, leading to heavy snow packs and precipitation in the mid and upper elevations of the drainage.

Cleugh *et al.* (1978) estimate that the greatest discharge from Lakelse River occurs in May and June due to snowmelt. Decreased stream flow in July and August is followed by an increase in September and October. Typical fall or mid-winter rain on snow events frequently generate peak discharges.

Lakelse Lake is the predominant feature of the upper watershed. It covers an area of 14.5 km2 (14,516 ha), with the majority of watershed tributary streams feeding directly into the lake. Lakelse Lake is approximately 8.7 km in length with an average width of 1.2 km. The average flushing rate of the lake is four times during the six-month spring and summer seasons, and once during the fall and winter (Kokelj, 2003). The lake has a maximum depth of 32 m and a mean depth of 7.8 m; a large portion (42%) of the lake is littoral. This extensive littoral zone affects temperature, dissolved oxygen, aquatic plant growth, and overall productivity of the lake (Cleugh *et al.* 1978).

Lakelse Lake water quality studies are reported in Brett (1950), Abelson (1976), Cleugh *et al.* (1978), McKean (1986), Wilkes and Lloyd (1990), Shortreed (1998) and Kokelj (2003). McMahon (1954) reported on Lakelse plankton and Warrington (1986) documented aquatic vegetation.

Lakelse Lake is considered to have been oligotrophic to slightly mesotrophic throughout the last several hundred years (Cummings 2002). This is due to its low phosphorous concentrations, the low oxygen depletion rates of its bottom waters, and low chlorophyll a concentrations. These attributes, together with the lake's high water quality, determine the recreational and fisheries importance of the lake. Physics (light, climate and thermo regime) and chemistry levels (nitrogen and phosphorous) suggest that increased nutrient loading would quickly increase lake productivity and phytoplankton biomass in Lakelse Lake.

Figure 8. Elodea mat in Lakelse Lake.
Kokelj 2003

Already low Nitrogen:Phosphorous ratios indicate that increases in phosphorous loading without concomitant increases in nitrogen loading could result in the development of undesirable blue-green algal blooms or eutrophication (Remington 1996). Since 2002, the lake has been experiencing a steady increase in the aquatic plant growth, *Elodea Canadensis* (Kokelj 2003).

Williams, Hatchery and Scully creeks are the major tributary streams of the thirteen tributaries feeding Lakelse Lake, as well as being the principal sockeye spawning streams (Skeena Fisheries Commission, 2003). These steeply graded creeks originating in the mountains to the east are fed from large areas of alpine mountain slopes. Brett (1950) indicates that water level fluctuations within Lakelse Lake reflect the fluctuations in volume of Williams Creek discharge.

Williams Creek and its three main tributaries, Sockeye, Myron and Llewellyn Creeks, comprise approximately 25% of the total stream length in the Lakelse Watershed. Within Williams Creek, the three lower reaches are low-gradient at 2% or less, and form a large alluvial fan that is shared by Sockeye and Blackwater Creeks (Reese-Hansen 2001). Streamflow connectivity is high and avulsions are common. On Williams Creek, upstream of Reach 3, the hillslopes are coupled to the creek with headwater streams that largely originate from small cirque glaciers and snowpacks.

3.2.2 Sockeye Habitat Requirements

Lakelse Lake sockeye are anadromous, dividing their life cycle into fresh water and ocean habitats that have different geographical and environmental variables. Freshwater habitats provide spawning, egg incubation, fry rearing and smolt migration, while the marine habitat accommodates the young migrants' physiological adaptation to salinity and allows ocean rearing and in-out migration corridors common to northeast Pacific sockeye.

The Lakelse Lake Sockeye Recovery Plan relates to the freshwater and estuarine habitats, particularly habitats that are critical to the sustenance and survival of Lakelse Lake sockeye. Critical habitat is defined as ***"the minimum extent and arrangement of habitat elements throughout the estuarine and freshwater life history of Lakelse Lake sockeye that are necessary to provide an acceptable probability for the survival or recovery and that are identified as critical habitat in this recovery plan."*** Critical habitats for sustaining and recovering Lakelse Lake sockeye populations include:

- Migratory routes from the ocean to Lakelse Lake for smolt and pre-spawning adults. This critical habitat requires a route clear of obstructions, appropriate water temperatures, flows, cover and healthy conditions in the estuary, Skeena River, and Lakelse River.

- Lakelse Lake, as pre-spawning sockeye hold for their prolonged residency before ascending spawning streams. Lakelse Lake sockeye fry and parr rear in the lake for one year utilizing a variety of the lacustrine habitats.

- The lower reaches of Williams, Sockeye, Hatchery, Scully and other creeks that support spawning, egg incubation, and downstream fry migration habitat. This critical habitat requires adequate flows (depth and velocity), high water quality, suitable substrate, and holding grounds. Spawning and incubation habitat is considered the factor most limiting for sockeye production in the Lakelse watershed.

3.2.3 Sockeye Habitat Status

Until recently, Lakelse Lake was one of the most productive sockeye rearing lakes in the Skeena Watershed (Skeena Fisheries Commission 2003). The very high sockeye values within the Lakelse watershed stem from the superb spawning and rearing habitat. Habitats critical to Lakelse Lake sockeye life histories have been impacted principally by forest development, settlement and housing, and transportation and utility corridors.

Significant human activities in the watershed began to occur in the 1950s and included a sawmill operation on the north end of the lake, increased logging activity, linear development, creek diversions, and raised wastewater effluent. Sediment cores obtained from Lakelse Lake in 2002 and analyzed by Cumming (2002), indicate that sedimentation rates in the north and south lake basins corresponded with the timing and rate of development.

3.2.3.1 Forestry

The Lakelse Watershed experienced large-scale industrial logging that was particularly intensive from the mid 1960s to the mid 1980s. Overall, 87% of the operable timber in the watershed has been logged. Over the last four to five decades, the Williams Creek sub-basin, which includes Williams, Llewellyn, Sockeye, and Blackwater creeks, has seen extensive forest harvesting development concentrated on stands on lower valley slopes and valley floor. Recent watershed assessments that reviewed logging-related impacts rated the Williams Creek sub-basin habitat components. Channel, fish habitat, riparian, hillslope, and road conditions are all rated as poor (Reese-Hansen 2001).

Forestry activities have occurred within the Scully Creek watershed since 1975, with development concentrated on the alluvial fan until 1980, followed by logging in the upper watershed until the present (Triton 1998). In addition to logging, the lower Scully Creek watershed has undergone extensive development and alteration since the early 1900s (Triton 1998). This development includes settlement, transportation and utility corridors, recreation, and agriculture, which have all incrementally contributed to channelization, channel diversion, bank instability, amplified sediment contribution, lack of instream habitat complexity, lack of flushing flows, colonization by beaver, and loss of spawning gravels.

Scully Creek has received preliminary restoration assessment and works in Reach 1. In Reach 2, large quantities of bedload are being deposited from upstream reaches and the flow is sometimes subsurface. Logging related landslides and the “Cat Fire” above the Scully Creek fan apex have exacerbated problems associated with levels of sediment and likely accelerated bedload mobilization. Instability of the fan due to logging and linear development has led to the complete diversion of surface water flows from the south channel (original mainstem) to the constructed channels flowing through the Mt. Layton Hotsprings property for the lowest kilometer, before entering the lake. The southern channel is currently fed only by groundwater flows.

Development activities within the lower reach of Hatchery Creek (downstream of Highway 37 South) include logging, settlement, transportation and utility corridors. Streamflow across the fan is channelized, and with large amounts of bedload movement aggradation has caused variable sections of the stream to flow subterranean. Cumulative impacts to the fisheries resource are rated very high (Gordon *et al,* 1996). Hatchery Creek is a designated Community Watershed where water quality, quantity, and flow timing are the principal values under the Forest Practices Code.

Some of the post-logging impacts to fish habitat within the Lakelse Watershed have been mitigated by time. Lasting impacts of timber harvesting are primarily to tributary riparian zones and stream structure/stability. Increased bedload movement has led to channel destabilization and aggradation on moderate to steep gradient stream fans. Many tributary riparian zones have seen an expansion of beaver habitat into areas that historically provided sockeye spawning habitat. Fish access is now problematic, and backwatering of these areas has decreased the quality of this habitat for spawning. Additionally, there are significant increases in the amount of fine sediment that is not being flushed through the system. The degraded habitat poses a major rehabilitation effort in relation to sockeye spawning and egg incubation habitat.

Figure 9. 1998 image shows Lakelse Lake and recent forestry, residential, and linear developments.

3.2.3.2 Linear Development

Transportation and utility systems are extensive in the Lakelse Watershed. Linear development includes Highway 37 South, a major north-south transportation route connecting Terrace and Highway 16 with Kitimat and tidewater to the south. As well as the highway, there are PNG's natural gas pipeline and a BC Hydro major transmission line.

In 1962, a significant slide of glaciofluvial marine clays occurred in the northeast region of the lake (Septer and Schwab 1995). This was partially a result of highway construction that intercepted groundwater flows (Kerby 1984). Linear development has caused fish passage problems and destabilized stream channels.

3.2.3.3 Residential Development

The Lakelse basin supports seasonal and full-time residences providing a variety of lifestyles for a population of 360 people (RDKS 2002). Mount Layton Hotsprings Resort operates water-based recreation, a restaurant, and a motel on the east shore of Lakelse Lake. There are two Provincial Parks located on the east side of the lake and at the northeast corner, which are popular stopping off points for local and non-local water-based recreation, picnics, and camping. Lakelse Lake is believed to be the most heavily utilized recreational lake in the region.

Smaller 1st Avenue streams supporting sockeye populations associated with or acted as distributary channels on the Granite Creek alluvial fan, such as Mountain, Salmon, and Hatchery creeks, have been impacted by channelization, flow diversions, and road crossings.

In 1974, Sinclair (1974) and Schouwenburg (1974) note that enrichment of Lakelse from nutrient-rich sewage would destroy the lake from a fish-producing and recreational standpoint. They recommended that the only alternative available was to divert the sewage away from the lake. The Regional District of Kitimat Stikine has expressed concerns about impacts of the current sewage disposal systems on water quality and fish habitat around the lake (Stantec 2000).

Kokelj (2003) notes that the rate of non-point source nutrients entering a lake from septic systems increases when there is no buffer of natural vegetation. In the case of Lakelse Lake this is significant, as 86% of the urban development lie within landforms considered poor to moderate for removing septic effluent (McKean, 1986). These residential developments with their associated septic systems, lack of riparian vegetation, and occasional stream diversions have enriched nutrients in the lake and have had adverse impacts on fish habitat.

In 2004 a Liquid Waste Management Plan for the Lakelse Lake area was initiated by the regional district in partnership with local community associations and agencies such as BC MOE and DFO. Potential sources of contaminants have been identified, and the committee is now working towards identifying, evaluating, and implementing options to resolve these issues.

3.2.3.4 Cumulative Effects

Development activities since the 1950s have been related to the observed increase in sediment delivery from 1950 to 1990 (Kokelj 2003). Increased sedimentation in the lake may have contributed to the creation of favourable habitat for *Elodea* *canadensis* colonization (Kokelj 2003). Growth of *Elodea canadensis* in the lake over the last several years has reached levels that seasonally occludes beaches and shorelines and currently occupies most of the volume of several shallow bays and patches of shorelines. This aquatic invasive plant has the potential to severely change fish habitat with increasing colonization of the littoral zone.

Decline of the sockeye stock in the watershed has resulted from the cumulative effects of land use practices, fish harvest management, and natural fluctuations in environmental conditions.

Figure 10. Sockeye spawning in Williams Creek. Dave Gordon

3.2.4 Sockeye Habitat Trends

Habitat trends revolve around the three critical habitat components used by sockeye: smolt and pre-spawning adults' migratory routes between the ocean and Lakelse Lake, Lakelse Lake for pre-spawning adults and rearing sockeye fry and parr, and the lower reaches of the main sockeye spawning creeks.

Habitat trends involving smolt and pre-spawning adult migratory passage need to consider the uncertainties revolving around proposed coastal finfish farm operations, the mixed stock fishery exploitation at the mouth of the Skeena River, potential increased stream temperatures affected by global climatic change, and proposed coastal development such as oil and gas.

Given the documented effects of past forest harvesting and the fact that most commercially available stands have been logged, it is unlikely that future forest development activities in the Lakelse Watershed will continue at similar levels and rates of logging compared to the past. As immature forests stands become commercially viable, the nature and extent of logging of second growth will become an issue.

The probability and extent of future impacts relating to past logging — for example, elevated stream temperatures or lateral channel movement that increases sediment delivery — is unknown. Potential increases to beaver impoundments are unknown.

The growth of *Elodea canadensis* in Lakelse Lake has recently been noted and it appears to be steadily increasing. Lakelse Lake residents and regulatory agencies are concerned about how *Elodea* growth will affect water quality and the fisheries value of the lake. Factors affecting *Elodea* growth are not well known, and the exact link between the *Elodea* infestation and sediment and nutrient inputs to the lake is currently unclear.

The relationship between *Elodea* and sockeye is not well understood, so the possibility that excessive plant growth may inhibit sockeye production should be monitored. An *Elodea* infestation can affect the food chain in the lake by displacing algal primary producers and potentially limit sockeye production (A. Smith cited in Kokelj, 2003). Decomposition of *Elodea* during the winter may cause harmful oxygen deficits that could stress aquatic food webs critical to juvenile sockeye health.

Population and settlement issues will potentially increase due to the fact that approximately 55% of the available lots in the Lakelse area are currently developed. The Lakelse Lake area is made up of approximately 480 parcels of land, of which only 280 lots have been developed as single family dwellings (Associated Engineering, 2004).

Habitat restoration or rehabilitation of degraded spawning and egg incubation areas will depend on the availability of committed funding. In addition, it is generally unknown how existing and proposed strategic policies, programs, and regulations will affect the Lakelse Lake sockeye recovery approach.

4.0 LAKELSE SOCKEYE STREAM ASSESSMENTS AND DISCUSSION

This section describes background research results along with information generated from preliminary sockeye spawning habitat fieldwork evaluations. Background research has included:

- acquisition, compilation, and analysis of archival documents,
- initial analysis of historic air photos,
- review of previous watershed restoration assessment reports,
- review of the Lakelse Sockeye Recovery Plan and subsequent projects,
- identification, assessment, and feasibility of potential options for improving spawning and incubation habitat in the watershed.

Results are presented by sub-basins that include Williams, Sockeye, Scully, Granite, Hatchery, and Salmon sub-basins. Archival documents that were reviewed are included in the Appendices.

4.1 WILLIAMS CREEK

Williams Creek drainage is located east of Lakelse Lake along the eastern margin of the rugged Coast Mountains. Williams Creek flows into the northeast corner of Lakelse Lake and is the largest tributary in the watershed. It is a 4^{th} order stream draining approximately 207 km^2 of mostly steep, high-elevation hillslopes. The mainstem is approximately 34.1 km in length.

Williams Creek and its three main tributaries, Sockeye, Myron and Llewellyn Creeks, comprise approximately 25% of the total stream length in the Lakelse Watershed. Upstream of reach three, the hillslopes are coupled to the creek with headwater streams largely originating from small cirque glaciers and snowpacks.

Williams Creek valley opens up into the relatively wide valley flat of Kitsumkalum Trough, where the creek has built a large, low-gradient alluvial fan shared by Sockeye and Blackwater creeks. Approximately one-third of the fan area is currently active with high stream channel flow connectivity, and avulsions are common. At the distal end of the 4 km long fan, Sockeye Creek enters Williams Creek from the north. From that confluence, a 2 km long, very low-gradient reach connects the alluvial fan with Lakelse Lake.

4.1.1 Williams Creek Sockeye Abundance

Williams Creek historically supported 80% of Lakelse sockeye spawners (Brett 1944). The escapement history of the Williams Creek sockeye run is vague until 1921. From that date to 1934, Skeena River Hatchery records and Fishery Inspector's reports indicate runs ranging from 2,500 to 25,000 sockeye with mean levels of approximately 15,000 sockeye. Hatchery records include partial counts from the fence located at the mouth of Williams Creek, which was operated for egg-taking operations.

In 1939, The Fisheries Research Board (FRB) initiated the Skeena River Investigation due to a definite trend showing that the commercial sockeye catch was falling off. The Skeena River sockeye catch fell from approximately 135,000 cases in 1909 to about 51,000 cases in 1935. Clemens (1939) reports on the three fences installed in the three mouths of Williams Creek for the purpose of accurately determining the number of sockeye entering it. In 1939, the total number of spawners through the fence was 24,085 with an approximately even percentage of sexes and fully mature fish.

The Williams Creek counting fences were reinstalled and operated by the Fisheries Research Board from 1944 to 1956 and from 1960 to 1965. Tagging at the Lakelse River fence and recapture at the Williams Creek fence provided information on the length of time sockeye held in the lake. Sockeye tagged at the Lakelse River fence and recovered at the Williams Creek fence showed that the fish spent an average of 54 days (range 42-69) in Lakelse Lake.

In addition to DFO Fishery Inspectors, the FRB conducted annual spawning ground surveys with Brett (1944, 1945) reporting over 20,000 and 50,000 sockeye in 1944 and 1945 respectively spawning in Williams Creek. Blackwater Creek was used by returning sockeye to reach the upper Williams Creek spawning grounds between 1944 and 1952; thus, escapement derived from the fence counts were under estimated (Shepard *et al.* 1952). The Blackwater Creek channel was termed the Blackwater Creek diversion and in 1953 was sealed off by the Department of Fisheries, thereby increasing the flow of water down the main channels of Williams Creek and allowing for accurate fence counts. From the mid-1970s to the mid-1980s, Blackwater Creek was again used to access Reach 3 of Williams Creek (Hipp 1985, Woloshyn 2008).

Figure 11. Construction of the Williams Creek counting fence, 1950.

Figure 11 shows construction of the new Williams Creek counting fence in 1950 following the flash flood on September 21, 1949, which destroyed the earlier fence. The fence was located on the west channel of the island at the mouth of Williams Creek and constructed using a pile driver assembled on-site and “A” frames instead of rock-filled pylons. The east channel fence remained unchanged except for minor modifications. Figure 12 below shows the fence across the west channel and the road coming down from the highway adjacent to the east channel. Figure 13 shows the Lakelse River counting fence that was located downstream of the lake. At the time, these fences were the major stock assessment tools determining the status of Lakelse sockeye.

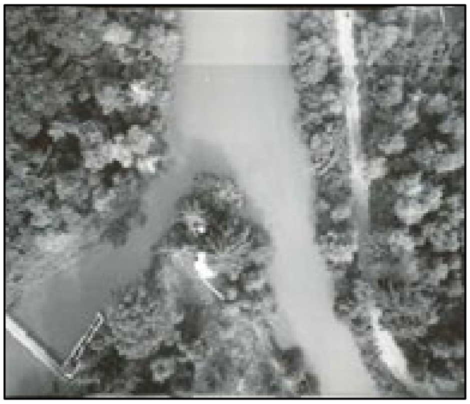

Figure 12. Williams Cr. Fence, 1960.

Figure 13. Lakelse R. fence, 1960.

Williams Creek sockeye typically enter the mouth of the Skeena River from early June through to late June. This run is known as the Lakelse early run. Tagging experiment results have clearly indicated that exploitation by the commercial fishery is usually not significant unless the run arrives late and commercial fishery starts early. Up until the late 1940s, the commercial fishery usually commenced on the last Sunday in June. In reviewing archival records, it is apparent that a second run enters Williams Creek mid-September.

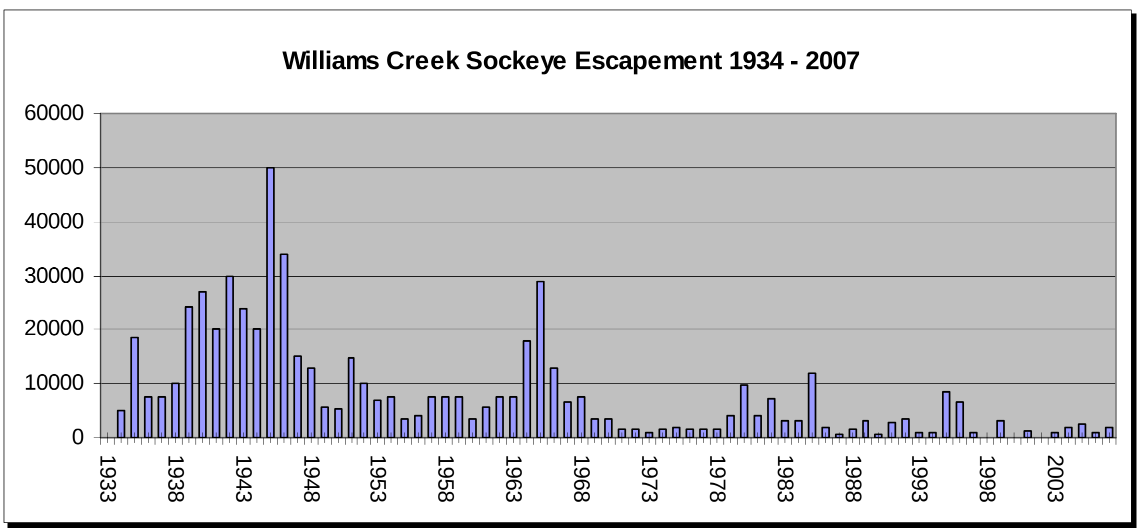

Figure 14. Williams Creek sockeye escapement 1934 - 2007.

Williams Creek sockeye escapement was relatively strong through the 1940s, and then fell off to a somewhat stable and comparatively low level through the 1950s. This decline may be related to the commercial fishery that opened a week earlier on June 22nd from 1949 through to 1954. However, all Skeena sockeye stock abundance was generally depressed during the 1950s. In the mid 1960s, the escapement peaked. Since that time, escapement has mostly fluctuated at low levels of abundance. Exploitation rates of Williams Creek sockeye have varied over time, but are modest in relation to other targeted Skeena sockeye stocks.

Cox-Rogers (2005) indicates that a 92% escapement decline has occurred over the last three generations or 12 years. This is corroborated by hydroacoustic juvenile surveys that show very low densities relative to the lake rearing capacity. The best information available indicates that the major problem with sockeye abundance is poor spawning success or egg to fry survival that limits fry recruitment into the lake. These dynamics are thought to be directly related to the state of the degraded spawning habitat that limits spawner access, spawner success, or egg to fry survival.

4.1.2 Williams Creek Sockeye Spawning Habitat

4.1.2.1 Physical Habitat

The focus of Williams Creek sockeye spawning habitat is the lower section from Lakelse Lake upstream to the Old Lakelse Lake Road crossing. This lower 6 km of Williams Creek flows across a low-gradient fan and onto an unconfined valley bottom before reaching Lakelse Lake. Historically, this was the principal spawning grounds for Williams Creek sockeye, particularly Reaches 1 and 2. Currently, Williams Creek provides variable quality sockeye spawning habitat for the lower 3.5 km. The alluvial fan is sectioned into three distinct reaches that reflect the physiography and dominating geomorphological processes.

Figure 15. Photo shows Williams Creek Reach 1 upstream to Highway 37S Bridge.

Reach 1 is located from the mouth of Williams Creek at Lakelse Lake and extends approximately 2 km upstream to the confluence of Sockeye Creek. The reach connects the distal end of the alluvial fan to the lake. The mouth at the lake is a delta that is continuing to build due to sand and fine sediment deposits. The reach is described as a single channel with low gradient and a mean channel bankfull width of 24 m. The channel is stable with fines and gravel substrate. Off-channel habitat is infrequent, and two tributaries partially drain the relatively extensive wetland west of Highway 37S. The reach contains excellent salmonid spawning, rearing, and overwintering habitat. Weiland and Bird (2007) note that Reach 1 is essentially a transport reach moving sediments from the fan to the lake. Reach 1 was historically considered the most important sockeye spawning habitat.

Figure 16. View across the mouth of Williams Creek.

Reach 2 is located from the confluence of Williams and Sockeye creeks upstream for 1.4 km and is the lowermost reach on the fan. The channel is buffered from Reach 3 by a decrease in gradient and developed distributary (flood) channels that connect with adjacent wetlands, which eventually drain to either Sockeye Creek to the north, or Blackwater Creek to the south, or back into the active channel. These distributary channels effectively reduce the sediment transport capability of Williams Creek (Weiland and Bird 2007). Extensive wetlands on both sides of the creek are maintained by beaver, which have been active in the reach since the early 1960s following logging activities.

Figure 17. Downstream view in mid-Reach 2.

Reach 2 average channel gradient is .082%, with a mean channel width of 24 m spread over multiple channels. The substrate is mostly gravels up to 8 cm. Channel stability is currently rated as moderately stable with slight aggradation. Figure 17 shows a segment of Reach 2; note the stumps in mid-channel indicating prior coniferous riparian forest. Between 1986 and 1993, Reach 2 has moved into and been active in its more northerly channel. Presently the southerly channel is a succession of beaver impoundments with little flow and infilling characteristics.

Figure 18. View across Reach 2 showing LWD, elevated gravel bar, and stumps in mid-channel.

Reach 3 extends upstream for 2.9 km to the apex of the fan located just above the Old Lakelse Road crossing of Williams Creek. This section of the fan has always been active to various degrees. From 1949 to 1969, Reach 3 followed a relatively straight pattern with few bars or islands. Weiland and Bird's (2007) air photo analysis indicate that the channel widened in width from 37.6 to 59.3 m from 1949 to 1960, then in 1975 again increased in width to 84.6 m. Relatively large side and mid-channel bars along with log jams developed as the channel began to wander across the valley bottom, eroding the riparian area. By 1988, the channel width decreased to 69.9 m and by 2001 to 54.2 m in width, indicating a gradual recovery. Recent avulsions (2001) of Williams Creek into Sockeye Creek through major distributary channels have left up to three km of creek bed dry at times of low flow (Culp 2002).

Figure 19. View upstream on Reach 3.

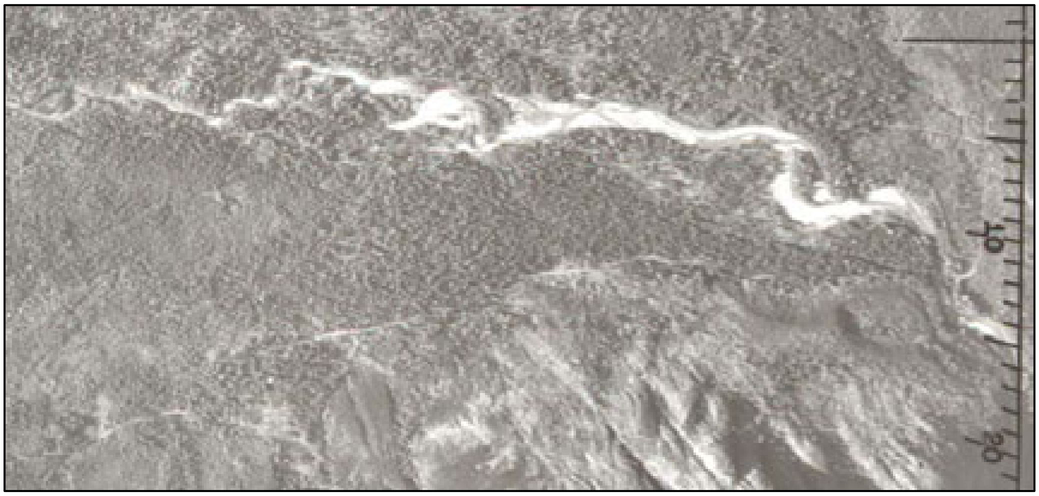

Figure 20. 1947 photo showing Reach 3.

Figure 21. 1986 photo showing Reach 3.

Figure 21 shows a 39-year difference in Reach 3 channel migration indicated by various avulsions and new channels, with an increase in width and extensive side and mid-channel bars.

4.1.2.2 Flood History

Since early 1900, Williams Creek has been noted for its flashy seasonal flows, and fishery managers have frequently noted that scouring damaged the spawning grounds. The most notable floods in the past century that likely had a significant impact on Williams Creek occurred in 1917, 1935, 1966, 1974, 1978, 1990, and 1991. Weiland and Bird's (2007) flood history records indicate that the magnitude of discharge events were generally below average between 1935 and 1955 and then remained above average until 1966. From 1967 to 1973, stream discharges were below average, from 1974 to 1978 above average, from 1979 to 1986 below average, and above average from 1987 to 1993. Williams Creek has been in a period of below average discharge since 1994.

4.1.2.3 Development History

Development on the fan began prior to 1947 with construction of what is now known as the Old Lakelse Lake Road and a bridge crossing Williams Creek in the upper portion of Reach 3. Between 1949 and 1960, logging occurred adjacent to Reach 4, and construction of Highway 37S utilized a ford in the upper section of Reach 1.

Most forest development on the fan occurred between 1960 and 1975 with streambank logging alongside Reaches 1 through 3. Logging roads cut through the riparian forests and wetlands with occasional crossings of the active channel. Williams Creek often occupied the logged riparian areas as the channel shifted laterally across the fan (Weiland and Bird 2007). In summary, forest development over the fan has been extensive, contributing to avulsion and active channel movement.

4.1.2.4 Channel Stability

The channel flowing across the fan was disturbed by riparian logging and large flood events in 1966 and 1974. Sediment accumulated from the watershed upstream of Reach 4 was transported down onto the fan and deposited primarily in Reach 3. Weiland and Bird (2007) indicate that sediment storage increased in Reach 3 by 73,000 ± 6,000 m^3/yr, which subsequently increased the width by 41%. Lateral migrations and channel braiding in this reach occurred in response to the development of sediment wedges and side bars, the majority of which now support low levels of deciduous vegetation.

Between 1975 and 1988, sediment stored in Reaches 3 and 4 was remobilized and transported to the lower channel reaches, with fine sediment eventually being deposited in Lakelse Lake. By 2001, channel widths were generally the same as in the late 1940s, as riparian vegetation covered portions of the active channel, indicating that channel recovery is moving ahead.

Figure 22. View downstream in Reach 3, Williams Creek from Old Lakelse Road Bridge.

It is apparent that Williams Creek is capable of moving sediment through its reaches relatively quickly, and any changes to bedload volume or mobility in Reach 4 will affect the reaches downstream on the fan. Deposition of bed materials transported downstream during flood events will impact the lower three reaches. The moderate to long-term outlook for channel stability on the Williams Creek fan in regard to sockeye spawning habitat is not positive.

4.1.3 Williams Creek Spawning Habitat Rehabilitation

The Lakelse Sockeye Recovery Plan is proposing investment in sockeye spawning habitat rehabilitation on or adjacent to Reaches 1 to 3. The future sediment regime and channel changes of Williams Creek are uncertain. Williams Creek is a high-energy stream where extreme flows and channel instability make it impractical to attempt rehabilitation of the main channel. However, potentially ideal sites are located on the alluvial fan where groundwater percolation is abundant and accessible. Potential Lakelse sockeye spawning habitat rehabilitation is guided by three principles: is the rehabilitation of the candidate site physically, biologically, and economically feasible?

4.1.3.1 Reach 1

Reach 1 is located from the mouth of Williams Creek at Lakelse Lake and extends approximately 2 km upstream to the confluence of Sockeye Creek. Historically, Reach 1 was the most important sockeye spawning habitat; this continues into the present. The channel is stable and there are no apparent channel disturbance indicators. There are minor riparian concerns upstream of the Highway 37 crossing. Key spawning characteristics used by sockeye such as substrate size, water depth and velocity, water temperature, and dissolved oxygen appear to be adequate.

However, gravel permeability appears to be insufficient in various sections of Reach 1. In 2007, biologists conducting escapement surveys commented on how relatively hard the substrate is: “It feels like walking on cement” (Jakubowski and Cox-Rogers 2007). It is important to note that Reach 1 frequently receives significant amounts of suitable gravel and fine sediment in high water and overbank events. Potential sockeye spawning habitat rehabilitation revolves around gravel cleaning and/or augmentation and possible off-channel spawning habitat development still to be explored.

Fine sediments are a natural component of streambed gravel. However, chronic fine sediment loading can greatly increase instream storage rather than floodplain storage, severely impacting salmonid spawning habitats. Large inputs of fine sediment to Reach 1 can result in the cementing of the substrate, which disrupts and slows down redd construction during spawning and reduces egg to fry survival by reducing inter-gravel water flow. Fine sediment deposition may also prevent fry from actually emerging from the gravel in the spring, and reduce or displace aquatic invertebrates, which may provide primary food resources. Presently, all sections of Reach 1 are compacted to some degree; variation in patchiness of sediment deposition is related to channel position and rate of flow.

In the early 1950s, a portion of Reach 3 flowed through a flood channel into Blackwater Creek. The diversion decreased flow to lower Williams Creek (Reach 1) and subsequently resulted in silting of the spawning gravel. In the late spring of 1953, blockage of the diversion increased flows, but it wasn’t until the fall freshets flows that Reach 1 benefitted from flushing flows. McDonald and Shepard (1955) note that by the spring of 1954, stream conditions had improved compared to earlier years; much of the silt and almost all of the algal growth had disappeared. Flushing of Reach 1 continued into 1955 with the appearance of the gravel showing considerable improvement.

Figure 20. View across Williams Creek Reach 1, 270 m downstream of the Highway 37S Bridge.

McDonald and Shepard (1955) report that these gravel condition changes were accompanied by modification of spawner distribution in Williams Creek. From 1952 to 1954, observations revealed a progressive shift in the concentration of spawners from the upstream Reach 3 gravel areas to those in Reach 1. From 1952 to 1954, fence count estimates of sockeye adults and of fry resulting from the spawning provided a means of determining and comparing the egg to fry survival in those years. Although the eggs deposited in 1953 were greater than in 1954, the number of fry produced in 1953 was only one-half that resulting from the 1954 seeding. McDonald and Sheperd (1955) conclude it is probable that stream improvement played a considerable role in increasing fry production from 7.8% in 1952 and 1953 to 17.2% in 1954.

McDonald and Shepard's observations were followed by a brief study conducted in Williams Creek in 1958 of average spawning gravel permeability compared to sockeye fry survivals. Twenty-three permeability readings in Reach 1 gave an average of 8,708 cm/hr (Wickett 1959). In the same two years with no or little silting, sockeye fry had a mean survival of 17%.

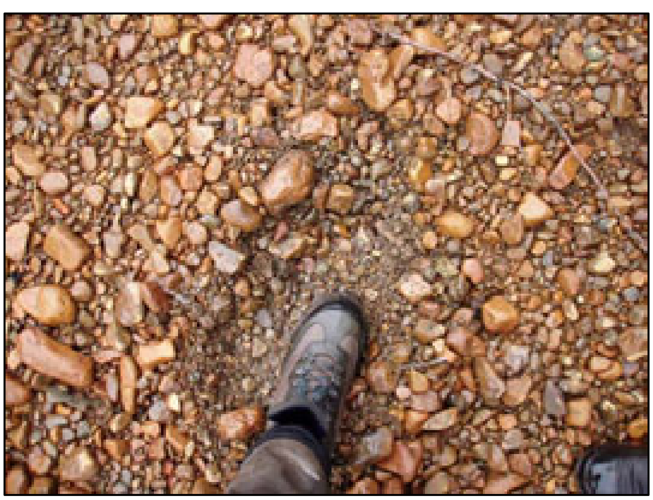

Figure 21. Photo shows typical gravel size, 350 m downstream of the Highway 37S Bridge.

A spawning gravel survey in Reach 1 will be conducted in 2008 that examines the quantity, quality, and spatial extent of suitable gravels, and inter-gravel oxygen and permeability/flow rates. This survey will also investigate whether loose well-sorted gravels overlay compacted sub-surface gravels, as well as the relative fine sediment content (percentage finer than 1 mm). Potential spawning gravel enhancement projects could include gravel augmentation to enhance discrete spawning grounds or to build spawning pads, as well as conducting gravel ripping/raking, or gravel cleaning.

There is a moderate amount of uncertainty and risk with either gravel augmentation and gravel cleaning activity. The duration and amount of project benefits resulting from gravel augmentation or cleaning would be dependent on the magnitude of future high water events. Stream flow and sediment transport could affect the project by delivering large amounts of fine through medium-size sediment, which may overlay gravel placements or move it downstream. Results from gravel cleaning projects are variable; a significant reduction in fine sediment does not guarantee increased spawning success.

An annual survey will be initiated to determine leakage flows out of Reach 3 into either Sockeye Creek or Blackwater Creek. These annual surveys will be beneficial to understanding and maintaining flushing flows.

Assessment of potential off-channel spawning habitat in Reach 1 was conducted in early 2008. Three groundwater channels were identified and investigated as to water quality attributes, substrate conditions, and fish accessibility. Surveys will include preliminary determination of the channel characteristics, conducting elevation and site plan surveys, and possibly establishing test pits and water quality standpipes in the winter of 2008-09.

In 2006, the Lakelse Sockeye Recovery team implemented a sockeye fry outplant program. In August 2006, 100,000 sockeye eggs and milt were collected from 32 females and 31 males from Williams Creek downstream of the highway bridge. Eggs were fertilized, incubated, and fin-clipped and at Snootli Creek Hatchery located near Bella Coola, B.C. In early May 2007, 98,000 sockeye fry were released into Williams Creek (Kujat 2007). In September 2007, this project continued with an estimated 100,000 sockeye egg-take, with the fry release proposed for late April 2008.

Figure 22. Williams Creek Reach 1, capture of sockeye broodstock.

4.1.3.2 Reach 2

Reach 2 is located from the confluence of Williams and Sockeye creeks upstream for 1.4 km. Reach 2 is buffered from Reach 3 by a decrease in gradient and developed distributary channels which may supply streamflow northward into Sockeye Creek, or southward into Blackwater Creek, or back into the main active channel. Reach 2 mainstem is considered high risk to rehabilitation efforts due to annual or semi-annual high water flows and the potentially high volume of sediment transferred downstream.

Historically, Reach 2 was an important sockeye spawning habitat. Between 1986 and 1993, Reach 2 has moved into and is active in its more northerly flood channel, and channel width appears to be increasing. Presently, the dominating features in Reach 2 are the large amounts of LWD and logjams and the elevated mid or side channel gravel bars. Gravels are primarily loose; though there are minor patches of relatively compacted gravels, fine sediments are infrequent. Secondary features are the distributary channels and the extensive wetlands connecting and intertwining with beaver impoundment complexes, particularly on the northern margins of Reach 2.

Figure 23. View downstream on Reach 2 approximately 220 m upstream from the confluence.

Potential rehabilitation of sockeye spawning habitat in Reach 2 revolves around assessing, restoring, or creating self-sustaining habitats in existing distributary and groundwater channels. Possible rehabilitation options need further assessment. Currently, there is inadequate understanding of the channel conditions in Reach 2, as well as uncertainty in regard to channel stability. The likeliest spawning habitat rehabilitation opportunity, the largely abandoned southerly channel, requires further assessment and surveys prior to identifying feasible candidate sites, if any.

Figure 24. View across Reach 2 to eroding banks, 110 m upstream of the confluence.

4.1.3.3 Reach 3

Reach 3 extends upstream for 2.9 km to the apex of the fan located just above the Old Lakelse Road crossing of Williams Creek. Rehabilitation of Reach 3 in-channel spawning sites is not recommended due to the flow, sediment transport regimes, and the laterally unstable channel. Field observations indicate that the highest success for establishing sockeye spawning habitat likely lies in re-establishing side-channel habitat on the alluvial fan where groundwater percolation may be expected. However, there is a limited number feasible candidate sites for suitable off-channel spawning habitat. This is due to substrate size and prevailing hydrological conditions, which include flood flows and suitable groundwater flows, as well as site accessibility.

Figure 25. View downstream over Reach 3, Williams Creek.

Several potential groundwater channel sites were investigated. Further assessments that include water quality attributes, substrate conditions, and fish accessibility to the channel are ongoing. These potential sites require baseline research studies to confirm initial assumed feasibility. Williams Creek R3-1 GW channel had initial assessments conducted in 2007, which included: 1. preliminary determination of site characteristics, 2. establishment of test pits and water quality standpipes, 3. elevation and site plan surveys. R3-1 GW channel encompasses five small channels converging into a single channel.

Figure 26. View upstream on lower section of Williams Creek R3-1 groundwater channel.

In February 2008, 10 test pits were established in the proposed Williams Creek Reach 3-1 site by T. Montague Contracting, utilizing a *CAT 320C Excavator*. Each test pit was dug to at least 3 m in depth. Test pit locations, substrate characteristics and quality, depth of groundwater, and water quality features such as dissolved oxygen, temperature, and percent saturation were documented, with results summarized in Table 4 below. Standpipes were installed and the test pits were backfilled; the standpipes will allow monthly monitoring of water depth, water temperature, and dissolved oxygen content. These attributes will help determine if channel development is feasible at the Reach R-3 site.

Test Pit Site	Substrate	DO (mg /L)	Water Temp (° C)	% Sat	Water level (cm)	Comments
I (site #1)	Cobble-boulder	10.2	2.9	76.5	90 cm	Flagging # 0 + 595 m (Allnorth Survey) and adjacent to logging marker A-26 (scored tree with orange paint and white and orange flagging). Water pouring in at 1.5 m.
C (site #2)	Sand, G/C/B	10.3	2.1	75.5	130	Adjacent to Allnorth survey flag # 0 +224 m. Ok water infiltration - not as good as pit # 1.
B (site #3)	-	-	-	-	-	Allnorth survey flag # 0 + 145 m
A (site #4)	-	-	-	-	~ 330	~ 0 + 100 m. Lots of organics in soil
3 (site #5)	Gravel, C/B/S	11.7	0.4	81.6	50	Adjacent to Allnorth survey flag # 0 + 135. 10 x the water at Site 1.
4 (site #6)	Beautiful gravel, some S/C	12.2	87.8	0.2	92	Adjacent to Allnorth survey flag # 0 + 179. Too close to river (not flood protected).
A (site #4)	Organics, some clay at 2 m	10.2	1.6	72.8	low infiltration at 150-200	Adjacent to Allnorth survey flag # 0 + 056 m. Substrate: ground to 150 cm - organics + cobble/gravel, 150 cm to 200 cm - gravel, 200cm - water and clay. Re-dug pit to place pipe in case of surface H2O opportunities.
B (site #3)	Sand w/ cobble, gravel mix	-	-	-	water at 3.36 m	East channel adjacent to Allnorth flag # 0 + 145 Test pit pipe length = 467 cm (added a piece of pipe). Small amount of water at gravel seam at 3.36 m. Too little water to do DO measurements.
2	Gravel, cobble with S/B	11.5	0.4	80.3	150 cm	~ 25 m d/s of Allnorth flagging # 0 + 109 m @ ~ 80 m. Low infiltration on all sides.
1	Sand with C/G/B	10.5	0.7	73.2	72 cm	Adjacent to Allnorth flag # 0 + 017

Table 4. R3-1 groundwater channel test pit excavation results.

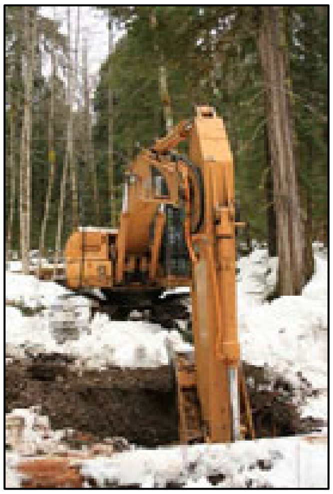

Figure 27. R3-1 test pit excavation.

Figure 28. Standpipe back-filling.

Figure 29. Standpipe installed.

In December 2007, AllNorth Consultants Ltd conducted a survey of existing conditions at R3-1 GW Channel. The survey recorded existing conditions and off-channel habitat at the R3-1 GW Channel located in Williams Creek Reach 3. R3-1 GW Channel is located downstream of the bridge on Old Lakelse Lake Road on the east bank as shown in Figure 30, which shows 'star 281' the Old Lakelse Road Bridge and 'star 276,' the outlet of R3-1 groundwater channel. At the time of the survey, two channels showed running water and three channels were dry. The survey picked up the existing and previously wetted channels in the area, enough topographic shots to create accurate contours, and the channel position in relation to the present water level in Williams Creek, as well as to Old Lakelse Lake Road. Using the plan data picked up in the field, profiles were created of all identified channels; these can help to evaluate the flow conditions through the site. The model, site plan, and profile plots can be found in Appendix 1: Maps

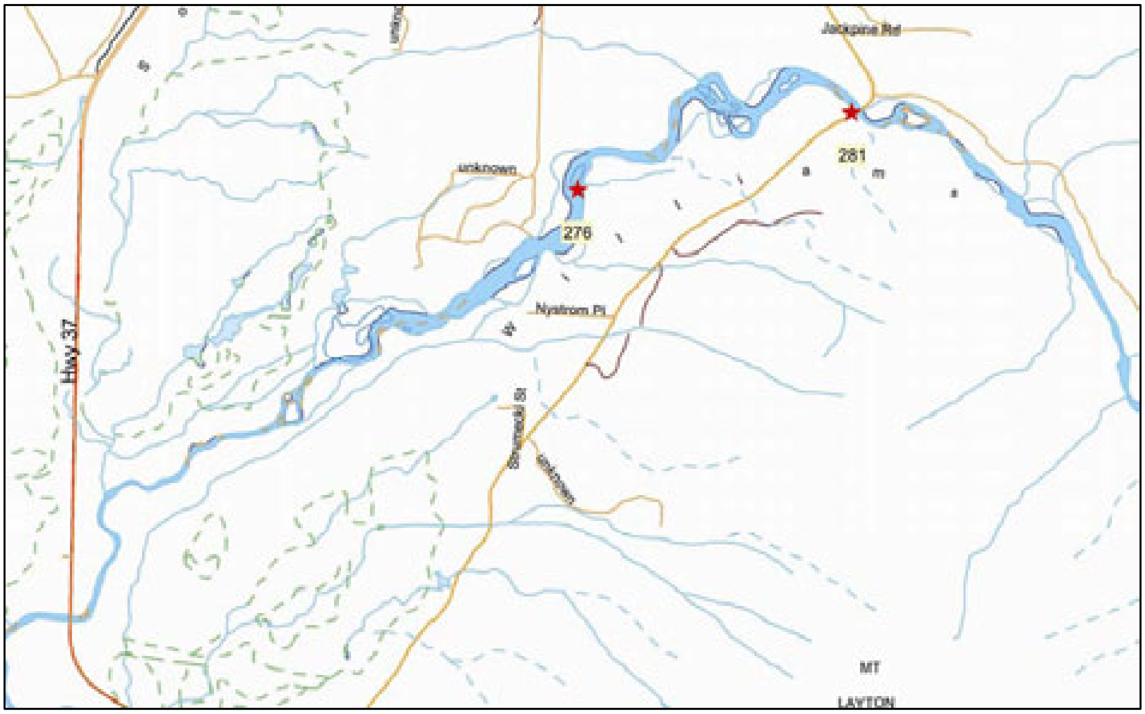

Figure 30. Map shows 'star 276' — the R3-1 groundwater channel outlet into Williams creek.

The potential limiting factors affecting the R3-1 GW Channel may be its location too far upstream of current sockeye spawning, even though it is within the range of historical spawning, and as well, the amount and quality of available groundwater flow. It may be that the channel will need to be seeded with adult sockeye spawners and possibly sockeye fry outplants. Proposed activities in 2008 include monitoring test pits attributes such as water temperatures, water levels, and dissolved oxygen levels. The location for a channel intake off the mainstem to facilitate flushing and attraction flows has been surveyed, but still remains to be designed. The feasibility of developing an in-stream incubation box and/or a small fish production facility at this site will also be examined in the near future.

In April 2008, photographic locations were established in the lower two reaches of Williams Creek. The intent is to record the channel conditions with ground-level photo documentation and provide an opportunity for re-photographic monitoring. Photo stations are positioned approximately every 100 m and include upstream, downstream, and across channel photos. Results from this initial photographic record are still in preparation.

Low-level aerial vertical photo program was conducted in April 2008. This reconnaissance level program will provide a current record of channel features and conditions. The photos were taken from a helicopter with a high resolution camera flown to produce 1:5,000 scale photos. It is intended that the photographs will be merged into mosaics used for planning, assessment and monitoring purposes.

4.2 SOCKEYE CREEK

Sockeye Creek drainage is located north of Lakelse Lake and flows into Williams Creek 2 km upstream from its mouth at the lake. Sockeye Creek is a 3rd order stream draining approximately 29.8 km^2 of equal amounts of low elevation valley bottom land and steep high elevation hillslopes on the west face of Mount Thornhill. The mainstem is roughly 8.5 km in length, and all tributaries are less than 5 km in length.

The lower two reaches totaling 5.3 km in length receive most of their discharge from the Williams Creek alluvial fan. Sockeye Creek flows between the sandur that forms Airport Hill and the western margins of Williams Creek fan. The upper reach is fed by a series of incised streams that drain the steep hillside.

4.2.1 Sockeye Creek Sockeye Abundance

Sockeye abundance records for Sockeye Creek are confused by the Williams Creek fence counts and irregular stream walks. In years the Williams Creek fence operated, Sockeye Creek counts were rolled into the Williams Creek aggregate sockeye escapement. There is also uncertainty involving early hatchery records from 1921 to 1935 as to where the egg-take fence was located. It appears to be in Williams Creek in some years and in Sockeye Creek in others. However, up into the mid-1930s, Williams Creek was frequently known as Sockeye Creek, and the current Sockeye Creek was known as Eliza Creek.

From escapement data, it appears that the decadal mean for Sockeye Creek ranges between 5-25% of Williams Creek escapement. Given the confounding situation, Figure 31 shows known sockeye escapement on Sockeye Creek. It is apparent that following the removal of Williams Creek fence in 1966, an increasingly regular escapement enumeration trend was initiated. The 7,500 sockeye recorded in 1965 appear to be a singular event. Since 1970, abundance has fluctuated at low levels.

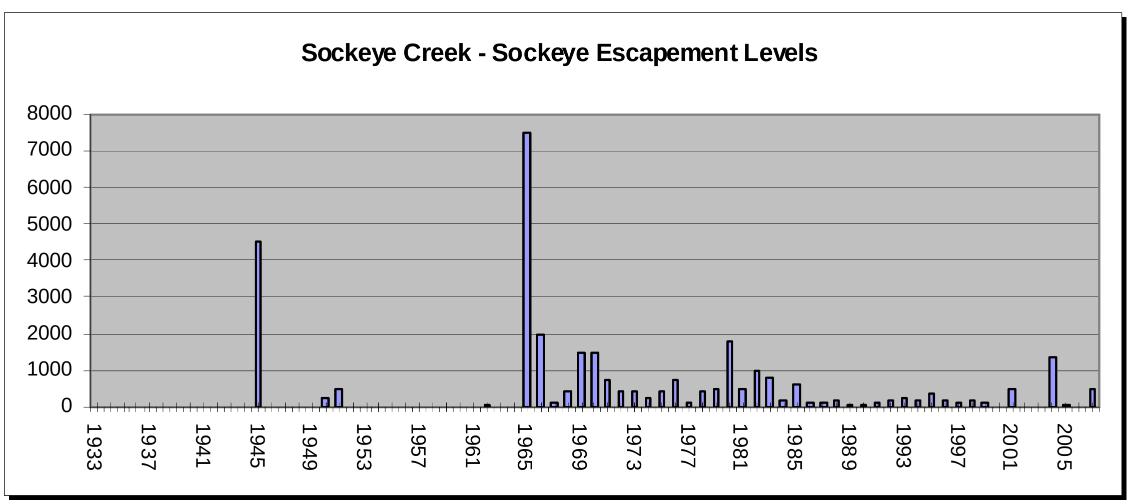

Figure 31. Sockeye Creek sockeye escapement 1933-2007.

4.2.2 Sockeye Creek Spawning Habitat

Reach 1 of Sockeye Creek extends from the Williams-Sockeye creeks confluence 1.8 km upstream and is adjacent to the highway and Powerline. Reach 1—2 break is just upstream from the road that provides access from the Highway 37S ‘chain up’ area. The overall gradient is less than 1% and the flow is primarily a quiet glide. The substrate is smaller gravel than downstream in Williams Creek, with a 50/50 mix of small gravel and fines except where flow increases and the fines are washed away. The slightly meandering channel banks are mostly composed of fine sediment and show slight erosion.

Figure 32. View across Sockeye Creek 580 m upstream of the confluence.

LWD is for the most part non-existent as the area was logged to its banks in the early 1960s, which has resulted in minimum overhead cover. The riparian vegetation has not gone back to coniferous forest since then and significant wetlands border the stream, particularly on the eastside. Observations indicate these wetlands drain through distributary channels mostly controlled by beaver activity. Note the extensive wetlands and non-forested areas above Sockeye Creek in Figure 33 below.

Figure 33. View shows Sockeye Creek—lower Reach 1. Williams Creek is on the right crossing under the powerline and Highway 37S.

Sockeye Creek Reach 2 extends upstream for 3.7 km with the reach break located at the confluence of the first major creek draining Mount Thornhill. The reach substrate is predominantly fine gravels with sand and occasional patches of fine material. The meandering channel receives moderate discharge from a network of wetland complexes located to the east that are controlled by beaver activity. Bank erosion in the main channel is slight on the outside corners, but is more extensive in the lower tributaries. Apparently, those tributaries contained major beaver impoundments that failed, resulting in relatively severe erosion. Reach 2 habitat is complex with riffles/pools/glides, and adequate LWD. The reach offers excellent sockeye and coho spawning, and as well, rearing for coho, cutthroat, Dolly Varden, and rainbow trout.

Figure 34. View downstream on Sockeye Creek Reach 2, about 110 m upstream of the reach break.

Figure 35. View of typical fine gravel in Reach 2.

4.2.2 Sockeye Creek Spawning Habitat Rehabilitation

Presently, there is no rehabilitation of sockeye spawning habitat under consideration in the Sockeye Creek drainage. Field assessments will continue to monitor ‘leakage’ of water from Williams Creek active channel into the Sockeye Creek drainage. The eastern distributary channels flowing into the lower reaches of Sockeye Creek could potentially provide off-channel sockeye spawning habitat, but beaver activity may pose a persistent, long-term liability.

Figure 36. View across Sockeye Creek Reach 2 to eastern tributary.

4.3 SCULLY CREEK

Schulbuckand (Scully hereafter) Creek drainage flows westward into the southeast corner of Lakelse Lake. Scully Creek is a 2nd order watershed with a catchment of approximately 28.6 km^2 and is composed of mostly steep, high elevation mountain sides. Elevation ranges from 78 m at Lakelse Lake to 1630 m at Gunsight Peak. Scully Creek has only one major tributary; however, many incised first-order streams contribute their discharge. The upper portion of the watershed has very high connectivity with the mainstem channel due to its primarily pinnate-style drainage pattern. As well, a lack of water storage within lakes or wetlands in the upper reach, along with a high precipitation index, indicates naturally high-peak flows.

From its headwaters, Scully Creek flows 11.5 km in a comparatively narrow valley before entering the Kitsumkalum Trough, where the creek has built up a low-gradient alluvial fan that it flows across for 3.4 km into Lakelse Lake. The fan is not well-defined; it shows a relatively flat gradient to the southern portion, then dips gently to the north. The fan was a series of wetland complexes with significant sub-surface flows until it was bisected by the highway in the 1950s, followed by channelization below the fan apex and excavation of drainage canals west of the highway.

4.3.1. Scully Creek Sockeye Abundance

Historically, Scully Creek was thought to support 12.5% of Lakelse Lake spawners, and typically escapement was 10% of Williams Creek sockeye escapement up until the 1970s. Since then, Scully Creek sockeye escapements have fluctuated from 5-200% of Williams Creek escapement. Scully Creek escapement records have existed since 1921; however, it wasn't until 1934 that comparative numbers were used. As shown in Figure 36, sockeye abundance was high in the 1940s, peaked in the 1960s, and was relatively high through the 1980s and 1990s.

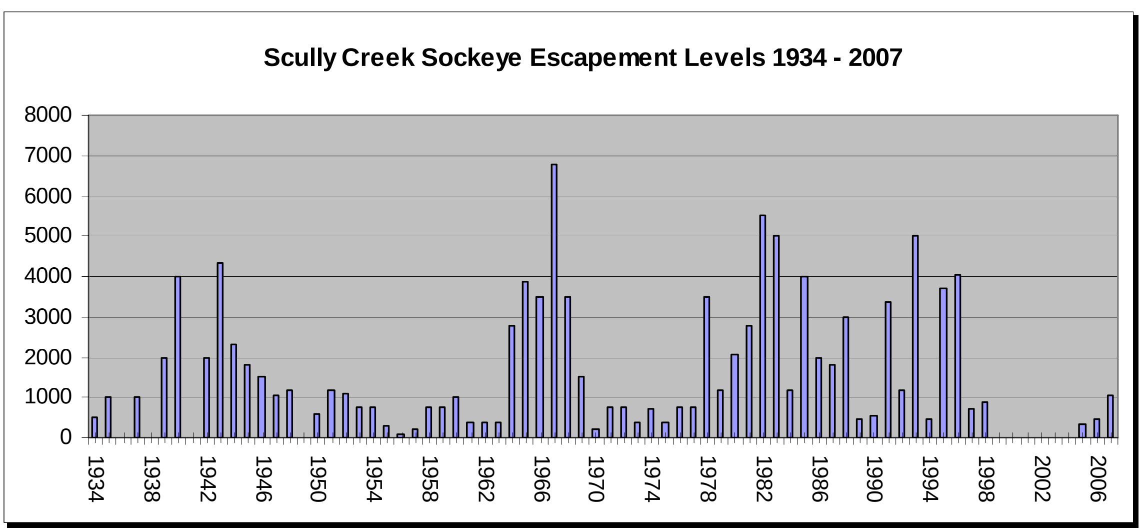

Figure 37. Scully Creek sockeye escapement.

4.3.2 Scully Creek Spawning Habitat and Rehabilitation

The story of Scully Creek sockeye spawning habitat is sad one from a fish perspective. Decisions involving land use and resource development focused on economic growth was followed by subsequent flood management activities.

Cumulative impacts have been detrimental to fish habitat with particular emphasis on sockeye spawning ground conditions.

Currently, Scully Creek has three main channels across its alluvial fan: North, Centre, and South, which reflect an intense period of channel activity from the late 1970s into the present. Karanka (1994) presents a backgrounder on land use development, flood events, and channel activity that describes events and the major channel movements.

Figure 38. Photo shows from the right to the left: Scully South, Scully Center, Scully North, and the northern drainage canal.

Scully Creek (Old Main Channel) flowed on the fan centre until the 1978 flood event, when it broke out in several places near the apex to fan right using logging roads as new channels. Subsequent flood events in 1988, 1993, and 1994 created new channels that primarily flowed to the north and then dispersed through the bush and wetlands before aggregating and coalescing with sub-surface flow along the east berm of Highway 37S.

Flood management measures were undertaken to divert flood waters from over-topping the highway and depositing water and sediment into the Mount Layton Hotsprings Resort pools, infrastructure, and vicinity (White 1994). These measures included installing culverts under the highway in 1995 and placing berms to direct water flow.

4.3.2.1 Scully Creek South - Reach 1

Scully South Creek Reach 1 is located from the mouth of Scully Creek upstream 3.2 km into a groundwater fed wetland. This low-gradient stable channel flows along the southern margin of Scully Creek fan. Historically, Scully Creek provided excellent spawning conditions for sockeye described by Foerster (1968):

> "The sockeye spawn during August and September from the mouth to 7300 ft. upstream, digging their redds in the stream bottom gravel which varies from quite fine near the lake to very coarse in the upper spawning areas. Spawning activity is greatest in areas above riffles which are formed by sunken logs. Tightly-packed gravel areas appear to be ignored by the fish. No area appears to be overcrowded and no superimposition of eggs by late spawners in redds used by early spawners was noted."

From historic air photos it is clear that most of Scully South Creek is the original mainstem channel and the prime sockeye salmon spawning area of the system prior to the 1978 flood that initiated rechanneling on the fan. The channel diversions have been identified as one of the major impacts to the system by the Lakelse Watershed Society (LWS).

Figure 39. View downstream in Scully Creek Reach 1.

The loss of flushing flows from the rechannelization events has resulted in a near-total loss of gravel recruitment and increased beaver activity. Since the early 1980s, there has been extensive construction of beaver dams and impoundments with a loss sockeye spawning grounds due to flooding and fine sediment accumulations. Other effects due to the loss of flushing flows and a general decrease in water quantity include: a loss of scour pools in association with LWD; lower egg to fry survival rates; decreased spawning opportunities; and inferior rearing habitat conditions. Riparian conditions are rated low—moderate due to logging streamside forests to the south, which resulted in blowdown into the creek as well as loss of future potential LWD. The currently usable substrate is dominantly gravel (3-8 cm) with occasional sandy patches.

Recent Lakelse Sockeye Recovery projects focused on Scully South Creek have included fish passage projects, flow augmentation, and the creation of off-channel spawning habitat. Fish passage at beaver dams in Scully South Creek has been managed with breaching during spawner migration periods. Fish passage at the Highway 37S crossing is through an elliptical multi-plate culvert, 5000 mm in width, fitted with twin fishways at its outlet, as shown in Figure 39. Replacement of the present culvert with an open bottom structure is proposed, but awaits funding.

Figure 40. View from culvert outlet downstream to fishways.

In 2004, a feasibility study was conducted to augment Scully South flows by excavating a channel to connect beaver pond and wetland complexes to Scully South. The feasibility study parameters that were explored included technical, biological and financial aspects. A topographic survey of a potential channel location was completed using a total station. This survey included water levels, cross sections from the proposed channel to mainstem Scully, channel profile, and portions of the road access.

In collaboration with BC Hydro, a hydrology study was conducted in early 2005 to determine the risks to the proposed off-channel site from high discharge rates in the upper portion of the fan. The beaver ponds and wetland complexes were sampled for water quality (dissolved oxygen, temperature), and fish presence-absence surveys captured many juvenile coho and Dolly Varden.

In 2005, DFO—under the auspices of the Lakelse Sockeye Recovery Plan, and in collaboration with the Lakelse Watershed Society—implemented a flow augmentation project. This project installed a sheet-pile dam to control flow augmentation; spawning channels were excavated, LWD was positioned for structure and cover, and the banks were seeded to manage erosion and planted with coniferous trees to support future cover and FWD needs (Miller and Kujat 2007).

A monitoring program was established to assess storage and flow capacity, as well as experimenting with staged freshets and assessing any downstream effects from introducing flushing flows. Spawning potential measured as incubation success in the excavated channel will be examined. An as-built survey was conducted in early 2007 that will assist in evaluation and monitoring changes to the site over time.

To improve spawning conditions in Scully South Creek, a survey will be conducted in 2008 to determine the feasibility of augmenting base flows with water from the apex of the fan. The survey will map the topography and existing conditions in order to create a plan view including contours and a profile of the most feasible and practical route.

Figure 41. View upstream on recently established spawning channel.

Figure 42. Water augmentation dam and supply for the spawning channel shown above.

4.3.2.2 Scully Center Channel – Reach 1

Scully Center Channel is located from Lakelse Lake upstream for 1.6 km to Highway 37S. The channel was excavated between 1986 and 1993 and runs through agricultural fields. The channel profile has V-shaped banks, approximately 3 m in height that have been extensively rip-rapped. The substrate is composed predominantly of anoxic marine clays with occasional patches of sand and silt and infrequent riffle areas with cobble and gravel.

At roughly 100 m spacing, log weirs span the channel creating glides upstream and plunge pools downstream. The logs used for the weirs are 0.3—0.5 m in diameter and either let into the bank or placed upstream of pilings to maintain their position. Some of the log weirs are undermined and lie above average flows.

Sockeye spawning rehabilitation in Scully Center Channel includes spawning platforms, gravel nourishment placements, and test incubation boxes. Scully Center Channel was surveyed in 2007 to map the topography and existing conditions in order to create a plan view, including contours and profile of the channel and of adjacent upstream and downstream sites. This will facilitate installation of pilot spawning platforms in mid to late-July 2008. Three spawning platforms will be constructed with a total lineal length of 200 m.

Incubation studies consisting of hydraulic sampling and test incubation boxes will continue in order to examine egg/alevin survival rates. Incubation studies will likely increase in scope in 2008 with placements in the newly constructed spawner platforms and in a natural setting such as Scully South Creek. This incubation study will utilize Jordan/Scotty incubators, developed to provide an efficient aid in the stream incubating of salmon eggs. The unique design minimizes most of the problems experienced by natural spawning such as fungus infection, predators, and silt suffocation.

Figure 43. Perpendicular log weir spanning Scully Center Channel.

Figure 44. View downstream on Scully Center Channel.

4.3.2.3 Scully North Channel – Reach 1

Scully North Channel is located from Lakelse Lake upstream for 1.3 km to Highway 37S. The channel was excavated prior to 1973 and expanded between 1986 and 1993; it presently flows amidst cultivated fields. The channel profile has V-shaped banks 3 m in height composed of highly erodible silt and clay that have been rip-rapped in several areas. The substrate is predominantly clay and silt with occasional patches of gravel, such as the 160 m section downstream of Highway 37S. That section of channel is at a slightly higher gradient and is likely the only preferred spawning locale in Scully North Channel as evidenced by redds.

Scully North Channel has log weir installations similar to those in Scully Center Channel. These are spaced roughly 100 m apart and span the channel, creating glides upstream and plunge pool downstream. Plunge pools depths are deeper, averaging 1.45 m. Some of the log weirs are undermined while others have caused bank erosion. Triton (1998) documents coho spawners and coho and cutthroat trout juveniles. Proposed sockeye spawning rehabilitation is limited in scope to the potential installation of pilot spawning platforms, if the Scully Center Channel evaluation records sustained growth in annual sockeye fry recruitment.

Figure 45. View on Scully North Channel downstream from the highway culvert outlet.

4.4 GRANITE CREEK

Hatchery Creek is the gazetted name for this stream; however, the local name in use is Granite Creek and hereafter will be referred to Granite Creek. Granite Creek is a 2^{nd} order stream located on the eastside of Lakelse Lake and drains its westward-facing basin that encompasses 31 km^2. The mainstem is approximately 11.75 km in length, and the apex of the fan is located 1.6 km upstream from the lake. From the apex, which is located about 150 m above Highway 37S, the very large, low-angle fan-delta has built out into the lake at the mouth of Granite Creek and to a width of 2.4 km along the lakeshore.

Similar to Scully Creek, the upper portion of the watershed has very high connectivity with the mainstem channel due to its drainage pattern. In addition, the lack of water storage in lakes or wetlands in the upper reach, coupled with a high precipitation index, indicates naturally high-peak flows.

Prior to the late 1950s, there were numerous old distributary channels spread over the slowly aggrading fan. During floods, much of the flow would escape from the main channel and spread over the fan in the distributary (flood-relief) channels. It is likely that both incoming sediment and log jams played a role in causing channel changes into or out of the distributary channels. The steep, stream-cut escarpments along upper Granite Creek experience occasional debris slides, which, along with avalanches, deposit LWD into the channel.

It is reported that in 1956, the Department of Highways blocked off a distributary which had been a major flood relief channel upstream of the present Highway 37S (Coulter 1976). This action was the initial cause of subsequent flooding. Flood events over the next 20 years gradually increased the damage to roads and property. The major flood in 1978 caused massive erosion and debris transport over the entire length of the channel and into the lake. In 1979, the channel was widened and dykes were constructed. The creek continues to move high levels of bedload. Currently, these dykes, constructed on either side of the channel, concentrate all the flow to the single outlet as shown in Figure 46.

Figure 46. View upstream on Granite Creek from above the lake.

4.4.1 Granite Creek Sockeye Abundance

There are no clear escapement records pertaining to Granite Creek sockeye. There are scattered references that range from a high of 11,000 in 1940 to a low of 65 in 1952. There is no doubt that 1940 was a banner year for sockeye in the Lakelse system with Williams Creek recording 27,000, Scully Creek enumerating 9,000, and North Granite 4,000 sockeye. It is apparent there were years with high sockeye abundance in Granite Creek. The last known Granite Creek escapement record is 65 sockeye in 1952. In the Annual Spawning Report for Lakelse Lake Watershed, Strachan (1932-1946) notes the following Granite Creek sockeye escapement:

> **1940** "Granite Creek was inspected on Sept. 22nd. Very few sockeye salmon were on the spawning beds then and most of them had spawned out and died by Sept.22nd. F.M Hall, Fishery Guardian, estimated 11,000 sockeye salmon on the spawning beds by Sept 4th. They were of a good size with few runts amongst them. The

escapement was better than the cycle years of 1935-36. No obstructions were observed."

1944 "The seeding of sockeye salmon to Granite Creek was light, only about 1000 sockeye salmon were on the spawning beds during the season, this very poor compared to the cycle year of 1940 when 11,000 sockeye salmon had ascended to the spawning beds. This is a small stream and would consider 11,000 sockeye salmon too much for the spawning beds."

1946 "The escapement of sockeye salmon to Granite Creek was poor only 100 sockeye salmon were on the spawning beds, this is much lighter than the cycle year of 1942 when the escapement was very good approximately between 4000-5000 sockeye salmon were on the spawning beds, males and females were evenly divided."

4.4.2 Granite Creek Spawning Habitat and Rehabilitation

Reach 1 of Granite Creek extends from the lake upstream for 1.6 km to Highway 37S and was the preferred spawning habitat for sockeye. Presently, it is confined between dykes, and the substrate is composed of large gravel and cobble. In Reach 1 the large amounts of bedload movement and transport, along with the average 80 m width, cause low and moderate discharge level flows to go sub-surface, thus creating a fish passage problem. The relatively large substrate size is evident in Figures 47 and 48.

Figure 47. View upstream on Granite Creek from the 1st Avenue Bridge.

Channelization has affected the hydrologic regime in Granite Creek and the other streams on the fan. Degraded habitat conditions and channel instability are a result of concentrating the stream flow and modifying the channel structure and process. Restoration will require reconstructing the channel planform, cross-section, and profile. This will require dedicating land and water resources to Granite Creek habitat restoration and is beyond the scope of the current Lakelse Sockeye Recovery Plan.

Sockeye habitat rehabilitation proposed for Granite Creek includes developing a proposed groundwater channel. In 2005, a survey was conducted upstream of 1st Avenue Bridge enabling the mapping of the topography and existing conditions in order to create a plan view, including contours and profile of the channel and adjacent sites upstream and downstream.

The intent of the survey was two-fold: 1) to help finalise plans for a proposed groundwater fed sockeye spawning channel and 2) to assist in planning an intake that could provide flushing flows into Hatchery Creek, which is located slightly to the north. Currently and into the short-term, the monitoring of test pits installed in 2005 upstream of the 1st Avenue Bridge is being continued. The monitoring consists of collecting water quality and flow attributes at the area shown in Figure 47.

Figure 48. View downstream on Granite Creek from the Highway 37S Bridge.

Figure 49. View upstream of Granite Creek and 1st Avenue Bridge.

4.5 HATCHERY CREEK

There is no gazetted name for this stream; however, the local name in use is Hatchery Creek and hereafter it will be referred to as Hatchery Creek. Other common names for this creek appearing on maps and in text include North Hatchery Creek and North Granite Creek.

In the past, Hatchery Creek functioned as the main as well as a distributary channel of Granite Creek. Prior to channelization of Granite Creek in the late 1950s, Hatchery Creek was approximately 1.2 km in length from the lake upstream to its confluence with Granite Creek. Coulter (1976) reports that Hatchery Creek was blocked by gravel and debris in 1958. In 1979, Fishery Officer Reports note that North Granite Creek was completely re-routed to protect houses from flooding and fish values were virtually eliminated (Nelson 1979). Northwest Hydraulic Consultants (1987) report logging on the fan that affected Hatchery Creek channel for 500 m, upstream of 1st Avenue.

Currently, Hatchery Creek is groundwater fed, and there are no fish passage concerns until the relatively large, well-established beaver dam is encountered, 225 m upstream of the 1st Avenue crossing. The creek averages 5 m in width with a coarse gravel-cobble substrate. The 1st Avenue crossing is an open-bottom concrete box culvert, 2.5 m in width and 1.2 m in height, that functions well.

Figure 50. View upstream of Hatchery Creek from the 1st Avenue crossing.

4.5.1 Hatchery Creek Sockeye Abundance

Sockeye escapement records for Hatchery Creek are few: in 1945 a light run was recorded, in 1946 50 were enumerated, and in 1952 there were 30 sockeye. There are no known recent escapement records.

Wisley (1919) reports in 1919:

> On September 23rd I went up the four small tributaries of Granite Creek; they all branch off about a mile and a half above the lake. There was no salmon above that point, as the creek bed is very rough and filled with large rocks and boulders. I saw a fair number below the forks.

Gibson (1920) reports:

> Granite Creek branches off below the hatchery in five different streams on its downward course to the lake. Each little stream is too small to be of any importance for spawning.

Hearn (1929) reports in 1929:

> "The smaller tributaries (with the exception of Salmon Creek in which planting operations were also carried out and which had its usual showing of fish) had practically no return fish this season, only a few at any time were seen off the mouths of either Hotsprings or Granite Creeks"

4.5.2 Hatchery Creek Spawning Habitat and Rehabilitation

Presently, Reach 1 of Hatchery Creek extends from the lake upstream for approximately 800m. Presently, Reach 1 is accessible to fish for about 565 m, at which point fish passage is blocked by a large beaver dam.

In 2005, habitat and topographic surveys were conducted in the creek to finalise plans for habitat improvements. These surveys identified areas of silt accumulation and small woody debris jams to be removed. It was also determined that sufficient large woody debris existed in the creek, so the plan to add more LWD to the creek was discontinued. Temperature data loggers were placed in order to add water quality information to baseline data. The topographic survey included Hatchery Creek from the 1st Avenue Bridge upstream to the section beyond the large beaver pond (Miller and Kujat 2006). The survey enabled mapping of the topography and existing conditions of the creek channel, the proposed groundwater channel, and various test pit areas.

Beaver dams, small woody debris jams, and silt accumulations were removed by excavator, and by hand where machine access into the channel was limited. Figure 51 shows the results of this work and where additional streamflow from breached beaver impoundments has cut through and helped flush silt downstream. Silt that was not removed in this phase was flushed out by fall freshet flows. In 2006, four test pits and a groundwater channel were excavated and LWD was positioned to provide initial cover for fish. 75 m^3 of screened pit-run gravel were placed and configured into spawning platforms through the channel. As a result of channel construction, downstream flows appear to have doubled. Monitoring activities include an as-built survey, a post-construction assessment, and on-going spawner and redd surveys (Miller and Kujat 2006).

Figure 51. View downstream on Hatchery Creek stream habitat improvements.

Figure 52. Hatchery Creek Groundwater channel with LWD placements.

In 2008, proposed habitat improvement projects in Hatchery Creek include a feasibility study of additional water augmentation, and an egg incubation investigation into egg to fry survival rates. The incubation study will utilize Jordan/Scotty incubators, which will provide an efficient aid in the stream incubating of salmon eggs. Monitoring of sockeye spawners and their redds will continue in 2008 and on an annual basis thereafter.

4.6 SALMON CREEK

There is no gazetted name for this stream; however, the local name in use is Salmon Creek and hereafter it will be referred to as Salmon Creek. The only other common name showing on some ca. 1950s maps is Wylie Creek.

Salmon Creek was the major distributary channel of Granite Creek that was cut off by Highway 37S construction in 1956 (Coulter 1976, Northwest Hydraulic Consultants 1987). Apparently, blocking off Salmon Creek was the cause of subsequent flood damage, and later flood control measures that led to the channelization of Granite Creek. The channel was cut off approximately 150 m upstream of the present highway crossing.

4.6.1 Salmon Creek Sockeye Abundance

The only known escapement records for Salmon Creek are the archival records that start in 1922, when Fishery Overseer Hopkinson (1922) reports:

> "Salmon Creek which only small will also be well seeded. The creek is only about a quarter mile long and narrow. Mr. Catt took about 500,000 eggs from this creek and also allowed quite a number of Sockeye to get through the traps. As at Williams Creek several schools were observed at the mouth".

Eaton reports in 1923:

> "Sockeye run at Scallabuchan and Hot Springs creeks ended about middle of Sept., but large schools at the mouths of Williams and Salmon Creeks as late as Oct. …..The last run of Sockeye at Williams and Salmon creeks, the females large, and weighing 9½ lbs. and a great many weight 7 lbs. Male small few weighing over 4½ lbs."

Hearn reports in 1925 - 1930:

> **1925:** "Salmon Creek: Run compared favorably to that of last year, only 91,000 eggs taken, fences opened Aug. 17th allowing large numbers of fish to proceed upstream."
>
> **1929:** "The smaller tributaries (with the exception of Salmon Creek in which planting operations were also carried out and which had its usual showing of fish) had practically no return fish this season, only a few at any time were seen off the mouths of either Hotsprings or Granite Creeks."
>
> **1930:** "All tributaries frequented by this species will be exceptionally heavy seeded, hoped no severe freshets to affect the successful natural seeding."

Strachan reports from 1932 to 1946:

1932 "Salmon Creek. A small creek entering the lake on the east side with a spawning bed of about one half mile. The escapement of sockeye was medium, showing an improvement over the 1928 cycle. Females and male evenly divided."

1933 “A very light seeding took place here. About the same as 1928 and light compared with 1929."

1934: "Sockeye. Aug 17. Spawning beds small, approx 1/2 mile long, approx 250 fish on spawning grounds, males outnumbered females 3 to 1. Water low. Hatchery collection 212,500 eggs."

1935: "Salmon Creek-Sockeye-Sept 1. Inspected 1/2 mile, about 200 fish seen, males outnumbering females two to one. Spawning beds small in this stream."

1936: “Salmon Creek-Sockeye-Sept. 9. Inspected for 2 miles, very heavy run of fish seen on the beds, mixed variety; males outnumber females 2-1, little damage has been done by the fall freshet of 1935 or spring freshet of 1936. Seeding better than cycle year of 1932.”

1939: "Salmon Creek was inspected on Sept 1st, a very heavy run of sockeye salmon was observed on the spawning beds of this stream, considerable damage was done by bears and would say that only a fair seeding took place, a large number of sockeye were destroyed by bears before they had spawned, sockeye salmon eggs were scattered all over the creek and numbers of dead sockeye salmon were also seen on the banks of the streams that had not spawned, no obstructions were observed, approximately 2000 sockeye in this stream. conditions for spawning satisfactory."

1940: “The inspection of Salmon Creek was carried out on Sept. 22nd. A light run of sockeye salmon was observed at this time with a small school of sockeye just entering the stream. On Sept. 4th, F.M. Hall, fishery Guardian, observed 9000 sockeye salmon on the spawning beds, but most of them had spawned and died by the time of his inspection. The sockeye were a good size with a few runts amongst them. The escapement was better than the cycle years of 1935-36. No obstructions were observed.”

1941: “Light seeding. Brood year medium. Decrease.”

1942: “The run of sockeye salmon to Salmon Creek at the time of this inspection was light. Only 500 were observed. The water was low and a small school was showing at the mouth. Fishery Guardian F.M. Hall states that a late run of sockeye had entered this stream bringing the number to approximately 2,000 on the spawning beds. Males and females were evenly divided. No obstructions were observed.”

1943: “The run of sockeye salmon to Salmon Creek was fair, approx. one thousand sockeye salmon were observed, this just half of the cycle year of 1939 when 2000 sockeye salmon were estimated on the spawning beds, males and females were evenly divided, bears had also done some damage as dead sockeye could be observed on the banks. No obstructions were observed.”

1944: During this inspection no sockeye salmon were observed in Salmon Creek, in the cycle year of 1940. Fishery Guardian F. Hall kept close watch and an estimated 9,000 sockeye salmon were on the spawning beds, salmon creek is a very small stream, no obstructions were observed.

1945: “The escapement of sockeye salmon to Salmon Creek was light only a few sockeye's were observed on the beds, this is lighter than

> the cycle year of 1941. None were observed lying off the mouth of this stream. No obstructions were observed."
>
> **1946:** "The seeding of sockeye salmon to the spawning beds in Salmon Creek was light only about 50 sockeye salmon were observed, this is much lighter than the cycle year of 1942 when approximately 2000 sockeye salmon were on the spawning beds, males and females were evenly divided."

Sockeye abundance was relatively modest in the 1930s compared to the 1940s. It is hoped that further research may bring more recent escapement records to light.

4.6.2 Salmon Creek Spawning Habitat and Rehabilitation

Presently, Reach 1 of Salmon Creek extends from the lake upstream for approximately 800 m and is mostly groundwater fed with minor amounts of surface flow from wetlands. At low flows, fish passage can be partially blocked by private driveways lacking adequate flow structures, such as the twin 500 CMPs shown in Figure 53.

Figure 53. View downstream from 1st Avenue to private crossing on Salmon Creek.

The culvert passing Salmon Creek under 1st Avenue is an open-bottom arch culvert, 2.8 m in width, which functions well. The gravel from the road shoulder is sloughing into the outlet and will likely get flushed downstream. Other than renewal of the 1st Avenue culvert crossing, there has been no spawning habitat rehabilitation.

In 2008, habitat and topographic surveys of the creek channel and adjacent areas will be conducted to plan habitat improvements. Following these surveys, test pits will be excavated upstream of the current watered channel to assess the feasibility of flow augmentation possibilities. If the habitat and test pit assessment results prove positive, a water augmentation project will be prioritized.

Figure 54. View upstream on Salmon Creek from 1st Avenue.

Figure 55. View upstream to Salmon Creek-1st Avenue culvert outlet.

5.0 LAKELSE SOCKEYE RECOVERY WORKSHOP

In October 2007, Resource Restoration experts Mel Sheng and Matt Foy along with approximately 30 restoration practitioners traveled to Terrace, BC to participate in a workshop that featured Lakelse sockeye spawning habitat rehabilitation and enhancement. The team reviewed air photos and historical data then conducted field work in the Williams, Scully, and Granite/Hatchery watersheds. Field work focused on investigating feasible options for improving spawning and incubation habitat for Lakelse sockeye. This was followed by discussions and review of potential sockeye rehabilitation options. Subsequent recommendations offered by the group include:

5.1 POTENTIAL SOCKEYE SPAWNING REHABILITATION OPTIONS

Year 1 (2007/08)

1) Explore feasibility of pilot gravel spawning platforms in the Hotsprings Channels of Scully Creek and develop designs (completed).
2) Survey potential channel opportunities and a river intake site for spawning channel in Williams Creek Reach 3 (completed).
3) Excavate test pits in potential spawning channel in Williams Creek Reach 3 and monitor temperature and water quality for 1 year (test pits completed, monitoring is ongoing).
4) Continue to monitor test pits in Granite Creek off-channel site (ongoing).

Year 2 (2008/09)

1) Install spawning platforms in Hotsprings Channels of Scully Creek and monitor spawning and incubation success (funded by PSC for 2008/09).
2) Monitor Williams Creek Reach 3 test pits and develop channel designs and proposal if results are promising (ongoing).
3) Explore feasibility of surface water pipeline from Scully fan apex to Scully groundwater channel to provide flushing and attraction flows (funded by PSC for 2008/09).

Year 3 (2009/10)

1) Install additional spawning platforms in Scully Hotsprings Channels if pilot gravel placements are functioning well.
2) Develop off-channel spawning habitat in Reach 3 of Williams Creek if test pit results are promising and seed with fertilized (eyed) eggs and adults.
3) Explore feasibility of developing a small enhancement facility on Williams Creek (streamside incubators, etc.) in the vicinity of the groundwater channel opportunities.

Year 4 and beyond (2010/11)

1) Continue monitoring developed projects for spawning and incubation success.
2) Continue reconnaissance and feasibility investigations of potential projects to increase the productive capacity of sockeye in the Lakelse watershed.

6.0 LAKELSE SOCKEYE SPAWNING HABITAT REHABILITATION

Over the course of this project, recommendations have been developed focused on rehabilitating sockeye spawning habitat and improving sockeye fry recruitment. These have been made based on: reviews of historical and current data; anecdotal observations by enumeration crews, field workers, and biologists; as well as the recommendations from the Lakelse Recovery Workshop. The recommendations presented by sub-basins below have not been prioritized or sequenced.

6.1 WILLIAMS CREEK REHABILITATION RECOMMENDATIONS

1) Install turbidity and sediment meters in lower Reach 1 of Williams Creek to determine when and how much turbidity contributes to the substrate.
2) Install a temperature and stage height data logger on lower Williams Creek.
3) Conduct annual ground level in-channel photographic monitoring.
4) Conduct a gravel permeability and embeddedness survey on Williams Creek Reach 1.
5) Consider gravel cleaning or augmentation in Williams creek Reach 1.
6) Investigate groundwater fed, off-channel spawning opportunities in Williams Creek Reach 1 and 2.
7) Monitor water quality in Williams Creek Reach 3 test pits.
8) Survey Williams Creek annually for possible leakage flows into the Sockeye and Blackwater drainages.
9) Conduct spawner enumeration surveys in Williams Creek.
10) Evaluate effectiveness of the Williams Creek fry outplant program.
11) Determine if a beaver management plan is required to secure fish passage.

6.2 SOCKEYE CREEK REHABILITATION RECOMMENDATIONS

1) Install turbidity meters in lower Reach 1 of Sockeye Creek to determine when and how much turbidity contributes to the substrate.
2) Install a temperature and stage height data logger on lower Sockeye Creek.
3) Conduct annual ground level in-channel photographic monitoring.
4) Conduct a gravel permeability and embeddedness survey on Sockeye Creek Reach 1.
5) Conduct spawner enumeration surveys in Sockeye Creek.
6) Determine if a beaver management plan is required to secure fish passage.

6.3 SCULLY SOUTH CREEK REHABILITATION RECOMMENDATIONS

1) Install a temperature and stage height data logger on lower Scully South Creek.
2) Examine feasibility of piping water from the Scully fan apex area to Scully groundwater channel to provide flushing and attraction flows.
3) Conduct an egg incubation trial in the excavated groundwater channel.
4) Assess possible groundwater flows to augment the mainstem flows.
5) Prepare a beaver management plan.
6) Plan for and install spawning gravels into the lower reach.
7) Replace the Highway 37S culvert and twin fishways with an open bottom structure.
8) Conduct a riparian assessment to determine future LWD and streambank cover on Reach 1.
9) Conduct a sediment source review and stream crossing survey in the developed upstream reaches.

10) Conduct spawner enumeration surveys in Scully South Creek.

6.4 Scully Center Channel Rehabilitation Recommendations

1) Install spawning platforms.
2) Assess LWD requirements to provide channel structure and overhead cover.
3) Assess streambank to determine stabilization and riparian conditions needed, if any.
4) Consider fry outplants or spawner seeding to accelerate spawning platform results.
5) Evaluate spawner and egg to fry survival success.

6.5 Scully North Channel Rehabilitation Recommendations

1) Survey, plan, and install spawning platforms or augment spawning gravel as needed.
2) Assess LWD requirements to provide channel structure and overhead cover.
3) Assess streambank to determine stabilization and riparian conditions needed, if any.
4) Consider fry outplants or spawner seeding to accelerate spawning platform results.
5) Evaluate spawner and egg to fry survival success

6.6 Granite Creek Rehabilitation Recommendations

1) Assess current groundwater monitoring and if feasible, install a groundwater fed channel.
2) Develop long-term thoughts on how to dedicate water and land resources to initiate restoration, or re-instate the hydrological and biological functions on Granite Creek fan, including Salmon, Hatchery, and South Granite creeks.

6.7 Hatchery Creek Rehabilitation Recommendations

1) Conduct an egg incubation evaluation to determine egg to fry survival success from the established groundwater channel.
2) Investigate possible flushing flow mechanisms utilizing water from the large beaver impoundment.
3) Conduct a feasibility study of additional water flow into Hatchery Creek.
4) Evaluate spawner access into the established groundwater channel.
5) Develop a fish passage protocol with private property holders.

6.8 Salmon Creek Rehabilitation Recommendations

1) Work with land owners to improve fish passage concerns.
2) Establish abutments at the 1st Avenue culvert crossings to mitigate road shoulder sediment sloughing into the creek.
3) Conduct a habitat survey to plan potential spawning habitat improvements.
4) Conduct a topographic survey to facilitate planning of spawning rehabilitation.
5) Install test pits to assess the feasibility of flow augmentation.
6) Consider fry outplants or spawner seeding to accelerate fry recruitment.

6.9 Lakelse Watershed Sockeye Rehabilitation Recommendations

1) Geo-reference low-level aerial photographs to facilitate planning and habitat assessment projects.

2) Establish round table discussions between stock assessment and habitat biologists to update and review recent findings, present evaluation and monitoring results, and re-focus if necessary.
3) Continue and increase communications with plan stakeholders.
4) Continue and increase communication with the public in regard to completed and proposed rehabilitation activities.
5) Develop a database that includes all project data and is easily accessible.
6) Continue monitoring and evaluating effectiveness of completed projects.
7) Assess Furlong, Hotsprings/Mountain, and Blackwater Creeks for potential sockeye spawning rehabilitation.
8) Conduct spawner enumeration surveys in Blackwater Creek.
9) Educate government agencies, decision-makers, and the public of the importance of protecting and conserving salmon ecosystem processes and salmon habitat compared to rehabilitating broken systems and degraded habitat.

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