Harrison River Watershed Habitat Status Report

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EXECUTIVE SUMMARY

Fisheries and Oceans Canada adopted the Wild Salmon Policy (WSP) for the conservation of wild Pacific Salmon in 2005, with the overall goal of restoring and maintaining healthy and diverse salmon populations and their habitats. Strategy 2 of WSP requires the assessment of habitats associated with salmon Conservation Units (CUs). The purpose of this document is to summarize the habitat conditions impacting salmon CUs in the Lower Harrison River Watershed (LHW), to select habitat indicators appropriate to the watershed and conservation units, and to identify existing reports to inform habitat status.

The Lower Harrison Watershed is the southernmost and downstream portion of the 8,324 km^2 Harrison-Lillooet watershed. Nine salmon Conservation Units are known to occupy 32 named habitats in the watershed, 17 of which are addressed in this document. The geographic scope of this project and preliminary identification of high-value habitat were determined from the Province of British Columbia Integrated Land Management Bureau's (ILMB) online mapping system iMap. Potential habitat indicators were selected based on the habitat type. Given the geographic scope of the work, and the presence of distinct conservation units in multiple sub-habitats, information was organized geographically. Interviews were conducted with DFO staff, as well as staff from the Regional District, Municipalities, and knowledgeable locals.

It was beyond the scope of this project to analyze raw data to inform habitat conditions, but we have identified available raw data that can be compiled into useful habitat status indicators. Land cover data is available for the watershed, albeit out-of-date. Water licenses in the watershed are mostly held by Fisheries and Oceans Canada, however new water licenses have been sought or obtained by independent power producers (IPPs) on several streams in the LHW, which will impact flow patterns in affected streams. LHW tributaries are naturally oligotrophic and although agricultural / urban pollutants are insignificant in much of the watershed, the southern portion is recipient to non-point and point-source pollution. Long-term temperature data is available from six habitats; where compiled, temperature data consistently indicated summer temperatures at levels stressful to fish. Tipella Creek was the only drainage in which known temperature data did not show stressful summer temperatures. Eleven high-value salmon streams in the LHW in the lower portion of the LHW are estimated to have critically low flows below the mean annual discharge benchmark for instantaneous flow for survival of most aquatic life. Those tributaries in the upper portion of the LHW all maintain adequate or good low flow summer habitat. Sakwi Creek is the most vulnerable to discharge instability, due to its denuded headwaters and high extraction allowances.

The most severe limiting factors in the Harrison Watershed result from excessive forest harvesting and the related channel instability, road density, riparian removal, and water temperatures increases. Impacts predicted due to climate change will further affect water temperatures and flows, reducing the availability and quality of habitat for alevin, fry and spawners. Nutrient availability in streams is low and may become a limiting factor if not replenished by returning adults. Water extraction from IPPs will impact flow patterns, and should be carefully monitored to ensure impacts to downstream spawners and eggs are minimized.

Forest harvest is the most significant land use in the LHW, and information regarding percent of watershed logged is out-date and sometimes conflicting. B.C. Ministry of Forests and Range maintains maps and archives of completed and planned forest harvest, and should be approached to access the data for analysis. By compiling statistics regarding road densities and forest harvest in the LHW, habitat managers would have the ability to infer a wide range of habitat status indicators, including riparian connectivity, water temperatures, and flow stability.

TABLE OF CONTENTS

List of Figures

List of Tables

1 Introduction

Fisheries and Oceans Canada adopted the Wild Salmon Policy (WSP) for the conservation of wild Pacific Salmon in 2005, with the overall goal of restoring and maintaining healthy and diverse salmon populations and their habitats. Strategy 2 of WSP requires the assessment of habitats associated with salmon Conservation Units (CUs). A two-stage approach of habitat status indicators, metrics and benchmarks were identified in Stahlberg et al. (2009) to provide a standardized pool of indicators for long-term monitoring of the quantity and quality of key salmon habitats. “Pressure” indicators access information at a large-scale using primarily remote information such as road densities and riparian connectivity to inform regional decision-making. In CUs where pressure benchmarks have been exceeded, “state” indicators will provide detailed descriptions of the condition of specific salmon habitats.

The purpose of the Lower Harrison Watershed Habitat Status Report is to summarize the habitat conditions impacting salmon CUs in the Lower Harrison River Watershed (LHW), to select habitat indicators appropriate to the watershed and conservation units, and to identify existing reports to inform habitat status. For each CU, we identify important habitat in need of protection to maintain salmon productivity, identify risks and constraints that may adversely affect productivity, identify areas where habitat restoration or rehabilitation would be desirable to enhance productivity, select habitat indicators, identify and assemble existing data pertaining to those habitat indicators, and identify potential habitat restoration / enhancement projects. This information has been compiled into habitat status tables for discrete CUs within the LHW, which are appended to this document. These tables follow the WSP Strategy 2 Habitat Status Template.

The following document discusses the methods used to inform the habitat status document, provides an overview of the salmon habitat conditions in the Harrison Watershed, and identifies threats and data gaps: Chapter 2 describes the steps taken to identify and synthesize information; Chapter 3 provides an overview of the LHW; Chapter 4 identifies CUs present in the LHW, and identifies the high value habitats used by those species; Chapter 5 describes the high value habitats independently, and discusses the availability of habitat indicators for each. Chapter 6 provides a discussion of pressure and state indicators available or recommended to inform habitat status decisions regarding the LHW.

2 Methods

This habitat status report for the Harrison River Watershed was conducted by way of the following steps, which are illustrated in Table 1. It should be noted that although the procedure is presented linearly, the actual process of assessing habitat status was more anachronistic, with steps 5-9 being revisited or occurring in parallel.

Table 1. Steps and information sources in the development of the Harrison Habitat Status Report.

Stage	Purpose	Sources of information/Description
Stage 1 Identify Geographic and Biological Scope of Work	Identify geographic scope of LHW and main tributaries	• BC Integrated Land Management Bureau: GeoBC iMap (http://webmaps.gov.bc.ca/imfx/imf.jsp?site=imapbc) • Fisheries Information Summary System (FISS 2010) Report Server for waterbody data (http://a100.gov.bc.ca/pub/fidq/main.do)
	Identify Pacific salmon CUs in LHW and high value habitats	• Holtby and Ciruna 2007
	Identify potential Habitat Indicators for habitat types	• Stalberg et al. 2009
	Identify relevant CU life history strategies and respective habitat requirements	• Diewert 2007
Stage 2 Identify Habitat Information Sources – Part 1	Search federal and provincial online data and library catalogues	• Department of Fisheries and Oceans online library catalogue: WAVES (http://inter01.dfo-mpo.gc.ca/waves2/search.html?__LANG=en) • BC Ministry of Environment: The Ecological Reports Catalogue (EcoCat) (http://a100.gov.bc.ca/pub/acat/public/welcome.do) • DFO Pacific Regions Headquaters Library: 200-401 Burrard St., Vancouver, BC V6C 3S4
Stage 3 Information extraction and organization	Develop information management spreadsheet	• Create/populate spreadsheet to organize incoming information geographically. • Chose and record bibliographic information of incoming information sources. • Create/populate spreadsheet for limiting factors, productivity and restoration information.
Stage 4 Identify Habitat Information Sources – Part 2	Expanded data search	Search for documents referenced by steps 1-5 sources and expand search to address specific indicators and habitats • Science/Academic-based search engines • Sector-based web searches • Community Mapping Network: Aquatic Information Partnership Atlas (http://cmnbc.ca/atlas_gallery/aquatic-information-partnership-aip-under-construction)
Stage 5 Interviews (Concurrent with Stages 3/4/6)	Interviews	• Identify regional and field staff in DFO / MOE / FVRD / FN. • Establish contacts / request interviews / request names of knowledgeable staff / citizens. • Determine knowledge base / identify information transfer venue: email, telephone, in-person. • Copy and return data / files. • Follow-up – pers. comm. confirmation / directed questions.

Stage	Purpose	Sources of information/Description
Stage 6 Habitat Status Report Development	Overview of sources and extraction of data	• Continue population of spreadsheets with data points addressing indicators, high value habitats, limiting factors, possible measures and recommendations. • Transfer data to CU-specific habitat status report spreadsheets. • Firm list of high value habitats based on sources of information and interviews
	Information transfer to report document	• Transfer CU-LHW-specific information to report. • Transfer habitat-specific information to report. • Construct maps.
	Habitat Indicator Confirmation	• Identify quantifiable data, conflicting data, uncompiled data and data gaps.
	Finalize draft report	• Complete background information, verify data/references. • Assemble appendices.

2.1 Identification of the Geographic and Biological Scope of Work

The first step in identifying the geographic scope of the LHW was to reference the Province of British Columbia Integrated Land Management Bureau's (ILMB) online mapping system iMap. We determined the extent of the LHW and identified its main tributaries, and produced a map of salmonid occurrences in the watershed.

Salmonid occurrences were sought from the Ministry of Environment's Fisheries Information Summary System (FISS 2010) using the watershed code (110 - Harrison) and a report was generated for each of the main tributaries containing Pacific salmon. These reports provided an initial understanding of salmonid distribution and high value habitats. Salmonid CUs present in the LHW geographic area were identified by Holtby and Ciruna's 2007 document *Conservation Units for Pacific Salmon under the Wild Salmon Policy*. We created a summary habitat table identifying tributary habitat use by species, differentiating between WSP CU location lists (locations where the CUs are known to or are believed to have successfully reproduced; according to Holtby and Ciruna 2007) and FISS-reported occurrences.

The preliminary high value habitats were compared and combined to form a reference list for habitat indicator consideration. Potential habitat indicators were selected based on the habitat type (Stalberg et al. 2009); for example, estuary indicators were not included in this habitat assessment as the LHW does not include any estuarine features.

Pacific Salmon life histories and species-specific habitat requirements were identified using Diewert's (2007) document *Habitat Requirements for ten Pacific Salmon Life History Strategies.* This document was referenced by Stalberg et al. (2009) as unpublished and was acquired from DFO. Population-specific life history data was extracted from FISS (2010) reports, Holtby and Ciruna (2007), and Foy (2007).

2.2 Identification of Habitat Information – Part 1

The first information sources sought were those referenced in LHW FISS reports. Searches for these and other salmon/LHW documents were conducted by way of the web-based government search engines listed in Table 1. Documents that had been identified by web-based searches but not available online were pursued at the DFO Pacific Region Headquarters Library in Vancouver and by contact with regional DFO and MOE staff. Recommended sources from Stahlberg et al.'s 2009 document entitled *Stream Indicators – Provisional Metrics and Benchmarks* were also accessed.

2.3 Extraction / Organization of Information

Given the geographic scope of the work, and the presence of distinct conservation units in multiple sub-habitats, we organized information geographically. We developed an information-management spreadsheet with column headings for each potential habitat indicator and sub-columns for each useful information source. Each occupied tributary was assigned a row, and information bearing on the particular habitat indicator was transferred into the column under the information source. For example, information regarding water temperature in Big Silver Creek from Wilson 1999 was placed in the row "Big Silver", under the column "Water Temperature", sub-column Wilson 1999. Bibliographic information from documents, articles, reports and other sources of information (e.g. iMap) was recorded in reference management software. A similar spreadsheet regarding limiting factors, restoration measures and productivity measures was also created and annotated with reference information.

In this manner, each document was assessed for relevant information and the information placed into accessible, organized pockets. The process was repeated for each new source of information and, as such, occurred in parallel for the duration of the project until all accessed data was organized and synthesized. Often, useful sources of information were identified in the literature cited or bibliographies of accessed reports. These sources were sought out where possible; where the documents were not found they are referenced in this document as "Citation, YEAR *in* Citation, YEAR".

2.4 Identification of Habitat Information – Part 2

Academic search engines were used to acquire journal articles regarding Pacific salmon runs and habitat studies in the Fraser and Harrison watersheds. Internet searches were also conducted to locate non-government or stakeholder information relating to Pacific salmon, Fraser River or the lower Harrison watershed. One notable source of information was the Community Mapping Network's Aquatic Information Partnership Atlas, which at the time of writing was not fully functional. This atlas will contain the information synthesized by the BC Watershed Statistics Atlas, which was not available for this report. Sector-based and service provider/licensing searches, mineral development and water license queries for example, where also conducted as per the recommendations of Stalberg et al. (2009). Background information regarding ecological aspects of salmonids, salmon habitat, and of the LHW, and current population and climate trends, were also accessed and recorded.

2.5 Interviews

Interviews were conducted with DFO staff, as well as staff from the Regional District, Municipalities, and knowledgeable locals. Interviews were requested through email, with an explanation of the purpose of the Habitat Status Report and a request for any applicable documentation that they may have in their possession. Many information managers were happy to provide electronic copies of reports and documents. Telephone conversations were used to discuss the availability of information and further direct questions regarding specific aspects of previous conversations or requests. In some cases, interviews were conducted in person where we were able to discuss the habitat with the aid of maps, and extract information from files. Some of these interviews resulted in boxes of uncompiled information in file-folders or data-binders, which were then reviewed and incorporated into the spreadsheets and final report. Personal communications are listed in detail in Appendix 1.

Unfortunately, although primary contact was made with several people, First Nations interviews were limited to one member of the Chehalis Indian Band. Knowledgeable members of the Chehalis, St'át'imc Xa'xtsa7 (Port Douglas), and Scowlitz bands should be consulted regarding their knowledge of historical changes in the watershed as well as current management concerns. In addition, local knowledge through conservation organizations, such as the Pacific Fisheries Resource Conservation Council, Nature Trust, the Heart of the Fraser, the B.C. Federation of Drift-Fishers, local Streamkeepers and Environmental Non-Government Organizations were not accessed due to time constraints.

2.6 Habitat Status Report Development

CU Habitat Status Report spreadsheets (Appendix 2) were generated for each CU using information accumulated in the organizational spreadsheets. CU-specific high value habitat lists were compiled from Holtby and Ciruna (2007), FISS reports, and interviews. High value habitats and associated limiting factors for each CU were imputed into a discrete “High Value Habitats – Habitat Indicators” spreadsheet, which provides habitat indicator data referenced in the CU status spreadsheets. CU-specific life-stage habitat requirements were inserted into the spreadsheets as per information from Diewert (2007). Next, CU spreadsheets were populated with general and habitat-specific data pertaining to limiting factors, productivity and habitat restoration/protection.

Concurrently, a draft report was outlined and introductions and methods drafted. Conservation units were defined and summarized in the context of the LHW, and high value habitat information was transferred from the information spreadsheet to the report for assimilation. Through this process, habitat indicators with quantifiable data were parsed from habitat information that will inform choices for future data collection. Data that was sparse or conflicting is considered a data gap, but noted in the spreadsheet. Likewise, un-complied data or existing but inaccessible data that could not be timely synthesized (such as watershed road density) are also noted in the tables.

2.7 Methods Recommendations

Accessing government reports and databases was time-intensive. Federal and Provincial databases are continuously evolving, improving and growing, and new data is being added continuously, even through the duration of this review. Although much information has been collected and compiled its presence is poorly known and data often inaccessible due to broken links and changing project administration. Several data sources identified in Stalberg et al. (2007) were inaccessible due to incomplete database development. Some data-collection and organization initiatives that were referenced in accessed reports had been re-named or the data re-routed into other organizations. Current web addresses to useful databases are listed in the Online References section of this document.

The B.C. Fisheries Information Summary System was well-organized, cross-referenced and very useful to the project. Federal and Provincial initiatives such as the British Columbia and Yukon Environmental Monitoring Networks Station Information Map Viewer (Environment Canada 2002), B.C. Integrated Land Management Bureau's iMap (ILMB 2010a) and Land and Resource Data Warehouse (ILMB 2010b), GeoBase (2009a, 2009b) provided useful information. This data, however, is provided in GIS format, and future Statements of Work for Habitat Status Reports should specify that GIS components are required. GIS downloads were used in the development of this report, however detailed analysis was not possible within the allotted scope of work.

We chose to conduct interviews after having searched online engines and having completed external information source extraction. However, interviews, once begun, were a very efficient method for information-gathering. We recommend identifying and speaking with knowledgeable staff at the very beginning of the information-gathering process.

3 Lower Harrison Watershed

Entering the Fraser River only 116 km from its mouth at the Georgia Strait, the Harrison River watershed is one of the largest, most accessible salmon spawning habitats on the South Coast. It contains all five salmonid species, counting 9 distinct CUs, and provides passage for anadromous fish to the productive Lillooet-Birkenhead drainages.

The Lower Harrison Watershed is the southernmost and downstream portion of the 8,324 km^2 Harrison-Lillooet watershed. The drainage stretches 177 km from the Harrison-Fraser confluence to the head of the Lillooet River; it lies within the Coast Mountains, with a small portion on the Fraser Lowland near Harrison River's confluence with the Fraser River. The Harrison Valley lies in a northwest-southeast orientation within the Coast Mountains. Harrison Lake, the centerpiece of the valley, is approximately 60 km long and 9 km across at its widest point.

Although this document reports only on habitat within the Lower Harrison Watershed, it is expected that Habitat Status Reports for the Lillooet-Birkenhead watershed will be completed during the implementation of WSP Strategy 2.

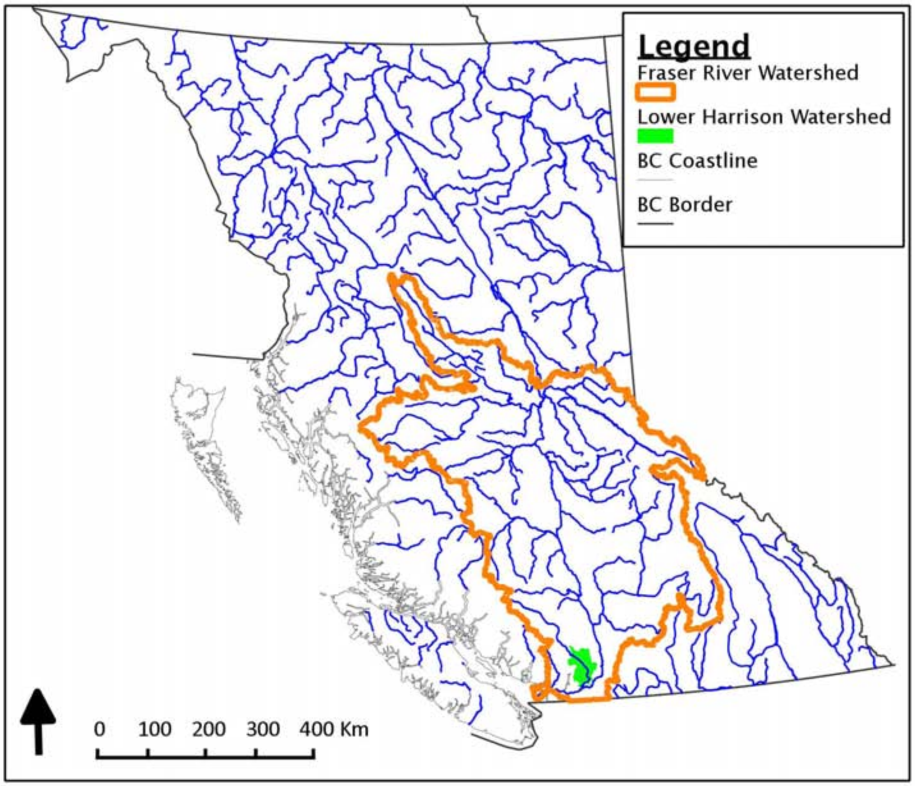

Figure 1. Location of the Lower Harrison Watershed within B.C. and the Fraser River Watershed.

Hydrologically, the LHW is split into two distinct regions: the Eastern Pacific Ranges and Southern Pacific Ranges Ecoregions (NHC 1994). The Pacific Ranges Ecoregion includes the Lillooet River drainage, which flows into the northern tip of Harrison Lake, and continues approximately halfway down Harrison Lake (NHC 1994). This region is characterized by low annual rainfall, compared to the downstream portion of the LHW, with most precipitation falling in the winter and held in storage over the winter. Melting snowpack and glaciers result in peak flows in May and June, and maintain reliable flows through the summer from Lillooet River into Harrison Lake. Monthly flows decline quickly after August, reaching a minimum in February under ice-cover; however, rainstorms in early fall and late winter also cause large flood events. Important salmon-bearing streams in the north portion of the LHW, including Douglas Creek, Tipella Creek, and Big Silver Creek, also follow this hydrograph (NHC 1994).

The lower portion of LHW exists in the Southern Fiord Ranges Ecoregion, which is characterized by high rainfall in the winter months with little precipitation stored in snow and ice. This results in large flows from October through February followed by low flows in the dry summer and fall months. Minimum discharge is typically in August. This hydrograph is followed by all of the important salmon-bearing streams in the southern portion of LHW, including Chehalis Creek, Weaver Creek, Trout Lake Creek and the Harrison River (NHC 1994). The southernmost portion of the Harrison River, near the mouth of the Fraser, is impacted in the early summer (June) by the Fraser River freshet which backwaters up the Harrison River into Harrison Bay, the Chehalis estuary and Morris Lake.

Development and resource extraction interests continue to put pressure on the watershed, and the multiplicity of users and interest groups make the area vulnerable to conflict between stakeholders (Braacz 2006). The Fraser Valley Regional District is considering the development of a Harrison River Watershed Strategy, and Braacz (2006) prepared a preliminary review of stakeholders and key issues facing the watershed (Lilley, Pers. Comm.)

Heritage Values

The entire Harrison River watershed falls under traditional First Nations territory, some of it overlapping between nations. Stó:lõ Nation territory encompasses most of the Lower Harrison watershed, extending up beyond the north end of Harrison Lake (Braacz 2006). The Chehalis band, now independent of Stó:lõ Nation, is widely involved in fisheries and resource management on the Harrison River. St'át'imc territory encompasses much of the Lillooet-Birkenhead watershed, with the southern border overlapping some of the upper Stó:lõ Nation traditional territory (Braacz 2006). There are several FN heritage sites, including three below the high water line on the northeast side of Harrison Bay (Braacz 2006), a graveyard on the left bank of the Harrison River, and many spiritually significant outcrops on Harrison Lake (Charlie, Pers. Comm.).

Conservation

Conservation initiatives are increasing in the Harrison watershed: the Heart of the Fraser Initiative was launched to promote the protection of Fraser River floodplains from unchecked development and industry, and include the Harrison River in its scope (HOTF 2005). In Febuary 2010, the Harrsion River was designated Canada's first "Salmon Stronghold", which intends to strengthen efforts to drive focused collaborative conservation projects within the watershed (PFRCC 2010).

The Fraser River Bald Eagle Festival Committee spearheaded an initiative to designate a portion of the Harrison River and Chehalis fan designated as a Wildlife Management Area (WMA), to "conserve the ecological integrity of riverine habitats of the Harrison and Chehalis Rivers" (MOE 1997). The WMA would protect 1,400 ha of river and delta habitats along the Harrison and Chehalis rivers; the Nature Trust of B.C. owns two properties (purchased 1978 and 1999) located within the Chehalis River delta and totaling 200 ha, which will be included in the WMA. The Nature Trust also received a 22-ha portion of Harrison Knob in 2006. A trail along the east shore of the Chehalis River within the proposed WMA was established in 2009 as a result of a joint effort including the Chehalis Indian Band and the B.C. Federation of Drift Fishers.

Two B.C. provincial parks are within the LHA: Sasquatch Provincial Park on the east shore of Harrison Lake, extending up the Trout Lake Creek watershed, and Kilby Provincial Park, a small, 3-Ha riverside park adjacent to Harrison Bay. Braacz (2007) also references a report developed by the "Fraser Lowlands Working Group" that identified three areas for consideration for provincial parks in the Harrison-Chehalis watershed: the Harrison River Park Proposal, encompassing 364 ha in five separate areas fronting Harrison River and protecting a variety of river shorelines and upland forest habitat; the Harrison Knob proposal, encompassing 671 ha of mixed forest and upland habitat; and the Chehalis River Park Proposal, encompassing 329 ha including existing Ministry of Forests recreation areas and an extension along the Chehalis River Canyon, protecting the canyon walls and rim and increasing management of existing campgrounds (FLPAS 1998 *in* Braacz 2006).

4 Salmonid Conservation Units

Conservation units (CUs) were described by Hotby and Circuna (2007) using ecotypic, biological (life history) and genetic characterizations. The Harrison River Watershed provides spawning and/or rearing habitat for all five species of anadromous Pacific Salmon (*Oncorhynchus spp.*), forming nine CUs. These include three distinct Sockeye units, three Chinook units, and one unit each of Coho, Chum, and Pink. Table 2 lists the conservation units of Pacific salmon and their endemic locations within the Lower Harrison Watershed as defined by Holtby and Ciruna (2007). The table contains additional citations for locales not listed by Holtby and Ciruna but referenced in other sources of published data (FISS, Personal communications).

Species occurrence maps are included in each species section, and include data retrieved from the provincial FISS online database as well as locations referenced in Holtby and Ciruna (2009).

*Table 2. Harrison Watershed Habitats for Oncorhynchus spp. Conservation Units. With Index Identification as per Holtby and Ciruna 2007. Sockeye (**SK**), Chinook (**CH**), Coho (**CO**), Chum (**CH**), Odd-Year Pink (**PK**). (•) denotes Holtby and Ciruna citation; (*) denotes FISS Report citation. Note that Conversation Units are not specified in FISS reports, therefore all SK and CH occurrences are shown in all CU columns. High value habitats addressed in this document are highlighted in bold.*

Habitat Name	Watershed Code	***Oncorhynchus spp.* Conservation Unit**								
		SK			**CH**			**CO**	**CM**	**PK**
		L-3-3	**L-3-4**	**R03**	**3**	**4**	**6**	**2**	**2**	**1**
Bateson Slough	110-068100				*	*	*			
Big Silver Creek	**110-599000**	•*	*	*	*	*	• *	• *	• *	• *
Chehalis Lake	**110-090200**	*	*	*				*		
Chehalis River	**110-090200**	*	*	• *	*	• *	*	• *	• *	• *
Cogburn Creek	**110-535100**	• *	*	*	*	*	• *	• *	• *	
Coho Creek	**110-090200-66600**							•*	•	
Connor Creek	110-149200-68600				*	*	*	*		
Davidson Creek	110-719300				*	*	*			
Douglas Creek	**110-987400**	• *	*	*	*	*	• *	*	•*	•
Duncan Slough	110-071000				*	*	*			
Elbow Creek	110-076200							*		

Habitat Name	**Watershed Code**	***Oncorhynchus spp.* Conservation Unit**								
		SK			**CH**			**CO**	**CM**	**PK**
		L-3-3	**L-3-4**	**R03**	**3**	**4**	**6**	**2**	**2**	**1**
Harrison Lake	**110**	*	*	*	*	*	*	*	*	*
Harrison River	**110**	*	*	•*	•*	*	*	•*	•*	•*
Hornet Creek	110-599000-08600	*	*	*				*		
Hotsprings Slough	110-232100-14200							*		
Lake Errock	110-036900							*		
Little Harrison Lake	110	*	*	*	*	*	*	*		
Maisal Creek	110-090200-42900							*		
Miami Creek	**110-232100**							•*		
Morris Creek	**110-149200**	*	*	*	*	*	*	*	*	*
Morris Lake	**110-149200**							*		
Mystery Creek	**110-581900**	*	*	*	*	*	*	•*	*	
Pretty Creek	110-090200-05000							*	*	
Sakwi Creek	**110-149200-85400-35600**	*	*	*				•*	•*	
Skwellepil Creek	110-090200-62400							*		
Slollicum Creek	110-327700							*	*	
Squawkum Creek	110-036900							•*	•*	•
Tipella Creek	**110-954600**	•*	*	*	*	*	*	•*	•*	*
Tretheway Creek	110-881400								*	
Trout Lake Creek	**110-259000**	•*	*	*				•*	•*	•*
Twenty Mile Creek	**110-588000**	*	*	*				•*	•*	*
Weaver Creek	**110-149200-85400**	*	•*	*	*	*	•*	•*	•*	•*

4.1 Chinook Conservation Units

Chinook salmon populations have the most highly variable life histories, with the Fraser River chinook being the most ecologically and genetically diverse in Canada (Holtby and Ciruna 2007). Typically, chinook salmon spawn in large rivers or in their headwaters and most individual spawning populations in British Columbia are fewer than one thousand spawners (Diewert 2007). Three distinct CUs of chinook salmon use the Lower Harrison Watershed, differentiated in large part by timing of spawning migration and rearing duration in freshwater. The CUs present in the LHW are categorized as either immediate-type or stream-type chinook (Diewert 2007). Lower Fraser River Fall White Chinook are immediate-type Chinook, which do not rear in freshwater, migrating instead to the Fraser estuary upon emergence (Holtby and Ciruna 2007). Lower Fraser River (LFR) Spring (CH 4) and Lower Fraser River (LFR) Summer (CH6) are both stream-type chinook CUs, with an extended freshwater rearing phase that lasts from one to two years (Diewert 2007). Figure 2 maps known chinook occurrences for all CUs in the LHW.

Labelle (2009) indicates that some Fraser River chinook stocks have decreased to 1970s levels from 10-30 years of stable or improved escapements, but these trends reflect crude estimates due to a lack of long-term indicator stocks in the mid-upper Fraser River chinook populations. Fraser River chinook have been observed migrating early, along with other late summer/early fall Fraser salmon; it is not known what effect this has on the chinook populations (Labelle 2009).

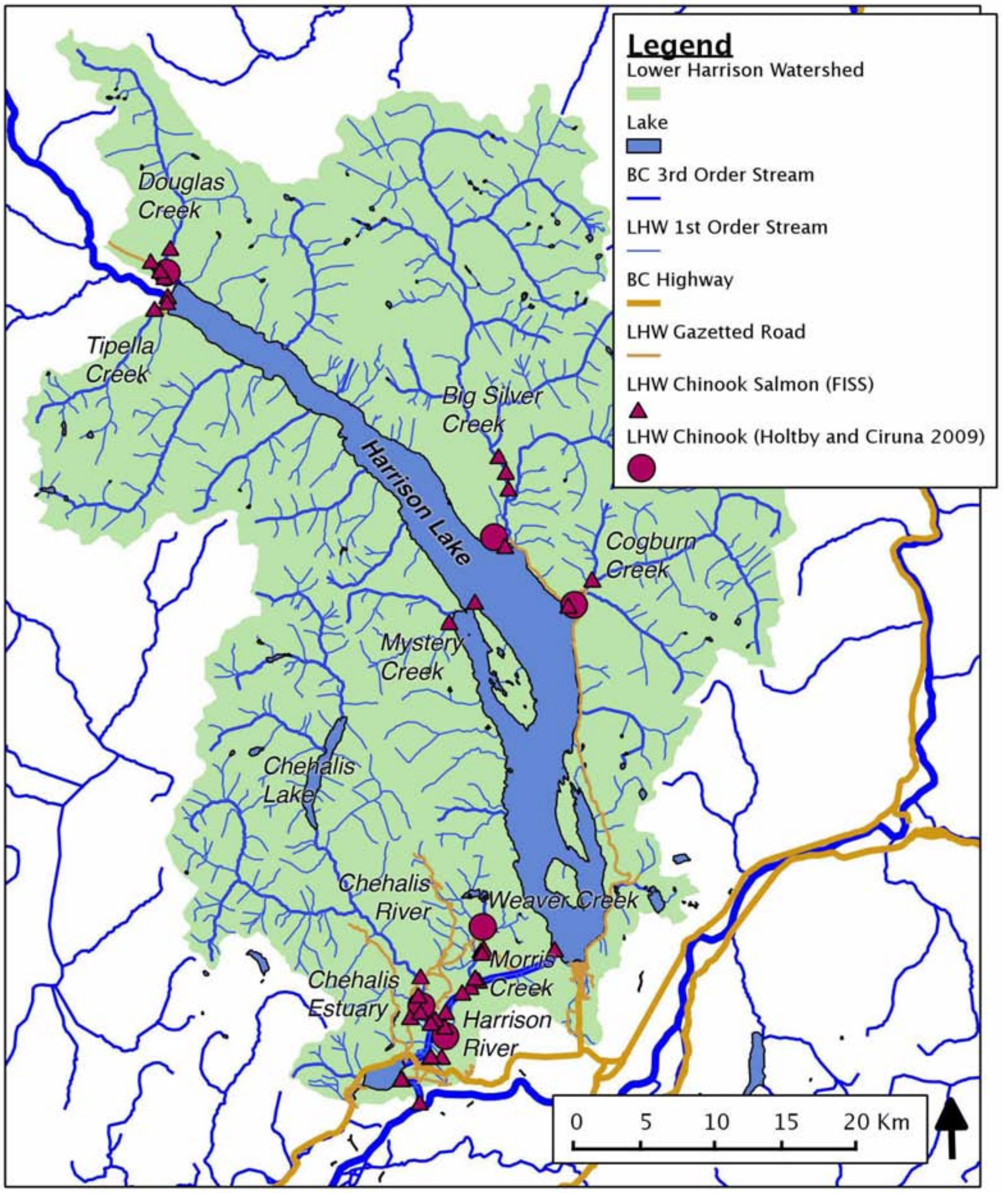

Figure 2. Chinook occurrences in the Lower Harrison Watershed, as described by Holtby and Ciruna (2007) and Provincial FISS databases. The three chinook Conservation Units are not differentiated in this image.

4.1.1 Lower Fraser Fall White (CH 3)

The Lower Fraser River (LFR) Fall White (CH3) is an immediate-type chinook (Holtby and Ciruna 2007) which spawns in Harrison River and migrates to the estuary soon after emergence (Diewert 2007). In the LHW, these chinook have short migrations to spawning grounds in Harrison River and delay their river entry until the first week of October (FISS 2010) when winter rains provide more favourable hydrologic conditions (NHC 1995). LFR Fall White chinook are native only to the Harrison

River below the lake, however hatchery and feral populations are distributed throughout the Lower Fraser River and tributaries (Holtby and Ciruna 2007). Foy also describes a small Harrison Lake – Lillooet run, estimated at less than 2000 spawners per year (Foy 2007). The Harrison River population is used as a source for chinook enhancement in Alouette, Capilano, Coquitlam, Chilliwack and Stave Rivers. Escapement trends of Fraser River summer run Chinook from 1975-2006 show substantial increases for the age 0.3 group compared to the age 1.2 group (which showed fluctuating escapement, with few large increases) indicating that the immediate-type life strategy may be more beneficial in the context of recent medium to long-term environmental changes (Labelle 2009).

These fall-run chinook with white flesh are unique, as the fry do not rear in the lake but in non-natal lower Fraser tributaries and Fraser estuary. Habitat conditions for this population within the Harrison River are considered relatively healthy (Foy 2007). Restoration of Harrison River side-channels is considered feasible and would recover a large amount of spawning habitat for this population, as the left and right banks of the Harrison River were damaged by navigation channel dredging in the mid-1960s (Foy 2007).

Habitat restoration projects along the lower Fraser River have improved rearing habitat available to Harrison River chinook fry, improving access to over 200 ha of freshwater tidal rearing habitat in Addington Marsh on the lower Pitt River and Colony Farm on the lower Coquitlam River (Foy 2007). Further restoration works at Colony Farm and Fraser River South Arm Marshes are planned (Foy 2007).

4.1.2 Lower Fraser Spring (CH 4)

The Lower Fraser River Spring CU is determined by genetics, life history and timing. LFR Spring Chinook are stream-type chinook, rearing for one to two years in freshwater (Diewert 2007). Holtby and Ciruna (2009) describe 3 spanwing locations for this CU, of which 1 (33.3%) exists within the (Chehalis River). These chinook are distinguished from other LHW CUs by their distinct spring migration timing (Holtby and Ciruna 2007). Their spawning migrations are observed in early May (FISS 2010), likely coincident with high flows due to meltwaters in the upper Chehalis watershed (NHC 1994). Foy (2007) indicates that spawners from this population have not been recorded since the 1980s, however he further suggests that this may be due to the remoteness of the spawning habitat and that a small undetected population may exist, warranting further assessment. Labelle (2009) suggests that this CU is subject to relatively low exploitation rates and recent escapement decline is likely due to lower survival rates in fresh water and/or the marine environment.

4.1.3 Lower Fraser Summer Chinook (CH 6)

The LFR Summer Chinook CU is the second stream-type chinook in the LHW, distinguished by its summer migration to the upper tributaries of the LHW (Holtby and Ciruna 2007). Holtby and Ciruna (2007) describe 10 locations for this CU, of which 4 (40%) exist within the LHW, as well as two populations that use LHW en route to the Lillooet Watershed. These chinook spawn and rear in the headwaters of the watershed, namely in Big Silver Creek, Cogburn Creek and Weaver Creek (Holtby and Ciruna 2007). They are also known in Douglas Creek and Tipella Creek (Foy 2007) and are likely the CU observed at Mystery Creek (FISS 2010).

Marine and freshwater harvesting may impact this CU, but Labelle (2009) suggests that exploitation rates are low and recent stock declines may be related to decreased survival rates in fresh water and/or the marine environment. In the LHW, efforts have been undertaken in Big Silver Creek to improve chinook spawning and rearing habitat (Foy 2007).

4.2 Lower Fraser River Chum Conservation Unit (CM 2)

Chum salmon are widely distributed and constitute the most abundant biomass of all the Pacific Salmon (Holtby and Ciruna 2007), and hence provide a wide-range of aquatic and terrestrial ecosystems in the Lower Fraser area with more marine-derived nutrients than any other Pacific salmon species (Foy 2007). Foy (2007) estimates at least 120 indigenous local popluations of Chum Salmon in the Lower Fraser area. They are said to be poor or reluctant jumpers, which is likely related to their occurrences in the lower reaches of rivers (Diewert 2007).

Holtby and Ciruna (2007) describe 81 locations for this CU, of which 12 (14.8%) exist within the LHW (Figure 3) and two populations use the LHW en route to the Lillooet watershed. FISS describes 17 locations for this species (Figure 3). Most of the Fraser chum production (>90%) comes from about 10 streams; the Harrison River produces a large portion of these due to an abundance of both natural spawning populations and hatchery-enhanced production (Labelle 2009). Chum are described in Coho Creek, above Chehalis Lake, by Holtby and Ciruna (2007) but are not shown to be present in either according to the FISS database - it is unlikely that chum exist in Coho Creek as the canyon downstream of Chehalis Lake is a barrier to chum (Stitt, Pers. Comm.).

The life history of this chum CU involves 3 to 4-year old fish migrating from September-November and spawning as late as January (Diewert 2007). These late-spawn timing chum are found where groundwater affects spawning areas in larger river floodplains or where there are deep groundwater discharges. Chum smolts emerge in spring and migrate to estuary/nearshore zones of ocean immediately (Diewert 2007). Chum are known to spawn on the beach at Harrison Hot Springs as well as at Green Point on Harrison Lake in Sasquatch Provincial Park (Stitt, Pers. Comm.), a rare characteristic for this species (Foy 2007). Populations that spawn at Cogburn Creek, Big Silver Creek, Mystery Creek and Trout Lake Creek are populations of interest due to their rare behaviour of spawning above large lakes (Foy 2007). Foy notes that chum salmon are extirpated from a significant number of their endemic streams due to degraded or destroyed habitats and remnant populations in some streams are at risk of extirpation.

A 3-6 week early spawning migration has been observed for Fraser River chum coincident with that of late-run Fraser salmon; it is not known what effect this has on chum populations (Labelle 2009).

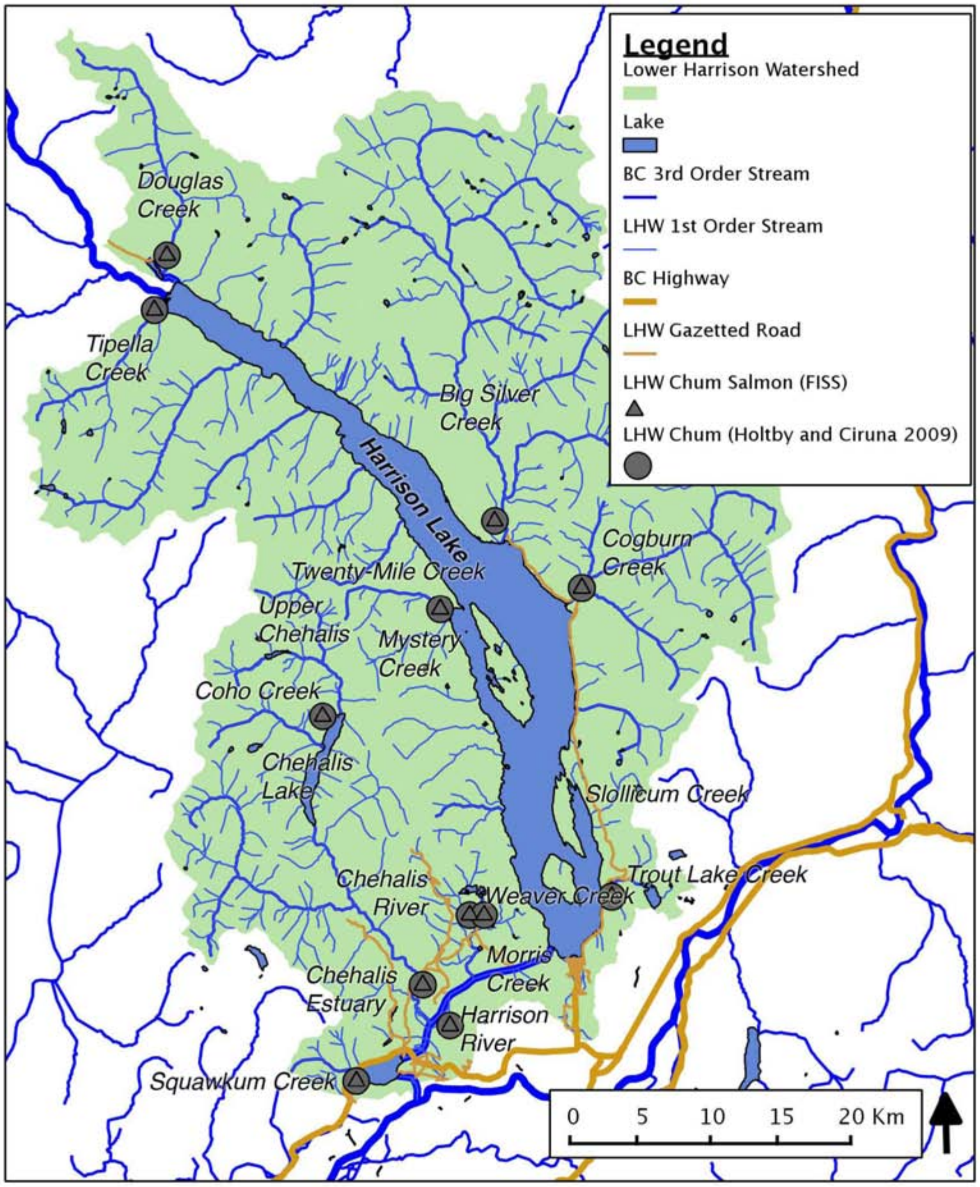

Figure 3. Chum salmon occurrences in the Lower Harrison Watershed, as described by Holtby and Ciruna (2007) and provincial FISS databases.

4.3 Lower Fraser Coho Conservation Unit (CO 2)

Coho are the most widespread salmon in the Harrison watershed, using most (possibly all) of the spawning habitats used by other salmonid species. The Lower Fraser River Coho CU was determined by genetics and habitat. Holtby and Ciruna (2007) describe 77 locations for this CU, of which 13 (16.9%) exist within the LHW; FISS indicates 28 coho streams in the LHW (Figure 4). These coastal coho are thought to be more opportunistic, straying from their natal streams to spawn in other (non-natal) locations more often than other Pacific Salmon species (Holtby and Ciruna 2007). As such, their spawning habitat is very diverse ranging from large river or lake systems to small headwater streams and drainage ditches (Diewert 2007). Coho in the LHW have been observed migrating in late fall and spawning from late fall to mid-winter (FISS 2010). These spawners are typically three years old, having spent two years in the ocean and a year rearing in freshwater (Diewert 2007).

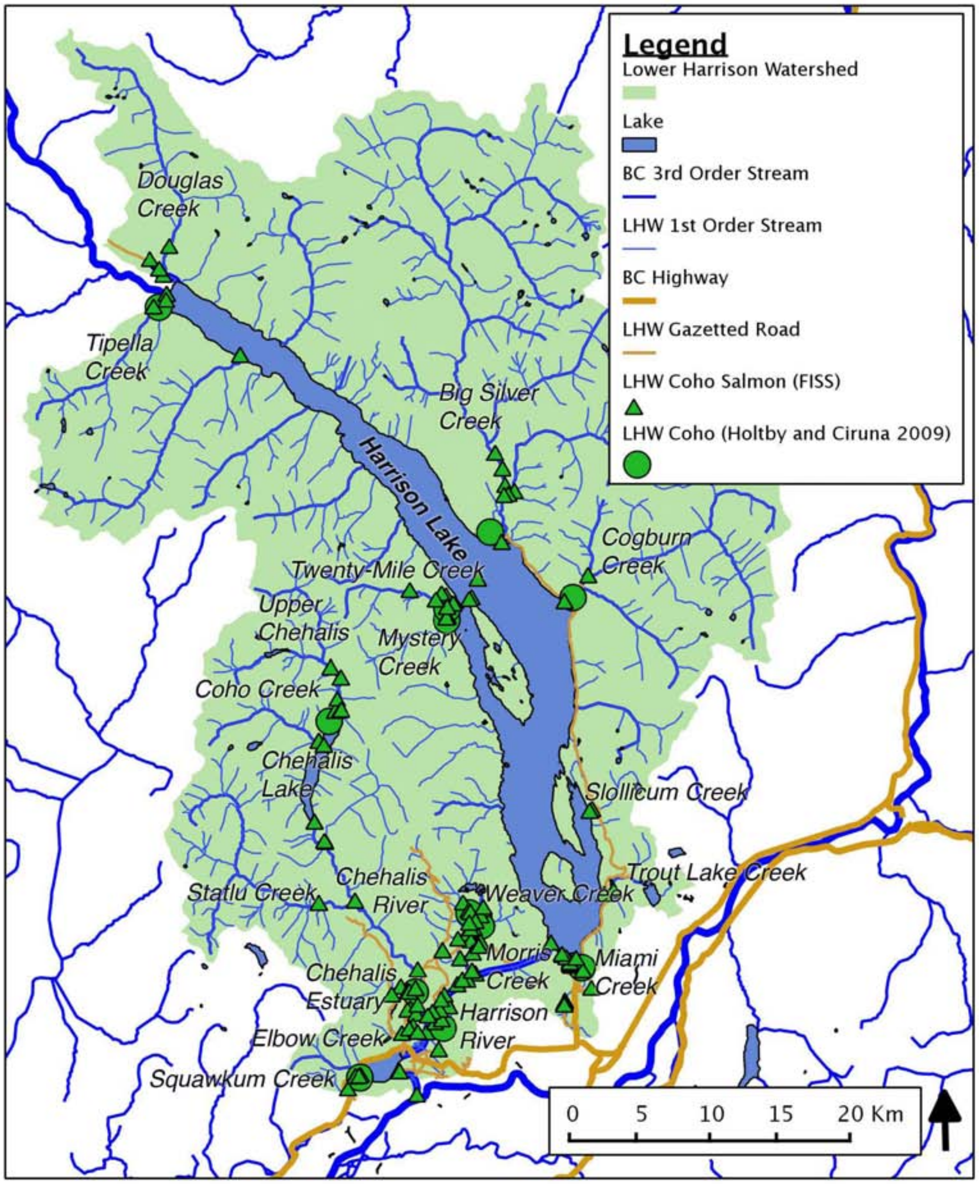

Figure 4. Coho salmon occurrences in the Lower Harrison Watershed, as described by Holtby and Ciruna (2009) and Provincial FISS databases.

Foy (2007) estimates at least 160 indigenous local spawning populations of Coho salmon occur in the Lower Fraser Area and approximately 10% (or greater) of these populations include hatchery produced adult salmon returns. These populations tend to be small (<500 spawners) and limited by the amount of rearing habitat for over-wintering and characteristically territorial juveniles (Holtby and Ciruna 2007). Over-wintering juvenile survival is the predominant factor in smolt production (Holtby and Ciruna 2007) and survival strategies include migrations to refugia in pools, ponds, side-channels and sloughs (Diewert 2007). For both refuge and migratory habitats, coho juveniles depend on large woody debris for cover from predators (Holtby and Ciruna 2007). Coho numbers have recently been significantly affected by declining freshwater and ocean productivity (Foy, 2007), which has resulted in strict conservation measures in southern BC fisheries (Labelle 2009). Labelle (2009) calls the reliability of survival estimates of Lower Fraser coho into question, noting that inaccessible habitat locations and fall water conditions obscure counts and that returns to natural streams are frequently a mix of naturally-produced and hatchery-produced coho.

Restoration has occurred in several coho streams over the past decade with restoration works completed on Miami River in 2006 and 2009, as well as the Chehalis River in 2006 (Foy 2007).

4.3.1 Coho Creek group

Coho Creek is tributary to Chehalis Lake on the Upper Chehalis River delta (the creek is often mis-labeled on maps). Although only 100 m long, this creek held very high spawning densities, estimated at 1500 spawners (Foy, Pers. comm.). The population was used as brood stock for the Weaver Creek Hatchery in the early years of operation (Stitt, Pers. Comm.) and it is assumed that fry reared in Chehalis Lake. In 2007, a massive avulsion into Chehalis Lake caused a tidal wave that scoured the shoreline and re-graded the Upper Chehalis delta, destroying the invert that was Coho Creek. In fall 2008 a channel was dug in the same approximate location as Coho Creek in order to restore coho spawning habitat on Chehalis Lake. It is hoped that survivors will return to spawn in the restored channel and that the run has not been eliminated by the avulsion (Foy, Pers. Comm.).

4.4 Lower Fraser Pink Conservation Unit (PK1)

Pink salmon, the most numerous Pacific salmon (Diewert 2007), is divided into two reproductively isolated “even-year” and “odd-year” brood lines on account of their fixed two-year life cycle (Holtby and Ciruna 2007). The odd-year run that returns to the Fraser River is the largest pink salmon run in British Columbia (Diewert 2007). The 2003 return for this population was the largest on record, but subsequent returns are now comprable to historical averages (Labelle 2009). Recent return estimates (2003-2008) are characterized by considerable uncertainty since they are based on expanded cumulative catches from marine purse seine test fisheries (Labelle 2009). Labelle (2009) suggests that the reliability of recent Fraser River Pink population data should be re-evaluated due to changes in estimation and monitoring procedures.

These salmon are the least dependent CU on freshwater, tending to spawn closer to the sea than any other Pacific salmonid and with minimal time between spawning migration, spawning, incubation and out migration (Diewert 2007). In the LHW, pink salmon have been observed in spawning migration during September and October (FISS 2010), spawning peaks around the third week of October (Holtby and Ciruna 2007). Water temperatures affect incubation duration, with lower the water temperature increasing the duration of incubation until emergence, upon which the fry migrate immediately to the ocean (Diwert, 2007).

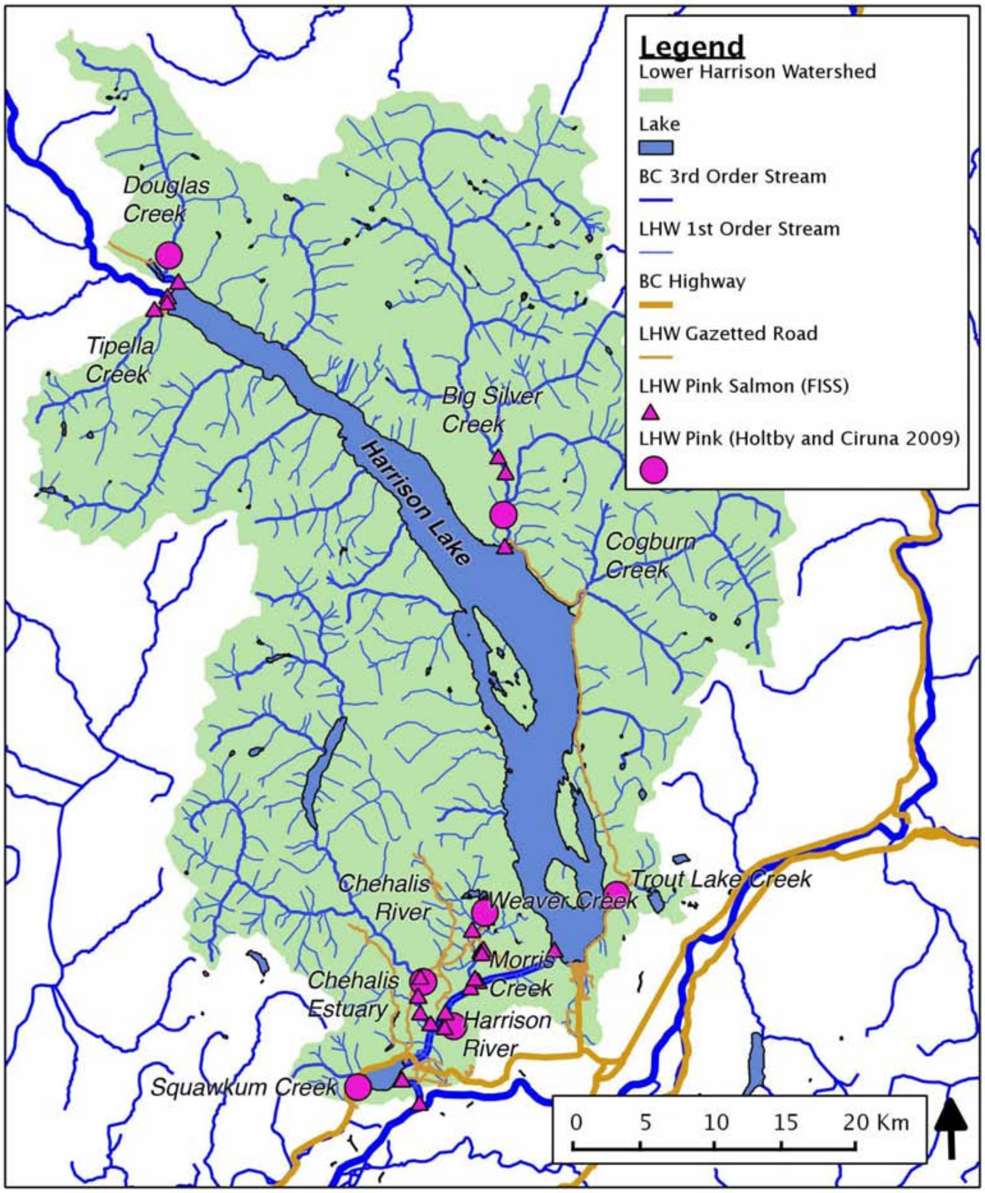

Figure 5. Pink salmon occurrences in the Lower Harrison Watershed, as described by Holtby and Ciruna (2007) and Provincial FISS databases.

Although the Fraser River 1 CU is ecotypically disparate, this odd-year Pink CU is genetically homogenous with no significant spawning timing differences (Holtby and Ciruna 2007). Of 59 database locations identified by Holtby and Ciruna (2007), 5 (8.5%) locations exist in the Lower

Harrison watershed, and two more pass through this watershed into the Lillooet watershed (Figure 5). Foy (2007) estimates at least 57 indigenous local spawning populations of odd-year pink salmon occur in the Lower Fraser Area with many populations at low levels of abundance, particularly those populations in small streams affected by mixed stock commercial fisheries. Foy (2007) further notes that stock management efforts to re-establish pink populations in historic habitats through transplant and enhancement programs have been successful for nine pink salmon populations within the Lower Mainland (Foy 2007).

A 3-6 week early spawning migration has been observed for Fraser River pink coincident with that of late-run Fraser River sockeye; it is not known what effect this has on pink populations (Labelle 2009).

4.5 Sockeye Conservation Units

Sockeye salmon have three distinct life history types: anadromous lake-type, anadramous river-type, and a freshwater obligate (Holtby and Ciruna 2007). Lake-type salmon require a nursery lake for freshwater rearing of juveniles, whereas the fry of river-type sockeye migrate immediately to estuaries (Diewert 2007). Most sockeye spawn as four year olds, after either several months rearing in nearshore/estuary zones or a full year in nursery lakes, followed by two or three years in the ocean (Diewert 2007). Run-timing and spawn-timing are key in differentiating sockeye populations, as Holtby and Ciruna (2007) noted that when compared within the same ecotype, river-type sockeye spawn later than their lake-type counterparts.

Foy (2007) estimates there are twenty-seven populations of lake-type salmon rearing in six nursery lakes (Lillooet, Harrison, Cultus, Kawakawa, Chilliwack and Pitt) in the Lower Fraser Area. The sockeye populations that spawn in the LHW are among 52 sockeye stocks characterized as " late-run" Fraser River sockeye populations, owning to their late summer/early fall spawning migrations (Labelle 2009). The 99 other Fraser River sockeye spawning populations are described as either early Stuart runs or summer runs (Labelle 2009).

Three sockeye CUs are defined in the LHW for a portion of their life cycle: two lake-type and one a river-type (Holtby and Ciruna 2007). FISS reports sockeye occurrences in fourteen streams plus observations in Harrison Lake, Chehalis Lake and Little Harrison Lake. Holtby and Ciruna (2007) categorized outlet and inlet spawners into two separate lake-type sockeye CUs: one spawning in Weaver Creek (L-3-4) and the other CU using the upper tributaries as natal grounds (L-3-3). River-type sockeye (R03) spawn in Harrison River and migrate directly to the Fraser estuary upon emergence from the gravels. A historic sockeye population in Chehalis Lake was thought to have become extinct around 1912, since post-contact settlement (Foy, 2007). In 1985 however, FISS reports indicated sockeye were observed spawning and rearing in Chehalis Lake and a further, small group of sockeye where caught in a gill net in 1997 during a BC Fisheries survey (FISS 2010) and again in 2001 (FISS 2010).

The Fraser River lake-type sockeye runs is one of the largest lake-type runs in British Columbia (Diewert 2007). Historically, late-run sockeye held for 3-6 weeks near the mouth of the Fraser River before moving upstream; however, beginning in 1994, this holding period decreased by 2-6 weeks in all years (Mathes et al. 2009); averaging ≤5 days in all years since 2000 except 2002 (22 days) (Labelle 2009). Late-run sockeye stocks of 2000 and 2001 migrated 4-6 weeks earlier than normal (Labelle 2009). Monitoring activities indicate that migration mortality has increased since the mid-1990s from under 20% to over 60%, with 90% mortality occurring in some years (Mathes et al. 2009). This early migration of late-run Fraser River Sockeye is occurring as the Fraser River is experiencing a >1.8°C increase in average peak summer water temperatures (over the past 40 years), with eight of the past 10 summers being the warmest on record (Mathes et al. 2009). These early-migrating, late-run sockeye are therefore now exposed to warmer water temperatures than historically encountered for considerably longer durations, as early migrations and environmental changes have not been met with changes in spawning times (Mathes et al. 2009). Investigations show the impact of this extended period of fresh water residency on early timing, late-run Fraser sockeye populations, such that these salmon suffer increases (since 1995) in both en-route mortality during spawning migrations and pre-spawning mortality, where females die on the spawning grounds with their eggs intact (Labelle 2009). Recent escapement estimates reflect these effects on Sockeye populations; for example the 2007 Fraser River Sockeye returns were the lowest on the cycle since 1947 and only 28% of the average return on the cycle since 1955 (Labelle 2009). Similarly, spawning success has also declined with the 2004 cycle return year showing the lowest spawning success in fifty years in 2008 (65%) for all stocks combined (Labelle 2009).

In 2009, the total return of Fraser River sockeye was the lowest in over 50 years. This was only a small fraction of the number expected. A "Think-Tank" of Scientists has been established to discuss the possible causes of the unexpectedly low numbers. This population collapse impacted the LHW's lake-type sockeye. It should be noted that, despite the collapse, the Harrison River stream-type sockeye was the only population to not only remain stable but increase in size. In a 2009 statement, the Think-Tank suggests that the problem of reduced productivity occurred after the juvenile fish began their migration toward the sea (Reynolds and Wood 2009).

4.5.1 Lake-type Harrison Downstream Lower Fraser (SK L-3-3)

This lake-type sockeye CU is so named due to the downstream migration of juveniles from the upper tributaries of the LHW into their nursery grounds in Harrison Lake (Holtby and Ciruna 2007). Natal streams in the LHW for this CU are listed as Big Silver Creek, Cogburn Creek, Douglas Creek, Tipella Creek and Trout Lake Creek (Holtby and Ciruna 2007). Spawning migration has typically been observed during August and September (FISS 2010). According to survey data from 1977-2007, this stock is relatively small with increasing production over the past 10 years (Labelle 2009).

4.5.2 Lake-type Upstream Lower Fraser (SK L-3-4)

This CU is identified by its upstream migration. In the LHW, the juveniles of the L-3-4 CU swim downstream from their natal grounds in Weaver Creek / Weaver Creek spawning tributaries and channels to the Harrison River then to rearing grounds in Harrison Lake. Spawning migrations have historically been observed in late September (Mathes et al. 2009) with spawning beginning in early October (FISS, Mathes et al. 2009). Peak spawning in the Weaver Creek system occurs in the third week of October but rarely before then due to low water levels in Weaver Creek, Morris Lake and Morris Slough (Mates et al. 2009).

Weaver Creek / Weaver Channel populations have experienced rapid declines in the last decade. It is suspected that this is due to effects of the *Parvicapsula minibicornis* parasite (Foy 2007) and increasing late-run mortality (Labelle 2009).

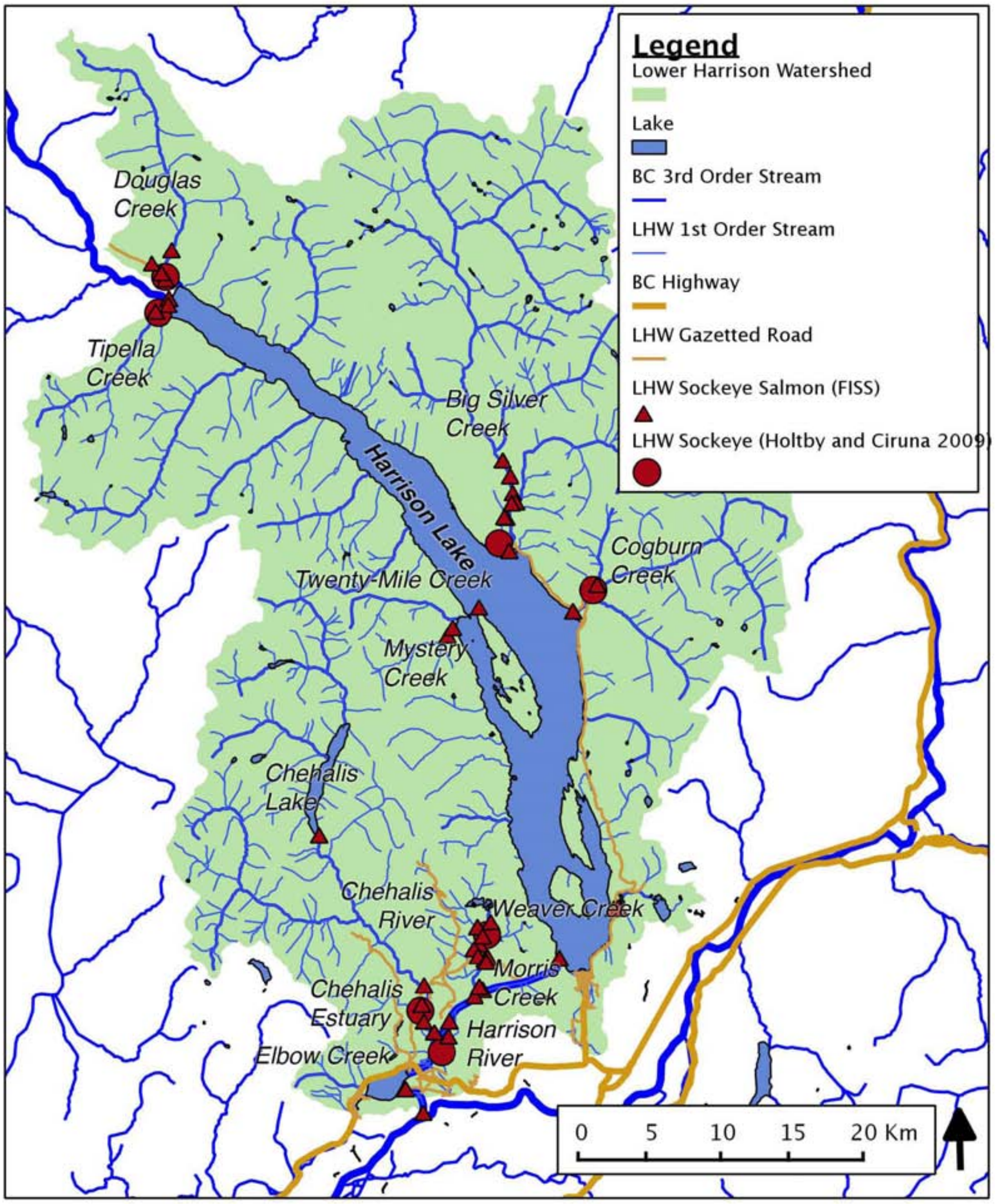

Figure 6. Sockeye occurrences in the Lower Harrison Watershed, as described by Holtby and Ciruna (2009) and Provincial FISS databases. The three sockeye Conservation Units are not differentiated in this image.

4.5.3 River-type Lower Fraser (R03)

This CU is genetically distinguished from other Fraser River river-type sockeye (Holtby and Ciruna 2007). Holtby and Ciruna (2007) identify six locations for this CU with two, the Chehalis and Harrison Rivers, occurring in the LHW. The river-type sockeye of the LHW have been observed migrating to natal grounds in the Harrison River rapids area during early October (FISS 2010) and spawn around the third week of February (Holtby and Ciruna 2007). Recent studies show the Harrison-Chehalis Sockeye, unlike other late-run Fraser River Sockeye populations, have had unprecedented, large escapements in recent years (Labelle 2009). It is not known if this is related to the immediate downstream migration of the fry to rear in the Fraser River estuary (Labelle 2009). This population is the only Fraser sockeye stock that increased in number during the 2009 sockeye collapse.

Habitat conditions for this population are thought to be relatively healthy. Potential restoration of Harrison River left and right bank side channels damaged by navigation channel dredging are considered options for future restoration efforts (Foy 2007). Reduced winter flows prevent entry to important side-channel spawning habitats which could also be seriously impacted by low water levels caused by dredging of gravel at Harrison Rapids or by the use of Harrison Lake as a regional water supply (Foy 2007).

5 High Value Habitats

High value habitats were identified as locations considered by Holtby and Ciruna (2007) and are shown in Figures 2-6. Each of these habitats is discussed below. Each section identifies the salmon species / CUs present in the habitat, provides a brief physical description of the drainage and salmon use within the drainage, as well as completed and proposed restoration projects. Data related to pressure and state indicators relevant to the watershed are provided where data has been compiled, or referred to where the data exists but is not compiled.

Tributaries are listed alphabetically, except where the habitat is within a previously-identified drainage; for example, Sakwi Creek is listed in Section 5.6 under Morris Creek.

5.1 Big Silver Creek

CUs in Big Silver River, as described by Holtby and Ciruna (2007), are SK L-3-3, CH6, CO2, CM2 and PK1.

Big Silver Creek is located 35 km north of the Village of Harrison Hot Springs, on the east side of Harrison Lake. It drains an area of 495 km^2 (NHC 1994), originating in the Lillooet Range of the Coast Mountains. Total length of the mainstem from headwaters to mouth is approximately 40 km. The lower 15 km of the mainstem is stable and contains a single major side-channel where the river splits approximately 2 km from its mouth on Harrison Lake (WRP 2000). The main tributaries of Big Silver Creek are Clear Creek and Hornet Creek; both have been heavily impacted by historic logging and Hornet Creek is still relatively unstable (WRP 2000).

The west (right) branch provides excellent spawning habitat whereas the east (left) branch contains mostly large rock (NHC 1995). A large boulder in the centre of the stream upstream of the fork forces high-flows around the rock, and acts a barrier to many fish (Stitt, Charlie, Foy, Pers. Comm.).

Spawning is limited to the lower 6 km of Big Silver due to a waterfall obstruction, although rainbow trout and possibly steelhead utilize canyon habitat from km 6 – 15. Chinook and coho are scattered throughout system downstream of the falls; chum spawning is concentrated in the upper 1.2 km of the west channel; coho spawning is concentrated in the top 2 km of the system before the falls and in the lower section of Hornet Creek (FISS 2010). There is limited sockeye rearing up to the falls. Habitat limitations in Big Silver are lack of off-channel habitats, nutrient limitations, and a lack of large woody debris (WRP 2000). Historic logging and road building has increased erosion, siltation and bedload movement, causing a chronic siltation and aggradation problem in the lower reaches (FISS 2010).

Restoration Works Completed

A Fisheries Research and Development fertilization experiment was conducted in Big Silver Creek watershed from 1991 – 1997, in which the mainstem was fertilized using liquid ammonium polyphosphate fertilizer during the summers of 1994-97. Physical, chemical and biological components were monitored throughout the project, and the fertilization was shown to stimulate growth at all trophic levels (Wilson et al. 1999). Fertilization continued in 1999, but was discontinued in 2000 (WRP 2000).

Major habitat restoration works took place at Big Silver Creek in 1991. Natural aggradation of the channel had caused flows to dewater the west branch, which had been a major spawning channel for all five salmonid species. The fork in Big Silver was re-graded and fortified to return flows to the west (right) branch of the stream to maximize spawning habitat potential and has been successful in maintaining flows since that time (Foy 2007).

Pressure Indicators:

Land cover alterations: The lower slopes of the watershed have been logged intensively over the last 40 years, but secondary growth is well-established (Nener and Warwick 1997): 24% of the total watershed has been logged, including 15% from recent or proposed harvesting. DFO has had concerns regarding continued logging in this area (FRAP 1999).

Watershed road development: Road density statistics are not available for this watershed.

Water extraction: Two water licenses for power generation have been granted to Cloudworks Energy Inc. totaling 3192.7 cfs (MOE Water Users' Community Query – Licensees 2010).

Riparian disturbance: Significant disturbance due to historic logging. We were not able to identify data specific to riparian disturbance.

Permitted waste management discharge: None.

State Indicators:

Suspended sediment: Channel destabilization and sedimentation from historic logging is an identified limitation in Big Silver Creek (FRAP 1999). Field notes from the 1950s to 1970s indicate heavy silting over 10- 90% of spawning grounds.

Water Quality: Baseline water quality data was collected in the summer of 1993 before the Big Silver Creek Fertilization experiment, and were reported in Wilson et al. 1999. Water transparency was measured in Big Silver Creek during 1993-1994 using a secchi disk. Transparency was usually above 2 m in July and August, and often above 4 m (Wilson et al. 1999). Pre-fertilization nitrate + nitrite concentrations averaged 38 – 46 µg/L in all three reaches from June to August, and increased sharply in September when water levels dropped to 88 – 91 µg/L. This stream is considered oligotrophic. Soluble reactive phosphorous (SRP) and total dissolved phosphorous (TDP) were at or below the 1 µg/L and 3 µg/L (respectively) detection limits in Big Silver, Clear Creek and Hornet Creek. Elevated levels were measured throughout the nutrient enrichment experiment, but were attributed to chronic contamination issues (Wilson et al. 1999).

Water Temperature: Wilson et al. (1999) measured water temperatures at multiple locations in Big Silver River from June – September from 1993-1997, and this data should be available for comparison to future monitoring data. Temperatures ranged between 7-17°C, with peak temperatures in August. The average growing-season temperatures of Big Silver Creek and its tributaries were over the 10°C temperature required by rearing salmonids (Wilson et al. 1999).

Discharge: The estimated mean annual flow of Big Silver Creek is 15.0 m^3/s (NHC 1994) and the naturalized summer 7-day mean low flow is 33% of the mean annual flow (FRAP 1999). There is no historic or current data from hydrometric stations in this watershed.

5.2 Chehalis River

CUs in Chehalis River, as described by Holtby and Ciruna (2007), are SK R03, CH4, CO2, CM2, and PK1. Steelhead are also present in this river, and spawn in restored habitats below the outlet from Chehalis Lake (Stitt, Pers. Comm). A historic run of red-fleshed chinook were known in the lower reaches of Chehalis River as late as the 1980s (Foy 2007).

The Upper Chehalis River drains the Upper Chehalis Lake, which is inaccessible to anadromous fish due to cascades, log jams, and a 9 m waterfall 6 km above Chehalis Lake. The lower reaches of the Upper Chehalis do provide some spawning habitat for coho and steelhead, and Coho Creek provided high-density spawning habitat for coho on the alluvial floodplain into Chehalis Lake (see S. 5.2.2). Below Chehalis Lake is approximately 2 km of spawning habitat, heavily used by steelhead. Downstream of these spawning gravels, Chehalis Canyon is a barrier to chum, chinook and pink salmon and is prone to channel-spanning log jams. One such jam was removed in the 1980s and removed before Chehalis River coho populations were lost (Foy 2007). A log-boom on Chehalis Lake is used to reduce jamming in the canyon below; log jams are regularly removed approximately 0.5 km downstream from Chehalis Lake.

Chehalis River flows out of the canyon onto its alluvial fan, just upstream of the Morris Valley Road bridge-crossing. The fan is wide, gradients are low and the river is currently eroding towards the east bank. The Chehalis River has a history of lateral and vertical instability resulting in abrupt channel changes and avulsions on its fan (NHC 1994). The Chehalis First Nation Reserve is on the banks of the Chehalis, and a new berm has been built to protect the reserve from river avulsions and to replace a dike built in 1968 that was heavily damaged during a 1978 flood (Foy, Pers. Comm.). Aggradation will continue on the Chehalis fan, and will continue to need management to prevent flooding (Foy, Pers. Comm.). Restoration of the historic sloughs east of the Chehalis Reserve would improve spawning and rearing habitat in the absence of the natural processes caused by the now restricted movement of the Chehalis River across its fan (Foy, Pers. Comm.). The right bank of the river near Chehalis hatchery is protected by a rock revetment (Foy, Pers. Comm.).

The Chehalis fan is the only significant aquifer within the LHW (Atwater et al. 1994 *in* NHC 1994), and is recharged from the Chehalis River. Shallow high-production wells provide water to the Chehalis River Hatchery and, as a result, reduce flows in the Chehalis River (Foy, Pers. Comm.).

Restoration and Enhancement Completed

The Chehalis River Salmon and Trout Enhancement Facility was built in 1982 and is operated by DFO to produce coho salmon, chinook salmon, chum salmon, pink salmon, steelhead trout, and sea-run cutthroat trout (Stitt, Pers. Comm.). Spawning gravel was placed at the outlet from Chehalis Lake to create spawning habitat for coho and steelhead in 1976. Rearing ponds were created and enhanced in the mid 1980's to compensate for impacts resulting from the expansion of Morris Valley Road (FRAP 1999 – location unclear). A second spawning gravel placement was completed at the Chehalis Lake outlet in 1996, and was complemented by large woody debris placement in 1998 through the Watershed Restoration Program (WRP 1999). In 1997, 30,000 m^2 of rearing habitat, including 500m^2 of spawning area was created at Kahl Creek, downstream of the Chehalis Hatchery, for coho, steelhead and cutthroat trout (Foy et al. 1997). In addition, a 480 m-long off-channel spawning, rearing and refuge habitat was created alongside the Statlu tributary to the Chehalis, at 9.5 Mile on the Chehalis Forest Service Road, which increased available spawning habitat from just 20 m in the main channel (WRP 1999).

Restoration and Enhancement Proposed

In 1997, proposals submitted to the Watershed Restoration Project in the Chehalis Watershed included: Stream Classification and Ground water Assessment of Upper Chehalis River Tributaries, Statlu River Waterfall Obstruction Removal Assessment, Coho Creek off-channel pool assessment, Pretty Creek Diversion Assessment, and Chehalis River Watershed Stream Classification Assessment). In addition, a proposal to increase chum and coho productivity of Chehalis River fan sloughs was provided by J.O. Thomas and Associates Ltd. in 2000 to DFO; this proposal involved removing in-streamth silt accumulations and developing pool / cover habitat units in the Harrison River side-channels (originally formed by movement of the Chehalis River across the fan). These proposals were identified in Foy's files, however it is not clear whether these proposals were accepted and funded; final reports regarding these projects were not found.

Pressure Indicators:

Land cover alterations: A detailed breakdown of land-use in the Chehalis watershed is provided in Table 4 (Environment Canada, 2002). The upper reaches of the Chehalis River have been heavily impacted by logging; the lower reaches of the Chehalis River are impacted by urban development, flood control, and forestry (FRAP 1999). Portions of the watershed are in transition from forest to rural residential lots and there is residential development on the Chehalis Reserve (FRAP 1999). A 1995 review of forest harvesting in the Harrison watershed found that the Chehalis watershed was heavily impacted by logging, assessed by determining the area of historic, recent and planned forest harvest as a percentage of the total basin area (McLennan and Recknell 1999). In 1994, 32% of the watershed had been logged and another 9% was proposed. Of particular concern was Statlu Creek, with 40% of the watershed logged and another 12% proposed (NHC 1994). A 1997 review of the watershed found that only 30% remained in mature or old-growth forest (Scott 1996 *in* McLennan and Recknell 1999), and the watershed then became a priority for the Watershed Restoration Program.

Watershed road development: Road density statistics are not available for this watershed.

Water extraction: Fisheries and Oceans Canada extracts water from the Chehalis River, with an allowable limit of 65 cfs for the Chehalis Fish Hatchery. Surface water is also removed from the Chehalis River approximately 1 km upstream of the hatchery, designed to provide at least 100 litres per minute (LPM) to the facility. Normal operating supply is 30-40 LPM, but is reduced to 25 LPM during high turbidity events. Chehalis First Nation extract up to 10 000 gallons/day for residential use (MOE Water Users' Community Query – Licensees 2010). The potential August and September water demand for industrial use is less than 1% of the naturalized summer 7-day mean low flow (NHC 1994).

Riparian disturbance: Logging and flood control are the main causes of riparian disturbance in this drainage. Total riparian disturbance has not been calculated for this watershed. McLennan and Recknell (1999) developed a riparian status summary for selected sub-drainages of the Chehalis watershed, as well as a riparian restoration plan. They found that 60% of the riparian vegetation in the selected sub-drainages had been harvested, of which 32% were significantly hydrologically impaired and another 28% were moderately impaired. McLennan and Recknell (1999) recommended that riparian restoration prescriptions be developed for three sites within the Chehalis watershed: one in the Upper Chehalis River, one on the Chehalis fan, and a third in the Statlu River Spotted Owl Special Management Zone. We were not able to find any reports regarding the completion of these proposed projects.

Permitted waste management discharge: Discharge Creek (a tributary to Maisal) receives sewage discharges from the Hemlock Valley Ski Area (FRAP 1999).

State Indicators:

Suspended sediment: Unknown. Sediment loads are high due to a combination of road-dirt from the Morris Valley Road bridge, which services logging traffic, as well as extensive logging in the watershed and land clearing for recreational trails and MOF campsites along the river. There is also significant sedimentation and pool infilling occur for the entire length Maisal Creek due to forest harvest and boulder slides on the left bank (FISS 2010).

Water Quality: Chehalis river water is very oligotrophic (Stitt, Pers. Comm). Water quality analysis conducted in July 1998 found water throughout the Chehalis watershed to be very low in nutrient values (Table 3), suggesting low potential ecological productivity.

Table 3. Water quality analysis in Chehalis River Watershed on July 24, 1998 (Foy, Pers. Correspondence).

Site Name	NO_2+NO_3 (mg/L)	o-PO_4 mg/L	SpCond (μS/cm)	pH
Upper Chehalis	0.064	< 0.001	8.0	6.79
Coho Creek	0.103	< 0.001	25.0	6.56

Site Name	NO_2+NO_3 (mg/L)	o-PO_4 mg/L	SpCond (μS/cm)	pH
Chehalis Lake outlet	0.076	< 0.001	11.0	7.38
Maisal Creek	0.048	< 0.001	43.0	7.57
Chehalis River – mid main	0.076	< 0.001	12.0	6.97
Statlu Creek	0.139	< 0.001	18.0	7.15
Chehalis River – above hatchery	0.090	< 0.001	18.0	7.52

Water Temperature: Daily temperature records are available in data binders at the Chehalis Fish Hatchery, but are not compiled. This is an easy source of state indicator data that should be accessed to inform the Chehalis watershed habitat status.

Discharge: Environment Canada Hydrometric Station #08MG001 measures flows at the Chehalis River near Harrison Mills, with daily flow readings from 1911 to present (Table 4). The mean annual flow of the Chehalis River is 37.7 m^3/s (EC web), with maximum and minimum discharge at 660 m^3/s and 3.02 m^3/s respectively. The Chehalis fan has low flow issues, and DFO regularly removes gravel from Chehalis River to maintain a channel leading to their hatchery. During low flows, much of the discharge moves through the thick gravel on the channel bed and gravel removal is required to maintain flow (FRAP 1999). FRAP (1999) reports that high flows occur in December, however IEC (1980) determined that while low summer flows are more common than low winter flows, low winter flows are more extreme, therefore over the long-term, the lowest flows occur in the winter months (IEC 1980). The naturalized summer 7-day mean low flow is 14% of the mean annual flow (Nener and Warwick 1997).

*Table 4. Summary statistics and land use data for Environment Canada Hydrometric Stations and related data, accessed through the British Columbia and Yukon Environmental Monitoring Networks (Environment Canada 2002). *Station 08MG022 measured water level, not m^3/s.*

	Station	08MG001	08MG023	08MG009	08MG012	08MG013	08MG022
	Description	CHEHALIS RIVER NEAR HARRISON MILLS)	CHEHALIS RIVER BELOW STATLU CREEK	WEAVER CREEK NEAR HARRISON HOT SPRINGS	HARRISON LAKE NEAR HARRISON HOT SPRINGS	HARRISON RIVER NEAR HARRISON HOT SPRINGS	HARRISON RIVER BELOW MORRIS CREEK *water level
	Dates	1/1/1911-present	1/1/1981-12/31/1983	1/1/1945-12/31/1964	1/1/1933-present	1/1/1923-present	1973-present
	Basin Area (Km^2)	383	357	42.2	134	7870	7950
	Max Discharge (m^3/s)	660	469	134		1930	12 m*
	Min Discharge (m^3/s)	3.02	5.49	0.063		67.1	8.16 m*
	Mean Discharge (m^3/s)	37.7	41	2.73		445	9.33 m*
		% Area	**% Area**	**% Area**	**% Area**	**% Area**	**% Area**
Agriculture	Landuse based agriculture activities undifferentiated as to crop (ie. land is used as the producing medium)				0.61	0.60	0.60
Alpine	Areas virtually devoid of trees at high elevations	9.71			25.31	25.28	25.03
Barren Surfaces	Rock barrens, badlands, sand and gravel flats, dunes and beaches where unvegetated surfaces predominate.	0.10			1.01	1.01	1.00
Fresh Water	Fresh water bodies (lakes, reservoirs and wide portions of major rivers).	1.72			3.87	3.88	3.90
Glaciers and Snow	Glaciers and permanent snow. Depending on the date of imagery, ephemeral snow may be included in this class.	0.20			8.25	8.25	8.16
Mining	Land used now (or in the past and remains unreclaimed) for the surface extraction of minerals or quarry materials.					0.00	0.00
Old Forest	Forest greater than or equal to 140 years old and greater than 6 meters in height. Areas defined as Recently Logged and Selectively Logged land uses are excluded from this class.	35.38			31.37	31.34	31.09
Rangelands	Unimproved pasture and grasslands based on cover rather than use. Cover includes drought tolerant grasses, sedges, scattered shrubs to 6 meters in height and less than 35% forest cover. Sparse forest stands are included with their understorey of drought tolerant shrubs and herbs.				0.03	0.03	0.03
Recently Burned	Areas virtually devoid of trees due to fire within the past 20 years. Forest less than or equal to 15% cover.				0.29	0.29	0.29

Station		08MG001	08MG023	08MG009	08MG012	08MG013	08MG022
Description		CHEHALIS RIVER NEAR HARRISON MILLS)	CHEHALIS RIVER BELOW STATLU CREEK	WEAVER CREEK NEAR HARRISON HOT SPRINGS	HARRISON LAKE NEAR HARRISON HOT SPRINGS	HARRISON RIVER NEAR HARRISON HOT SPRINGS	HARRISON RIVER BELOW MORRIS CREEK *water level
Recently Logged	Timber harvesting within the past 20 years, or older if tree cover is less than 40% and under 6 meters in height.	16.47			6.14	6.13	6.10
Recreation	Land used for private or public outdoor recreational purposes. Ski resorts and golf courses are included. This class does not include recreational areas within built-up portions of cities, towns and villages, which are mapped as urban areas. This class includes waterfront cottage areas if they are at least 200 meters wide.	0.02			0.12	0.12	0.16
Residential / Agricultural Mix	Areas where agriculture activities are intermixed with residential and other buildings with a building density of between 2 to 0.2 per hectare.				0.04	0.04	0.04
Selectively Logged	Areas where the practice of selective logging can be clearly interpreted on the Landsat TM image and TRIM aerial photography.				0.31	0.31	0.31
Sub-alpine Avalanche Chutes	Areas below the tree line that are devoid of forest growth due primarily to snow avalanches. Usually herb or shrub covered	5.47			7.26	7.25	7.18
Urban	All compact settlements including built up areas of cities, towns and villages as well as isolated units away from settlements such as manufacturing plants, rail yards and military camps. In most cases residential use will predominate in these areas. Open space which forms an integral part of the urban agglomeration, e.g. parks, golf courses, etc. are included as urban.				0.15	0.15	0.15
Wetlands	Wetlands including swamps, marshes, bogs or fens. This class excludes lands with evidence or knowledge of haying or grazing in drier years.				0.65	0.65	0.67
Young Forest	Forest less than 140 years old and greater than 6 meters in height. Areas defined as Recently Logged and Selectively Logged land uses are excluded from this class.	30.93			14.59	14.66	15.28

5.2.1 Chehalis Lake

Chehalis Lake is 8.6 km long with a north-south orientation, surface area of 685 ha, mean depth of 79 m and maximum depth of 138 m. The lake provides rearing habitat for coho fry, and creates a hydrologic and thermal buffer for the lower Chehalis River from flash-floods and sediment pulses (Foy, 2007). In December 2007, a massive avulsion into Chehalis Lake caused a tidal wave that scoured the shoreline and re-graded the Upper Chehalis delta, removing riparian vegetation around the lake up to 10 m elevation from the high water mark. Impacts to fish were not measured, but the large amounts of silt, mud and debris in the lake would have caused stressful conditions for overwintering fry and resident fish. Sockeye salmon had been known to occur in Chehalis Lake until the late 1800s, and was believed to have gone extinct due to altered thermal regimes from local logging in 1912 or a logjam barrier in the Chehalis Canyon (Foy 2007). Since then, sockeye salmon have been caught in gill-net sampling in Chehalis Lake in 1997 and 2001 during sampling for dolly varden / bull trout research (FISS 2010). Beach-spawning sockeye or kokannee populations may still exist in this lake (Foy 2007).

Pressure Indicators:

Riparian disturbance: The riparian vegetation of Chehalis Lake is undisturbed by anthropogenic uses, however the 2007 landslide into the lake caused significant destruction to riparian vegetation surrounding the lake.

Permitted waste management discharges: None.

Land Cover Alterations: Forest harvesting exists in the Chehalis Lake watershed, however we were unable to find any compiled area data to quantify logging as a pressure indicator. Data from the Ministry of Forests and Range should be compiled to provide a measure of the equivalent clearcut area (ECA) in the watershed, a measure that includes a regeneration recovery factor to reflect hydrologic recovery of cutblocks as they regenerate. NHC (1994) suggests that allowable ECA may range from 20-40%. There is currently no residential or urban land use in the Chehalis Lake watershed.

Watershed road development: Road density statistics are not available for this watershed.

Water extraction: None.

State Indicators:

Productive Capacity: Unknown.

Coldwater refuge zone: Unknown.

5.2.2 Coho Creek

CUs in Coho Creek, as described by Holtby and Ciruna (2007), are CO2 and CM2.

Coho Creek is tributary to Chehalis Lake on the Upper Chehalis River delta (the creek is often mis-labeled on maps). Although it drains an area of only 9 km^2 and is only 100 m long, this creek has held very high spawning densities, estimated at 1500 spawners / 100 m length (Foy, Pers. Comm.). The population was used as brood stock for the Weaver Creek Hatchery in the early years of operation (Stitt, Pers. Comm.) and it is assumed that fry rear in Chehalis Lake.

The Salmonid Enhancement Program (SEP) had constructed a groundwater-fed spawning channel in the upper part of the creek (year unknown) ensuring stable summer flows (NHC 1994). Debris removal was also conducted on Coho Creek in 1970 to increase spawning area (FRAP 1999). FRAP (1999) reported that potential enhancement opportunities for Coho Creek included a spawning channel for pink salmon and an incubation box for coho. In 2007, a massive avulsion into Chehalis Lake caused a tidal wave that scoured the shoreline and re-graded the Upper Chehalis delta, destroying the invert that was Coho Creek. In fall 2009 a channel was dug by DFO in the same approximate location as Coho Creek in order to restore coho spawning habitat on Chehalis Lake.

Pressure Indicators:

Land cover alterations: Coho creek was reportedly logged before 1963, but there is no record of this in the Ministry of Forests Silvicultural Records (NHC 1994).

Watershed road development: Road density statistics are not available for this watershed.

Water extraction: None.

Riparian disturbance: Coho creek was reportedly logged before 1963, but there is no record of this in the Ministry of Forests Silvicultural Records (NHC 1994).

Permitted waste management discharge: none.

State Indicators:

Suspended sediment: No data.

Water Quality: No data.

Water Temperature: No data.

Discharge: No data.

Length of key spawning areas: Approximately 100 m (Foy, pers. Comm.).

5.3 Cogburn Creek

CUs in Cogburn Creek, as described by Holtby and Ciruna (2007), are SK L-3-3, CH6, CO2, and CM2. Cogburn Creek drains an area of 203 km^2 east of Harrison Lake, but has an impassable 3 m waterfall 1.5 km upstream of the mouth that limits spawning (FISS 2010). Potential rearing habitat is found in two side-channels within the lower reach, and the first four reaches are of highest value for salmonids in the watershed (FISS 2010). Chum spawn in the lower 1st km of Cogburn Creek (FISS 2010). Cogburn logging company operates on Harrison Lake directly south of the mouth of Cogburn Creek.

Pressure Indicators:

Land cover alterations: FRAP 1999 indicated that 8% of the total watershed had been logged, including 7% from recent activity with another 4% proposed. Ortho-imagery suggests that the watershed has been heavily logged, and should be re-assessed.

Watershed road development: Road density statistics are not available for this watershed.

Water extraction: None.

Riparian disturbance: We were not able to identify data specific to riparian disturbance.

Permitted waste management discharge: None.

State Indicators:

Suspended sediment: No data.

Water Quality: No data.

Water Temperature: No data.

Discharge: Average annual discharge is estimated at 6.15 m^3/s (NHC 1994). The naturalized summer 7-day mean low flow is 33% of the mean annual flow (Nener and Warwick 1997).

Length of key spawning areas: Impassable falls 1.5 km upstream of mouth (FRAP 1999).

5.4 Douglas Creek

CUs in Douglas Creek, as described by Holtby and Ciruna (2007), are SK L-3-3, CH6, CM2 and PK1. FISS also documents coho salmon in this river. Sockeye and coho are most abundant, with an excess of 1000 and 100 individuals (respectively) during peak years (CELP 2003).

Douglas Creek drains a 103.2 km^2 watershed at the north end of Harrison Lake, directly east of the mouth of the Lillooet River. The lower reaches have high fisheries values, although they are channelized. Impassable falls exist at 0.9 km upstream of the mouth of Douglas Creek to Harrison Lake, and another steep gradient barrier exists 1.6 km upstream of the confluence (FISS 2010). Chinook, chum, coho and sockeye all spawn upstream to the first barrier, and mostly spawn in the lower 750 m (Nener and Warwick 1997). Douglas Creek is unstable and prone to flooding; skidder activity has caused severe slumping in the drainage and logging in the 1960s left the stream unstable for several years (Nener and Warwick, 1997).

Independent Power Production

Cloudworks Energy operates an independent power project (IPP) in Douglas Creek, where water is diverted from upper reaches for power generation and returned to the creek upstream of the first barrier falls and the upper limit for anadromous fish utilization (CELP 2003). The powerhouse is set back 100 m from the creek to minimize riparian disturbance. The design flow for the project is 10.0 m^3/s, and will provide 32 MW of power. This IPP project provides a significant amount of data to inform quantitative habitat status (CELP 2003).

Enhancement works proposed by CELP (2003) involve the construction of a rearing pond and water supply channel adjacent to upper reach 1 of Douglas creek to provide an off-channel rearing habitat complex and constructed spawning channel.

Pressure Indicators:

Land cover alterations: 1% of the total watershed has been logged recently and 1% is proposed for harvest. Skidder activity caused severe slumping and logging in the 1960s which left the stream unstable for several years (Nener and Warwick 1997). Gravel mining (Matsqui Pits) caused severe sedimentation of the Douglas Creek headwaters in the early 1980s resulting in a Fisheries Act prosecution – the pit areas have now been developed for housing (FRAP 1999). The constructed IPP increases road density and clearing in the watershed.

Watershed road development: Road density statistics are not available for this watershed.

Water extraction: A water extraction license for power generation purposes was granted in 2006 to the Douglas Creek Project Partnership for 392 cfs, and an application has been submitted by Cloudworks Energy Inc. for another 12.36 cfs for conservation purposes.

Riparian disturbance: The lower channel has been channelized. This unstable system is prone to flash floods (Nener and Warwick 1997).

Permitted waste management discharge: None.

State Indicators:

Suspended sediment: Low (CELP 2003).

Water Quality: Baseline water quality data was collected on Douglas Creek in 2002 to add to the 2001 water quality database reported on in KPL (2002a *in* CELP 2003). Douglas Creek is oligotrophic, with total phosphate 0.002mg/L-0.003mg/L; ortho-phosphate concentrations were at or below lab detection levels; conductivity was below 25µs/cm over a 6 year period (Quilty 2001 *in* CELP 2003); ammonia and nitrite nitrogen values were at lab detection levels, and nitrogen values of 0.37 mg/L - 0.46mg/L were lower than long-term mean of 0.79mg/L (Quilty 2001 *in* CELP 2003).

Water Temperature: Reported summer stream temperatures ranged between 10° C and 15°C with a max temp of 16.8°C (CELP 2003). Temperature data compared to MOE water quality guidelines did not often exceed the prescribed maxima (CELP 2003).

Discharge: Mean annual discharge at the mouth of Douglas Creek is 6.33 m^3/s. Instream flows meet BC Fisheries broad-based guidelines for minimum flows (Hatfield et al. 2002, unpubl. draft *in* CELP 2003). Therefore, following the construction of the IPP, minimum instream flows are as follows:

- 0.45 m^3/s overwintering flow release from Nov. 1 – May 31.
- 0.90 m^3/s summer rearing release from July 1 – Oct. 31.
- 1.8 m^3/s as rainbow trout spawning release from June 1 – June 30.

Length of key spawning areas: Anadramous spawning is limited to below impassable falls at km 0.9 on Douglas Creek (CELP 2003). A constructed spawning channel and rearing habitat is proposed for the lower reaches of Douglas Creek (CELP 2003).

5.5 Harrison River

CUs in Harrison River, as described by Holtby and Ciruna (2007) are SK R03, CH3, CO2, CM2, and PK1. The Harrison River provides crucial spawning habitat for sockeye CU R03, which spawn almost exclusively in the Harrison Rapids, as well as for the LFR Fall White chinook CU (CH3) (Holtby and Ciruna 2007).

The Harrison River is a short, large tributary flowing southwest from Harrison Lake for 16.5 km, entering the Fraser River 116 km upstream from Georgia Strait (Ennis 2010). The Harrison River between Chehalis Village and Harrison Lake is well graveled, straight, and confined by bedrock through much of its course (FRAP 1999). The river flows through small rapids and difficult water at the Chehalis Fan; this rapid provides an important control on water levels in upstream habitat and Harrison Lake at low discharges (FRAP 1999). The river then widens into a complex system with multiple side-channels and in-river islands below the confluence of the Chehalis River. Downstream, near the confluence with the Fraser, the Harrison River expands into a wide backwater called Harrison Bay. The Harrison drains an area of 8,324 km^2, which includes the Lillooet drainage. A detailed breakdown of land use is shown in Table 4 (p. 28); 41% of the watershed is alpine, barren land, avalanche chutes or glacier; 31% of the watershed is old forest (greater than 140 years old); 15% is young forest, and 6% is recently logged (Environment Canada 2002). Much of the lower floodplain at Harrison Mills has been diked and riparian removed around 5 km of the area, now used for agriculture. Another 2 km of riparian has been removed by the development of a residential area and golf course on the right bank of the Harrison on the Elbow Creek fan (ILMB 2010a).

In the days of the Fraser Canyon Goldrush (1858 era), sandbars at the confluence with the Fraser River were dredged (Ennis 2010). The Harrison River was then dredged regularly until the early 1960s for navigation at the request of log boom operators (IPSFC 1967). In 1964, dredging near the upper end of Harrison Rapids in the vicinity of a control section of the river was halted by the Department of Public Works and Fisheries and Oceans in order to study the effects of the dredging on river levels and spawning grounds. The assessment concluded that spoils from the dredging covered approximately 15,900 square yards (1.3 ha) of sockeye spawning grounds in the river, as well as 100,400 square yards (8.4 ha) of spawning ground in the main channel formerly used by pink, chinook and chum salmon, much of it the most valuable spawning gravel in the area. In addition, dredging at the control section near the upper end of the rapids lowered the water level at the upper end of important spawning back-channels on the left bank of the river, significantly increasing the frequency of zero-flow in the channel in March when salmon fry begin to emerge from the gravel (IPSFC 1967). Channels on the right bank of the river also dry up at higher river discharges, and the entrances to these sloughs were confined by dredge spoil piles resulting in lower flows and sediment build-up. Diversion of the Chehalis River from its east branch also shut off sources of water for these right bank channels at low flow. Lowering of water levels upstream of the control point further reduced sockeye spawning area by 5,300 square yards along the left bank of the river (IPSFC 1967). As a result, dredging of the rapids near the control point was discontinued (Foy, Pers. Comm.). The document describing dredging in the Harrison River and its impacts on salmon spawning is included as Appendix 4.

Reduced winter flows are likely to further reduce entry to important side-channel spawning habitats, which could be seriously impacted by low water levels caused by dredging of gravel at Harrison Rapids or by the use of Harrison Lake as a regional water supply (Foy 2007).

Enhancement facilities on the Harrison River include: two groundwater spawning channels for chum (Billy Harris Channel and Ed Leon Channel), two other spawning channels for chum (Little Mountain Side channel and Pretty's SEP Channel), and the Smokehouse Hatchery for chinook (FRAP 1999). A Ministry of Environment proposal to designate a Harrison WMA is in process, and would protect 1,400 ha of river and delta habitats along the Harrison and Chehalis rivers; the Nature Trust of B.C. owns two properties, located within the Chehalis River delta and totaling 200 hectares, which will be included in the wildlife management area. The objective of the WMA would be to conserve the ecological integrity of riverine habitats of the Harrison and Chehalis Rivers (MOE 1997).

In 1981, Fisheries and Oceans Canada proposed enhancement works regarding the development of a large spawning channel in a side channel on the left bank of the Harrison River. The new channel would regrade the top end of the side-arm to ensure adequate flows for incubation at all water stages, primarily for the enhancement of pink salmon. A second proposal to regrade the same channel was submitted in 1992, however the work was not completed (Foy, Pers. Comm.)

Pressure Indicators:

Land cover alterations: 31% of the watershed is old forest (greater than 140 years old); 15% is young forest, and 6% is recently logged (Environment Canada 2002). Along the Harrison River, development occurs at Elbow Creek, Chehalis Village, and Harrison Hot Springs.

Watershed road development: Road density statistics are not available for this watershed.

Water extraction: Three domestic / business water licenses have an allowable extraction of 0.001 m^3/s.

Riparian disturbance: The lower Harrison River and a number of tributaries are impacted by logging, riparian removal, channelization and an accumulation of development activities. Along the Harrison, 7 km of riparian have been removed as a result of agriculture at Harrison Mills and the development of a golf course and housing subdivision on the Elbow Creek fan (ILMB 2010). Lougheed Highway runs alongside the north portion of Harrison Bay, and a railroad runs along the south portion, however neither restricts the movement of the river.

Permitted waste management discharge: One sewage waste outfall is permitted on Harrison River, from the Harrison River Lodge (MOE Water Users' Community Query – Licensees 2010).

State Indicators:

Suspended sediment: No data.

Water Quality: No data.

Water Temperature: Continuous water temperature monitoring near the mouth of the river (at the south end of Harrison Bay) from 1988 to 1993 show that maximum July and August stream water temperatures often exceed 20°C (Nener and Warwick, 1997). Thermal data loggers that were placed at a depth of 5 m in Harrison River from August – November 2004 indicated that late August river water temperatures were 16.5-18.0°C, above critical disease thresholds for holding salmon (Mathes et al. 2010). Early-run sockeye salmon holding in the watershed survived these high temperatures by moving to Harrison Lake for cooler temperatures; no early-run sockeye that remained in Harrison River to hold were found to survive until spawning (Mathes et al. 2010).

Discharge: Environment Canada hydrometric gauge #08MG022 (Table 4) measures the water level of Harrison River at Morris Creek. The mean annual water level at that location is 9.33 m (above sea level), with a maximum measured level of 12 m and a minimum level of 8.16 m. The mean annual discharge of the Harrison River at Harrison Hot Springs (at the upper end of the Harrison River, drainage area 7,870 km^2 of 8,400 km^2) is 445 m^3/s (Hydrometric gauge #08MG013) (Table 4). Harrison rapids, at the Chehalis fan, provides an important control on water levels at low discharges. During the spring, the rapids are backwatered and inundated from the freshet flows on the Fraser River (NHC 1994). Both of the hydrometric stations are upstream of the Harrison Rapids.

Length of key spawning areas: Spawning maps and locations for the five salmonid species were well documented in the late 1960s following the dredging, however we were unable to find spawning maps using data from the last half-century. Changes in the river's morphology, habitat succession, and flow changes are likely to have impacted spawning locations, and surveys should be repeated to compare historic with current use. A document entitled "Spawning distribution of salmon in the mainstem of the Harrison and Stave River during November and December 1967" is appended to this document (Appendix 5). Salmon Research on spawning sockeye salmon by the laboratory of Dr. Scott Hinch at U.B.C. in 2004 will provide detailed habitat use data for sockeye salmon in the area. Harrison River is a major chum salmon producing system: most spawning occurs throughout Chehalis flats in groundwater-fed channels which were originally part of the Chehalis River, with a spawning area approximately 176,000 sq. yds. (FRAP 1999). Appended to this document is an un-dated map of chum spawning in the Harrison River (Appendix 6).

5.5.1 Harrison Lake

Harrison Lake is about 60 km long and 9 km across at its widest point, with a surface area of 220 km^2 and a mean depth of 151 m (Mathes 2010). The Lake is oriented northwest-southeast. It is fed by the glacial Lillooet River from its northernmost point, and flows into Harrison River in the south. The resort community of Harrison Hot Springs is situated at the south end of the lake, about 95 km east of Vancouver. Chinook, chum, coho, pink and sockeye adults hold in Harrison Lake before moving into tributaries to spawn (FISS 2010). Coho and sockeye juveniles rear and overwinter in the lake. Chum are known to spawn on beaches at the south end of the lake, on the public beach at Harrison Hot Springs as well as on the shores at Sasquatch Park on the east shore (Stitt Pers. Comm.).

Pressure Indicators:

Riparian disturbance: Riparian connectivity along much of Harrison Lake is intact, however residential development at the south end is reducing riparian cover in urbanizing area. Further development of the shores is likely, as development from the Fraser Valley reaches up into the Harrison watershed. At the resort town of Harrison Hot Springs, riparian vegetation is absent along the 2.2 km shoreline; residential development along Rockwell Drive on the south-east shore of the lake has resulted in another 2 km of riparian removal.

Permitted waste management discharges: Two permitted waste discharges outlet into Harrison Lake, one from the Village of Harrison Hot Springs (PE-116, lat/long 49.3073/121.7969) of sewage waste following treatment, and one from Harrison Hot Springs Hotel (PE-6197, lat/long 49.3044/121.7842) of dechlorinated hot tub water (Freyman, Pers. Comm.)

Land Cover Alterations: A detailed breakdown of land use by Environment Canada (2002) hydrometric station #08MG012 (Harrison Lake near Harrison Hot Springs) at is shown in Table 4; 41% of the watershed is alpine, barren land, avalanche chutes or glacier; 31% of the watershed is old forest (greater than 140 years old); 15% is young forest, and 6% is recently logged. At its base, Harrison Lake drains an area of approximately 7,870 km^2, which includes the Lillooet drainage.

Mining: Three placer mining operations on Harrison Lake extract gold, iron pyrite, zinc, copper, silver, lead and molybdenum at Doctor's Point, Rockwell Drive, and Seneca (ILMB 2010a). None of these operations appear to have large land cover footprints.

Forestry: Forest harvesting is extensive throughout the Harrison Lake Watersheds, however we were unable to find any compiled area data to quantify logging as a pressure indicator. Data from the Ministry of Forests and Range should be compiled to provide a measure of the equivalent clearcut area (ECA) in the watershed, a measure that includes a regeneration recovery factor to reflect hydrologic recovery of cutblocks as they regenerate. NHC (1994) suggests that allowable ECA may range from 20-40%.

Residential/ Urban Use: The Village of Harrison Hot Springs and residential developments along the south-east shore of Harrison Lake cover approximately 7 km^2 of the Harrison Lake Watershed.

Road Density: Road density statistics are not available for this watershed.

Water extraction: Seven water licenses total maximum removal of 112,000 gallons/day or 100,000,000 gallons/annum (MOE Water Users' Community Query – Licensees 2010).

State Indicators:

Productive Capacity: Harrison Lake's importance to sockeye production is described in Shortreed et al. (2001); sockeye fry are substantially larger than those found in most coastal lakes and some interior rearing lakes, and fry survival is within the normal range with higher than average growth-rates. Productive capacity of the combined Harrison-Lillooet drainage is calculated at 796 000 escapement, approximately double the annual average (Shortreed et al. 2001).

Coldwater refuge zone: A formal investigation of coldwater refuge zones in Harrison Lake has not been compiled, however given the lake's depth and size it is clear that thermal refuges do exist. Mathes et al. (2010) and Patterson (2005) measured temperatures in the Harrison River and Harrison Lake during sockeye spawning in 2004 (from August – November). Within Harrison lake, water temperatures in the shallow regions of the lake (20-40 m) averaged 14.5 °C; the lake is stratified during the summer, and the thermocline was at ~45, weakening in late October. In the deep regions of Harrison Lake (>50 m), the temperatures throughout the study was 6.5°C.

5.6 Morris Creek / Slough

Morris Creek is not identified by Holtby and Ciruna (2007), but FISS records show all five salmon species occurring within Morris Creek. Morris Creek is slough-like, draining Morris Lake into the Harrison River at a very low gradient. Morris Lake is fed by Weaver Creek, which originates at Weaver Lake and is joined by Sakwi Creek upstream of constructed spawning channels. Salmon spawn in a large wetland at the historic delta of Weaver Creek (Pearson, Pers. Obs.). The wetland is flooded most years from May – July during the Fraser freshet, as water backs up from the Fraser River up Harrison River and Morris Creek to the wetland, providing approximately 40 ha of rearing habitat (Pearson, pers. Obs.). Chum spawn from the mouth of Morris Creek to 800 m upstream; coho, pink and sockeye utilize the tributaries (FISS 2010).

Hydrology and morphology of Morris Creek have been impacted by past logging activity and residential / ski-resort development impacts upstream in the Weaver and Sakwi Creek watersheds. Morris Creek had previously been used as a log dump, and is now recovering (Nener and Warwick 1997).

Morris Creek, Weaver Creek and Sakwi Creek are threatened by summer water demand for residential use and IPP development, as well as natural summer low flows (NHC 1994). No water level monitoring stations exist on Morris Creek or Sakwi Creek, however.

Pressure Indicators:

Land cover alterations: Intensive forestry and the development of a ski resort in the Sakwi watershed have significantly impacted the hydrology and aggradation of the Morris watershed.

Watershed road development: Road density statistics are not available for this watershed.

Water extraction: None on Morris Creek. There is a large volume of water storage and no irrigation demand. However, see sections 5.6.2 and 5.6.1 regarding extractions on Weaver and Sakwi Creeks.

Riparian disturbance: The creek is more like a slough, and has been used as a log dump in the past (Nener and Warwick 1997).

Permitted waste management discharge: Morris Creek has been used as a log dump in the past, and the watershed is now recovering; sewage has been discharged into the creek from development (FRAP 1999).

State Indicators

Suspended sediment: No data.

Water Quality: No data.

Water Temperature: No data.

Discharge: The mean annual flow is estimated at 2.51 m^3/s (NHC 1994). The naturalized summer 7-day mean low flow is 8% of the mean annual flow (Nener and Warwick 1997). Data binders with daily water levels are available from the Weaver Creek Spawning Channel office (Stitt, Pers. Comm.)

Length of key spawning areas: Anadromous fish have access to all the tributary systems.

5.6.1 Morris Lake

Morris Lake is drained by Morris Creek, and accepts flows from Weaver Creek. It has a surface area of 8 ha, mean depth of 4 m, maximum depth of 12 m (Mathes et al. 2010). Salmon use this lake to hold before entering Weaver Creek. We were unable to find any data on Morris Lake, however Patterson (2005) indicates that a temperature logger was placed in Morris Lake in the summer of 2004. FISS (2009) reports water discoloration in the lake due to silt inputs from Sakwi Creek that may impact fish production and angling. No escapement data is available.

5.6.2 Weaver Creek

Weaver Creek CUs, as described by Holtby and Ciruna (2007), are SK R03, CH6, CO2, CM2 and PK1. Weaver Creek drains an area of 42.4 km^2 from Weaver Lake, which is inaccessible to anadromous fish due to several rock obstacles below the outlet (FISS 2010). Below these obstacles, approximately 1 km downstream of Weaver Lake is a 1.2 km reach of high-value spawning habitat in which chum, coho and sockeye have been documented (FISS 2010). At the lower end of this reach is the confluence with Sakwi Creek, a high-velocity flashy stream with large gravel loads that disrupt downstream spawning areas. For this reason, very little spawning occurs below the confluence of Sakwi and Weaver. Most Weaver sockeye fry rear in Harrison Lake.

The Weaver Creek spawning channel was constructed in 1969 to provide high quality spawning habitat to sockeye, chum, and pink salmon (Stitt, Pers. Comm.) below the confluence of Sakwi, in part because of damage to Weaver and Sakwi Creeks from sedimentation. Weaver Creek has been dredged annually to prevent gravel build-up and maintain access to the spawning channels; excess gravel was used to dyke Weaver Creek to prevent water and sediment for entering the spawning channel. Annual gravel extraction was approximately 20,000 m^3. In recent years, dredging has been altered to the annual excavation of a trench in Weaver Creek to 'catch' excess gravels and sediment traveling downstream (Stitt, Pers. Comm.)

Weaver Creek has low flow issues, which are aggravated by sediment accumulation and loss of surface water to the channel bed. Water for the spawning channel is taken from storage on Weaver Lake and a diversion from Sakwi Creek, and is designed for a discharge of 0.56 m^3/s (20 cfs) during spawning and 0.38 m^3/s (10 cfs) during incubation (IPSFC 1964 in NHC 1994). This flow is used to supplement low flows in Weaver Creek during part of the year (NHC 1994).

A hydrometric gauge on Weaver Creek was in place from 1945 - 1964, however land-use statistics were not compiled by Environment Canada.

Pressure Indicators:

Land cover alterations: Development of the Hemlock Valley Ski Resort at the head of the Sakwi creek tributary has resulted in heavy inputs of gravel and logging debris into the creek. Nener and Warwick (1997) indicated that 1% of the total watershed had been logged, and there is no further proposed harvesting (to 1998). However, it is known that logging has caused heavy inputs of gravel and logging debris into the creek, and has resulted in unstable flow. Formal land cover analysis would be very useful in this watershed.

Watershed road development: Road density statistics are not available for this watershed.

Water extraction: Fisheries and Oceans retains a water license to store 2160 acre-feet per annum (2.66 million m^3) in Weaver Creek (since 1964), as well as an extraction license for 20 cfs (0.57 m^3/s) for conservation purposes. Two domestic licenses total 1000 gallons per day. Nener and Warwick (1997) identify the potential August and September water demand for domestic, waterworks and industrial uses as 6% of the naturalized summer 7-day mean low flow.

Riparian disturbance: We were not able to identify data specific to riparian disturbance.

Permitted waste management discharge: None.

State Indicators:

Suspended sediment: Downstream of Hudson Bridge (Morris Valley road over Weaver Creek) has been dredged annually with the removal averaging 20,000 m^3 in order to maintain access to spawning channel.

Water Quality: No data.

Water Temperature: Data uncompiled. Data binders with daily water temperature records are available from the Weaver Creek Spawning Channel office (Stitt, Pers. Comm.).

Discharge: The mean annual flow is estimated at 2.51 m^3/s (NHC 1994). The naturalized summer 7-day mean low flow is 8% of the mean annual flow (Nener and Warwick 1997). Data binders with daily water levels are available from the Weaver Creek Spawning Channel office (Stitt, Pers. Comm.)

Discharge: Environment Canada's hydrometric station #08MG009 has operated at Weaver Creek from 1945 – 1964. During that time the mean annual discharge was 2.73 m^3/s; maximum discharge was 134 m^3/s, and minimum discharge was 0.063 m^3/s (Table 4).

Length of key spawning areas: Spawning habitat in Weaver Creek is optimal below Weaver Lake and above the confluence with Sakwi Creek, as well as in the Weaver Creek spawning channels.

5.6.3 Sakwi Creek

CUs in Sakwi Creek, as described by Holtby and Ciruna (2007), are CO2, and CM2. FISS databases also show sockeye occurrences. These three species have been found in the lower 1.6 km of Sakwi Creek, but spawning success is likely poor due to high sediment-loads from upstream reaches (Stitt, Pers. Comm.). The Sakwi watershed drains an area of 14 km^2, but has a large impact on downstream Weaver Creek habitat. The north part of Sakwi Creek was logged before 1963, causing extensive erosion, particularly on the west slopes of the canyon below Hemlock Valley (NHC 1988 *in* NHC 1994). Roads, trails and clearing for the Hemlock Valley Ski Resort at the head of Salkwi Creek in the 1970s appears to have also caused significant erosion and sediment input to the creek, resulting in substantial gravel and logging debris into Sakwi and Weaver Creeks.

This watershed has been significantly damaged by land-clearing activities and road-building, and has not yet stabilized from activities that occurred over 40 years ago. Damage to headwaters will not be restored, as they have been developed into a recreational resort area.

Pressure Indicators:

Land cover alterations: The north part of the creek was logged prior to 1963 and caused heavy input of gravel and logging debris to Sakwi and Weaver Creeks, resulting in extensive erosion and scouring. Nener and Warwick (1997) indicate that only 3% of the total watershed has been logged, and there is no proposed harvesting (to 1998). This, however, contrasts with the clear orthophoto evidence of clearing for ski runs to the highest elevation points of the watershed at the north end, as well as large cutblocks in the western portion of the watershed.

Watershed road development: Road density statistics are not available for this watershed, however road density is high due to ski hill maintenance and historic logging.

Water extraction: Fisheries and Oceans Canada holds a water license, issued in 2002, to remove 20 cfs (0.57 m^3/s) from Sakwi Creek for use in the Weaver Creek spawning channels. A license application has been submitted by Sakwi Creek Power Corporation for another 24.72 cfs (0.70 m^3/s) (MOE Water Users' Community Query – Licensees 2010). No other water licenses exist on Sakwi Creek. The potential August water demand for irrigation and waterworks use is ten times (1000%) of the naturalized summer 7-day mean low flow (0.13 m^3/s).

Riparian disturbance: Riparian disturbance is significant due to roads, residential development and the development of a ski hill in the Sakwi Creek headwaters (FRAP 1999).

Permitted waste management discharge: None.

State Indicators:

Suspended sediment: Development of the Hemlock Valley Ski Resort has caused heavy input of gravel and logging debris into this major tributary of Weaver Creek (Nener and Warwick 1997).

Water Quality: Development of the Hemlock Valley Ski Resort has caused heavy input of gravel and logging debris into this major tributary of Weaver Creek (Nener and Warwick 1997).

Water Temperature: No data.

Discharge: The estimated mean annual flow for Sakwi Creek is 0.66 m^3/s (NHC 1994). The naturalized summer 7-day mean low flow is 8% of the mean annual flow. Each of the water extractions permitted from Sakwi Creek exceed the mean annual flow, and their combined use doubles the mean annual flow. In addition, summer low flows are estimated at approximately 0.13 m^3/s, and the permitted extractions exceed this estimated flow by 1000%.

Length of key spawning areas: Chum and coho spawn from the Sakwi confluence with the Weaver to 1.2 km upstream (FISS 2010), however, spawner counts are low and survivorship is very poor due to yearly scouring events and subsequent bedload instability (Stitt, Pers. Comm.).

5.7 Mystery Creek

CUs in Mystery Creek, as described by Holtby and Ciruna (2007), are CO2. FISS reports also document occurrences of sockeye, chinook and chum in Mystery Creek. The watershed drains 30 km^2, but has an impassable waterfall only 0.5 km from the mouth of the river. Chum beach-spawn in the lower section of the system by Harrison Lake, and both coho and chum are known to spawn in the lower 0.5 km of the drainage (Stitt, Pers. Comm.; FISS 2010).

Pressure Indicators:

Land cover alterations: In 1994, Mystery Creek was identified as significantly threatened by logging, as 53% of the watershed had been logged and 75% of the watershed was proposed for further harvest (NHC 1994).

Watershed road development: Road density statistics are not available for this watershed.

Water extraction: None.

Riparian disturbance: Unknown.

Permitted waste management discharge: None.

State Indicators:

Suspended sediment: No data.

Water Quality: No data.

Water Temperature: No data.

Discharge: The estimated mean annual flow for Mystery Creek is 1.43 m^3/s, with estimated summer low flows of 0.27 m^3/s (NHC 1994). The naturalized summer 7-day mean low flow is 8% of the mean annual flow (FRAP 1999). The creek is prone to flash flooding and summer low flows are severe (Nener and Warwick 1997).

Length of key spawning areas: Chum spawn in the lower end of Mystery Creek below the impassable falls located 0.5 km upstream (FRAP 1999).

5.8 Miami Creek

Miami Creek flows north from the town of Agassiz through the village of Harrison Hot Springs. The upper reaches are ditched and treated as a drainage system that drains dairy and hazelnut farms as well as rural residential housing (Nener and Warwick 1997). A sluice-gate and pump-station at the mouth of the river artificially maintained high water levels in the river for recreational purposes, restricting anadromous passage. In the early 1990s the Village of Harrison Hot Springs constructed a new flood-box, which lowered water levels by 1m and allowed spawning for the first time in many years. A new bridge over the Miami River at Highway 9 in 2009 re-graded the gravels below the bridge-deck and improved spawning habitat (Pearson, Pers. Obs.).

Much of the Miami watershed is impacted by residential and agricultural development, and the resultant lack of riparian vegetation along the lower reaches, combined with artificially high waters (for recreation) and nutrients form upstream, have caused eutrophication and chronic weed growth. Weeds are removed mechanically by a floating cutter (NHC 1994). Miami Creek has been severely constrained, diverted, infilled, and degraded by adjacent land use and non-point source pollution (FRAP 1999).

Pressure Indicators:

Land cover alterations: FRAP (1999) identified residential housing on 9% of the total watershed area, agriculture on 22%, and 10% in parks. Development over the last decade and large proposed housing developments will change the urban:wild ratio dramatically, and should be formally evaluated.

Watershed road development: Road density statistics are not available for this watershed, however the watershed contains an urban resort town, and therefore road densities are high.

Water extraction: No water licenses exist on the Miami River. NHC (1994) identified small irrigation and domestic licenses for which the potential August water demand was <1% of the naturalized summer 7-day mean low flow (Nener and Warwick, 1997).

Riparian disturbance: The Village of Harrison Hot Springs and part of the Town of Agassiz are located in the watershed. There is a lack of riparian vegetation along the majority of the creek, and upper reaches have been ditched and are treated as a field drainage system (Nener and Warwick 1997).

Permitted waste management discharge: None.

State Indicators:

Suspended sediment: No data.

Water Quality: No data.

Water Temperature: No data.

Discharge: The annual mean flow of Miami Creek is 0.92 m^3/s. The naturalized summer 7-day mean low flow is 11% of the mean annual flow.

Length of key spawning areas: Unknown.

5.9 Tipella Creek

CUs in Tipella Creek, as described by Holtby and Ciruna (2007), are SK L-3-3, CO2, and CM2. FISS reports also document chum and pink occurrences in Tipella Creek. Tipella is located at the northwest end of Harrison Lake, and drains a total area of 62.8 km^2. Approximately 1700 m of low-gradient habitat with placid flow provides spawning habitat for chinook, chum, coho, and sockeye, up to a gradient barrier with falls (FISS 2010). Beaver damming is an annual problem between the mouth of the creek and the logging road, however it is unknown if this is an impassable obstruction (FISS 2010).

Independent Power Production

Cloudworks Energy Inc. operates the Tipella Creek Hydroelectric diversion and powerhouse, which is located 50 m below an impassable obstruction, therefore impacting spawning coho habitat. To offset habitat losses to spawning coho, the tailrace channel will be configured to provide a stable 40 m^2 spawning bed in the lower section (Lewis et al. 2006). The project also impacted 7,294 m^2 of permanently altered riparian habitat and 409 m^2 of net aquatic habitat loss, with riparian restoration, aquatic restoration, or off-site silvicultural actions as compensation (Lewis et al. 2006).

Pressure Indicators:

Land cover alterations: A logging camp is located at the mouth and its implications for water quality are unknown; 3% of the total watershed has been logged recently and there is no proposed harvesting (to 1998) (Nener and Warwick 1997).

Watershed road development: Road density statistics are not available for this watershed.

Water extraction: A water license was granted to the Tipella Creek Project Partnership in 2006 for 254 cfs for power generation purposes, and another application has been proposed for a further 21.2 cfs by Cloudworks Energy Inc. for conservation purposes (MOE Water Users' Query - Licensees 2010).

Riparian disturbance: Unknown. The Tipella Creek Hydroelectric project permanently impacted 7,294m^2 of riparian habitat (Lewis et al. 2006).

Permitted waste management discharge: None.

State Indicators:

Suspended sediment: No data.

Water Quality: No data.

Water Temperature: Temperature loggers installed by OnStream and Ecofish were collected from February – December 2005 at the FSR bridge. Mean daily temperatures in the summer were 10.2°C and 8.7°C in August and September, respectively, with a maximum reading of 12.2°C in August 2005 (Lewis et al. 2006).

Discharge: The estimated mean annual discharge for Tipella Creek is 7.4m^3/cm (NHC 1994), with the naturalized summer 7-day mean low flow at 25% of the mean annual flow (Nener and Warwick 1997). Lewis et al. (2006) provide a mean annual discharge at the lower diversion site as 4.75 m^3/s. Under post-project operation, the mean annual discharge will be reduced by 71% and managed throughout the year to provide adequate flows for resident and anadromous fish in their various life stages (Lewis et al. 2006).

Length of key spawning areas: Anadramous spawning is limited to 1700m from the mouth of Tipella Creek with Harrison Lake, due to a gradient barrier and impassable falls (FISS 2010).

5.10 Trout Lake Creek

CUs in Trout Lake Creek, as described by Holtby and Ciruna (2007), are SK L-3-3, CO2, CM2, and PK1. Trout Lake Creek drains an area of 24 km^2, dropping sharply from Trout Lake approximately 1 km upstream of the mouth of the river. The lower reach of Trout Lake Creek is encroached upon by a subdivision with a limited setback from development (NHC 1994), and upper Trout Creek is constrained on the north side by Rockwell Drive. However, much of the watershed is now encompassed in Sasquatch Provincial Park.

Anadromous spawning is limited to the lowest 0.4 km of Trout Lake Creek, due to an impassable culvert at the main logging road. Chum spawning is concentrated at mouth of the creek, with the majority of spawning on the beach; sockeye spawning is concentrated at the mouth, while coho spawn up to the culvert (FISS 2010). A cascade above these culverts, approximately 0.8 km from the mouth is also impassable to anadromous fish (NHC 1994). Trout Lake Creek is threatened by both summer water demand, assessed by comparing potential water demand for irrigation, industry and waterworks to natural summer low flows, and summer low flows, assessed by comparing the summer low flow to the mean annual flow to indicate the ability of the stream to accept water extractions (NHC 1994). In high flows the creek moves a large bedload, and the channel is aggrading. Ministry of Transportation and Highways regularly removes gravel beneath their bridge on Rockwell Drive, and bank stabilization walls have been erected in the lower reaches to floodproof residential properties (NHC 1994).

Pressure Indicators:

Land cover alterations: Trout Lake Creek watershed was completely logged by 1956. Logging has altered the hydrology, deposited sediment, and led to erosion in many parts of the system (FRAP 1999). Residential development in the lower reach has reduced riparian vegetation and constrained the channel. Parking lots and campsites for recreational activities exist in Sasquatch Provincial Park.

Watershed road development: Road density statistics are not available for this watershed.

Water extraction: No water licenses currently exist for Trout Lake Creek. NHC (1994) identified industrial and residential water extraction that would potentially demand 44% of the naturalized 7-day mean low flow.

Riparian disturbance: Riparian disturbance around Trout Lake Creek has not been formally assessed.

Permitted waste management discharge: None.

State Indicators:

Suspended sediment: No data. The creek moves a large bedload and the channel is aggrading and building a large fan.

Water Quality: No data.

Water Temperature: No data.

Discharge: The mean annual flow of Trout Lake Creek is estimated at 1.14 m^3/s (NHC 1994). The potential August and September water demand for domestic and industrial use is 44% of the naturalized summer 7-day mean low flow (Nener and Warwick 1997)

Length of key spawning areas: Anadromous spawning is limited to the lowest 0.4 km of Trout Lake Creek, due to an impassable culvert at the main logging road. Chum spawning is concentrated at mouth of the creek, with the majority of spawning is on the beach, sockeye spawning is concentrated at the mouth, while coho spawn up to culvert (FISS 2010).

5.11 Twenty Mile

CUs in Twenty Mile Creek, as described by Holtby and Ciruna (2007), are CO2 and CM2. FISS reports also document occurrences of sockeye and pink salmon in Twenty Mile Creek. This creek drains a 20 km^2 watershed, and transports large quantities of coarse sediment onto its fan; the Ministry of Transportation and Highways regularly cleans debris from under their bridge (FISS 2010). It is unknown whether a cascade 0.4 km upstream from the mouth is impassable to salmonids; falls located 4 km upstream of the mouth are impassable. Chum and coho are known to spawn in the lower 400 m of Twenty Mile Creek.

Pressure Indicators:

Land cover alterations: 10% of the total watershed has been logged recently, and 1% is proposed for harvest (Nener and Warwick 1997).

Watershed road development: Road density statistics are not available for this watershed.

Water extraction: None.

Riparian disturbance: No data.

Permitted waste management discharge: None.

State Indicators:

Suspended sediment: Aggradation is occurring in this stream: a large quantity of coarse sediment is transported to the creek fan (Nener and Warwick 1997).

Water Quality: No data.

Water Temperature: No data.

Discharge: The estimated mean annual flow for Twenty Mile Creek is 0.98 m^3/s (NHC 1994). The naturalized summer 7-day mean low flow is 7% of the mean annual flow, and the stream often dries up in summer (Nener and Warwick 1997).

Length of key spawning areas: Spawning may be limited to 0.4 km of spawning habitat downstream of a cascade. If fish are able to overcome the cascade, impassable falls occur 4 km from the mouth of the stream.

6 Habitat Indicator Analysis

It is beyond the scope of this project to analyze raw data to inform habitat conditions, but we have identified data gaps and available raw data that can be compiled into useful habitat status indicators.

6.1 Pressure Indicators

Compiled pressure indicators for the larger Lower Harrison Watershed are few. The only indicator with complete information is the Land Cover Alterations category, due to Environment Canada's detailed land-use analysis of 2002.

6.1.1 Total Land Cover Alterations

Compiled land-use data is available for Harrison Lake / River and the Chehalis River due to a 2002 Environment Canada project to compile land-use data for watersheds monitored by hydrometric gauges (Environment Canada 2002). We were unable to obtain a methods document for the analysis, but can surmise that the project was performed by digital orthophoto analysis (Environment Canada 2002). Although it is beyond the scope of this project to analyze the shapefiles, detailed land cover data is available from GeoBase in ESRI shapefile format at no charge (GeoBase 2009a). Statistics for sub-watersheds of interest could be compiled with relative ease however the source data would be at least ten years old. GeoBase land cover data is based on circa-2000 vector data are the result of vectorization of raster thematic data originating from classified Landsat 5 and Landsat 7 ortho-images, with forest cover data from a collaboration between Canadian Forest Service (CFS) and the Canadian Space Agency (CSA) in partnership with the provincial and territorial governments, and agricultural coverage from the Agriculture and Agri-Food Canada (AAFC) (GeoBase 2009a).

Stalberg et al. 2009 indicates that a thorough literature review is still required to determine a method for weighing different land use categories and to establish benchmarks based on the expected magnitude and duration of each land use impact, both in isolation and in concert with other land use activities.

The most recent compiled forest harvest data we were able to find was 1997 for most watersheds. Data from the Ministry of Forests and Range should be compiled to provide a new image of the harvesting impacts on LHW.

6.1.2 Riparian disturbance

Stalberg et al. (2009) recommend the BC Watershed Statistics Atlas as a source of information regarding riparian disturbance; despite significant effort, we were not able to find any compiled statistics. Riparian disturbance data was only available for the Chehalis drainage, where riparian disturbance was identified at 60% (McLennan and Recknell 1999). Stalberg et al. (2009) propose a benchmark of 5% riparian disturbance as a point of concern.

6.1.3 Watershed road development

We were unable to find compiled road density data for LHW or any of its sub-drainages. Although BC Watershed Statistics Atlas and GeoBC have compiled road shapefiles, these only apply to gazetted roads, and do not contain Forest Service Roads (ILMB 2010b). As most roads in the LHW are developed and maintained only for forest harvesting purposes, the Ministry of Forests and Range should be consulted to acquire the most recent maps; road densities will be highest in the same areas that have significant historic or planned forest harvest. A quick survey of publicly available ortho-imagery (Google, iMap) shows logging roads spidering across the watershed, particularly in the lower elevation areas of the west side of the valley around Mystery Creek, Twenty Mile Creek, Weaver Creek and the Chehalis River watersheds. Stalberg et al. 2009 recommend road density thresholds at 0.4 km/km^2.

6.1.4 Water extraction

Licensed water extraction information for specific creeks was obtained through B.C. Ministry of Environment's Water License Web Query (MOE 2010). However, unlicensed water use is impossible to measure and is likely significant in developed areas.

The majority of identified water licenses (by volume) were held by Fisheries and Oceans Canada Ltd., whereas residential use was insignificant in most areas. New water licenses are sought or obtained by micro-hydro / independent power producers (IPPs) on several streams in the LHW; three IPPs are operational or under construction in the upper end of the LHW, in Tipella Creek, Douglas Creek, and Stokke Creek, and another 25 water licenses for power generation purposes are being sought in the watershed (IPP Watch 2008).

6.1.5 Permitted Waste Discharges

Permitted waste discharges were provided by Liz Freyman at the Ministry of Environment, indicating only three permitted waste discharges into Harrison Lake and Harrison River. The Village of Harrison Hot Springs is currently evaluating the potential connection of their sewage waste to the District of Kent's waste treatment facilities (Connolly, Pers. Comm.)

6.2 *State Indicators*

6.2.1 Suspended sediment

We were unable to identify any suspended sediment data in the LHW. However, sediment is identified as a limiting factor in many of the LHW tributaries due to forest harvesting and roads leading to channel instability.

6.2.2 Water Quality

Water quality data, where available, consistently indicate that LHW tributaries are oligotrophic, with NO_2+NO_3 levels measured in Harrison Lake and Harrison River tributaries were all below the 100µg/L threshold. Phosphorous levels are below or at detection limits in most systems as well. Agricultural and urban runoff are insignificant to most portions of the watershed, however there are likely non-point source and point-source pollutants entering Harrison Lake from the Village of Harrison Hot Springs and its associated developments, as well as along the Harrison River, Harrison Bay and Harrison Mills.

6.2.3 Water Temperature

Long-term temperature data is available for Weaver Creek and Chehalis Creeks from the Weaver Creek Spawning Channel and Cheahlis Hatcheries, respectively, but has not been compiled. Big Silver Creek, Douglas Creek, Tipella Creek, and Harrison River have some seasonal water temperature associated with them, most of which indicated summer temperatures at levels potentially harmful to fish. Tipella Creek was the only drainage in which known temperature data did not show stressful summer temperatures. A review of species-specific maximum temperature limits for chinook, coho and chum salmon is available in Richter and Kolmes (2005). Available temperature data from LHW streams should be reviewed against these recommendations. See Section 7.2.3 for a discussion on climate change impacts.

6.2.4 Discharge

NHC (1994) was consulted to express the sensitivity of salmon streams throughout the Harrison Habitat Management Area (which also included drainages to the south into the Fraser). They analyzed data for watersheds with hydrometric stations and water level gauges, and estimated flows in un-gauged watersheds by transferring data from nearby, similar streams (NHC 1994). This report provides Mean Annual Discharge (MAD) estimates for the salmon streams in the LHA, as well as estimates of summer and winter low-flows. It uses this data to rank the streams' sensitivity to human impacts based on their geomorphic and hydrologic regime (NHC 1994).

All of the streams in the lower portion of the LHW (those in the Southern Fiord Ranges Ecoregion) are estimated to have 7-day summer low flows below the 20% benchmark indicated in the Stahlberg et al. document, and most of those fall below the critical 10% of MAD benchmark for instantaneous flow for survival of most aquatic life. Stalberg et al. (2009) recommend that where insufficient flows are found to meet the 20% MAD benchmark, more rigorous and localized examinations should be initiated. In the LHW, this applies to 11 high value habitat salmon streams.

It may be that salmon in streams with associated lake rearing habitat are less susceptible to low flows.

Those tributaries in the upper portion of the LHW (in the Pacific Ranges Ecoregion) all maintain 7-day summer low flows above the 20% benchmark for maintaining adequate habitat, and most of these maintain flows above the 30% benchmark to sustain good quality habitat (discussed in Appendix 14 of Stalberg et al. 2009). Winter low flows drop to 11 – 20 % MAD in the upper tributaries during the winter months (NHC 1994).

Stalberg et al. (2009) stress that these benchmarks are guidelines only, and that discharge impacts will vary significantly across different watersheds. NHC (1994) identified those streams most sensitive to summer low flows as Morris Creek, Weaver Creek, Sakwi Creek and Trout Lake Creek.

Sakwi Creek is the most vulnerable to discharge instability, due to its denuded headwaters and high extraction allowances; its estimated MAD is 0.66 m^3/s (NHC 1994) with a naturalized summer 7-day low flow of 8% MAD. Each of the water extractions permitted from Sakwi Creek exceed the MAD, and their combined use doubles the mean annual flow. In addition, summer low flows are estimated at approximately 0.13 m^3/s, and the permitted extractions exceed this estimated flow by 1000%.

6.2.5 Length of Spawning Habitat

Information regarding length of spawning habitat is available in FISS reports and obstruction locations are available for public download through ILMB's GIS data service (ILMB 2010b).

7 Limiting Factors, Threats and Recommendations

7.1 Limiting Factors

The most severe limiting factors in the Harrison Watershed result from excessive forest harvesting and the related channel instability, road density, riparian removal and water temperatures increases. Road improvements and the associated development that would follow could significantly impact habitat connectivity in the watershed. Impacts predicted due to climate change will further affect water temperatures and flows, reducing the quantity and quality of habitat for alevin, fry and spawners. Nutrient availability in streams is low and may become a limiting factor if not replenished by spawners. Water extraction from IPPs will impact flow patterns, and should be carefully monitored to ensure impacts to downstream spawners are minimized.

7.2 Threats

7.2.1 Forestry

Forest harvest is the most significant land use in the LHW, and information regarding percent of watershed logged is out-date and sometimes conflicting. B.C. Ministry of Forests maintains maps and archives of completed and planned forest harvest, and should be approached to access the data for analysis. Several of the sub-drainages in the LHW are unstable and at risk due to forest harvest, according to information from the late 1990s. The associated road networks are not publicly available in digital format, and should also be accessed to derive statistics for watershed road densities. A thorough multi-scale analysis of harvest history, harvest planning, and road densities will be the most efficient manner of informing habitat status for the greater watershed and its tributaries. Stalberg et al. (2009) recommend Equivalent Clearcut Area analysis, a measure that includes a regeneration recovery factor to reflect hydrologic recovery of cutblocks as they regenerate, and provides an accurate and common measure of peak flow hazard in harvested watersheds. A 15 – 20% benchmark is proposed, with consideration to additional disturbance and inherent instability (Stalberg et al. 2009).

The majority of roads in the LHW are developed and maintained only for forest harvesting purposes, and GIS data is available by request from the Ministry of Forests and Range. Road densities will be highest in the same areas that have significant historic or planned forest harvest. Road density and road-crossing data will provide a strong indication of poor habitat quality both as a single metric and in concert with harvest statistics. Recent research on road networks associated with forest harvest studied land cover impacts on water temperature in northern BC. Nelitz et al. (2007) found high probabilities that increases in road density and stream crossings in watersheds are associated with increases in residual temperature, citing a 60% probability that the summer maximum weekly average temperature in their study area would increase by 1.25°C for a road density of 2 km/km^2 of watershed area and by 3.25°C for a road density of 4 km/km^2.

By compiling statistics regarding road densities and forest harvest in the LHW, habitat managers would have the ability to infer a wide range of habitat status indicators, including riparian connectivity, water temperatures, and flow stability.

7.2.2 Development and Resource Extraction

Residential development is increasing in the LHW, especially in the southern portion around the Harrison River / Chehalis area. In addition, the In-SHUCK-ch First Nation has been lobbying the Provincial Government to improve the Harrison West Forest Service Road to link the Fraser Valley with the Lillooet River valley and Highway 99 in Pemberton (Braacz 2006). This proposed upgrade, termed the Sasquatch Highway, has been in the proposal stage since 2003. A highway up the west coast of the Harrison River would have significant impacts on all of the western drainages due to the inevitable development that would follow.

Mining pressures in the Harrison watershed are in the early stages; gold, silver, zinc, molybdenum and many other valuable ores have been identified in the Harrison valley, and three existing small-scale mines are identified in the watershed by FISS, at Doctor's Point, Rockwell Drive, and Seneca. Mosquito Consolidated Gold Mines Ltd. is pursuing an aggregate mining project in the Statlu watershed, as well as placer mining for gold in the Chehealis watershed (Braacz 2006).

The Fraser Valley Aggregate Pilot Project was initiated by the Minister of State for Mines in response to continued conflict surrounding aggregate mining operations in the Fraser Valley Regional District (FVRDAPP 2009). The purpose was to develop recommendations to reduce conflicts and ensure a long-term, stable aggregate supply in the Fraser Valley. The final recommendations report designates 'green', 'yellow' and 'red' zones for aggregate extraction throughout the Fraser Valley. Red zones prohibit aggregate extraction, yellow zones will permit aggregate extraction subject to provincial and government approval conditions, and green zones will be zoned for aggregate extraction such that no land use approvals are required (FVRDAPP 2009). Interestingly, this document does not reference fish or fish habitat, nor provincial / federal environmental regulations. Large areas of the LHW, encompassing Long Island, Echo Island, and the lower portions of tributaries to the Harrison River, particularly around Lake Errock and Harrison Bay, are designated as yellow and green zones (FVRDAPP 2009). Of particular concern is a proposed green zone in the Lake Errock watershed, which has recently been cleared and mining operations begun (Bales, Pers. Comm.)

7.2.3 Climate Change

The LHC and the larger Harrison-Lillooet watershed will likely be impacted by climate change. Taylor and Langlois (2000) predict a 3-4°C increase in average monthly temperatures in the Fraser Valley by the end of the 21st century, with increased precipitation in winter, a drop in precipitation in the spring, little change in summer months, and increased precipitation in the fall. Warmer temperatures mean that a larger percentage of the precipitation will fall as rain, rather the snow, however increased winter precipitation at higher elevations could lead to larger snowpacks where mean temperatures remain below freezing.

Increased winter and early spring precipitation may mean increased flooding and high flows (Taylor and Langlois 2000) when alevin are emerging from the gravel, reducing survival at early stages. In addition, summer drought will reduce increase evapotranspiration and soil-water deficits, decrease summer and fall stream flows (Taylor and Langlois 2000) in already-sensitive streams, as well as increase demand for irrigation and waterworks infrastructure. Higher water temperatures (Taylor and Langlois 2000) will increase stresses to rearing juveniles as well as returning adults. Stream temperature and water flows will be the most significant state indicators that will inform managers' knowledge of the impact of climate change on salmonids in temperature and flow-sensitive streams. Fraser River water temperatures have already increased by 1.8°C (Mathes et al. 2010), and are expected to continue rising as air temperatures rise and precipitation patterns change (Langlois 2000).

Lake temperatures, however, are stabilized in the short-term due to the large glacial inflows to Lillooet Lake, ensuring that excessively warm temperatures do not occur in either Lillooet Lake or Harrison Lake at any time (Shortreed et al. 2001). Due to this glacial inflow, Harrison-Lillooet sockeye are less susceptible to climate change than upper Fraser stocks (Shortreed et al. 2001). Cold-water refugia in Harrison Lake are therefore less susceptible to warming and may continue to provide thermal shelter for pooling spawners and rearing fry. Sockeye that remain in Harrison River to hold are more susceptible to temperature-related disease stressors (Mathes et al. 2010). Hague et al. (2010) modeled a 1°C increase in average summer water temperature over 100 years, and indicate that this modest increase would triple the number of days per year exceeding critical salmonid thermal thresholds. In 80% of future climate simulations, ≥ 90% Weaver Creek sockeye salmon were predicted to encounter temperatures exceeding their population-specific thermal optimum for maximum aerobic scope. Once again, early-run sockeye were more likely to experience sub-optimal temperatures than later entrants (Hague et al. 2010).

Water temperature monitoring in streams is now inexpensive and easy, as waterproof thermal loggers are commercially available and require very little labour to install, monitor, and collect data. Thermal loggers should be installed in each high value habitat as an easy, valuable indicator of habitat quality.

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List of Appendices

Harrison Habitat Status Report - Communications Summary

Agency	Name	Title	Phone	Email	First Contact Date	Response?	Meeting?	In-person or via phone?	Result
DFO	**Matt Foy**	Senior Biologist, Resource Restoration Division	604-666-3678	matthew.foy@dfo-mpo.gc.ca	Feb 15, '10	yes	Mar 15, '10	DFO offices	Habitat restoration history, proposals, constructed. CU definitions, maps.
	Vince Busto	Habitat Engineer, Water Use Section	604-666-8281	vince.busto@dfo-mpo.gc.ca	Feb 15, '10	yes	Feb 17, '10	Phone	
	Tom Cadieux	Retired		hrtminer@telus.net	Feb 15, '10	yes			Feb 16th - pass on to Mark Johnson and Matt Foy
	Mark Johnson	Community Advisor	604-824-4715	mark.johnson@dfo-mpo.com	Feb 17, '10	yes			Feb 17th - pass on to Ken Peters and Don Johnson
	Al Stobbart	Director, FVRD Area G; DFO Hatchery Manager Upper Pitt, Inch Creek, etc		astobbart@fvrd.bc.ca	Feb 15, '10	yes			Feb 16th - pass on to Ken Peters
	Ken Peters	Senior Technician, Sockeye & Pink Analytical Program	604-831-5328 (h)	ken.peters@dfo-mpo.gc.ca	Feb 16, '10	yes	Feb 19th	Phone	Habitat / escapement history. Sockeye CU info, high value habitats, threats, limiting factors, research. Follow-up email fwd to Jeremy Hume
	Jeremy Hume	Research Biologist, Cultus Lake	604-824-4705	Jeremy.Hume@dfo-mpo.gc.ca	Mar 22, '10	yes		email	followed up on questions re: sockeye rearing in Harrison Lake
	Don Johnson	Operations Manager, Chehalis Fish Hatchery							
	Rick Stitt	Operations Manager, Weaver Creek Spawning Channels	604-796-9444	rick.stitt@dfo-mpo.gc.ca	Mar 1 '10	yes	Mar 5, '10	Weaver Creek Hatchery	High value habitats, habitat status data for Weaver Creek, history
	Wayne Charlie	Operations staff, Weaver Creek Spawning Channels	604-796-9445			yes	Mar 5, '10	Weaver Creek Hatchery	Habitat knowledge, historic knowledge.
	Craig Sciankowy	Habitat Biologist, Mission	604-814-1079	craig.sciankowy@dfo-mpo.gc.ca	Mar 26, '10				re: development proposals in LHW
	Kimberly Sandve	Co-op student			Multiple	yes	Multiple		provided documents / support
	Angeleen Olson	Intern		angeleen.olson@dfo-mpo.gc.ca	Mar 16, '10	yes			Provided construction reports on LHW habitat enhancement projects
FVRD	**Lance Lilley**	Watersheds Planner	604-702-5006	llilley@fvrd.bc.ca	Feb 2, '10	yes	Feb 11 '10	in-person	provided referrals to Wendy Bale, Dave Bennet
	Wendy Bale	Director, Area C	604-302-8740	larkspurlandscapes@shaw.ca	Feb 15, '10	Feb 15 '10	Feb 25 '10	in-person	Habitat threats, aggregate removal
	Dave Bennett	Planner	604-702-5052	dbennett@fvrd.bc.ca	Feb 17, '10	yes		email	proivded referrals for IPPs in Harrison watershed
MOE	**Greg Wilson**	Fisheries Biologist, Ecosystem Section	604 582-5365	greg.wilson@gov.bc.ca	Feb 15,'10	no			not returning until May 2010
	Duane Jesson	Fisheries Biologist, Ecosystem Section		duane.jesson@gov.bc.ca	Feb 15, '10	no			
	Krista Payette	Environmental Impact Biologist, Environmental Quality Section	604 582-5225	krista.payette@gov.bc.ca	Mar 4, '10	yes		email	Mar 5th - Pass to Liz Freyman
	Liz Freyman	Environmental Impact Biologist, Environmental Quality Section	604 582-5216	liz.freyman@gov.bc.ca	Mar 4, '10	yes		email	March 5t - Harrison waste discharges
	Jennie Aikman	Regional Planner, Lower Mainland Office	604 824-2316	jennie.aikman@gov.bc.ca	Mar 4, '10	yes		email	Provided planning documents re: Harrison Lake WMA proposal
	Rob Knight	Inventory Specialist, Fish and Wildlife Section		rob.knight@gov.bc.ca	Mar 1, '10	yes		email	re: MOE reports library
First Nations	**Martha Fredette**	STEP Coordinator	604-796-0627	marthafredette@stolotribalcouncil.ca	Feb 15, '10	yes		email	Feb 16th - pass on to Murray Ned
	Murray Ned	Sto:lo TC Fish		murray.ned@stolotribalcouncil.ca	Feb 16, '10	yes		email	Feb 18th - pass on to Ernie Cray, Kim Charlie, Andy Philips
	Ernie Crey			ernie.crey@stolotribalcouncil.ca	Feb 19, '10	no			
	Andy Phillips	Chief, Scowlitz		andy.philips@stolotribalcouncil.ca	Feb 19, '10	no			
	Kim Charlie	Fisheries Coordinator Chehalis	604-796-2116 x248	kim.charlie@chehalisband.com	Feb 19, '10				Follow-up phone calls
Other	**Dave Barrett**	Salmon Table		davlinpacific@telus.net	Feb 17, '10	no			

Appendix 2 Conservation Unit Habitat Status Report Tables

(appended as .xls files to digital document)

Page A2-1. Chinook Salmon – Lower Fraser Fall White CH3 Conservation Unit

Page A2-2. Chinook Salmon – Lower Fraser Spring CH4 Conservation Unit

Page A2-3. Chinook Salmon – Lower Fraser Summer Chinook CH 6 Conservation Unit

Page A2-4. Chum Salmon – Lower Fraser River Chum Conservation Unit

Page A2-5. Coho Salmon – Lower Fraser Coho Conservation Unit

Page A2-6. Pink Salmon – Lower Fraser Pink Conservation Unit

Page A2-7. Sockeye Salmon – Lake-type Harrison Downstream Lower Fraser SK L-3-3 Conservation Unit

Page A2-8. Sockeye Salmon – Lake-type Upstream Lower Fraser SK L-3-4 Conservation Unit

Page A2-9 Sockeye Salmon – River-type Lower Fraser Conservation Unit

Conservation Unit: Chinook, Lower Fraser River Fall White - Lower Harrison Watershed Habitat Status Report

Species: Oncorhynchus tshawytscha | Watershed: Lower Harrison Watershed

Life Stage	**Habitat Requirement for each life stage**	**Known limiting factors & high value habitats**	**Performance Indicators for habitat limiting factors**	**Performance Indicators Status**	~~**Performance Indicators Thresholds**~~	**Possible measures to address limiting factors**	**Possible measures to maintain productivity**	**Habitat Protection & Restoration Measures Undertaken**
Spawner/Egg/ Alevin	Diewart (2007): Quantity of prime spawning grounds and incubation area determine freshwater production. Immediate-type chinook require about 24 m^2 of gravel per spawning pair, with optimal gravel size of 2.0 cm - 10.6 cm diameter. Good subgravel flow is vital to egg survival since chinook eggs are the largest of all the Pacific salmon. Embryos/alevin survival is higher in stable flow regimes that are high enough to supply adequate oxygen but do not cause gravel movement. Survival/development optimal with incubation temperatures between 4.5°C and 12.8°C.	Chinook have been observed in 15 tributaries to **Harrison River** and **Harrison Lake**[4]. The high value habitat for the Lower Fraser River fall while Chinook, as reported by Holtby and Ciruna (2008) is the Harrison River. Documented spawning areas are throughout the mainstem, along bars and in side channels, particularly from 1.8-6.8 km above Harrison River bridge and in the rapids. Limitations: Harrison River: high level-development in Harrison Mills and agricultural activity in lower reaches[5], loss of vegetation, blocked culverts[4], high summer water temperautres[20].	**See Appendix 3**. Harrison River: land cover alterations, riparian disturbance, water temperature.	**See Appendix 3**. Harrison River: summarized land use data from Env Can. (2002, 7 km riparian disturbance/golf course, summer high water temperatures20.		A proposal to remove silt accumulations and develop pool/cover habitats in the Harrison River side-channels was submitted (Foy Pers. Comm.).	Higher escapements should be allowed whenever possible, and monitoring programs that track changes in survival and exploitation rates should be maintained to identify the main factors responsible for improving escapement monitoring rocedures[14]. Foy (2007) notes that returns data from CWT tagging of Harrison River chinook smolts should be available "beginning in a few years" to more consistently measure the Harrison River chinook population. Monitoring of overall CU to determine status of spawning sites. Participation in Land Use Planning processes to ensure that Salmon & salmon habitats are considered in any landscape level decisions. Continue to apply the habitat provisions of the Fisheries Act to downstream migration routes and non-natal tributarie to ensure access to and productivity of habitats.	The Harrison River chinook stock has been used to populate the Chilliwack River, Chehalis River, Stave River, Alouette River, Coquitlam River, Nicomekl River, and Capilano River during the last 15 years[13]. This has created a more robust meta-pupulation structure, making it more resilient to localized catastrophic events within any one watershed[13]. Harrison River: the rapids and lower portion of the river, which are part of the spawning area, have been dredged to maintain a navigation channel[6]. A number of habitat restoration projects along the lower Fraser River, in tidal rearing areas, have been developed to increase amount of chinook fry rearing habitat[13].
Fry/Juvenile Summer (N/A for immediate ocean migrants, ie. pink, chum, some chinook & sockeye pop'ns)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fry/Juvenile Winter (N/A for immediate ocean migrants as above)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Smolt	Diewart (2007): Immediate-type chinook are highly dependent on estuary habitat and require an unimpeded migration path with cover from predators.	LFR fall white fry swim to the ocean immediately[2] or shortly after emergence.	**See Appendix 3**. As above.	**See Appendix 3**. As above.		N/A	N/A	Habitat provisions of the Fisheries Act have been applied for approximately 35 years.
~~**Marine Coastal**~~								
~~**Marine Offshore**~~								
Returning Adult Migration	Diewart (2007): Adults require flows sufficient to provide access to spawning grounds. High water temperatures or extreme high or low flows can delay river entry and affect survival. Optimum temperature for upstream migration is 9.4°C - 14.2°C.	Low flows and high water temperatures may prevent returning chinook migrants from reaching spawning grounds and reduce spawning habitat in Harison River[7]. Returning adult chinook have been oberseved holding in Harrison River and Lake prior to moving to spawning grounds[4].	**See Appendix 3**. As with Spawner/Egg/Alevin with emphasis on adequate summer/fall flows and water temperatures.	**See Appendix 3**. Temperature data is lacking throughout the LHW, and recent available data for Harrison River is suggestive of increasing temperatures with summer highs rising above optimum thresholds[20]. Hydrometric guage discharge data for Harrison River is available from station 08MG013.		Pre-spawning monitoring of known and emerging high quality spawning sites for removal / breaching of beaver dams throughout the spawning period.	A formal investigation of coldwater refuge zones in Harrison Lake should be conducted and analysis of overall logged area in the watershed and its possible effects on holding spawners.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years. Community monitoring of access to major left-bank spawning areas has occurred from approximately 1999 to present. Beaver dams have been breached, and beaver removed.
~~**Habitat Productivity Model**~~								

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Conservation Unit: Chinook, Lower Fraser River Spring - Lower Harrison Watershed Habitat Status Report

Species:Oncorhynchus tshawytscha		**Watershed: Lower Harrison Watershed**						
Life Stage	**Habitat Requirement for each life stage**	**Known limiting factors & high value habitats**	**Performance Indicator(s) for habitat limiting factors**	**Performance Indicator(s) Status**	~~**Performance Indicators Thresholds**~~	**Possible measures to address limiting factors**	**Possible measures to maintain productivity**	**Habitat Protection & Restoration Measures Undertaken**
Spawner/Egg/ Alevin	Diewart (2007): Stream-type chinook require about $16m^2$ of gravel per spawning pair, survival best in areas of coarser gravel and low rates of sedimentation, good subgravel flow is vital to egg survival since chinook eggs are the largest of all the Pacific salmon; embryos/alevin is higher in more stable flow regimes that are adequate to supply the required level of oxygen but not high enough to cause gravel movement; survival/development best if incubation temperatures between 5°C and 15°C with healthy riparian vegetation and high water quality.	Chinook have been observed in 15 tributaries to Harrison River and Harrison Lake[4]. The high value habitat for Lower Fraser River Spring Chinook, as reported by Holtby and Ciruna (2008) is the **Chehalis River** (spawning below canyon barrier, Stitt, Pers. Comm.). **Limitations:** Chehalis River: unstable[5], 32% logging in watershed (esp. Pretty Creek)[4], campsites, bridges, inhabited areas[4], suspended sediment, nutrient poor (Foy, Pers. Comm.).	**See Appendix 3.** Chehalis River: land cover alterations, suspended sediments, water quality.	**See Appendix 3.** Chehalis River: uncompiled land use/forest harvest data, no suspended sediments data, oligotrophic (Foy Pers. Comm.)		According to Foy (Pers. Comm.) proposals submitted to the Watershed Restoration Project in the Chehalis watershed include: stream classification and ground water assessment of upper Chehalis tributaries, Statlu River Waterfall Obstruction Removal Assessment, Coho Creek off-channel pool assessment, Pretty Creek Diversion Assessment and a Chehalis River watershed stream classification assesment. A further proposal to remove silt accumulations and develop pool/cover habitats in the Harrison River side-channels was submitted (Foy Pers. Comm.).	Foy (2007) suggests that research should be undertaken to determine if indigenous chinook populations exist in the upper Chehalis River. Monitoring of overall CU to determine status of spawning sites. Participation in Land Use Planning processes to ensure that Salmon & salmon habitats are considered in any landscape level decisions. Continue to apply the habitat provisions of the Fisheries Act to downstream migration routes and non-natal tributarie to ensure access to and productivity of habitats.	Chehalis River: gravel removals maintain flow, log-boom is used to reduce jamming in the canyon below, log jams regularly removed, and hatchery built in 1982, berm surrounds hatchery (Stitt, Pers. Comm.), two spawning gravel placements to creat spawning habitat, 480 m of off-channel spawning, rearing and refuge created16.
Fry/Juvenile Summer	Diewart (2007): Juvenile chinook are most often found where substrate size is small, velocity and temperature are moderate and depth shallow; silt-free streams with 40-60% pool-ratio are optimal. They prefer main river channels along margins and are not often found in off-channel habitat. Preferred temperature range is between 12°C - 14°C.	Chinook fry rear one year in freshwater and three years at sea; High value habitat for spring run Chinook offspring are Chehalis River and Harrison River[4] during outmigration.	**See Appendix 3.** As above with emphasis on riparian cover and adequate spring/summer flows; Chehalis River: low summer flows	**See Appendix 3.** As above with empshsis on riparian cover and adequate spring/summer flows to provide diverse, protected habitat for rearing fry. Chehalis River: flow data available from hydrometric gauge 08MG001		Harrison Lake: Increase escapement through harvest reduction[8].	A formal investigation of overall logged area in the watershed and the possible effects of logging/water shed development on rearing juvenile salmon, especially with regard to nursery Lakes. Harrison Lake: increased fry recruitment - spawning channel or spawning ground improvement (more data required to confirm the suggested recommendation), lake fertilization (more data required to confirm the suggested recommendation). rationale for enhancement: enhancement larger stock with probable short-term economic benefit[8]. Additional investigation of the early life stages of fry is warranted.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years. No juvenile salmon restoration activities have taken place to date.
Fry/Juvenile Winter	Diewart (2007): During the winter, stream-chinook fry in larger systems typically move out of tributaries and into the river mainstem, where they seek out deep pools or spaces between boulders and rubble. In systems with lake access, juveniles may overwinter in the lake.	Unknown	**See Appendix 3.** As above with emphasis on riparian cover and adequate winter flows. Chehalis River: low winter flows	**See Appendix 3.** Same as above and additionally Chehalis River: flow data available from hydrometric gauge 08MG001		Insufficient information	A formal investigation analysis of overall logged area in the watershed and its possible effects on over wintering juveniles. Additional investigation of fry over-wintering grounds is warranted.	As above.
Smolt	Diewart (2007): In larger rivers, juveniles migrate close to the river edges where velocity is reduced and cover is increased. Mortality is significant during downstream migration and loss to predators is considered to be the most significant cause of mortality. Temperatures should not exceed 10°C in late winter to prevent accelerated smoltification.	Unknown	N/A	N/A		Insufficient information		
Marine Coastal								
Marine Offshore								

Conservation Unit: Chinook, Lower Fraser River Spring - Lower Harrison Watershed Habitat Status Report								
Species:Oncorhynchus tshawytscha		**Watershed: Lower Harrison Watershed**						
Life Stage	**Habitat Requirement for each life stage**	**Known limiting factors & high value habitats**	**Performance Indicator(s) for habitat limiting factors**	**Performance Indicator(s) Status**	~~**Performance Indicators Thresholds**~~	**Possible measures to address limiting factors**	**Possible measures to maintain productivity**	**Habitat Protection & Restoration Measures Undertaken**
Returning Adult Migration	Adults require access to spawning grounds, high water temps or extreme high or low flows can delay river entry and affect survival; migrating chinook salmon prefer temperatures from 9.4°C to 14.2°C	Low flows and high water temperatures may prevent returning chinook from reaching their natal streams and reduce spawning habitat throughout the Harrison Watershed. Returning adult chinoook have been oberseved holding in Harrison River and Lake prior to moving to spawning grounds[4].	**See Appendix 3.** As with Spawner/Egg/Alevin with emphasis on adequate summer/fall flows and water temperatures.	**See Appendix 3**. Temperature data is lacking throughout the LHW, and available data is suggestive of increasing temperatures with summer highs rising above optimum thresholds. Likewise, discharge data is largely comprised of outdated estimates with some indication that water extractions are contributing to low flows.		As for spawner/egg/alevine. Pre-spawning monitoring of known and emerging high quality spawning sites, and removal of beaver or breaching of beaver dams throughout the spawning period.	A formal investigation of coldwater refuge zones in Harrison Lake should be conducted and analysis of overall logged area in the watershed and its possible effects on holding spawner habitat.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years. Community monitoring of access to major left-bank spawning areas has occurred from app 1999 to present. Beaver dams have been breached, and beaver removed.
~~**Habitat Productivity Model**~~								

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Conservation Unit: Chinook, Lower Fraser River Summer - Lower Harrison Watershed Habitat Status Report

Species: Oncorhynchus tshawytscha | **Watershed: Lower Harrison Watershed**

Life Stage	Habitat Requirement for each life stage	Known limiting factors & high value habitats	Performance Indicator(s) for habitat limiting factors	Performance Indicator(s) Status	~~Performance Indicators Thresholds~~	Possible measures to address limiting factors	Possible measures to maintain productivity	Habitat Protection & Restoration Measures Undertaken
Spawner/Egg/ Alevin	Diewart (2007): Stream-type chinook require about 16m^2 of gravel per spawning pair, survival best in areas of coarser gravel and low rates of sedimentation, good subgravel flow is vital to egg survival since chinook eggs are the largest of all the Pacific salmon; embryos/alevin is higher in more stable flow regimes that are adequate to supply the required level of oxygen but not high enough to cause gravel movement; survival/development best if incubation temperatures between 5°C and 15°C with healthy riparian vegetation and high water quality.	Chinook have been observed in 15 tributaries to Harrison River and Harrison Lake[4]. High value habitats for Lower Fraser River Summer Chinook, as reported by Holtby and Ciruna (2008), are **Big Silver Creek** (spawning lower than impassable rock at 750 m[4]), **Cogburn Creek** (spawning below rock falls[4]), **Douglas Creek** (spawn in lower ~750 m [4]), and **Weaver Creek** (chinook spawning between confluence with Sakwi Creek and barrier falls, Stitt, Pers. Comm.). Limitations: Big Silver Creek: 24% of total watershed has been logged, increased siltation, erosion5, summer high water temperatures[19], lack of off-channel habitats, nutrient limitations, and lack of large woody debris[16]; Cogburn Creek: watershed appears to have extensive logging in lower reaches[1,3], barrier: culvert no flow in times of low water [4]; Douglas Creek: summer high water temperatures, low productivity[13]; Weaver Creek: steep gradient d/s reach channel is dry in many spots[4], ski resort development resulted in heavy sediment inputs[5].	**See Appendix 3.** Big Silver Creek: Land cover alterations, suspended sediment, water quality, riparian disturbance; Cogburn Creek: land cover alterations, discharge; Douglas Creek: water temperature, water quality; Weaver Creek: suspended sediments, discharge.	**See Appendix 3.** Big Silver Creek: Uncompiled Forest harvest data, no data on suspended sediment, oligotrophic[19], no riparian disturbance data; Cogburn Creek: land cover alterations, discharge; Douglas Creek: summer 2003 water temperatures and nutruent data from CELP (2003); Weaver Creek: no suspended sediment data, uncompiled daily water data from spawning channel.		Enhancement works proposed for Douglas Creek include construction of rearing pond and water supply channel to increase off-channel rearing/spawning habitat[15].	Foy (2007) suggests that genetic testing be undertaken to genetically confirm the existence of these indigenous chinook salmon and that it may be desirable to enhancethese populations to >500 individuals using fish cultures. Monitoring of overall CU to determine status of spawning sites. Participation in Land Use Planning processes to ensure that Salmon & salmon habitats are considered in any landscape level decisions. Continue to apply the habitat provisions of the Fisheries Act to downstream migration routes and non-natal tributarie to ensure access to and productivity of habitats.	Habitat enhancement / restoration has occurred at Big Silver Creek to retain important spawning grounds for multiple species[7] including restoration of the west branch of the lower Big Silver Creek in 1994 and reconstruction of large wood jam in 1999[13]. Fertilization in mainstem from 1994-1997 and 1999 to increase primary production[4].
Fry/Juvenile Summer	Diewart (2007): Juvenile chinook are most often found where substrate size is small, velocity and temperature are moderate and depth shallow; silt-free streams with 40-60% pool-ratio are optimal. They prefer main river channels along margins and are not often found in off-channel habitat. Preferred temperature range is between 12°C - 14°C.	High value habitats for summer run fry are same as above with the addition of Harrison Lake (rearing).	**See Appendix 3.** As above with emphasis on riparian cover and adequate spring/summer flows. Harrison Lake: riparian cover, water temperatures.	**See Appendix 3.** As above with empshsis on riparian cover and adequate spring/summer flows to provide diverse, protected habitat for rearing fry. Harrison Lake: no formal riparian disturbance data for most of lake but developed areas effected by lack of riparian vegetation, water temperature data from Mathes et al. (2010) and Patterson et al. (2005).		Harrison Lake: Increase escapement through harvest reduction[8].	A formal investigation of overall logged area in the watershed and the possible effects of logging/water shed development on rearing juvenile salmon, especially with regard to nursery Lakes. Harrison Lake: increased fry recruitment - spawning channel or spawning ground improvement.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years.
Fry/Juvenile Winter	Diewart (2007): During the winter, stream-chinook fry in larger systems typically move out of tributaries and into the river mainstem, where they seek out deep pools or spaces between boulders and rubble. In systems with lake access, juveniles may overwinter in the lake.	High value habitats for summer run fry are same as above with the addition of Harrison Lake (rearing).	See Appendix 3. As above with emphasis on riparian cover and adequate spring/summer flows. Harrison Lake: riparian cover, water temperatures.					

Conservation Unit: Chinook, Lower Fraser River Summer - Lower Harrison Watershed Habitat Status Report

Species: Oncorhynchus tshawytscha		**Watershed: Lower Harrison Watershed**						
Life Stage	**Habitat Requirement for each life stage**	**Known limiting factors & high value habitats**	**Performance Indicator(s) for habitat limiting factors**	**Performance Indicator(s) Status**	~~**Performance Indicators Thresholds**~~	**Possible measures to address limiting factors**	**Possible measures to maintain productivity**	**Habitat Protection & Restoration Measures Undertaken**
Smolt	Diewart (2007): In larger rivers, juveniles migrate close to the river edges where velocity is reduced and cover is increased. Mortality is significant during downstream migration and loss to predators is considered to be the most significant cause of mortality. Temperatures should not exceed 10°C in late winter to prevent accelerated smoltification.	High value habitats for summer run fry are same as above with the addition of Harrison Lake and River (during outmigration)[4].	See Appendix 3. As above with emphasis on riparian cover and adequate spring/summer flows. Harrison Lake: riparian cover, water temperatures.					N/A
~~**Marine Coastal**~~								
~~**Marine Offshore**~~								
Returning Adult Migration	Adults require access to spawning grounds, high water temps or extreme high or low flows can delay river entry and affect survival; migrating chinook salmon prefer temperatures from 9.4°C to 14.2°C	Low flows and high water temperatures may prevent returning chinook from reaching their natal streams and reduce spawning habitat throughout the Harrison Watershed. Returning adult chinoook have been observed holding in Harrison River and Lake prior to moving to spawning grounds[4].	**See Appendix 3.** As with Spawner/Egg/Alevin with emphasis on adequate summer/fall flows and water temperatures.	**See Appendix 3.** Temperature data is lacking throughout the LHW, and available data is suggestive of increasing temperatures with summer highs rising above optimum thresholds. Likewise, discharge data is largely comprised of outdated estimates with some indication that water extractions are contributing to low flows.		Pre-spawning monitoring of known and emerging high quality spawning sites, and removal of beaver or breaching of beaver dams throughout the spawning period.	A formal investigation of coldwater refuge zones in Harrison Lake should be conducted and analysis of overall logged area in the watershed and its possible effects on holding spawners.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years. Community monitoring of access to major left-bank spawning areas has occurred from approximately 1999 to present. Beaver dams have been breached, and beaver removed.
~~**Habitat Productivity Model**~~								

References (applicable to multiple data sheets, therefore some of these citations may not be referenced in the above table)

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Conservation Unit: Chum, Lower Fraser - Lower Harrison Watershed Habitat Status Report

Species: Oncorhynchus keta | **Watershed: Lower Harrison Watershed**

Life Stage	Habitat Requirement for each life stage	Known limiting factors & high value habitats	Performance Indicators for habitat limiting factors	Performance Indicators Status	~~Performance Indicators Thresholds~~	Possible measures to address limiting factors	Possible measures to maintain productivity	Habitat Protection & Restoration Measures Undertaken
Spawner/Egg/ Alevin	Diewart (2007): Chum salmon construct redds in the mainstem of the river or in side-channels and are generally immediately upstream of turbulent flows with a source of upwelling water. Gravel is moderately sized with minimal fine sediments; chum embryos and alevins survival is higher in more stable flow regimes. Eggs and alevins show decreased survival at temp below 4.5°C and above 14°C.	Chum have been observed in 18 tributaries to Harrison River and Harrison Lake[4]. High value habitats as reported by Holtby and Ciruna (2008) are **Big Silver Creek** (spawning lower than impassable rock at 7.5 km[4]), Chehalis River (spawning throughout mainstem[4]), **Cogburn Creek** (spawning below rock falls[4]), **Coho Creek** (unlikely due to canyon barrier, Stitt, Pers. Comm.), **Douglas Creek** (spawn in lower ~750 m)[4], **Harrison River** (rapids area and between confluences of Chehalis River and Morris Creek, Foy, Pers. Comm.), **Sakwi Creek** (spawning from mouth to 1.2 km upstream[4]), **Squawkum Creek** (chum spawing in upper sections[4]), **Tipella Creek** (spawing from mouth to gradient barrier at 1700m[4]), **Trout Lake Creek** (chum spawning concentrated at mouth majority of spawning is on beach[4]), **Twenty Mile Creek** (spawning in lower 400 m of system[4]) and **Weaver Creek** (chum scattered utilization throughout to rock falls[4]). Chum are also known to beach spawn in **Harrison Lake** (Foy, Pers. Comm.). **Limitations**: Big Silver Creek: 24% of total watershed has been logged, increased siltation, erosion[4], summer high water temperatures[19], lack of off-channel habitats, nutrient limitations, and lack of large woody debris[16]; Chehalis River: unstable[5], 32% logging in watershed (esp. pretty creek)[4], campsites, bridges, inhabited areas[4], suspended sediment, nutrient poor (Foy, Pers. Comm.); Cogburn creek: lower reaches extensively logged[1], barrier: culvert no flow in times of low water[4]; Coho Creek, a tributary to upper Chehalis Creek draining to Chehalis Lake, that historically contained extremely high spawning densities (Pers Comm Foy, Stitt, Charlie) was eliminated by an avulsion of Skwellepil Creek into Chehalis Lake in December 2007; Douglas Creek: summer high water temperatures, low productivity[13]; Harrison River: high level-development b/c Harrison Mills and agricultural activity in lower reaches[5], loss of vegetation, blocked culverts[4], high summer water temperautres[20]; Sakwi Creek: watershed appears to be degraded due to logging[1], unstable stream[4], heavy input of gravel and logging debris[5] (affecting spawning success, Stitt, Pers. Comm.), high water demand[5,] riparian disturbance due to development (Pearson, Pers. Obs.); Squawkum Creek: low flow occur during spawning, water quality issues b/c discharges[5]; Trout Lake Creek: lower reach encroached by subdivision, riparian disturbance[4], high water demand[5], channel is aggrading[5]; Twenty Mile Creek: aggradation, high sediment load5, watershed appears to be extensively logged[1]; Weaver Creek: steep gradient d/s reach channel is dry in many spots[4], ski resort development resulted in heavy sediment inputs[5].	**See Appendix 3.** Big Silver Creek: Land cover alterations, suspended sediment, water quality, riparian disturbance. Chehalis River: land cover alterations, suspended sediment, water quality. Cogburn Creek: land cover alterations, discharge. Coho Creek: discharge. Douglas Creek: water temperature, water quality. Harrison River: land cover alterations, riparian disturbance, water temperature. Sakwi Creek: land cover alterations, riparian disturbance, suspended sediment, water extration. Squawkum Creek: discharge, permitted waste discharge. Trout Lake Creek: land cover alterations, riparian disturbance, water extraction, suspended sediments. Twenty Mile Creek: suspended sediments, land cover alterations. Weaver Creek: suspended sediments, discharge.	**See Appendix 3.** Big Silver Creek: Uncompiled land-use/Forest harvest data, no data on suspended sediment, oligotrophic19, no riparian disturbance data; Chehalis River: uncompiled land use/forest harvest data, no suspended sediments data, oligotrophic (Foy Pers. Comm.); Cogburn creek: uncompiled land use/forest harvest data, no direct discharge measurements; Coho Creek: no discharge data; Douglas Creek: summer 2003 water temperatures and nutruent data from CELP (2003); Harrison River: summarized land use data from Env Can. (2002, 7 km riparian disturbance/golf course, summer high water temperatures20; Sakwi Creek: uncompiled forest harvest data, no riparian disturbance, no suspended sediments data, MOE water licences; Squawkum Creek: estimated discharge data, conflicting permitted waste discharge information; Trout Lake Creek: uncompiled land use/forest harvest data, no riparian disturbance data, no water extraction dat, no suspended sediment data; Twenty Mile Creek: uncompiled land-use/forest harvest data, no suspended sediment data; Weaver Creek: no suspended sediment data, uncompiled daily water data from spawning channel.		According to Foy (Pers. Comm.) proposals submitted to the Watershed Restoration Project in the Chehalis watershed include: stream classification and ground water assessment of upper Chehalis tributaries, Statlu River Waterfall Obstruction Removal Assessment, Coho Creek off-channel pool assessment, Pretty Creek Diversion Assessment and a Chehalis River watershed stream classification assesment. A further proposal to remove silt accumulations and develop pool/cover habitats in the Harrison River side-channels was submitted (Foy Pers. Comm.). Enhancement works proposed for Douglas Creek include construction of rearing pond and water supply channel to increase off-channel rearing/spawning habitat15. The following recommendations are from Ionson (1995): fund an aerial surveillance program to monitor large areas (impacts of agriculture, logging, and linear developments should be investigated). Land-use and its effects on salmon habitat in the Miami Creek watershed should be formally evaluated.	Foy (2007) recommends designating Harrison River, Weaver Creek and Squawkum Creek as wild chum populations and those of Cogburn Creek, Big Silver Creek, Mystery Creek, Trout Lake Creek should be designated at populations of interest that represent rare behaviour of spawning above large lakes. Foy (2007) also suggests genetic testing should be done on indigenous chum populations to confirm relationship between chum populations in the lower Fraser area. Formal land cover analysis would be useful in Weaver Creek watershed and monitoring of overall CU to determine status of spawning sites (Pearson, Pers. Obs.) Monitoring of overall CU to determine status of spawning sites. Participation in Land Use Planning processes to ensure that Salmon & salmon habitats are considered in any landscape level decisions. Continue to apply the habitat provisions of the Fisheries Act to downstream migration routes and non-natal tributarie to ensure access to and productivity of habitats.	DFO Stock Assessment Division monitors chum salmon in the Harrison River; OHEB monitors chum salmon in the Chehalis River and Weaver Creek and the Chehalis FN monitors chum salmon returning to the sloughs of the Harrison River and other spawning streams in this area[13]. Habitat enhancement / restoration has occurred at Big Silver Creek[7] to retain important spawning grounds for multiple species and fertilization in mainstem from 1994-1997 and 1999 to increase primary production. Coho Creek restoration was undertaken in Fall of 2009 by the digging of a channel in the Upper Chehalis Estuary in the stream's approximate historic location (Foy, Pers. Comm.). Harrison River: four groundwater spawning channels (for chum) and a hatchery for chinook[17], Harrison Willife Management Area proposal in process[18]. Squawkum Creek: lower portions of ck channelized to prevent flooding. Chehalis River: gravel removals maintain flow, log-boom is used to reduce jamming in the canyon below; log jams reguarly removed; hatchery built in 1982, berm surrounds hatchery (Stitt, Pers. Comm.); two spawning gravel placements to create spawning habitat, 480 m of off-channel spawning, rearing and refuge created[16]. Weaver Creek: Constructed spawning channel developed in part because of damage to Weaver and Sakwi Creeks from sedimentation; downstream of Hudson bridge Weaver is dredged annually to maintain access to spawning channel; dredged material used to dyke Weaver Creek spawning channel. Miami Creek: a flood-box was built in 1990s to lower water levels and allow spawning, gravel re-graded below bridge-deck in 2009 improving spawning habitat (Pearson, Pers. Obs.). Trout Lake Creek: MTH removes gravel from beneath bridge. Twenty Mile Creek: MTH cleans debris under bridge (coarse sediment)[6].
Fry/Juvenile Summer (N/A for immediate ocean migrants, ie. pink, chum, some chinook & sockeye pop'ns)	N/A	N/A	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Fry/Juvenile Winter (N/A for immediate ocean migrants as above)	N/A	N/A	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Smolt	Diewart (2007): an unimpeded migration path with cover from predators is important; water temp range: 6.7°C-13.3°C	Chum juveniles emerge in spring and migrate to estuary/nearshore zone of ocean immediately[2]. High value habitats for Chum smolts are Harrison Lake and Harrison River, during outmigration[4].	**See Appendix 3.** As above with emphasis on riparian disturbance and water temperatures, plus Harrison Lake: riparian disturbance, water temperature.	**See Appendix 3.** As above plus Harrison Lake: no formal riparian disturbance data for most of lake but developed areas affected by lack of riparian vegetation; water temperature data from Mathes et al. (2010) and Patterson et al. (2005).		Additional investigation of the early life stages of fry is warranted.	A formal habitat assessment should be conducted in Chehalis Lake to determine habitat status and which species are presently utilizing this habitat.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years. No juvenile salmon restoration activities have taken place to date.
~~**Marine Coastal**~~								
~~**Marine Offshore**~~								
Returning Adult Migration	Diewart (2007): adults require access to spawning grounds. High water temperatures or extreme high or low flows can delay river entry and affect survival. Optimum temperature range for successful upstream migration is 8.3°C to 15.6°C.	Low flows and high water temperatures may prevent returning chum from reaching their natal streams and reduce spawning habitat throughout the Harrison Watershed. Returning adult chum have been oberseved holding in Harrison River and Lake prior to moving to spawning grounds[4].	**See Appendix 3.** As with Spawner/Egg/Alevin with emphasis on adequate summer/fall flows and water temperatures.	**See Appendix 3.** Temperature data is lacking throughout the LHW, and available data is suggestive of increasing temperatures with summer highs rising above optimum thresholds. Likewise, discharge data is largely comprised of outdated estimates with some indication that water extractions are contributing to low flows.		As for spawner/egg/alevin. Pre-spawning monitoring of known and emerging high quality spawning sites, and removal of beaver or breaching of beaver dams throughout the spawning period.	A formal investigation of coldwater refuge zones in Harrison Lake should be conducted and analysis of overall logged area in the watershed and its possible effects on holding spawner habitat.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years. Community monitoring of access to major left-bank spawning areas has occurred from approximately 1999 to present. Beaver dams have been breached, and beaver removed.
~~**Habitat Productivity Model**~~								

References (applicable to multiple data sheets, therefore some of these citations may not be referenced in the above table)

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Conservation Unit: Coho, Lower Fraser-A - Lower Harrison Watershed Habitat Status Report

Species: Oncorhynchus kisutch | **Watershed: Lower Harrison Watershed**

Life Stage	Habitat Requirement for each life stage	Known limiting factors & high value habitats	Performance Indicators for habitat limiting factors	Performance Indicators Status	~~Performance Indicators Thresholds~~	Possible measures to address limiting factors	Possible measures to maintain productivity	Habitat Protection & Restoration Measures Undertaken
Spawner/Egg/ Alevin	Diewart (2007) 2007: Coho spawning grounds are very diverse, ranging from large river systems to small headwater streams and drainage ditches. They require unimpeded access to their home spawning grounds, and require gravels small enough to be moved by fish and large enough to allow good intragravel flow (1.3 cm - 15 cm diameter). Optimum spawning temperatures are between 5.6°C-13°C. Incubating eggs require a stable supply of clean, oxygen-rich water, with optimum temperatures between 4.4°C-13.3°C. Winter flooding may cause eggs/alevins to be exposed and/or swept downstream; associated silt-loads hinder water circulation and reduce oxygen availability in teh redds.	Coho have been observed in 28 tributaries to Harrison River and Harrison Lake[4]. High value habitats as reported by Holtby and Ciruna (2008) are **Big Silver Creek** (spawning lower than impassable rock at 7.5 km[4]), **Chehalis River** (spawning below highway overpass, Foy, Pers. Comm.), **Cogburn Creek** (spawning below rock falls[4]), **Coho Creek**, **Harrison River** (rapids area and between confluences of Chehalis River and Morris Creek Foy, Pers. Comm.), beach spawning in **Harrison Lake**[4], **Miami Creek** (spawning in upper tributaries[4]), Mystery Creek (spawning in lower section of system[4]), **Sakwi Creek** (spawning from mouth to 1.2 km upstream[4]), Squawkum Creek (spawing in upper sections below lake[4]), **Tipella Creek** (spawing from mouth to gradient barrier at 1700m[4]), **Trout Lake Creek** (spawning from mouth to culvert at 0.4km[4]), **20 Mile Creek** (spawning in lower 400m of system[4]) and **Weaver Creek** (major spawning in upper section to rock falls[4]). **Limitations:** Big Silver Creek: 24% of total watershed has been logged, increased siltation, erosion[4], summer high water temperatures[19], lack of off-channel habitats, nutrient limitations, and lack of large woody debris[16]; Chehalis River: unstable[5], 32% logging in watershed (esp. pretty creek)[4], campsites, bridges, inhabited areas[4], suspended sediment, nutrient poor (Foy, Pers. Comm.); Cogburn creek: lower reaches extensively logged[1], barrier: culvert no flow in times of low water[4]; **Coho Creek**, a tributary to upper Chehalis Creek draining to Chehalis Lake, that historically contained extremely high spawning densities (Pers Comm Foy, Stitt, Charlie) was eliminated by an avulsion of Skwellepil Creek into Chehalis Lake in December 2007; Harrison River: high level-development b/c harrison mills, and agricultural activity in lower reaches[5], loss of vegetation, blocked culverts[4], high summer water temperautres[20]; Miami Creek: development-residential 9%, agriculture 22%, parks 19% of total watershed[4], lack of riparian vegetation along lower creek[4], upper reaches ditched[5]; Mystery Creek: 46% of watershed logged and 29% proposed4, appears to have extensive logging1; summer low flow severe[4]; Sakwi Creek: watershed appears to be degraded due to logging1, unstable stream[4], heavy input of gravel and logging debris5 (affecting spawning success, Stitt, Pers. Comm.), high water demand[5], riparian disturbance due to development; Squawkum Creek: low flow occur during spawning, water quality issues b/c discharges[5]; Trout Lake Creek: lower reach encroached by subdivision, riparian disturbance4, high water demand[5], channel is aggrading[5]; Twenty Mile Creek: aggradation, high sediment load[5], watershed appears to be extensively logged[1]; Weaver Creek: steep gradient d/s reach channel is dry in many spots[4], ski resort development resulted in heavy sediment inputs[5].	**See Appendix 3.** Big Silver Creek: Land cover alterations, suspended sediment, water quality, riparian disturbance; Chehalis River: land cover alterations, suspended sediment, water quality; Cogburn Creek: land cover alterations, discharge, Coho Creek: discharge; Harrison River: land cover alterations, riparian disturbance, water temperature; Miami Creek: land cover alterations, riparian disturbance, Mystery Creek: land cover alterations, discharge; Sakwi Creek: land cover alterations, riparian disturbance, suspended sediment, water extration; Squawkum Creek: discharge, permitted waste discharge; Trout Lake Creek: land cover alterations, riparian disturbance, water extraction, suspended sediments; Twenty Mile Creek: uncompiled land-use/forest harvest data, no suspended sediment data; Weaver Creek: suspended sediments, discharge.	**See Appendix 3.** Big Silver Creek: Uncompiled Land use/Forest harvest data, no data on suspended sediment, oligotrophic19, no riparian disturbance data; Chehalis River: uncompiled land use/forest harvest data, no suspended sediments data, oligotrophic (Foy Pers. Comm.); Cogburn creek: uncompiled land use/forest harvest data, no direct discharge measurements; Coho Creek: no discharge data; Harrison River: summarized land use data from 2002 Env Can., 7 km riparian disturbance/golf course, summer high water temperatures20; Miami Creek: uncompiled land cover alterations; no data riparian disturbance; Mystery Creek: uncompiled forest harvest data, no directly measured discharge data; Sakwi Creek: uncompiled forest harvest data, no riparian disturbance, no suspended sediments data, MOE water licences; Squawkum Creek: estimated discharge data, conflicting permitted waste discharge information; Trout Lake Creek: uncompiled land use/forest harvest data, no riparian disturbance data, no water extraction dat, no suspended sediment data; Weaver Creek: no suspended sediment data, uncompiled daily water data from spawning channel.		According to Foy (Pers. Comm.) proposals submitted to the Watershed Restoration Project in the Chehalis watershed include: stream classification and ground water assessment of upper Chehalis tributaries, Statlu River Waterfall Obstruction Removal Assessment, Coho Creek off-channel pool assessment, Pretty Creek Diversion Assessment and a Chehalis River watershed stream classification assesment. A further proposal to remove silt accumulations and develop pool/cover habitats in the Harrison River side-channels was submitted (Foy Pers. Comm.). Enhancement works proposed for Douglas Creek include construction of rearing pond and water supply channel to increase off-channel rearing/spawning habitat[15].	Foy (2007) suggests that Harrison River, Weaver Creek, Big Silver Creek, Miami River, Sakwi Creek, Mystery Creek, Twenty-Mile Creek, Trout Lake Creek, upper Chehalis River, Coho Creek, Statlu Creek, and Squawkum Creek be designated as wild coho populations and be monitored. Foy (2007) further suggests using local populations broodstock to provide fry and smolts for supplementing hatchery designate streams. Formal land cover analysis would be useful in Weaver Creek watershed and monitoring of overall CU to determine status of spawning sites (Pearson, Pers. Obs.). Participation in Land Use Planning processes to ensure that Salmon & salmon habitats are considered in any landscape level decisions. Continue to apply the habitat provisions of the Fisheries Act to downstream migration routes and non-natal tributarie to ensure access to and productivity of habitats.	DFO OHEB monitors wild coho salmon populations in Weaver Creek. OHEB and public watershed groups monitor streams supporting hatchery coho salmon including Cogburn Creek and Chehalis River[13]. Enhancement / restoration has occurred at Big Silver Creek[7] to retain important spawning grounds for multiple species and fertilization in mainstem from 1994-1997 and 1999 to increase primary production. Coho Creek restoration was undertaken in Fall of 2009 by the digging of a channel in the Upper Chehalis Estuary in the streams' approximate historic location (Foy, Pers. Comm.). Harrison River: four groundwater spawning channels (for chum) and a hatchery for chinook[17], Harrison Wildife Management Area proposal in process[18]; Squawkum Creek: lower portions of creek channelized to prevent flooding; Chehalis River: gravel removals maintain flow, log-boom is used to reduce jamming in the canyon below, log jams reguarly removed, and hatchery built in 1982, berm surrounds hatchery (Stitt, Pers. Comm.), two spawning gravel placements to creat spawning habitat, 480 m of off-channel spawning, rearing and refuge created[16]; Weaver Creek: (downstream of hudson bridge) dredged annually for a number of years to maintain access to spawning channel, dredged material used to dyke Weaver Creek spawning channel, channel developed in part because of damage to Weaver and Sakwi Creeks from sedimentation; Miami Creek: floodbox lowered water levels, weeds removed mechanically; Miami Creek: a flood-box was built in 1990s to lower water levels and allow spawning, gravel re-graded below bridge-deck in 2009 improving spawning habitat (Pearson, Pers. Obs.); Trout Lake Creek: MTH removes gravel from beneath bridge; Twenty Mile Creek: MTH cleans debris under bridge (coarse sediment)[6].
Fry/Juvenile Summer	Diewart (2007):Coho fry take cover under boulders, under overhanging branches and tend to seek out quiet backwaters, side channels and small creeks; in stream environments fry are found in both pool and riffles areas, where they set up and defend territories. During summer, carrying capacity of streams maybe constrained due to low flows which limit the quantity of pool habitat; high water temperatures can also affect coho distribution, abundance and survival	Coho fry rear in nursery lakes/ponds/tributaries for 1 year[10]. Fry from Coho Creek are known to rear in Chehalis Lake (Foy, Pers. Comm.) which was heavily impacted by an avulsion of Skwellepil Creek in December 2010 and throughout tributaries in canyon[4]. Coho have also been observed rearing and overwinter in above-noted tributaries, notably Miami Creek, and Harrison Lake[4]. Limiting factors for nursery lakes: Chehalis Lake: significant riparian disturbance from 2007 landslide.	**See Appendix 3**. As above with emphasis on riparian cover and adequate spring/summer flows. Nursery lake indicators: Chehalis Lake: riparian disturbance.	**See Appendix 3.** As above with empshsis on riparian cover and adequate spring/summer flows to provide diverse, protected habitat for rearing fry. No formal data regarding Chehalis Lake riparian conditions.		A formal habitat assessment should be conducted in Chehalis Lake to determine habitat status and which species are presently utilizing this habitat. Harrison Lake: type of enhancement/restoration indicated:increased escapement through harvest reduction[8]. Additional investigation of fry rearing ground habitat and behaviour is warranted.	A formal investigation of overall logged area in the watershed and the possible effects of logging/water shed development on rearing juvenile salmon, especially with regard to nursery Lakes. Harrison Lake: increase fry recruitment through spawning channel or spawning ground improvement Additional investigation of fry rearing ground habitat and behaviour is warranted.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years. No juvenile salmon restoration activities have taken place to date.
Fry/Juvenile Winter	Diewart (2007): Quantity of suitable winter habitat limits coho production; juveniles seek deep pools and/or a variety of off-channel habitats that provide protection from high winter flows. Winter cover such as log jams, exposed roots and flooded brush areas (ie riparian vegetation) become crucial as they provide protection from predation, freezing, high flows and stabilize stream banks.	As above with emphasis on protective riparian habitat.	**See Appendix 3.** As above with emphasis on riparian cover and adequate spring/summer flows. Nursery lake indicators: Chehalis Lake: riparian disturbance.	**See Appendix 3.** Same as above and additionally Chehalis River: flow data available from hydrometric gauge 08MG001		A formal habitat assessment should be conducted in Chehalis Lake to determine habitat status and which species are using this habitat.	A formal investigation analysis of overall logged area in the watershed and its possible effects on over wintering juveniles.	As above
Smolt	Diewart (2007): Coho smolts require adequate migration corridors between rearing areas and the ocean with appropriate cover and food for migrating smolts. Temperature should not exceed 10 0C in late winter to prevent accelerated smoltification.	As above with emphasis on protective riparian habitat.						
~~**Marine Coastal**~~								
~~**Marine Offshore**~~								
Returning Adult Migration	Diewart (2007): Adults require access to spawning grounds. High water temps or extreme high or low flows can delay river entry and affect survival; migration occurs in temperatures between 7.2°C and 15.6°C	Low flows and high water temperatures may prevent returning coho from reaching their natal streams and reduce spawning habitat throughout the Harrison Watershed. Returning adult coho have been observed holding in Harrison River and Lake prior to moving to spawning grounds[4].	**See Appendix 3.** As with Spawner/Egg/Alevin with emphasis on adequate summer/fall flows and water temperatures.	**See Appendix 3.** Temperature data is lacking throughout the LHW, and available data is suggestive of increasing temperatures with summer highs rising above optimum thresholds. Likewise, discharge data is largely comprised of outdated estimates with some indication that water extractions are contributing to low flows.		As for spawner/egg/alevin. Pre-spawning monitoring of known and emerging high quality spawning sites, and removal of beaver or breaching of beaver dams throughout the spawning period.	A formal investigation of coldwater refuge zones in Harrison Lake should be conducted and analysis of overall logged area in the watershed and its possible effects on holding spawner habitat.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years. Community monitoring of access to major left-bank spawning areas has occurred from approx. 1999 to present. Beaver dams have been breached, and beaver removed.
~~**Habitat Productivity Model**~~								

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Conservation Unit: Odd-Year Pink, Fraser River - Lower Harrison Watershed Habitat Status Report

Species: Oncorhynchus gorbuscha | **Watershed: Lower Harrison Watershed**

Life Stage	Habitat Requirement for each life stage	Known limiting factors & high value habitats	Performance Indicator(s) for habitat limiting factors	Performance Indicator(s) Status	~~Performance~~ ~~Indicators~~ Thresholds	Possible measures to address limiting factors	Possible measures to maintain productivity	Habitat Protection & Restoration Measures Undertaken
Spawner/Egg/ Alevin	Diewart (2007): Pink salmon prefer coarse gravel with a few large cobbles, along with a mixture of sand a small amount of silt; water depth must be sufficient to cover the redd at all times. High gravel permeability and low rates of sedimentation generate higher survival. Optimum temp range for incubation is 5°C-16°C, flow range preferred by pink salmon is from 40 to 70 cm/s.	Odd-year Pink have been observed in 11 tributaries to Harrison River and Harrison Lake[4]. High value habitats as reported by Holtby and Ciruna (2008) are **Big Silver Creek** (spawning lower than impassable rock at 7.5 km [4]), **Chehalis River** (spawning throughout mainstem4), **Douglas Creek** (spawn in lower ~750 m [4]), **Harrison River** (rapids area and between confluences of Chehalis River and Morris Creek, Foy, Pers. Comm.), **Squawkum Creek** (chum spawing in upper sections[4]), **Trout Lake Creek** (chum spawning concentrated at mouth majority of spawning is on beach4), and **Weaver Creek** (chum scattered utilization throughout to rock falls4). **Limitations**: Big Silver Creek: 24% of total watershed has been logged, increased siltation, erosion[4], summer high water temperatures[19], lack of off-channel habitats, nutrient limitations, and lack of large woody debris16; Chehalis River: unstable[5], 32% logging in watershed (esp. Pretty Creek)4, campsites, bridges, inhabited areas[4], suspended sediment, nutrient poor (Foy, Pers. Comm.); Harrison River: high level-development b/c Harrison Mills, agricultural activity in lower reaches[5], loss of vegetation, blocked culverts[4]; Douglas Creek: summer high water temperatures, low productivity[13]; Harrison River: high level-development b/c harrison mills, and agricultural activity in lower reaches[5], loss of vegetation, blocked culverts[4], high summer water temperautres[20]; Squawkum Creek: low flow occur during spawning, water quality issues b/c discharges[5]; Trout Lake Creek: lower reach encroached by subdivision, riparian disturbance[4], high water demand5, channel is aggrading[5]; Weaver Creek steep gradient d/s reach channel is dry in many spots[4], ski resort development resulted in heavy sediment inputs[5].	**See Appendix 3.** Big Silver Creek: Land cover alterations, suspended sediment, water quality, riparian disturbance. Chehalis River: land cover alterations, suspended sediment, water quality. Douglas Creek: water temperature, water quality. Harrison River: land cover alterations, riparian disturbance, water temperature. Squawkum Creek: discharge, permitted waste discharge. Trout Lake Creek: land cover alterations, riparian disturbance, water extraction, suspended sediments. Weaver Creek: suspended sediments, discharge.	**See Appendix 3.** Big Silver Creek: Uncompiled land-use/Forest harvest data, no data on suspended sediment, oligotrophic[19], no riparian disturbance data; Chehalis River: uncompiled land use/forest harvest data, no suspended sediments data, oligotrophic (Foy Pers. Comm.); Douglas Creek: summer 2003 water temperatures and nutrient data from CELP (2003); Harrison River: summarized land use data from Env Can. (2002), 7 km riparian disturbance/golf course, summer high water temperatures[20]; Squawkum Creek: estimated discharge data, conflicting permitted waste discharge information; Trout Lake Creek: uncompiled land use/forest harvest data, no riparian disturbance data, no water extraction data, no suspended sediment data; Weaver Creek: no suspended sediment data, uncompiled daily water data from spawning channel.		According to Foy (Pers. Comm.) proposals submitted to the Watershed Restoration Project in the Chehalis watershed include: stream classification and ground water assessment of upper Chehalis tributaries, Statlu River Waterfall Obstruction Removal Assessment, Coho Creek off-channel pool assessment, Pretty Creek Diversion Assessment and a Chehalis River watershed stream classification assesment. A further proposal to remove silt accumulations and develop pool/cover habitats in the Harrison River side-channels was submitted (Foy Pers. Comm.). Enhancement works proposed for Douglas Creek include construction of rearing pond and water supply channel to increase off-channel rearing/spawning habitat[15].	As there is no formal monitoring of pink populations, Foy (2007) recommends monitoring wild pink populations and further suggests designating Harrison River, Weaver Creek, Chehalis River, Cogburn Creek, and Big Silver Creek as indigenous pink salmon populations. Monitoring of overall CU to determine status of spawning sites and formal land cover analysis would be useful in Weaver Creek watershed.	The Chehalis Hatchery cultures pink salmon for release into lower Fraser stream and the Weaver Creek Spawning Channel produces significant numbers of pink fry each spring[13]. Habitat enhancement / restoration has occurred at Big Silver Creek[8] to retain important spawning grounds for multiple species as well as fertilization in mainstem from 1994-1997 and 1999 to increase primary production. Chehalis River: gravel removals maintain flow, log-boom is used to reduce jamming in the canyon below, log jams reguarly removed, and hatchery built in 1982, berm surrounds hatchery (Stitt, Pers. Comm.), two spawning gravel placements to creat spawning habitat, 480 m of off-channel spawning, rearing and refuge created[16]. Squawkum Creek: lower portions of creek channelized to prevent flooding. Chehalis River: gravel removals maintain flow and channel leading to hatchery, berm surrounds hatchery. Weaver Creek: (downstream of Hudson bridge) dredged annually for a number of years to maintain access to spawning channel, dredged material used to dyke Weaver Creek spawning channel, channel developed in part because of damage to Weaver and Sakwi Creeks from sedimentation.
Fry/Juvenile Summer (N/A for immediate ocean migrants, ie. pink, chum, some chinook & sockeye pop'ns)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fry/Juvenile Winter (N/A for immediate ocean migrants as above)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Smolt	Diewart (2007): Optimum migration temperatures between 2°C and 16°C; migration occurs during the night, and presence of cover (rocky substrate) is required during daylight hours.	Pink juveniles emerge in spring and migrate to estuary/nearshore zone of ocean immediately. High value habitats for outmigrants are the above-noted tributaries and additioally Harrison Lake[4].	**See Appendix 3.** As above with emphasis on riparian disturbance and water temperatures, plus Harrison Lake: riparian disturbance, water temperature.	**See Appendix 3.** As above plus Harrison Lake: no formal riparian disturbance data for most of lake but developed areas effected by lack of riparian vegetation, water temperature data from Mathes et al. (2010) and Patterson et al. (2005).				Habitat provisions of the Fisheries Act have been applied for approximately 35 years.
~~**Marine Coastal**~~								
~~**Marine Offshore**~~								
Returning Adult Migration	Diewart (2007): adults require access to spawning grounds, high water temps (migrating pink salmon prefer temperatures from 7.2°C to 15.6°C) or extreme high or low flows can delay river entry and affect survival.	Low flows and high water temperatures may prevent returning pink migrants from reaching their natal streams and reduce spawning habitat throughout the Harrison Watershed. Returning adult pink have been oberseved holding in Harrison River and Lake prior to moving to spawning grounds[4].	**See Appendix 3.** As with Spawner/Egg/Alevin with emphasis on adequate summer/fall flows and water temperatures.	**See Appendix 3.** Temperature data is lacking throughout the LHW, and available data is suggestive of increasing temperatures with summer highs rising above optimum thresholds. Likewise, discharge data is largely comprised of outdated estimates with some indication that water extractions are contributing to low flows.		As for spawner/egg/alevin. Pre-spawning monitoring of known and emerging high quality spawning sites, and removal of beaver or breaching of beaver dams throughout the spawning period.	A formal investigation of coldwater refuge zones in Harrison Lake should be conducted and analysis of overall logged area in the watershed and its possible effects on holding spawner habitat.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years. Community monitoring of access to major left-bank spawning areas has occurred from approximately 1999 to present. Beaver dams have been breached, and beaver removed.
Habitat Productivity Model								

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Conservation Unit: Lake-type Sockeye, Harrison (D/S)-L - Lower Harrison Watershed Habitat Status Report								
Species: Oncorhynchus nerka		**Watershed: Lower Harrison Watershed**						
Life Stage	**Habitat Requirement for each life stage**	**Known limiting factors & high value habitats**	**Performance Indicators for habitat limiting factors**	**Performance Indicators Status**	~~**Performance Indicators Thresholds**~~	**Possible measures to address limiting factors**	**Possible measures to maintain productivity**	**Habitat Protection & Restoration Measures Undertaken**
Spawner/Egg/ Alevin	Diewart (2007): Sockeye salmon require high quality, extensive gravels. Those sockeye that spawn on lake shores require access to undisturbed shorelines with quality gravel and clean, upwelling groundwater to ensure high survivals. During incubation, eggs and alevins require a stable environment with an uniterrupted supply of clean, oxygen rich water. Winter flooding and high proportions of fine sediment reduce survival, Optimum water temperature range for sockeye incubation is 4.4°C -13.3°C.	Sockeye have been observed in 16 tributaries to Harrison River and Harrison Lake[4]. High value habitats for Harrison Downstream Sockeye, as reported by Holtby and Ciruna(2008) are **Big Silver Creek** (spawning lower than impassable rock at 7.5km [4]), **Douglas Creek** (spawn in lower ~750 m [4]), **Tipella Creek** (spawing from mouth to gradient barrier at 1.7 km [4]), **Trout Lake Creek** (spawning from mouth to culvert at 0.4km [4]). **Limitations:** Big Silver Creek: 24% of total watershed has been logged, increased siltation, erosion4, summer high water temperatures[19], lack of off-channel habitats, nutrient limitations, and lack of large woody debris[16]; Douglas Creek: summer high water temperatures, low productivity[13]; Trout Lake Creek: lower reach encroached by subdivision, riparian disturbance[4], high water demand, channel is aggrading[5].	**See Appendix 3.** Big Silver Creek: Land cover alterations, suspended sediment. Douglas Creek: water temperature, water quality. Trout Lake Creek: land cover alterations, riparian disturbance, water extraction, suspended sediments.	**See Appendix 3.** Big Silver Creek: Uncompiled Forest harvest data, no data on suspended sediment; Douglas Creek: summer 2003 water temperatures and nutruent data from CELP (2003); Trout Lake Creek: uncompiled land use/forest harvest data, no riparian disturbance data, no water extraction data, no suspended sediment data.		Enhancement works proposed for Douglas Creek include construction of rearing pond and water supply channel to increase off-channel rearing/spawning habitat[15].	Monitoring of overall CU to determine status of spawning sites. Participation in Land Use Planning processes to ensure that Salmon & salmon habitats are considered in any landscape level decisions. Continue to apply the habitat provisions of the Fisheries Act to downstream migration routes and non-natal tributaries to ensure access to and productivity of habitats.	StAD monitors the dominant Big Silver Creek and Cogburn Creek populations strough a stream survey program[13]. Habitat enhancement / restoration has occurred at Big Silver Creek[7] to retain important spawning grounds for multiple species and fertilization in mainstem from 1994-1997 and 1999 to increase primary production. Trout Lake Creek: MTH removes gravel from beneath bridge[6].
Fry/Juvenile Summer	Diewart (2007): After emerging, fry migrate directly to nursery lake and require appropriate cover to limit exposure to predators during migration. Upon reaching the lake juveniles spend first few weeks in near shore, therefore shoreline habitats must remain favourable to the production of insect populations. Subsequently, fry spend most of their time in offshore waters of nursery lake., Water quality must support abundant food sources with optimum water temperatures from 12°C - 14°C.	Rear in freshwater for one year. Sockey fry have been observed rearing in Big Silver Creek[4] and Harrison Lake[2].	**See Appendix 3.** Harrison Lake	**See Appendix 3.** Harrison Lake: discharge data available from hydrometric station 08MG012, water temperature reference data available[20].		Harrison Lake: Increase escapement through harvest reduction[8].	A formal investigation of overall logged area in the watershed and the possible effects of logging/water shed development on rearing juvenile salmon, especially with regard to nursery Lakes. Harrison Lake: increase fry recruitment - spawning channel or spawning ground improvement.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years. No juvenile salmon restoration activities have taken place to date. A pilot fry salvage is scheduled for spring 06 to investigate utility of this technique in the area.
Fry/Juvenile Winter			**See Appendix 3.** Harrison Lake	**See Appendix 3.** Harrison Lake: discharge data available from hydrometric station 08MG012, water temperature reference data available[20].		Additional investigation of fry over-wintering habitat and behaviour is warranted.	A formal investigation analysis of overall logged area in the watershed and its possible effects on over wintering juveniles. Additional investigation of fry over-wintering grounds is warranted.	As above.
Smolt	Diewart (2007): Smolts require open migration corridors that are free from obstacles and provide sufficient cover such as healthy, abundant streamside vegetation as well as woody debris and large substrate material.	Harrison River	**See Appendix 3.** Harrison River.	**See Appendix 3.** Harrison River.				
~~**Marine Coastal**~~								
~~**Marine Offshore**~~								

Conservation Unit: Lake-type Sockeye, Harrison (D/S)-L - Lower Harrison Watershed Habitat Status Report								
Species: Oncorhynchus nerka		**Watershed: Lower Harrison Watershed**						
Life Stage	**Habitat Requirement for each life stage**	**Known limiting factors & high value habitats**	**Performance Indicators for habitat limiting factors**	**Performance Indicators Status**	**~~Performance Indicators Thresholds~~**	**Possible measures to address limiting factors**	**Possible measures to maintain productivity**	**Habitat Protection & Restoration Measures Undertaken**
Returning Adult Migration	Diewart (2007): Highly dependent on estuary habitat. Sockeye require an unimpeded migration path with cover from predators; optimum migration temperatures are between 7.2°C and 15.6°C.	Low flows and high water temperatures may prevent returning sockeye from reaching their natal streams and reduce spawning habitat throughout the Harrison Watershed. Returning adult sockeye have been oberseved holding in Harrison River and Lake prior to moving to spawning grounds[4].	**See Appendix 3.** As with Spawner/ Egg /Alevin with emphasis on adequate summer/ fall flows and water temperatures.	**See Appendix 3.** Temperature data is lacking throughout the LHW, and available data is suggestive of increasing temperatures with summer highs rising above optimum thresholds. Likewise, discharge data is largely comprised of outdated estimates with some indication that water extractions are contributing to low flows.		As for spawner/egg/alevine. Pre-spawning monitoring of known and emerging high quality spawning sites, and removal of beaver or breaching of beaver dams throughout the spawning period.	A formal investigation of coldwater refuge zones in Harrison Lake should be conducted and analysis of overall logged area in the watershed and its possible effects on holding spawners.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years. Community monitoring of access to major left-bank spawning areas has occurred from app 1999 to present. Beaver dams have been breached, and beaver removed.
~~Habitat Productivity Model~~								

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Conservation Unit: Lake-type Sockeye, Harrison (U/S)-L - Lower Harrison Watershed Habitat Status Report								
Species: Oncorhynchus nerka		**Watershed: Lower Harrison Watershed**						
Life Stage	**Habitat Requirement for each life stage**	**Known limiting factors & high value habitats**	**Performance Indicators for habitat limiting factors**	**Performance Indicators Status**	~~**Performance Indicators Thresholds**~~	**Possible measures to address limiting factors**	**Possible measures to maintain productivity**	**Habitat Protection & Restoration Measures Undertaken**
Spawner/Egg/ Alevin	Diewart (2007): Sockeye salmon require high quality, extensive gravels. Those sockeye that spawn on lake shores require access to undisturbed shorelines with quality gravel and clean, upwelling groundwater to ensure high survivals. During incubation, eggs and alevins require a stable environment with an uniterrupted supply of clean, oxygen rich water. Winter flooding and high proportions of fine sediment reduce survival, Optimum water temperature range for sockeye incubation is 4.4°C -13.3°C.	High value habitats for Harrison Upstream Sockeye, as reported by Holtby and Ciruna[2], are **Weaver Channel** and **Weaver Creek** (spawning between confluence with Sakwi Creek and barrier falls, Stitt, Pers. Comm.). Limitation: Weaver Creek: steep gradient d/s reach channel is dry in many spots[4], ski resort development resulted in heavy sediment inputs[5].	**See Appendix 3.** Weaver Creek: suspended sediments, discharge.	**See Appendix 3.** Weaver Creek: no suspended sediment data, uncompiled daily water level and temperature data from spawning channel.			Enhancement projects for this CU should be given high priority as these populations have experienced rapid declines and river harvest should be restricted during upriver migrations[13]. There may be a need in the future for inclusion into a more intense fish culture program to reduce pobablility of extirpation[13]. Monitoring of overall CU to determine status of spawning sites. Participation in Land Use Planning processes to ensure that Salmon & salmon habitats are considered in any landscape level decisions. Continue to apply the habitat provisions of the Fisheries Act to downstream migration routes and non-natal tributarie to ensure access to and productivity of habitats.	OHEB operates a weir that counts most of the sockeye returning to Weaver Creek[13]. Weaver Creek: (downstream of Hudson bridge) dredged annually for a number of years to maintain access to spawning channel, dredged material used to dyke Weaver Creek spawning channel, channel developed in part because of damage to Weaver and Sakwi Creeks from sedimentation[6]. Weaver Creek spawning channel was constructed in 1969 to provide adequate high quality spawning habitat[13].
Fry/Juvenile Summer	Diewart (2007): After emerging, fry migrate directly to nursery lake and require appropriate cover to limit exposure to predators during migration. Upon reaching the lake juveniles spend first few weeks in near shore, therefore shoreline habitats must remain favourable to the production of insect populations. Subsequently, fry spend most of their time in offshore waters of nursery lake., Water quality must support abundant food sources with optimum water temperatures from 12°C - 14°C.	Harrison Upstream Sockeye fry swim downstream to harrison river and then upstream to rear in Harrison lake[2].	**See Appendix 3.** Harrison Lake	**See Appendix 3.** Harrison Lake: discharge data available from hydrometric station 08MG012, water temperature reference data available[20].			A formal investigation of overall logged area in the watershed and the possible effects of logging/ watershed development on rearing juvenile salmon, especially with regard to nursery Lakes. Shortreed et al (2001) suggest fry recruitment may be increased by spawning channel or spawning ground improvement (more data required to confirm the suggested recommendation), and lake fertilization (more data required to confirm the suggested recommendation).	Habitat provisions of the Fisheries Act have been applied for approximately 35 years.
Fry/Juvenile Winter	Diewart (2007): Smolts require open migration corridors that are free from obstacles and provide sufficient cover such as healthy, abundant streamside vegetation as well as woody debris and large substrate material.	As above with emphasis on protective riparian habitat.	**See Appendix 3.** Harrison Lake	**See Appendix 3.** Harrison Lake: discharge data available from hydrometric station 08MG012, water temperature reference data available[20].			A formal investigation analysis of overall logged area in the watershed and its possible effects on over wintering juveniles.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years.
Smolt	Diewart (2007): Smolts require open migration corridors that are free from obstacles and provide sufficient cover such as healthy, abundant streamside vegetation as well as woody debris and large substrate material.	Harrison River	**See Appendix 3.** Harrison River.	**See Appendix 3.** Harrison River.				Habitat provisions of the Fisheries Act have been applied for approximately 35 years.
~~**Marine Coastal**~~								
~~**Marine Offshore**~~								

Conservation Unit: Lake-type Sockeye, Harrison (U/S)-L - Lower Harrison Watershed Habitat Status Report								
Species: Oncorhynchus nerka		Watershed: Lower Harrison Watershed						
Life Stage	**Habitat Requirement for each life stage**	**Known limiting factors & high value habitats**	**Performance Indicators for habitat limiting factors**	**Performance Indicators Status**	**~~Performance Indicators Thresholds~~**	**Possible measures to address limiting factors**	**Possible measures to maintain productivity**	**Habitat Protection & Restoration Measures Undertaken**
Returning Adult Migration	Diewart (2007): Highly dependent on estuary habitat. Sockeye require an unimpeded migration path with cover from predators; optimum migration temperatures are between 7.2°C and 15.6°C.	Low flows and high water temperatures may prevent returning sockeye from reaching their natal streams and reduce spawning habitat throughout the Harrison Watershed. Returning adult sockeyek have been oberseved holding in Harrison River and Lake prior to moving to spawning grounds[4].	**See Appendix 3.** As with Spawner/Egg/Alevin with emphasis on adequate summer/fall flows and water temperatures.	**See Appendix 3.** Temperature data is lacking throughout the LHW, and available data is suggestive of increasing temperatures with summer highs rising above optimum thresholds. Likewise, discharge data is largely comprised of outdated estimates with some indication that water extractions are contributing to low flows.		Shortreed et al (2001) suggest escapements from Harrison Lake may be increased through harvest reduction[8]. Pre-spawning monitoring of known and emerging high quality spawning sites, and removal of beaver or breaching of beaver dams throughout the spawning period.	A formal investigation of coldwater refuge zones in Harrison Lake should be conducted and analysis of overall logged area in the watershed and its possible effects on holding spawners.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years. Community monitoring of access to major left-bank spawning areas has occurred from approximately 1999 to present. Beaver dams have been breached, and beaver removed.
~~Habitat Productivity Model~~								

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Conservation Unit: River-type Sockeye, Lower Fraser - Lower Harrison Watershed Habitat Status Report

Species: Oncorhynchus nerka		**Watershed: Lower Harrison Watershed**						
Life Stage	**Habitat Requirement for each life stage**	**Known limiting factors & high value habitats**	**Performance Indicator(s) for habitat limiting factors**	**Performance Indicator(s) Status**	~~**Performance Indicators Thresholds**~~	**Possible measures to address limiting factors**	**Possible measures to maintain productivity**	**Habitat Protection & Restoration Measures Undertaken**
Spawner/Egg/ Alevin	Diewart (2007): Sockeye salmon require high quality, extensive gravels. Those sockeye that spawn on lake shores require access to undisturbed shorelines with quality gravel and clean, upwelling groundwater to ensure high survivals. During incubation, eggs and alevins require a stable environment with an uniterrupted supply of clean, oxygen rich water. Winter flooding and high proportions of fine sediment reduce survival, Optimum water temperature range for sockeye incubation is 4.4°C -13.3°C.	High value habitats for Lower Fraser Sockeye, as reported by Holtby and Ciruna (2007), are **Chehalis River** (spawning throughout mainstem[4]) and (in the rapids of) **Harrison River** . **Limitations:** Chehalis River: unstable[5], 32% logging in watershed (esp. pretty creek)4, land cover alterations: campsites, bridges, inhabited areas[4], suspended sediment, nutrient poor (Foy, Pers. Comm.); Harrison River: high level-development b/c Harrison Mills, and agricultural activity in lower reaches[5], loss of vegetation, blocked culverts[4], high summer water temperautres[20].	**See Appendix 3.** Chehalis River: land cover alterations, suspended sediment, water qualit; Harrison River: land cover alterations, riparian disturbance, water temperature.	**See Appendix 3.** Chehalis River: uncompiled land use/forest harvest data, no suspended sediments data, oligotrophic (Foy Pers. Comm.); Harrison River: summarized land use data from Env Can. (2002, 7 km riparian disturbance/golf course, summer high water temperatures[20].		According to Foy (Pers. Comm.) proposals submitted to the Watershed Restoration Project in the Chehalis watershed include: stream classification and ground water assessment of upper Chehalis tributaries, Statlu River Waterfall Obstruction Removal Assessment, Coho Creek off-channel pool assessment, Pretty Creek Diversion Assessment and a Chehalis River watershed stream classification assesment. A further proposal to remove silt accumulations and develop pool/cover habitats in the Harrison River side-channels was submitted (Foy Pers. Comm.).	StAD monitors this CU but population estimates are approximations only, more accurate methods should be employed[13]. Potential restoration of Harrison River left and right bank side channels damaged by navigation channel dredging are considered options for future restoration efforts[13]. Monitoring of overall CU to determine status of spawning sites. Participation in Land Use Planning processes to ensure that Salmon & salmon habitats are considered in any landscape level decisions. Continue to apply the habitat provisions of the Fisheries Act to downstream migration routes and non-natal tributarie to ensure access to and productivity of habitats.	Harrison Willife Management Area proposal in process[18]; Harrison River: the rapids and lower portion of the river, which are part of the spawning area, have been dredged to maintain a navigation channel; chehalis river: gravel removals maintain flow and channel leading to hatchery, berm surrounds hatchery[6].
Fry/Juvenile Summer **(N/A for immediate ocean migrants, ie. pink, chum, some chinook & sockeye pop'ns)**	N/A	N/A	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Fry/Juvenile Winter **(N/A for immediate ocean migrants as above)**	N/A	N/A	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Smolt	Diewart (2007): River sockeye migrate directly to estuaries upon emergence. Smolts require open migration corridors that are free from obstacles and provide sufficient cover such as healthy, abundant streamside vegetation as well as woody debris and large substrate material.	Lower Fraser Sockeye fry swim downstream to Fraser River estuary immediately upon emergence[2].	**See Appendix 3.** As above.	**See Appendix 3.** As above.				Habitat provisions of the Fisheries Act have been applied for approximately 35 years.
Marine Coastal								
Marine Offshore								
Returning Adult Migration	Diewart (2007): Adults require access to spawning grounds, high water temps or extreme high or low flows can delay river entry and affect survival, migration temperatures between 7.2°C and 15.6°C preferred.	Sockeye adults have been observed holding in harrison lake and harrison river[4]. Low flows and high water temperatures may prevent returning coho from reaching their natal streams and reduce spawning habitat throughout the Harrison Watershed	**See Appendix 3.** As with Spawner/Egg/Alevin with emphasis on adequate summer/fall flows and water temperatures.	**See Appendix 3.** Temperature data is lacking throughout the LHW, and recent available data for Harrison River is suggestive of increasing temperatures with summer highs rising above optimum thresholds20. Hydrometric gauge discharge data for Harrison River is available from station 08MG013.		Pre-spawning monitoring of known and emerging high quality spawning sites, and removal of beaver or breaching of beaver dams throughout the spawning period.	A formal investigation of coldwater refuge zones in Harrison Lake should be conducted and analysis of overall logged area in the watershed and its possible effects on holding spawners.	Habitat provisions of the Fisheries Act have been applied for approximately 35 years. Community monitoring of access to major left-bank spawning areas has occurred from approximately 1999 to present. Beaver dams have been breached, and beaver removed.

Conservation Unit: River-type Sockeye, Lower Fraser - Lower Harrison Watershed Habitat Status Report								
Species: Oncorhynchus nerka		Watershed: Lower Harrison Watershed						
Life Stage	**Habitat Requirement for each life stage**	**Known limiting factors & high value habitats**	**Performance Indicator(s) for habitat limiting factors**	**Performance Indicator(s) Status**	**~~Performance Indicators Thresholds~~**	**Possible measures to address limiting factors**	**Possible measures to maintain productivity**	**Habitat Protection & Restoration Measures Undertaken**
~~Habitat Productivity Model~~								

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APPENDIX 3 High Value Habitats and Indicators

(appended as .xls files to digital document)

Lower Harrison Watershed High Value Habitats

		Pressure Indicators							State Indicators			
Habitat	**Watershed Code**	***Land-use data***	***Forest Harvest***	***Road Density***	***Riparian disturbance***	***Watershed road development***	***Water extraction***	***Permitted Waste discharge***	***Water Temperature***	***Suspended sediment***	***Water Quality***	***Discharge:***
Big Silver Creek	**110-599000**	Uncompiled - GeoBase 2009a	Uncompiled - MoFR / Outdated data from Nener and Warwick 1997: 24% logged, 15% from recent or proposed	Uncompiled - MOFR / GeoBase 2009b	No data	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	Two licenses have been applied for by Cloudworks Energy Inc. for power generation totaling 3192.7 cfs.	None	Limiting factor - summer highs data: Wilson et al. 1999.	Limiting factor - no data	Limiting factor - nutrient poor (data: Wilson et al. 1999): nitrate + nitrite 38 – 46 ug/L ; phosphorous undetectable	Estimated: NHC 1994.
Chehalis Lake	**110-090200**	Uncompiled - GeoBase 2009a	Uncompiled - MoFR	Uncompiled - MOFR / GeoBase 2009b	Significant disturbance from 2007 landslide	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	None	None	No data	No data	No data	No data
Chehalis River	**110-090200**	Environment Canada (2002)	Uncompiled - MoFR / Outdated data from FRAP 1999: 24% logged, 15% recent / McLennand and Recknell (1999): 30% remaining in old or mature forest in 1997.	Uncompiled - MOFR / GeoBase 2009b	60% of the riparian vegetation in the selected sub-drainages had been harvested, of which 32% were significantly hydrologically impaired and another 28% were moderately impaired (McLennan and Recknell 1999)	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	Fisheries and Oceans Canada: 65 cfs for the Chehalis Fish Hatchery.	Discharge Creek (a tributary to Maisal) receives sewage discharges from the Hemlock Valley Ski Area (FRAP 1999). Not communicated by L. Freyman @ MOE.	Uncompiled - data available from Chehalis Fish Hatchery	Limiting factor - no data; thought to be hight due to road traffic and logging in the watershed	Limiting factor - nutrient poor (data: Foy, Pers. Correspondence): NO2+NO3: 0.90mg/L; oPO4 < 0.001 mg/L	Hydrometric gauge 08MG001: summer/winter low flows limiting factor
Cogburn Creek	**110-535100**	Uncompiled - GeoBase 2009a	Uncompiled - MoFR / Outdated data from FRAP 1999: 8% of the total watershed had been logged, including 7% from recent activity with another 4% proposed	Uncompiled - MOFR / GeoBase 2009b	No data	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	None	None	No data	No data	No data	Estimated: NHC 1994
Coho Creek	**110-090200-66600**	Uncompiled - GeoBase 2009a	Uncompiled - MoFR / Outdated data from Nener and Warwick 1997	Uncompiled - MOFR / GeoBase 2009b	Significant disturbance from 2007 landslide	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	None		No data	No data	No data	No data
Douglas Creek	**110-987400**	Uncompiled - GeoBase 2009a	Uncompiled - MoFR / Outdated data from Nener and Warwick 1997: 1% of the total watershed has been logged recently and 1% is proposed for harvest	Uncompiled - MOFR / GeoBase 2009b	No data; lower channel has been channelized	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	Cloudworks IPP - 404.36 cfs	None	Limiting factor - summer highs, data: CELP 2003.	low (CELP 2003)	Limiting factor - nutrient poor (data: CELP 2003)	Data: CELP 2003; modified by IPP.
Harrison Lake	**110**	Environment Canada (2002); three placer mining operations (ILMB 2010a); residential development covers approximately 7 km^2	Uncompiled - MoFR /31% of the watershed is old forest (greater than 140 years old); 15% is young forest, and 6% is recently logged (Environment Canada 2002)	Uncompiled - MOFR / GeoBase 2009b	riparian vegetation absent along 2.2 km shoreline at Harrioson Hot Springs, residential development along Rockwell Drive on the south-east shore of the lake has resulted in another 2 km of riparian removal	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	Seven water licences total maximum removal of 112,000 gallons/day or 100,000,000 gallons/annum	Two permitted waste discharges	Data: (Mathes et al. 2010), Patterson et al. 2005	No data	No data	Hydrometric Gauge 08MG012 - Harrison Lake near Harrison Hot Springs:, daily level 1933-2008 and real-time
Harrison River	**110**	Environment Canada (2002)	Uncompiled - MoFR / 31% of the watershed is old forest (greater than 140 years old); 15% is young forest, and 6% is recently logged (Environment Canada 2002)	Uncompiled - MOFR / GeoBase 2009b	7km riparian disturbance from development / golf course.	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	Three domestic / business water licenses have an allowable extraction of 0.001 m^3/s.	One business sewage outfall (fishing lodge)	Limiting factor - summer highs, data: Mathes et al. 2010.	No data	No data	Hydrometric gauge 08MG013 - WATER LEVEL THRESHOLD??
Miami Creek	**110-232100**	FRAP (1999) identified residential housing on 9% of the total watershed area, agriculture on 22%, and 10% in parks; Uncompiled - GeoBase 2009	Uncompiled - MoFR / Outdated data from Nener and Warwick 1997	Uncompiled - MOFR / GeoBase 2009b	lack of vegetation along majority of creek due to development (Nener and Warwick 1997)	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	None	None	No data	No data	No data	Estimated: NHC 1994

Habitat	Watershed Code	*Land-use data*	*Forest Harvest*	*Road Density*	*Riparian disturbance*	*Watershed road development*	*Water extraction*	*Permitted Waste discharge*	*Water Temperature*	*Suspended sediment*	*Water Quality*	*Discharge*:
		Pressure Indicators							***State Indicators***			
Morris Creek	**110-149200**	Uncompiled - GeoBase 2009a	Uncompiled - MoFR / Outdated data from Nener and Warwick 1997	Uncompiled - MOFR / GeoBase 2009b	No data	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	None	None	No data	No data	No data	Estimated: NHC 1994
Morris Lake	**110-149200**	Uncompiled - GeoBase 2009a	Uncompiled - MoFR / Outdated data from Nener and Warwick 1997	Uncompiled - MOFR / GeoBase 2009b	No data	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	None	None	No data	No data	No data	Estimated: NHC 1994
Mystery Creek	**110-581900**	Uncompiled - GeoBase 2009a	Limiting Factor: Uncompiled - MoFR / Outdated data from Nener and Warwick 1997: 53% of the watershed had been logged and 75% of the watershed was proposed for further harvest	Uncompiled - MOFR / GeoBase 2009b	No data	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	None	None	No data	No data	No data	Estimated: NHC 1994
Sakwi Creek	**110-149200-85400-35600**	Uncompiled - GeoBase 2009a	Uncompiled - MoFR / Conflicting reports; outdated data from Nener and Warwick 1997	Uncompiled - MOFR / GeoBase 2009b	Limiting factor - no data, but thought to be significant due to roads and development	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	Fisheries and Oceans Canada license, 20 cfs (0.57 m3/s); Sakwi Creek Power Corporation for another 24.72 cfs (0.70 m3/s) . The potential August water demand for irrigation and waterworks use is ten times (1000%) of the naturalized summer 7-day mean low flow (0.13 m3/s).	None	No data	No data; thought to be significant due to development and logging	No data	Limiting Factor / Estimated: NHC 1994
Squawkum Creek	**110-036900**	Uncompiled - GeoBase 2009a	Uncompiled - MoFR	Uncompiled - MOFR / GeoBase 2009b	thought to be some disturbance due to development	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	None	conflicting data: no MOE record but FRAP (1999) states discharges and septic fields from settlement around Errock Lake	No data	No data	No data	Estimated: NHC 1994 and Nener and Wernick 1997
Tipella Creek	**110-954600**	Uncompiled - GeoBase 2009a	Uncompiled - MoFR / Outdated data from Nener and Warwick 1997: 3% of the total watershed has been logged recently	Uncompiled - MOFR / GeoBase 2009b	IPP permentently impatcted 7,294 m^2 of riparian habitat (Lewis et al. 2006)	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	Tipella Creek Project Partnership:r 254 cfs for power generation purposes;21.2 cfs by Cloudworks Energy for conservation purposes	None	Ok - data from Lewis et al 2006.	No data	No data	Data: Lewis et al. 2006; modified by IPP.
Trout Lake Creek	**110-259000**	Uncompiled - GeoBase 2009a	Uncompiled - MoFR / Outdated data from Nener and Warwick : 1997: Trout Lake Creek watershed was completely logged by 1956	Uncompiled - MOFR / GeoBase 2009b	No data; thought to be high in lower reach due to residential development	Uncompiled - BC Watershed Atlas / National Road Network / MoFR; thought to be high due to residential development, campgrounds and historical logging	conflicting data: no water licenses listed by MOE but, NHC 1994 identified industrial and residential water extraction	None	No data	No data; thought to be high b/c channel is building up debris	No data	Limiting Factor (Nener and Warwick, 1997) Estimated: NHC 1994
Twenty Mile Creek	**110-588000**	Uncompiled - GeoBase 2009a	Uncompiled - MoFR / Outdated data from Nener and Warwick 1997: 10% of the total watershed has been logged recently, and 1% is proposed for harvest	Uncompiled - MOFR / GeoBase 2009b	No data	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	None	None	No data	No data; thought to be high b/c aggradation is occuring	No data	Estimated: NHC 1994
Weaver Creek	**110-149200-85400**	Uncompiled - GeoBase 2009a	Uncompiled - MoFR / Conflicting reports; Outdated data from Nener and Warwick 1997	Uncompiled - MOFR / GeoBase 2009b	No data	Uncompiled - BC Watershed Atlas / National Road Network / MoFR	Fisheries and Oceans: 2160 acre-feet per annum in Weaver Creek (since 1964),20cfs for conservation purposes. Two domestic licenses total 1000 gallons per day	None	Uncompiled - data available from Weaver Creek Spawning Channels	No data (annual dredging of 20,000 m^3)	No data	Estimated: NHC 1994 / Uncompiled daily water level data available from Weaver Creek Spawning Channels

APPENDIX 4 Harrison River Dredging Impacts 1967

Final Draft
May 1967 Per [illegible]

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ENGINEERING

THE EFFECTS OF DREDGING IN THE HARRISON RIVER ON RIVER LEVELS AND SALMON SPAWNING GROUNDS

THE EFFECTS OF DREDGING IN THE HARRISON RIVER ON RIVER LEVELS AND SALMON SPAWNING GROUNDS

INTRODUCTION

The fisheries problems associated with dredging of that section of the Harrison River which is used by salmon for spawning purposes, were discussed in a previous report (Anonymous, 1958). Suggestions were made for planning of dredging times to avoid periods when salmon were in the river, and for selection of disposal areas to avoid burying spawning grounds and to avoid drying up of side channels. These suggestions were made to minimize any effects on the salmon runs while maintaining the transportation channel. Continued dredging in the Harrison River coupled with observed lack of flow over a major part of the spawning area at low water during the spring of 1962 and again in 1964 has led to concern over the possible effects of the dredging on the spawning grounds. In June 1964, dredging near the upper end of Harrison Rapids in the vicinity of a control section of the river was discontinued by the Department of Public Works upon request by the Department of Fisheries, and arrangements were made for a cooperative study of the Harrison River at the next low water period. The Department of Public Works undertook to obtain soundings and provide ground control, and the Department of Fisheries and the International Pacific Salmon Fisheries Commission undertook to obtain aerial photography and mapping. This work was completed by the end of 1965. Pending completion of the surveys and analysis of data, the Department of Public Works agreed not to do any further dredging in the upper portion of Harrison Rapids. This report presents the findings of the study.

SALMON SPAWNING GROUNDS

All five species of Pacific salmon spawn in the Harrison River in the vicinity of the rapids (FIGURE 1). Sockeye spawn along the west side of the island forming the left bank of the main channel from the island out to the edge of the deeper part of

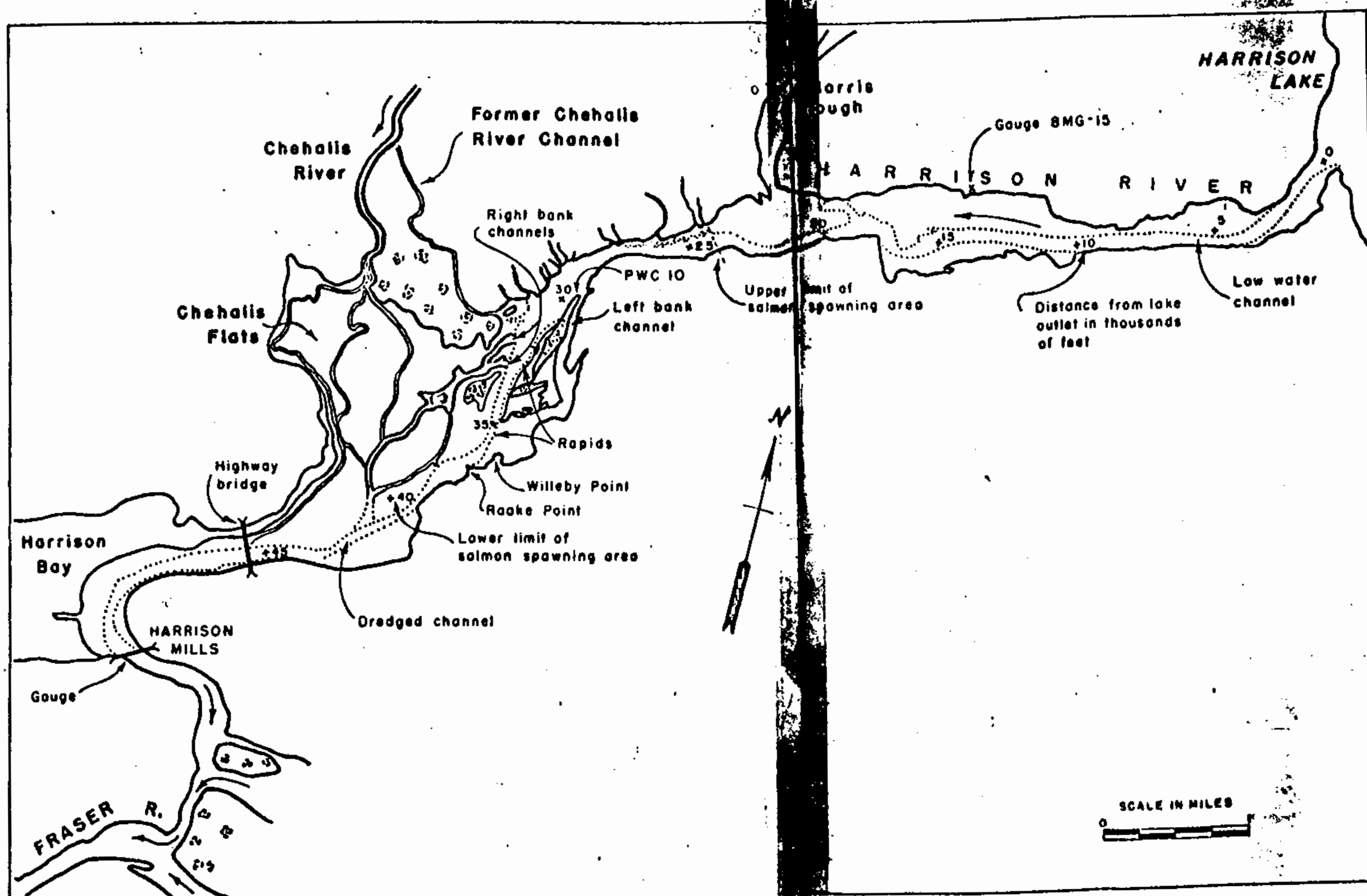


FIGURE 1 - Plan of Harrison River.

the channel. Pink, chum and chinook salmon spawn throughout the river from below Raake Point up to the mouth of Morris Slough, and the left bank and right bank side channels in the rapids section. Coho salmon spawn near the upper end of the left bank channel, and along the left bank downstream from Morris Slough. Details of the spawning grounds used by each species are given in an earlier report (Anonymous, 1958).

Spawning occurs in the period from September 1 to February 28, each of the five species of salmon having a characteristic period. The discharge in the Harrison River can vary considerably during this period, ranging from a high of approximately 43,900 cfs to a low of 2,170 cfs. At flows higher than approximately 6,000 cfs under present channel conditions, the area available for spawning is considerably greater than at lower discharges. During the period of pink salmon spawning in 1957, it is estimated that 1,418,000 sq yd of spawning ground was available at a river discharge of 9,850 cfs of which 410,000 sq yd were in the left bank channel, and 230,000 sq yd were in the right bank channel. At this discharge the area of the principle sockeye spawning area was 248,000 sq yd. At the extreme low flow, the wetted area of the river in the section utilized by salmon reduces to approximately 260,000 sq yd, or about one fifth, which is entirely within the main river channel. The margin of the main channel along the left bank upstream from Willeby Point was a preferred spawning area for chinook and sockeye salmon before it was covered with dredge spoils. Approximately four fifths of the wetted area of the river in the portion utilized by salmon is in the shallower margins and side channels, where any reduction in water depth is more critical than a similar reduction in the main channel.

Successful utilization of these spawning areas is dependent upon a flow of water over the gravel beds at all times. Depositions of gravel over the spawning ground render the affected areas useless by raising the elevation above low water levels. Deepening of channels lowers the river surface at low water levels and expose spawning areas. Confinement of the river between gravel spoil banks at low water reduces the wetted area available to the salmon. The data on the Harrison River have been examine to determine the extent to which the dredging in past years has produced these kinds of changes in the spawning grounds.

RECORD OF DREDGING

The first "improvements" in Harrison River were constructed near the beginning of the century (Anonymous, 1949) for the movement of logs from Harrison Lake to the Frase River. Subsequently a sheer boom and wing dams were built and dredging was done in various locations. Details of the amounts of material dredged at various locations are given in TABLE 1 (Walkey, 1966). The total amount dredged from the river has been 722,600 cu yd of which (a) 235,000 cu yd were in the vicinity of the railway bridge, (b) 275,600 cu yd were below the rapids, and (c) 212,000 cu yd were in or above the rapids.

The dredging is not done on a regular basis, but upon request by operators moving booms of logs down the Harrison River. These operators report areas where they are having difficulty because of shallow depth in the channel, or because of protruding bars which impede the movement of booms around bends in the river. These areas are then dredged to remove the trouble spots. The dredgings are deposited in piles or rows along the edge of the channel creating a dike which confines the river at low levels. The dredging from the 1951-52 operation and possibly the 1953-54 operation below the rapids can be seen in FIGURE 2. Dredgings from operations after 1957 may be seen in FIGURES 3 and 4. The dredging is usually done during the early summer high water period to facilitate movement of the dredge through the river. Starting in 1951 a scraper dredge has been used. This dredge moves gravel by means of a large blade which is pulled across the river bed by cables. The operation is simila

TABLE 1 - Location and amount of material dredged from the Harrison River.

Fiscal Year		Location and Remarks	Amount cu yd
1936-37	(b)	Clamshell operating from below rapids to highway bridge	79,600
1938-39	(c)	Clamshell spot dredging below rapids and dredging through rapids to deep water beyond (past present control point)	56,000
1944-45	(c)	Clamshell operating in and above rapids	26,000
	(a)	Suction dredge operating on bed above railway bridge	95,000
1946-47	(a)	Suction dredge operating above railway bridge	120,000
	(b)	Suction dredge below rapids	38,000
1951-52	(b)	Scraper operating between 6000 and 8000 feet upstream from highway bridge	53,000
1953-54		Scraper operating but no details	-
1954-55	(a)	Dragline scraper on bend above railway bridge	20,000
1957-58	(b)	Dragline scraper operating 1 mile upstream from highway bridge	75,000
1958-59	(c)	Scraper operating near Willeby Point	34,000
1959-60	(c)	Scraper operating at lower end of rapids	35,000
	(c)	Scraper operating near Raake Point	22,000
1961-62	(c)	Scraper operating near Willeby Point	12,000
1963-64	(b)	Scraper operating ½ mile downstream from rapids	30,000
1964-65	(c)	Scraper operating in rapids	2,000
	(c)	Scraper operating above rapids near Johnson Point	25,000
1965-66	(c)	Scraper operating near Raake Point, no details	-
		Totals (a)	235,000
		(b)	275,600
		(c)	212,000
		Total	722,600

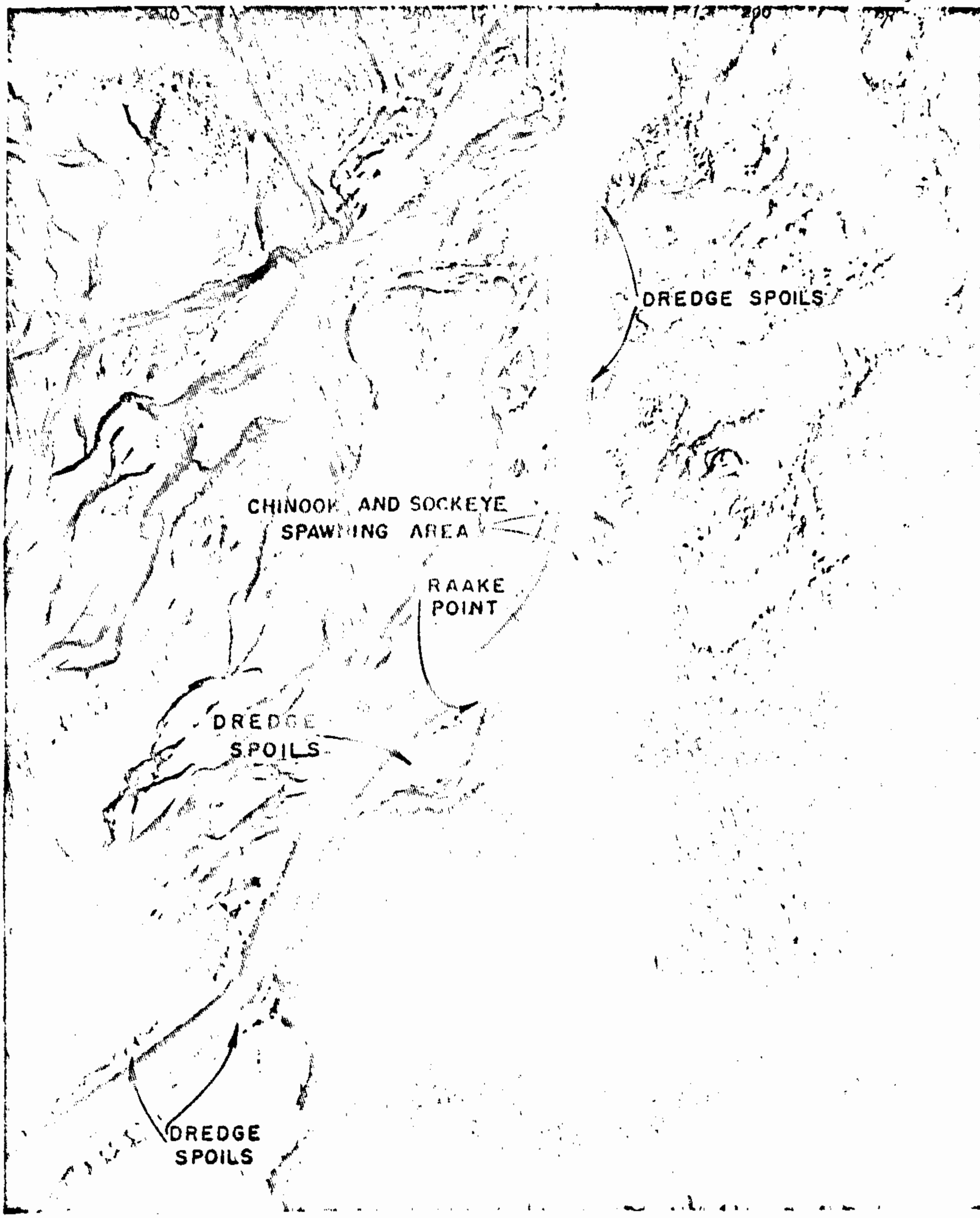


FIGURE 2 - Lower end of rapids on Harrison River, May 7, 1954 at a discharge of 6,550 cfs, and Harrison Mills gauge 20.20.

FIGURE 3 - Harrison River Rapids, March [illegible], 1965 at discharge of 7,710 cfs and Harrison Mills gauge [illegible], showing dredge spoils deposited since [illegible]. (Compare with FIGURE 10).

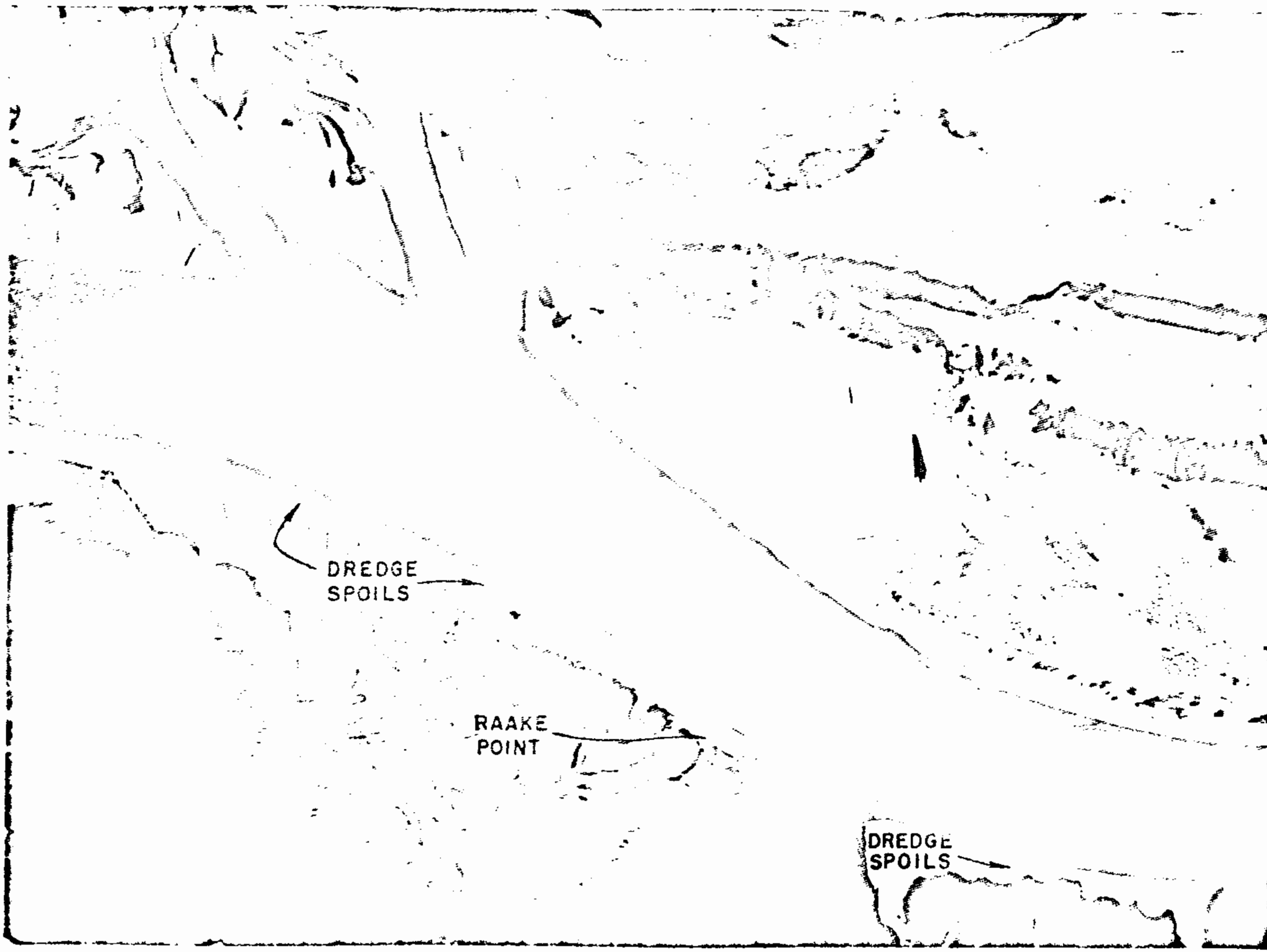


FIGURE 4 - Lower end of Harrison Rapids on March 13, 1965 showing dredge spoils in the vicinity of Raake Point and Willeby Point.

to an underwater bulldozer. The gravel cannot be transported to a particular disposal area, but is piled along adjacent parts of the river bank.

The dredging has created a well defined deeper channel from about midway up the rapids down to the road bridge. Photos of this portion of the river in 1930, prior to dredging, (FIGURE 5) show that this channel did not exist below Raake Point at that time. Above the rapids a well defined channel existed in 1930 which appears to be the same as the present channel. Below the road bridge a channel also existed in 1930, which is similar to the present channel but has been modified by dredging at the sharp bend upstream from the railway bridge. Thus it appears that the principal area affected by dredging is in the rapids.

A major portion of the flow of the Chehalis River used to flow down a branch that discharged into the Harrison River and the right bank channel at the upper end of the rapids (FIGURE 5). During the November 1949 flood this east branch of the Chehalis River was blocked off by a log jam and the entire flow of the river was diverted down the west branch. The removal of flow from the east branch of the Chehalis River has contributed to the observed reduction in water levels in the right bank side channels of the Harrison River and probably has eliminated a major flow of bed materials into the Harrison River.

SURVEY DATA

Ground and water surface elevations, maps and aerial photos of the Harrison River obtained by the Department of Public Works from an aerial survey made on March 31, 1951 and subsequent soundings form a basis for examination of the changes that have occurred in the river bed since that time. Harrison Lake level was 29.22 on that date and the discharge is estimated to have been 6,180 cfs. The Department of Public Works also has aerial photos taken near low water for a number of years. The British

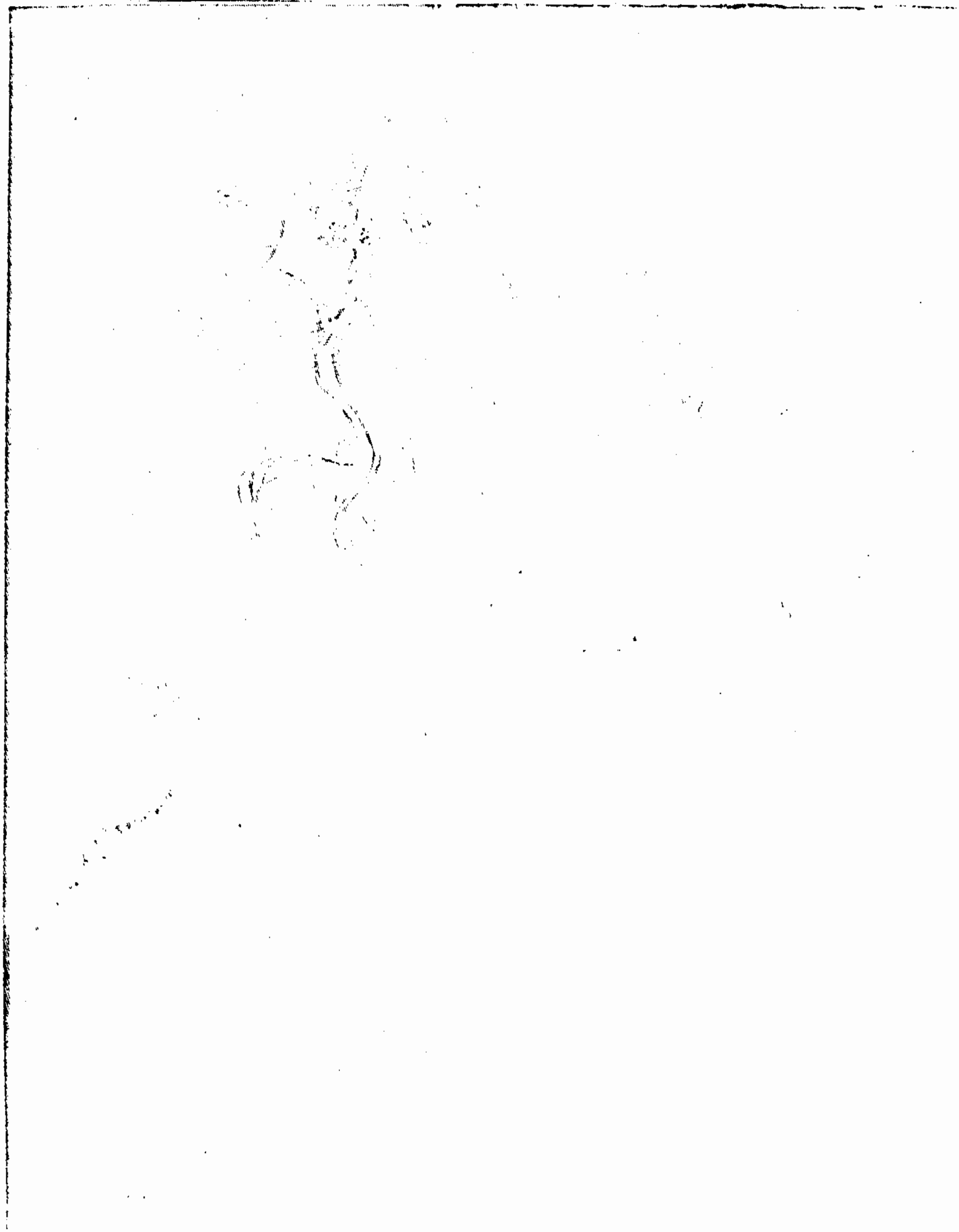


FIGURE 5 - Harrison River [illegible] 10, [illegible] discharge greater than 10,000 cfs and estimated Harrison Mills gauge of [illegible].

Columbia Department of Lands and Forests obtained an aerial photo of the river on May 10, 1930 at unknown discharge, and on May 7, 1954 at a discharge of 6,550 cfs. The International Pacific Salmon Fisheries Commission obtained an aerial photo on October 6, 1957 at a discharge of 9,850 cfs. The Commission also surveyed the plan and profile of the river between October 16 and 29, 1957 at flows ranging from 5,320 cfs to 6,930 cfs. Water surface levels in relation to the top end of the left bank side channel were observed by the Commission on March 27, 28, 1964. Discharge records were obtained from the Water Resources Branch.

During the current cooperative study, the Department of Fisheries and the Commission obtained aerial photography on March 13, 1965 at a flow of 7,710 cfs together with outline mapping and lines of elevations on the exposed river bed. The Department of Public Works established ground control for the pictures and subsequently obtained soundings in June 1965. The Commission obtained an additional plan and profile of the river between March 24 and April 6, 1965 at flows between 5,420 cfs and 6,690 cfs. The Department of Public Works obtained a profile on April 5, 1966 at a flow of 13,300 cfs, and the Commission obtained a partial profile in the upper portion of the river on May 2 and 3, 1966 at a flow of 10,800 cfs. Elevations at the principal points referred to in this report are summarized in TABLE 2. All elevations are Geodetic, referenced to Bench Mark 301-J near Harrison Mills.

RESULTS OF STUDY

Areas Covered by Dredge Spoils

From comparison of aerial photos taken prior to dredging with recent photos it is evident that spoils from dredging have been deposited along the river adjacent to the channel that was dredged. These spoils have been deposited over areas that formerly would have been available for spawning by salmon. Salmon still spawn in

TABLE 2 - Elevation and discharge relationships, Harrison River.

Date	Harrison River Discharge, CFS	Harrison Lake Elevation	Gauge 8MG-15	Harrison River at Morris Slough	Harrison River at PWC 10
Oct. 22/57	5,600	29.36	-	-	29.02
Oct. 16/57	6,900	29.80	-	29.41	-
Nov. 1 /57	10,200	30.79	-	30.29	-
Jan. 29/63	5,090	29.12	28.83	-	-
Jan. 27/63	5,560	29.31	29.00	-	-
Jan. 22/63	6,980	29.83	29.50	-	-
Feb. 4 /63	7,690	30.06	29.66	-	-
Jan. 13/63	10,800	30.90	30.59	-	-
Apr. 6 /65	5,420	29.27	-	-	28.60
Mar. 22/65	5,600	29.34	-	-	28.76
Mar. 30/65	5,700	29.38	-	-	28.74
Mar. 29/65	5,850	29.44	-	-	28.77
Mar. 23/66	6,300	29.62	-	-	28.82
Mar. 24/65	6,690	29.73	-	-	29.31
Mar. 30/66	7,200	29.90	-	-	29.62
May 2 /66	10,800	30.93	30.65	30.65	-
May 3 /66	10,900	30.98	-	30.72	29.95
Apr. 5 /66	13,300	31.57	-	-	30.40
Nov. 5 /64	15,300	32.05	-	-	30.72

a limited fringe area along the channel sides of the spoil banks. However, the areas covered by the spoils now have elevations well above low water and are no longer useable for spawning.

It is estimated from the photos that 15,900 sq yd of the sockeye spawning area have been covered, and that 100,400 sq yd of pink, chinook and chum salmon spawning area have been covered. The dredge spoils on the left bank upstream from Raake Point have resulted in a very serious loss of spawning ground most preferred by chinook salmon.

Effect of Dredging on Harrison Lake Levels

Examination of the relationship between Harrison Lake level and Harrison River discharge in 1923 and in 1966 (FIGURE 6) shows that there has not been any significant change in the relationship during the period when dredging has been done.

Effect of Dredging on Water Levels at the Mouth of Morris Slough

During the survey of May 2, 1966 it was found that the water surface of the Harrison River was practically level between Morris Slough and the gauge (8MG-15) 1.4 miles upstream. This indicates that this portion of the river is the head pond of a control section downstream. Examination of the profiles (FIGURE 7) shows a marked increase in river gradient at a point 2,500 feet downstream from Morris Slough, indicating a control section at that point. Data on river elevation at Morris Slough for 1957 and 1966 shows a slight increase in elevation in 1966 compared to 1957 at similar discharge (TABLE 3 and FIGURE 8). It is concluded that dredging since 1957 has not lowered water levels at the junction with Morris Slough. Since the drop between Harrison Lake and this point is small and probably is required to create flow in the river, it also is unlikely that dredging prior to 1957 had any effect on water levels above this control.

TABLE 3 - Drop in water surface between Harrison Lake and Morris Slough.

DATE	DISCHARGE CFS	ELEVATION		FEET DROP IN WATER SURFACE
		Harrison Lake	Harrison River at Morris Slough	
October 16, 1957	6,900	29.80	29.41	0.26
November 1, 1957	10,200	30.79	30.29	0.47
April 5, 1966	13,300	31.45	31.30	0.15
May 2, 1966	10,800	30.95	30.65	0.30

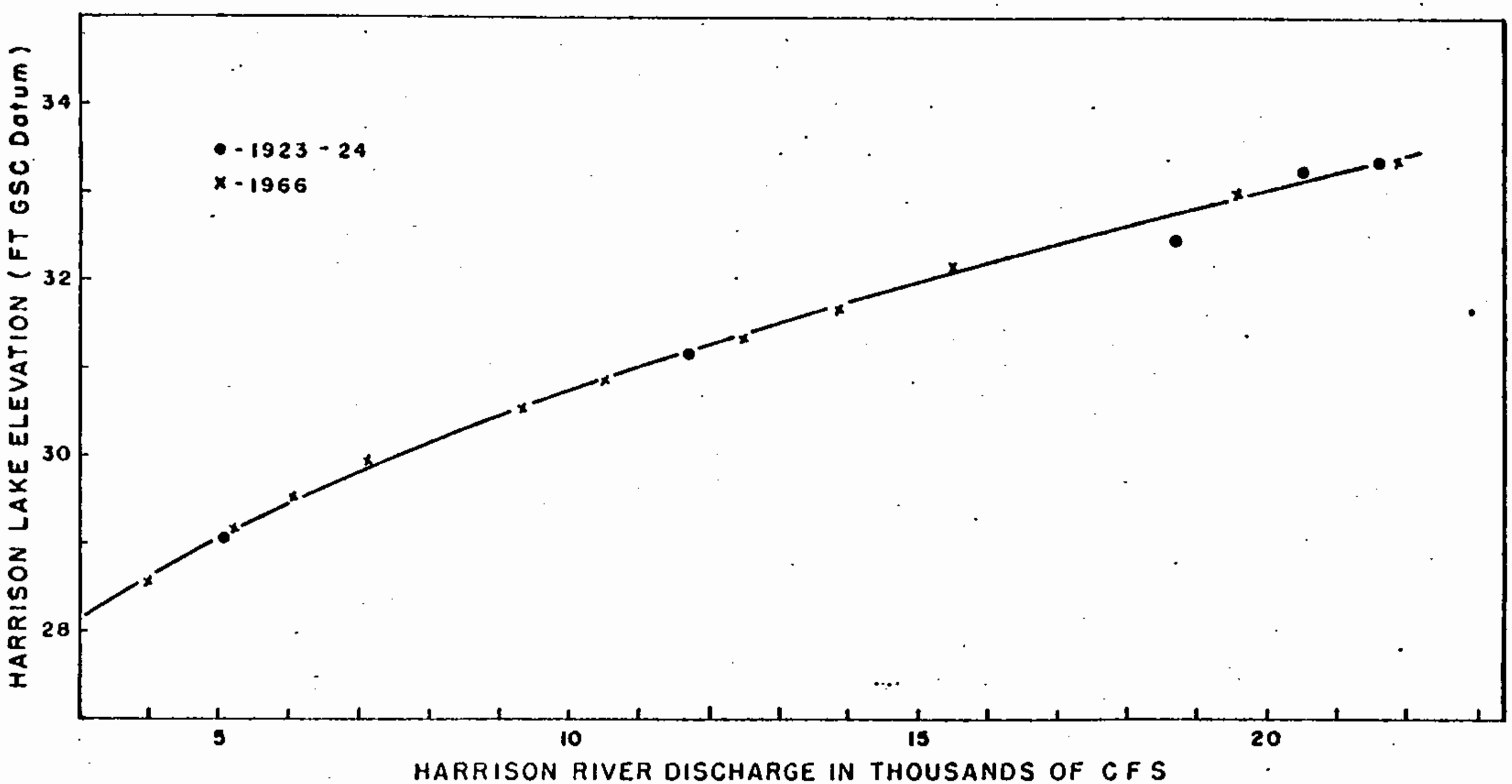


FIGURE 6 – Relationship between Harrison Lake level and Harrison River discharge.

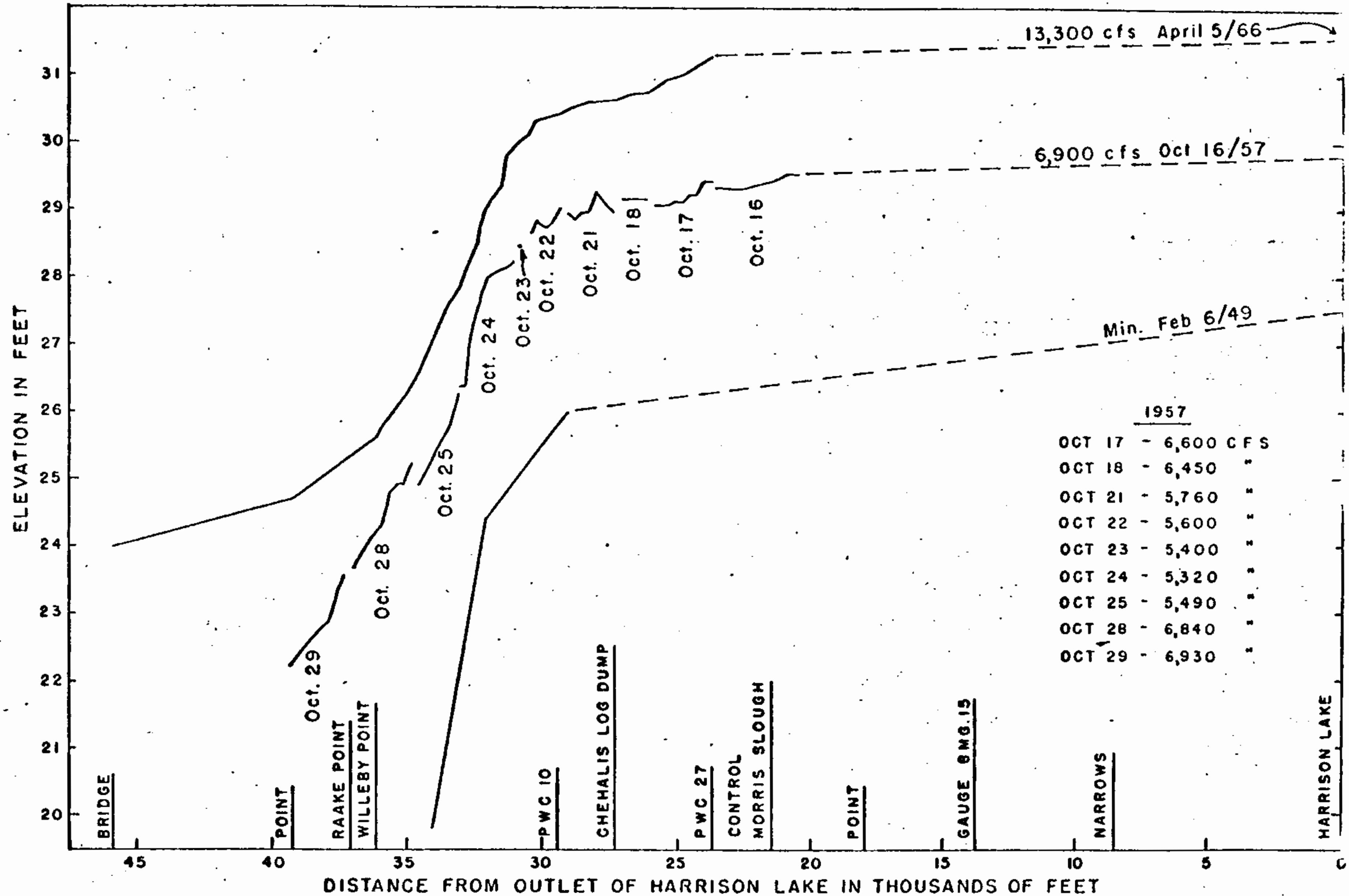


FIGURE 7 - Water surface profiles, Harrison River.

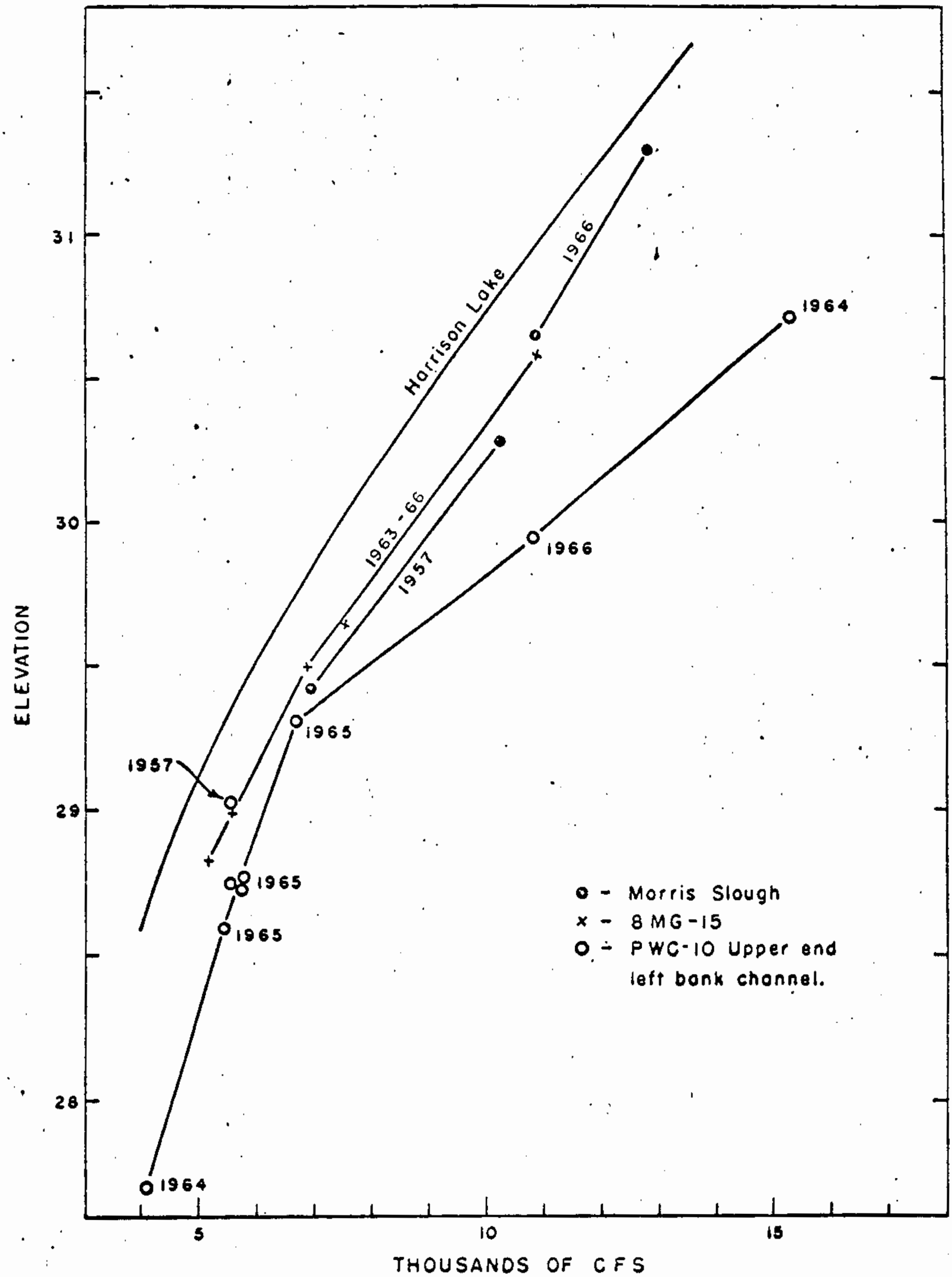


FIGURE 8 - Elevation and discharge relationships, Harrison River.

Effect of Dredging on Water Levels at the Upstream End of Left Bank Side Channel

There is a second increase in river gradient at a point 1,000 feet downstream from the top end of the left bank side channel (PWC 10, FIGURE 7), indicating a second control section. It appears from the record (TABLE 1) that this section was dredged in 1938 and possibly also in 1944, as well as in 1964.

It is not possible to determine if the dredging before 1957 had any effect on river levels above this control section. In October 1957 (TABLE 2) there was only 0.34 drop between Harrison Lake and the upper end of the left bank channel, or the same drop as was recorded between Harrison Lake and gauge 8MG-15 in 1963 at the same discharge. Since some difference in elevation is required between the two points to obtain discharge in the Harrison River, it is considered unlikely that there was any substantial change in this drop from 1923 to 1957.

However, the 1965 survey data (FIGURE 8) shows a decrease in elevation of 0.26 feet at PWC 10 in 1965 compared to 1957 at a discharge of 5,600 cfs. The plot of the data (FIGURE 8) indicates that the decrease in elevation would be more at lower discharges, and less at a discharge of 6,700 cfs. Comparison of river bottom elevations in this portion of the river taken in 1951 and in 1965 shows a decrease of 0.7 feet in the crest of the control point and a shift of its location to a point 500 feet downstream (FIGURE 9).

One of the principal causes for concern over water levels in the Harrison River was the observed lack of flow in the left bank side channel at low river levels (FIGURE 10) and the exposure of the sockeye spawning areas in the main channel adjacent to the island. Observation on March 27, 28, 1964 indicated that surface flow down the left bank channel ceased when the flow in the river was about 4,300 cfs. Data on water levels and discharge into this channel measured at the entrance to the channel are given in TABLE 4. On the basis of the river bottom contours at the entrance to the

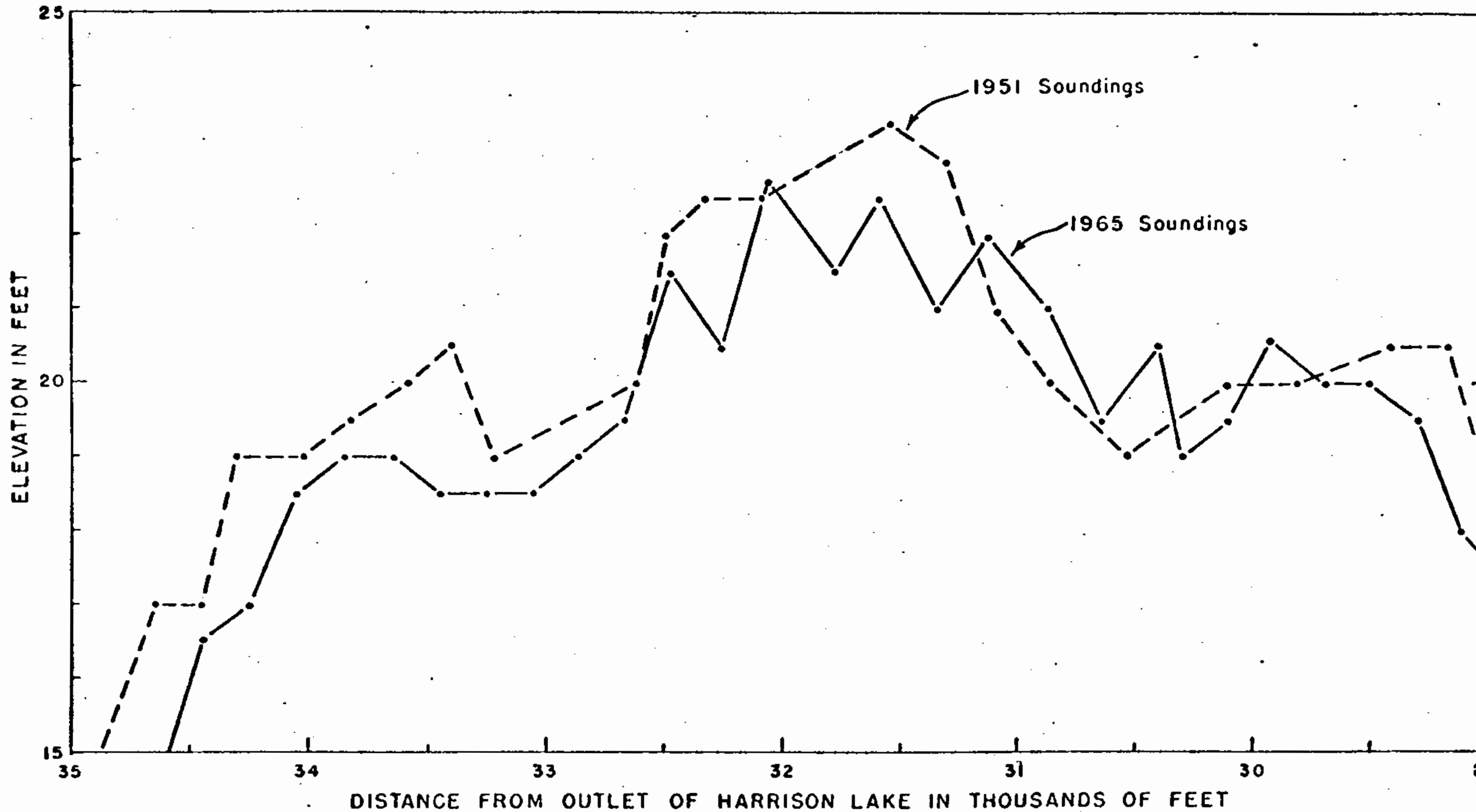


FIGURE 9 – Profile of the deepest points in the Harrison River in the vicinity of the control section at the upper end of the rapids.

FIGURE 10 - Harrison River left bank channel looking downstream on April 3, 1962; main channel discharge ~~2,770~~ cfs. 3,080 c/s

TABLE 4 - River elevations and discharge in left bank channel.

Date	River Elevation at Channel Entrance	Harrison River Discharge at Harrison Lake, cfs	Side Channel Discharge at Entrance, cfs
March 27, 1964	27.7	4,300	0
April 6, 1965	28.6	5,420	
March 31, 1965	28.76	5,600	
Oct. 22, 1957	29.02	5,600	
March 30, 1965	28.74	5,700	
March 29, 1965	28.77	5,850	96
March 24, 1965	29.31	6,690	
May 2, 1966	29.95	10,800	
Nov. 5, 1964	30.72	15,300	1,411

channel (FIGURE 11) it is estimated that the river elevation at which surface flow starts into the channel is 27.7. During the March 1965 survey it was noted that with the inflow of 96 cfs to the channel, the surface flow did not extend continuously down the channel. At several points the surface flow disappeared beneath gravel bars, and it is estimated that, at that flow, about 30 per cent of the channel bottom was above the water surface. When this area was observed on April 3, 1962 it was estimated (Goodlad, 1962) that the Harrison River would have to rise from 1½ to 2 feet to obtain a surface flow down the channel. At that time the flow in the Harrison River was 3,080 cfs. On the basis of the stage discharge relationships (FIGURE 12) at the upper end of the channel, a rise of 1½ feet would result in about the same flow condition as observed in March 1965. It is concluded that approximately 6,000 cfs is the minimum flow in the Harrison River which will maintain a continuous surface flow down the left bank channel. This would be the minimum desirable flow to allow emergi salmon fry to migrate downstream from the spawning ground in the left bank channel. At 4,300 cfs river discharge, there is no surface flow down the left bank channel, but there is a flow through the gravel bed which supplies water to the buried eggs.

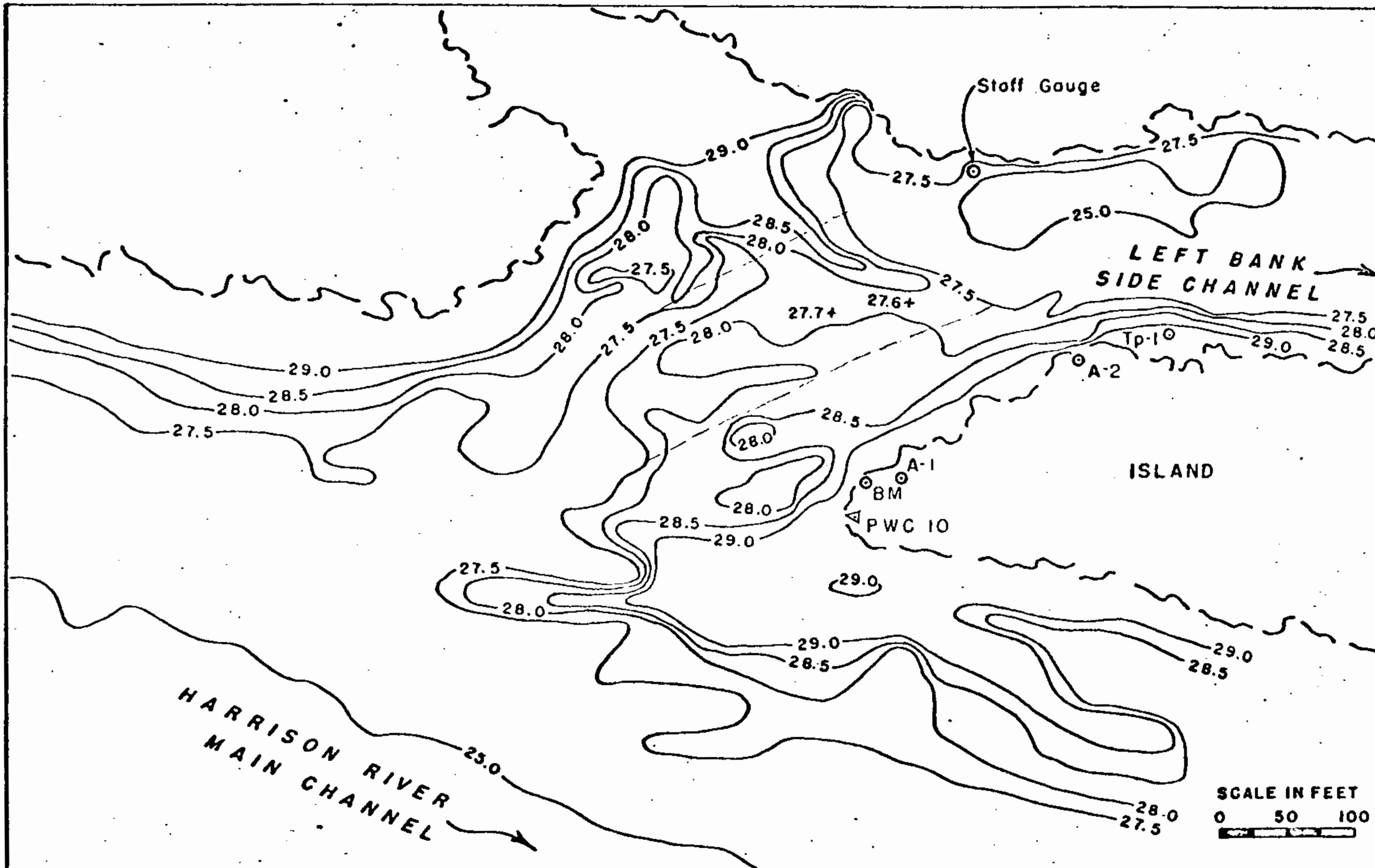


FIGURE 11 - Channel bottom topography, Harrison River at entrance to left bank channel.

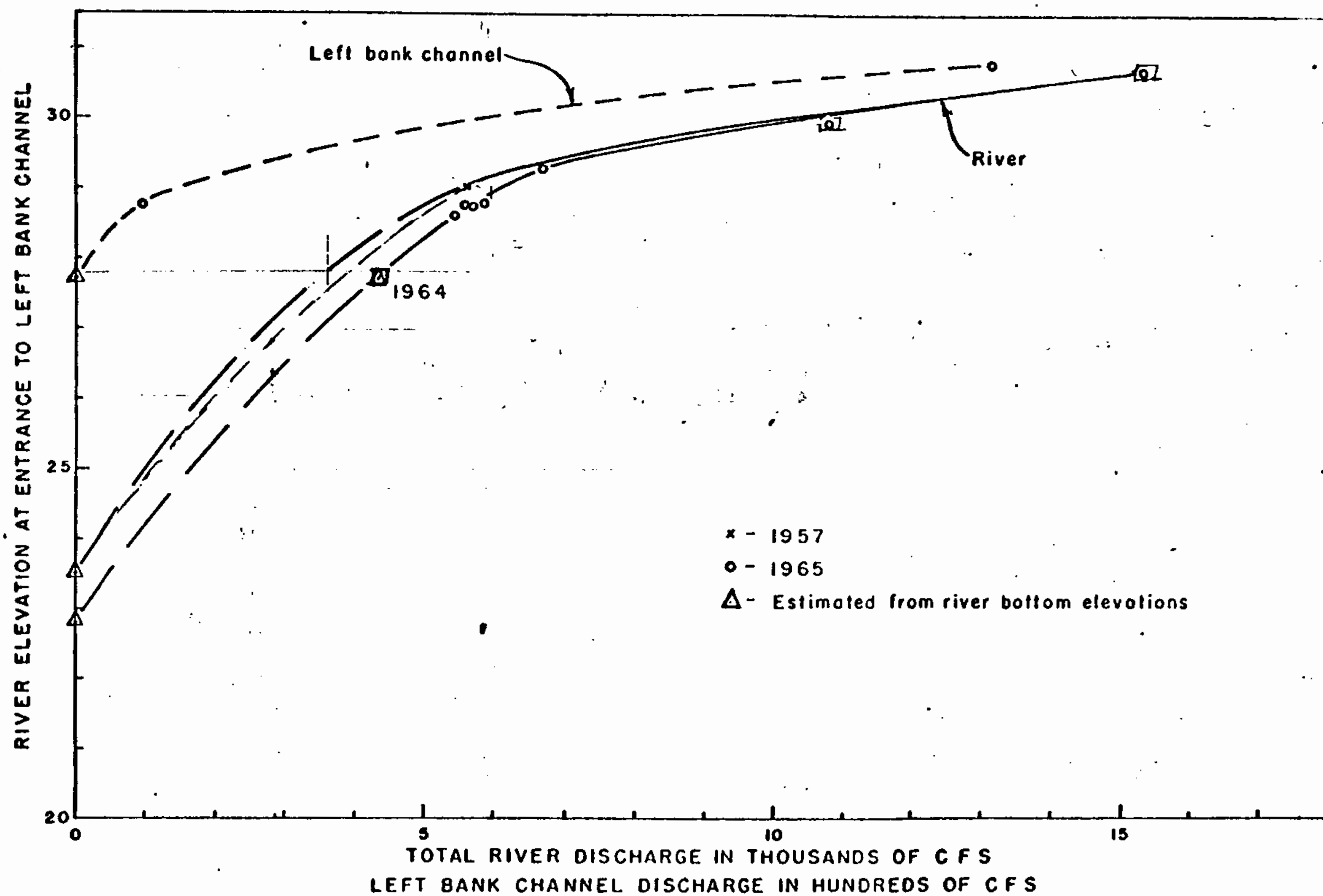


FIGURE 12 - Stage-discharge relationships, Harrison River at top end of left bank channel.

TABLE 5 - Harrison River discharge on March 1.

Year	Discharge cfs
1923	6,050
1924	14,500
1934	11,500
1935	13,700
1936	3,700
1937	3,820
1938	4,300
1939	4,150
1940	8,750
1941	7,600
1942	3,950
1943	6,650
1944	3,820
1945	6,850
1946	9,200
1947	9,450
1948	4,900
1949	4,500
1950	10,350
1951	6,800
1952	5,860
1953	5,980
1954	12,500
1955	3,620
1956	2,480
1957	6,250
1958	15,000
1959	4,620
1960	4,980
1961	14,300
1962	5,360
1963	12,800
1964	4,860
1965	8,760
1966	4,000

TABLE 6 - Per cent frequency of flows on March 1 suitable and unsuitable for fry emergence in left bank side channel.

	FLOWS SUITABLE FOR EMERGENCE		FLOWS NOT SUITABLE FOR EMERGENCE	
	Before Dredging	After Dredging	Before Dredging	After Dredging
Flow	5,200 cfs or more	6,000 cfs or more	less than 3,500 cfs	less than 4,300 cfs
Per Cent Frequency	60	51.5	2.9	23

Effect of Dredging on Water Levels at the Upstream End of the Right Bank Side Channels

Field observers have reported on several occasions since 1957 that the two side channels near the upper end of the right bank side of the rapids have gone dry. Comparison of the water levels at the entrance to these channels for similar flows in 1957 and 1965 (TABLE 7) shows that water levels were lower in 1965 than in 1957. The entrances to the channels were dry in 1965 at a higher discharge than in 1957 when there was water flowing into the channels.

TABLE 7 - Water levels at entrance to upper and lower right bank side channels, 1957 and 1965.

Location	Date	Discharge cfs	Water Surface Elevation	Remarks	Harrison Mills Elevation
Lower Channel	Oct. 24, 1957	5,320	26.33	flowing water	20.65
	Mar. 30, 1965	5,700	26.03	dry	18.64
Upper Channel	Oct. 24, 1957	5,320	27.90	flowing water	20.65
	Mar. 31, 1965	5,600	27.33	dry	18.62

Bottom elevations in the entrance to these channels show that flow into the upper channel would stop at a river elevation of 27.5 (FIGURE 13) and that flow into the lower

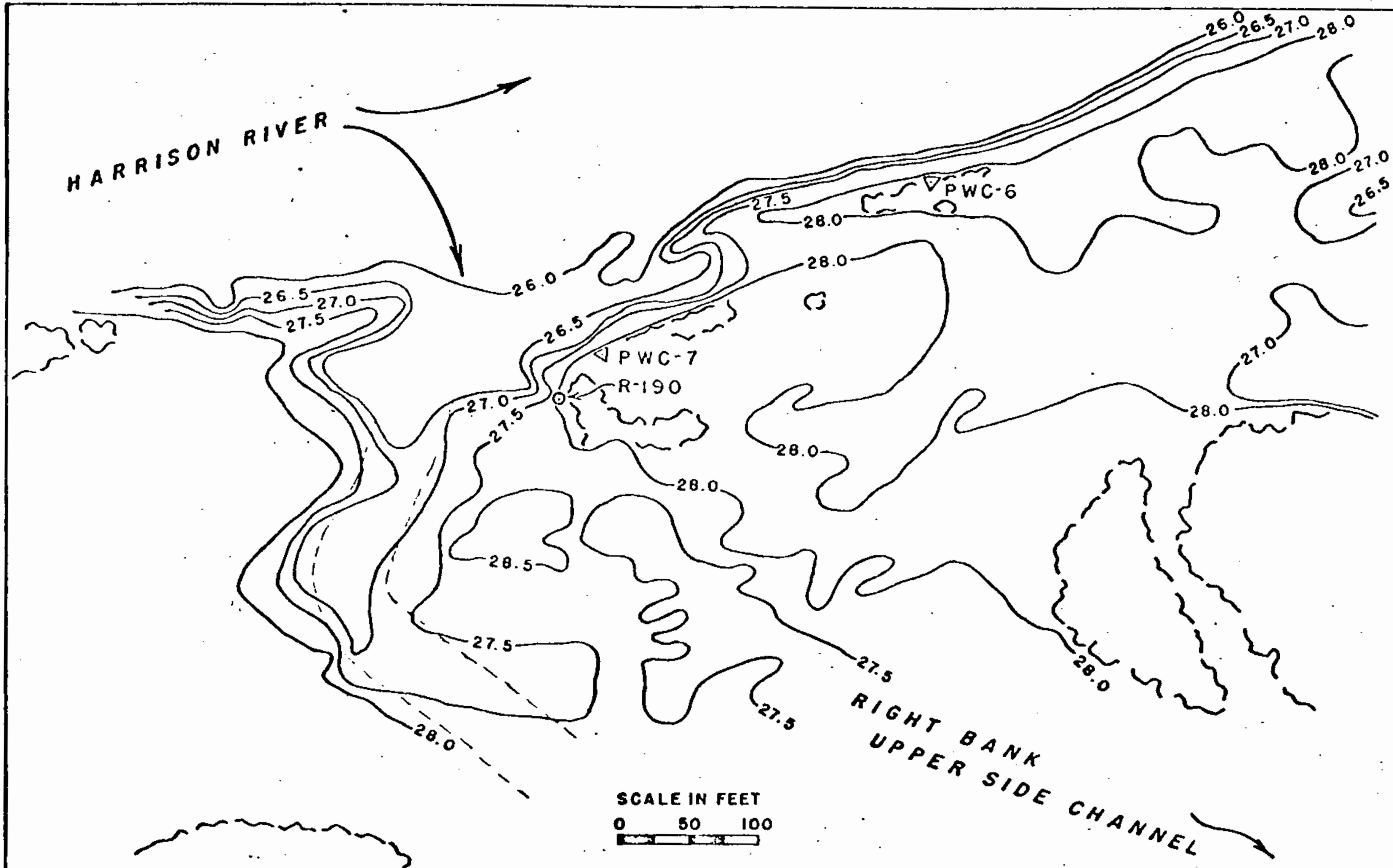


FIGURE 13 - Topography at entrance to right bank upper side channel.

channel would stop at a river elevation of 26.5 (FIGURE 14) in 1965. Evidently the bottom elevation at the lower channel has been raised between 1957 and 1965, or water would not have been flowing in the channel at the level observed in 1957. Examination of the aerial photos (FIGURE 3) obtained on March 15, 1966 at a flow of 7,710 cfs shows that there was no surface flow into the upper channel at this flow, but water was entering the lower channel. At this time, the water elevation at the upper channel must have been just under 27.5 feet, indicating that more than 2,400 cfs additional flow was required in 1965 to obtain the same elevation as in 1957. Water levels at the entrance to these channels are only slightly affected by backwater from the Fraser River when it is low. Using 21 cross sections from the 1965 survey, a series of backwater profiles were calculated for a discharge of 5,500 cfs in the Harrison River (FIGURE 15). These profiles show that for a 1 foot difference in elevation at the lower end of the rapids, the difference in elevation at the entrance to the lower right bank channel would be 0.2 feet, and at the upper right bank channel it would be 0.1 fee When the aerial photo was taken on March 15, 1965, the Harrison Mills gauge was 19.84 or 0.8 feet lower than on October 24, 1957, so that the resulting difference in elevation at the upper channel entrance would be less than 0.1 feet. The reduction in water leve observed in 1965 at these channel entrances therefore was not due to backwater, but was the result of a change in that portion of the Harrison River between 1957 and 1965.

The record of dredging (TABLE 1) shows that the rapids section was dredged in 1958-59, 1959-60, 1961-62 and 1964-65. Altogether 105,000 cu yd were removed from the main channel by scraper and disposed along the edges of the channel. Most of the dredging was done in the vicinity of Raake Point and Willeby Point, but some was done in the upper part of the rapids. The spoils from this may be seen in FIGURE 3, by comparison with FIGURE 16. In FIGURE 3, material dredged from the channel adjacent to the two right bank channel entrances can be seen piled over a substantial part of

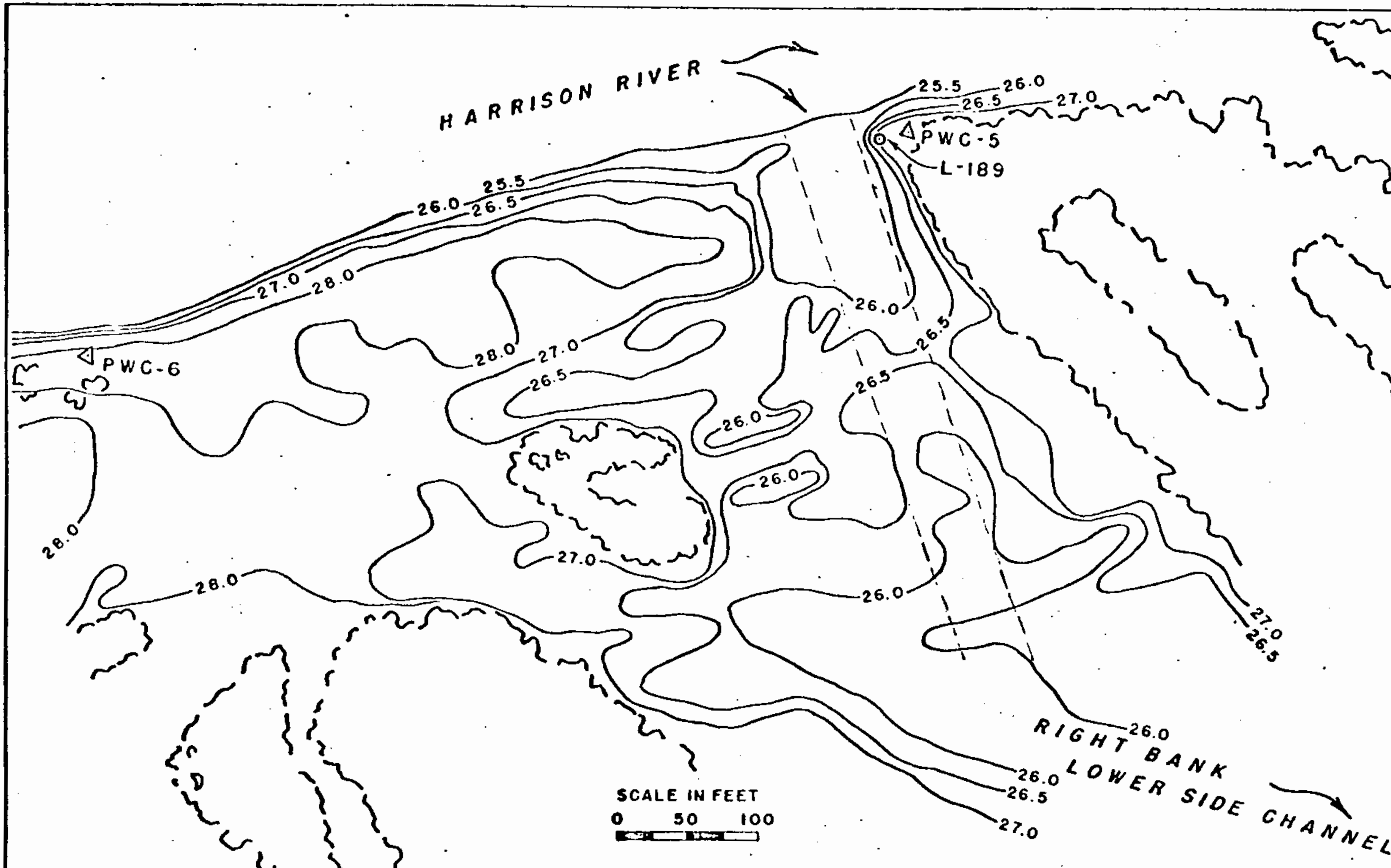


FIGURE 14 - Topography at entrance to right bank lower side channel.

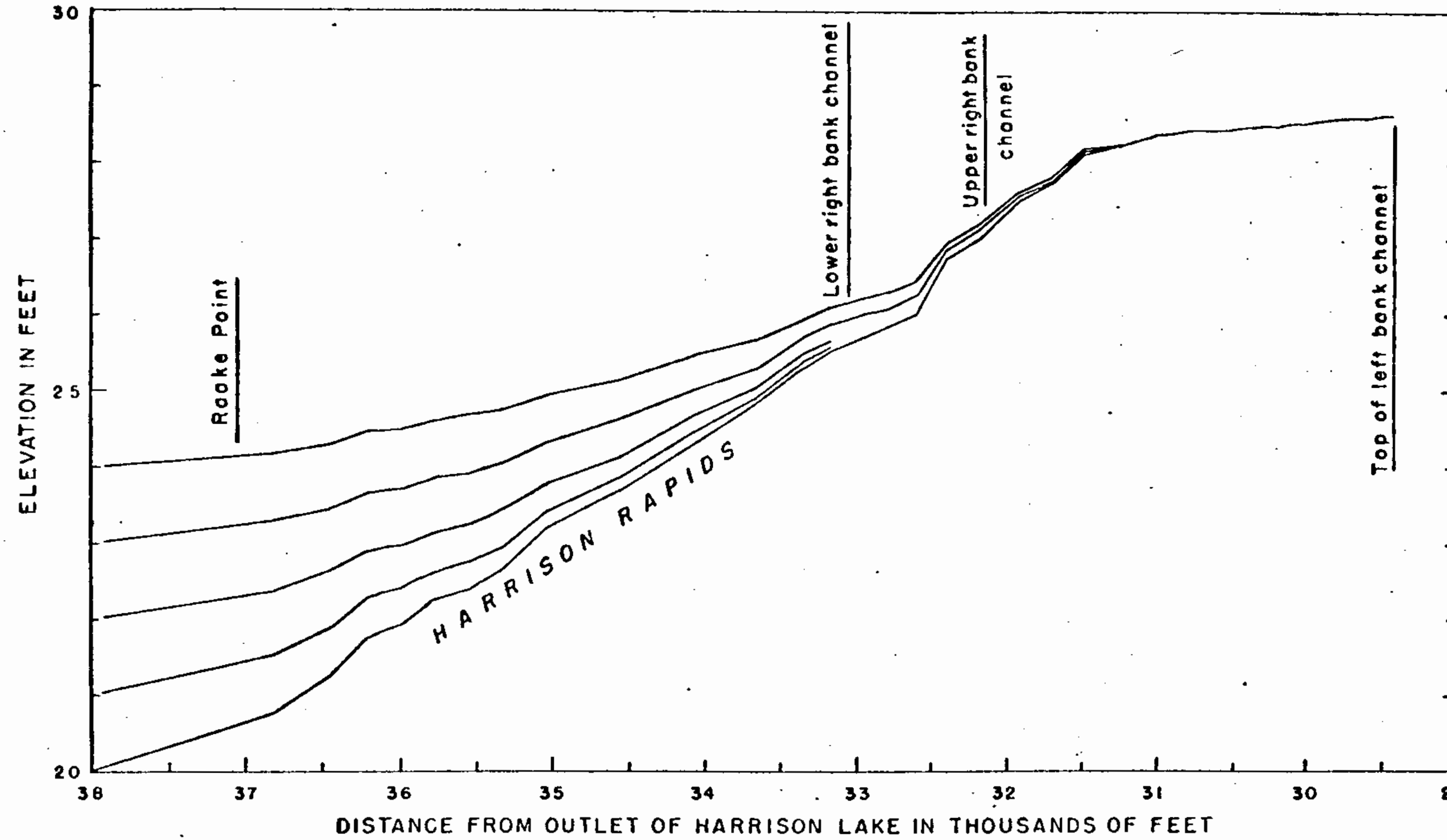


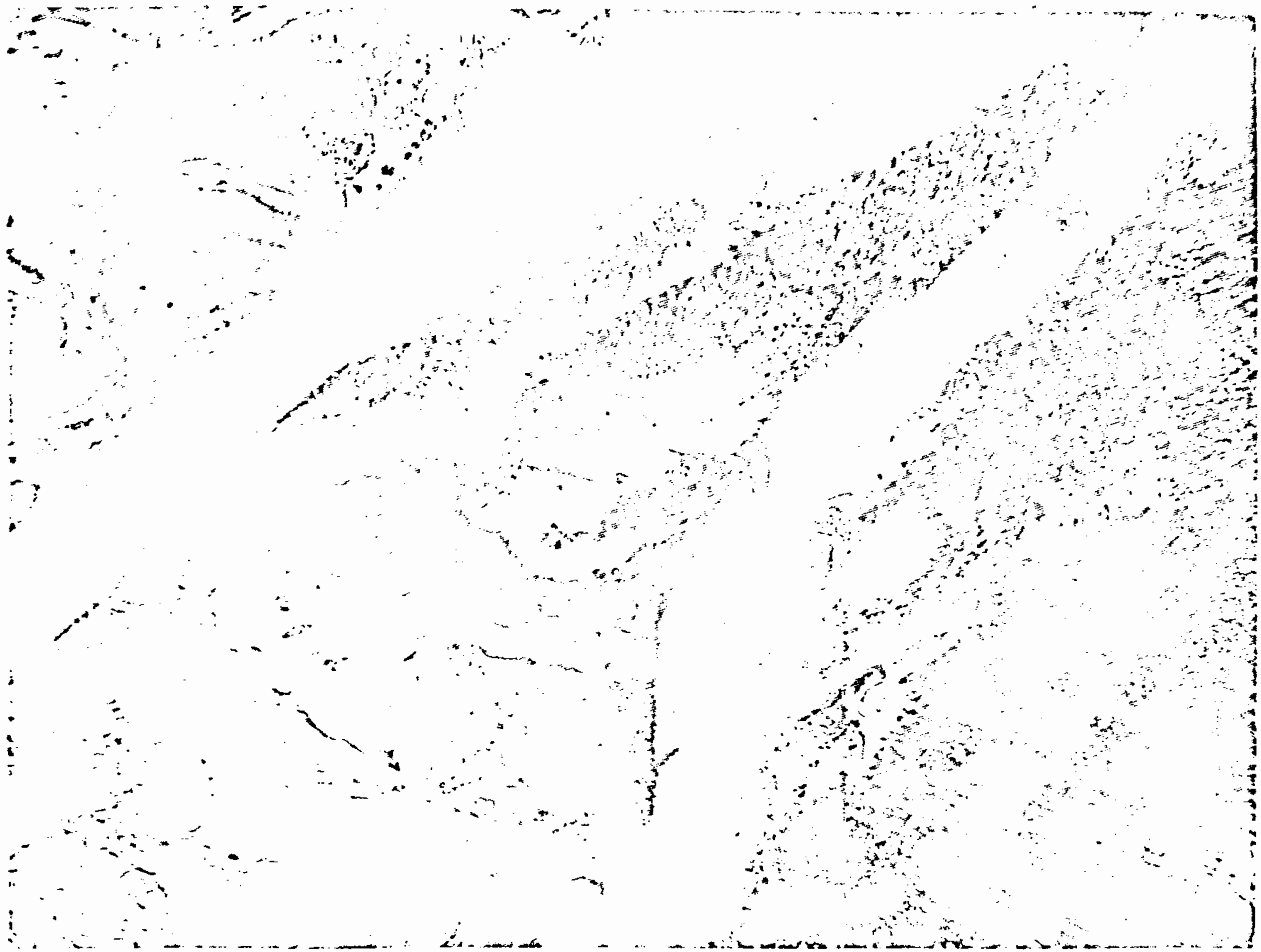
FIGURE 15 - Computed backwater curves, Harrison River, for a discharge of 5,500 cfs and various elevations near Raake Point.

At a river flow of 3,080 cfs, there was still a flow of water through the gravel bed (Goodlad, 1962) but some dead eggs were found above the subsurface water level. It would appear that 4,300 cfs is about the minimum flow level for present conditions to maintain subsurface flow through the redds in the left bank channel. However, there i evidence that a long delay in emergence will result in mortality to fry, even though subsurface flow is adequate to provide other conditions essential to life. Consequent such low flows are not desirable, and it is essential that, when the fry are ready to emerge, there should be sufficient surface flow to permit them to leave the gravel and migrate naturally to their rearing area.

Examination of the elevations in the left bank channel downstream from its upper end shows that, apart from the entrance, the highest elevation controlling flow down the channel is 27.6. The 27.5 contour extends upstream along both sides of the channel to within 70 feet of the same contour in the main river channel. At the entrance to the channel (FIGURE 11) the bottom elevations increase up to 27.7. If this obstruction was not present, the surface flow down the channel would still be reduced to zero at a river level of 27.7 (the March 1965 survey indicates 0.1 feet drop from the channel entrance to the next control point). Considering that at low discharge the river level at this point was at least 0.26 feet higher prior to dredging (FIGURE 12), the level of 27.7 would correspond to a discharge of about 3,500 cfs before dredging. On this basis, a river flow of 5,200 cfs would provide an adequate surface flow in the side channel to permit emerging fry to migrate downstream.

The emergence of salmon fry from the gravel commences by March 1 in the Harrison River. The discharge of the Harrison River on March 1 for the period of record of Harrison Lake elevations, is given in TABLE 5. The frequencies of river flow considered suitable and unsuitable for fry emergence before and after dredging are give in TABLE 6. The dredging has substantially reduced the frequency of flows suitable for fry emergence and greatly increased the frequency of flows not suitable for emergen

These changes in river levels resulting from what may seem to be small changes in river bottom elevation illustrate the serious effects of the dredging on the survival c



[illegible] - Harrison River Bridge, October 6, 1957 at a discharge of 9,850 cfs and Harrison Hills [illegible] the sockeye spawning ground along the left bank side of the channel. Approximately 16,000 sq yd of spawning ground were covered by the piled gravel. In addition, part of this material was removed from the control section in the vicinity of the entrance to the upper right bank channel. It is considered that this dreding was responsible for the observed change in waterl levels at the entrance to the right bank channels between 1957 and 1965.

The remains of the early piling for a wing dam across the entrance to these channels may still be seen in FIGURE 3. The structure is also visible in FIGURE 17. It is apparent from comparison of these photos that there has been an accumulation of material along this line of piling, particularly in the vicinity of the lower entrance. Trees are now growing along this material where none were present in 1930. The higher elevations are also evident from the 1965 sounding data. It appears that the remaining entrances to these channels are much narrower than they were in 1930. It is not possible to determine if the bottom elevations in the present entrances to these channels are higher than the original entrances as a result of accumulation of material behind the wing dam. It is reasonable to suppose that the wing dam was constructed with the expectation that this would occur, so that the flow of the river would be concentrated in a single channel. Examination of early pictures indicates that at one time these channels may have been a major part of the low water flowage system of the Harrison River through the gravel delta area at the mouth of the Chehalis River. This is no longer the case, and the change can only be attributed to the efforts made to produce a single major channel. The reduction in flow down these channels may also have been aggravated by the diversion of the Chehalis River from its east branch.

Effect of Dredging on Water Levels at the Sockeye Spawning Grounds in the Upper Section of the Rapids

It has been shown that at low river discharge, the water level at the upstream

[illegible] 17 - Harrison Rapids [illegible]

[illegible] 17 - Harrison Rapids, [illegible] left bank [illegible] wing dam across right bank channels.

end of the left bank channel has been lowered 0.26 feet, or more and that at the upstream end of the upper right bank channel it has been lowered more than 0.5 feet. These locations are at the upper end and midpoint respectively of the sockeye spawning grounds on the left bank of the main channel adjacent to the island. These reductions in river level, combined with the dredge spoils disposed on part of the area, result in a reduction of 5,300 sq yd in the available spawning area in the upper 2,600 feet of shoreline at a discharge of 5,300 cfs (FIGURE 18). This discharge is representative of the minimum flow during October, November and December.

Effect of Dredging on Water Levels at the Lower End of the Rapids and on Bed Load Movement

Water levels in and below Harrison Rapids are affected by the level of the Fraser River. During periods of high water in the Fraser River the effect may extend to Harrison Lake, but at lower Fraser River levels, it does not extend past the rapids. Profiles of this lower part of the river taken in 1957, 1965 and 1966 are shown in FIGURE 19. Comparison of the upstream portions of the profiles taken November 1, 1957 and May 3, 1966 at almost identical discharges, shows the water level in the rapids to be higher in 1957 than in 1966, even though the level at Harrison Mills was higher in 1966 than in 1957 (FIGURE 20). This reduction in water level is attributed to the dredging done near Raake Point in the summer of 1965 since the profile taken on March 31, 1965 does not indicate a reduction in elevation compared to comparable discharge and Harrison Mills level in 1957.

A water elevation of approximately 25 feet at a point 35,000 feet from Harrison Lake is required to place water over the spawning grounds located behind the dredge spoils just upstream from Willeby Point. If water levels are high enough water enters the area through a gap in the dredge spoils. The effect of the dredging appears to be variable and is probably most pronounced in the low water period immediately following the dredging. This area has been dredged in 1936, 1946, 1951, 1958, 1959, 1961, 1963

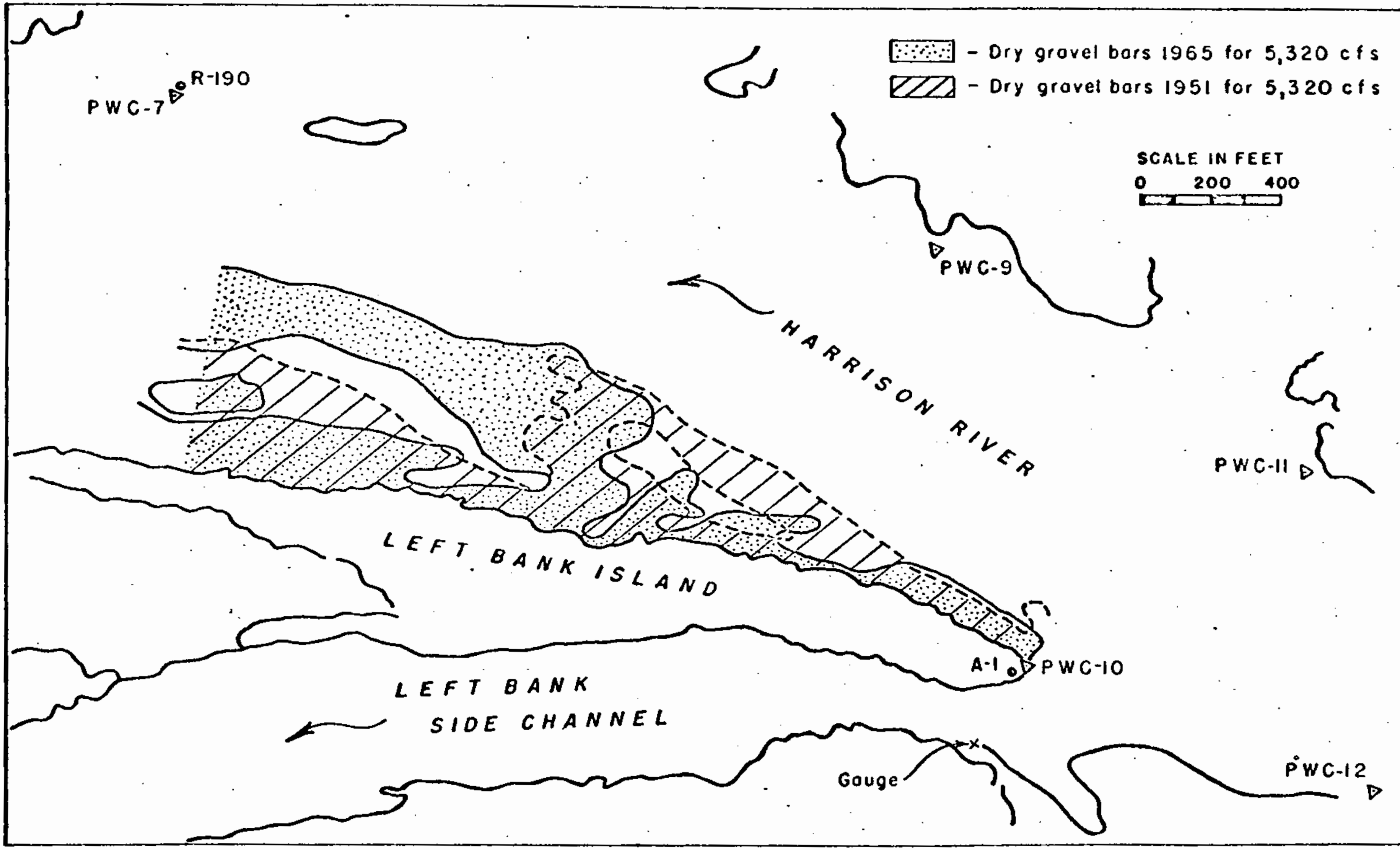


FIGURE 18 - Sockeye spawning grounds on the left bank near the upper end of Harrison River showing change in exposed areas from 1951 to 1965.

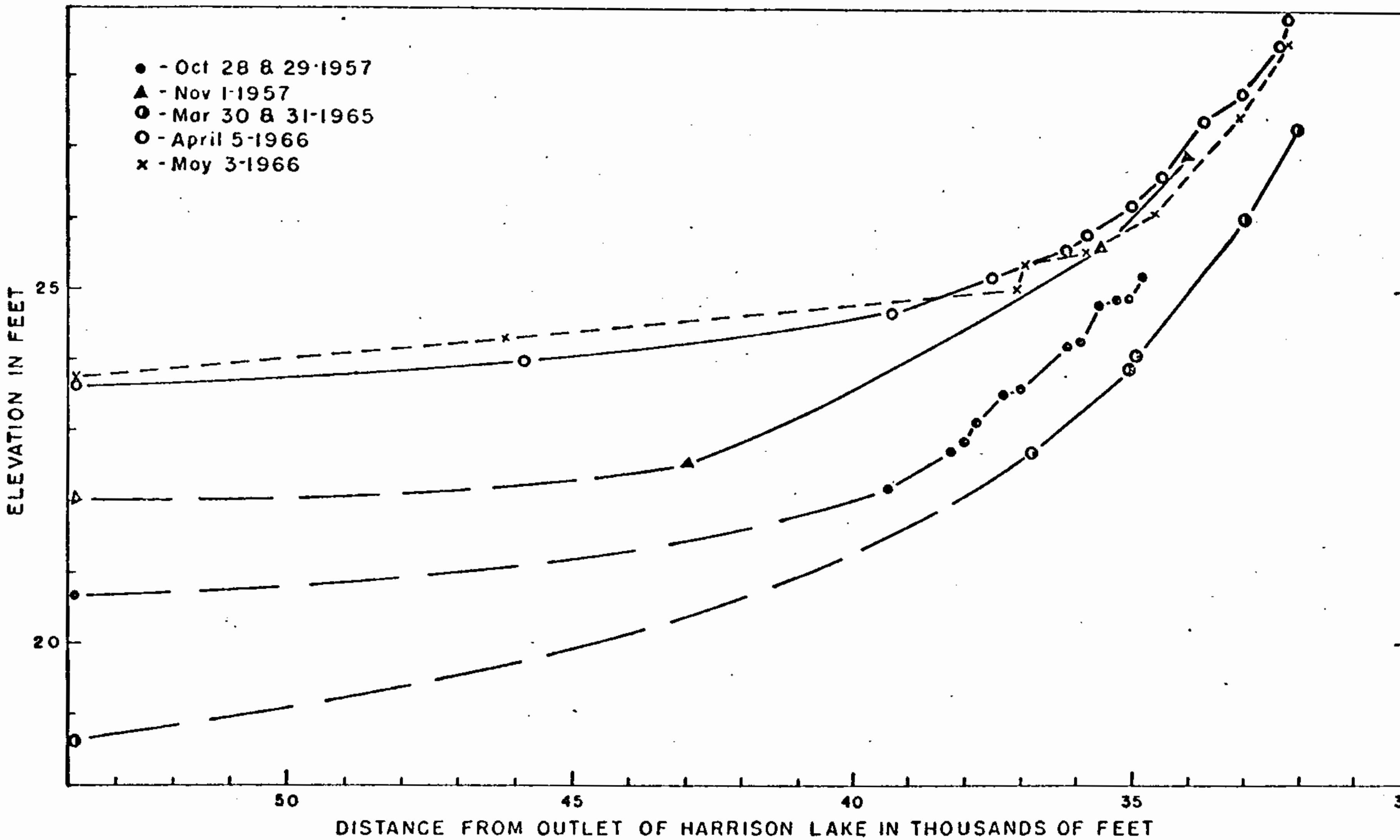


FIGURE 19 - Profiles of Harrison River below the rapids.

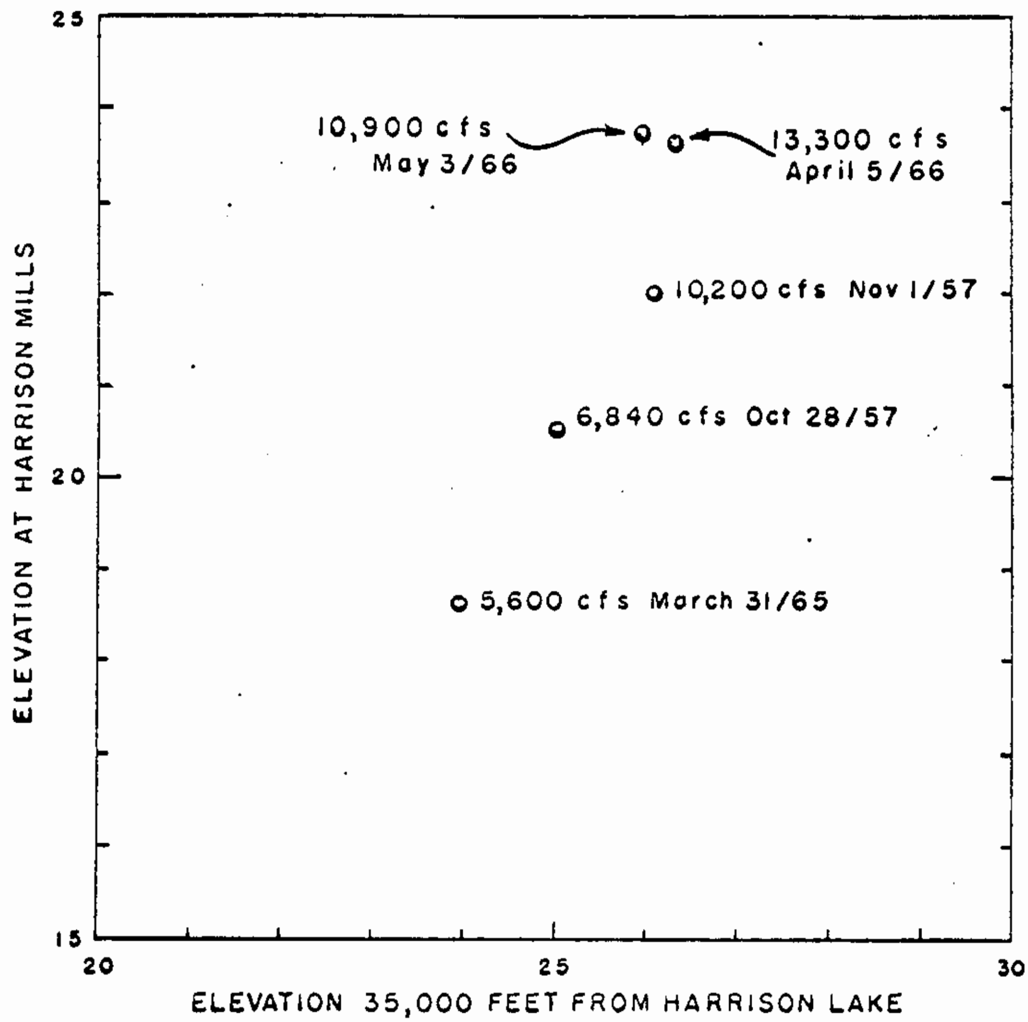


FIGURE 20 - Relation between water elevation of Harrison Mills and Harrison River discharge and water elevation near the lower end of the rapids.

and 1965. The lowering of water levels and the partial segregation of the area from the main channel by the piles of dredgings since 1957 have greatly reduced the utilization of the remaining area by salmon.

It appears that dredging in the vicinity of the lower end of the rapids lowers the water level but that the change is not permanent due to replacement of the gravel by bed load movement from upstream or from the spoil banks along the edge of the river. On the basis of gravel samples obtained from the river banks in 1959 and the river slopes and depths measured in 1965, the stream bed materials in the rapids would be stable at flow of 5,500 cfs. For the conditions of the profile at 13,300 cfs recorded on April 5, 1966, there would be a bed load movement of approximately 26,000 pounds per day per foot width in the deepest part of the section near the lower end of the rapids, 35,000 feet from the lake, tapering off to zero at the banks. Further upstream in the rapids the movement would not be as great, because of reduced depth and bed tractive force.

Maximum discharges in the Harrison River during the annual spring freshet often exceed 50,000 cfs. The data for three such discharges in recent years (TABLE 8) show that for the three particular freshets there was still a drop of 4 to 5 feet between Harrison Lake and Harrison Mills.

TABLE 8 - Elevations at Harrison Lake and Harrison Mills during three peak discharges in Harrison River.

Date	Discharge	Harrison Lake	Harrison Mills	Difference
July 17, 1964	53,000	38.95	34.84	4.11
June 21, 1961	51,500	38.47	33.24	5.23
June 12, 1956	56,300	39.60	34.85	4.75

No profiles of the Harrison River are available for these high discharges, but on the basis of the profiles at lower flows at least 2 to 3 feet of this drop would occur in the rapids in the vicinity of the control point. Presumably this control point was stable under such conditions prior to any dredging, but lowering of the control by dredging would increase the bed tractive force and could result in an unstable condition with far reaching consequences.

Duration of Water Levels Suitable for Towing Log Booms

It has been stated (Walkey, 1957) that dredging is done in the Harrison River to deepen the navigation channel to 6 feet below low water for a width of 150 to 200 feet. However the same booms and tugs continue down the Fraser River when the dredging plan is to maintain a minimum depth of 4 feet (Walkey, 1958). It is estimated that at the existing control section near the upper end of the rapids, a discharge of 17,000 cfs would be required to fulfill the 6 foot minimum depth requirement, except when river levels are affected by backwater from the Fraser River. A depth of 4 feet at this section would be obtained with a flow of 5,600 cfs.

On the basis of records from 1950 to 1966 a river flow of 17,000 cfs or more can be expected for 97 to 128 days in the period May to September, whereas a flow of 5,600 cfs can be expected for a period of 231 days from March to November to a full year with the same width of channel.

Apparently part of the difficulty in towing logs down the river arises from hauling longer booms, which tend to bind on the curves. It appears that the length of time logs can be transported down the river depends to a large extent on the size of booms being hauled. The type of tug used for the hauling may also be a consideration. If the period May to September is not adequate to handle the available log supply, it is suggested that for the balance of the towing season towing practices be modified to shorter and narrower booms, and if necessary to shallower draft tugs, to take advantage of the longer period for which a 4 foot minimum depth prevails.

CONCLUSIONS

1. The spoils from dredging in the Harrison River have covered approximately 15,900 sq yd of sockeye spawning grounds in the Harrison River. The areas covered are generally close to the shipping channel and, being in deeper water, were previously part of the best portion of the spawning ground. The spoils have also covered 100,400 sq yd of spawning ground in the main channel formerly used by pink, chinook and chum salmon. The areas covered are considered to have been the most valuable part of the total area in the main channel utilized by these species.

2. Dredging at the control section near the upper end of the rapids has lowered the crest of the bottom profile by 0.7 feet and has shifted the crest 500 feet downstream. This dredging has lowered the water level at the upper end of the left bank channel by 0.26 feet between 1957 and 1965 at a discharge of 5,600 cfs. As a result a flow of 4,300 cfs is required in Harrison River to obtain surface flow down th channel, compared to only 3,500 cfs before dredging. This change has increased greatly the frequency of occurrence of zero flow in the channel on March 1, when the salmon fry start to emerge from the gravel.

3. Dredging in the vicinity of the two upper entrances to side channels on the right bank of the rapids has lowered river levels 0.3 to 0.5 feet at these points, causing the channels to go dry at higher river discharge in 1965 than in 1957. The width of the entrances to these channels was reduced by the early wing dam built across them, and by piles of dredge spoils, so that they are no longer major flowage channels. The bottom elevations at the entrance to these channels have probably been raised by the action of the wing dam and by disposal of dredge spoils. This is evident at the lower right bank channel entrance. The diversion of the Chehalis River from its east branch has shut off a substantial source of water for these right bank channels at low flow, since water previously flowed directly from this branch into the

upper ends of the channels.

4. The lowering of water levels upstream from the upper right bank channel entrance, combined with disposal of dredge spoils on the left bank, has reduced the sockeye spawning area by 5,300 sq yd along the left bank for a distance of 2,600 feet downstream from the upper end of the island.

5. Dredging at the lower end of the rapids upstream and downstream from Willeby Point lowers the water level at the spawning grounds at the downstream end of the left bank channel and has reduced the use of this area for spawning by salmon. Stream bed materials removed by dredging are gradually replaced from upstream or from the left bank channel delta. The continued removal of gravel could eventually result in degradation of the river bed with consequent increased slopes, shortening of the rapids, and possible increased scouring at the control section near the upper end of the rapids.

RECOMMENDATIONS

1. It is recommended that no dredging should be done at or near the control section near the upper end of the rapids or the control section downstream from Morris Slough. This recommendation is made to prevent further lowering of water levels at the upstream ends of the left and right bank channels and to prevent disturbance of these important controls on water level throughout the upper part of Harrison River and on Harrison Lake.

2. It is recommended that dredging in the Harrison River from the upper end of the rapids to the point 2,000 feet downstream from Raake Point be discontinued indefinitely except possibly in specific locations where the need for dredging can be demonstrated in advance by survey data. This recommendation is considered necessary to prevent lowering of water levels at the spawning grounds at the downstream end of the left bank channel and to prevent degradation of the river bed by movement of bed

materials downstream to the dredged areas. Any dredging that is approved could only be done during June, July or August between the end of fry emergence and the first adult spawner returns, and the dredged materials must be disposed of on land above the river level or in other designated areas not used by salmon for spawning where such disposal would not affect the flow of water to spawning grounds.

3. It is recommended that the upstream entrance to the left bank side channel be lowered to elevation 27.5 for a width of 100 feet as indicated on FIGURE 11 to partially restore the low water flow into this channel.

4. It is recommended that the upstream entrance to the upper right bank channel be lowered to elevation 26.5 and the entrance to the lower right bank channel be lowered to elevation 25.5 for a width of 50 feet as indicated on FIGURES 13 and 14, to restore the low water flow into these channels. It is estimated that the excavation required would be about 650 cu yd.

5. It is recommended that the accumulated dredge spoils along the left bank of the main channel upstream from Raake Point be removed to the elevation of the adjacent gravel delta of the left bank side channel (approximately elevation 25) and that the dredge spoils along the left bank near the upper end of the rapids be removed to the elevation of the adjacent river bed to restore the spawning grounds lost in these areas. These spoils should not just be levelled by scraper, but should be removed by suction dredge or other means for disposal on high ground or in areas not used by salmon for spawning. It is estimated that the excavation required would be approximately 10,000 cu yd.

6. It is recommended that towing of logs down the Harrison River be planned for the period when water levels are adequate without dredging. On the basis of discharge records and the 1965 survey data, towing should be possible for a period of 33 to 52 weeks each year if towing practices are modified during part of this time to utilize a minimum depth of 4 feet.

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APPENDIX 5 Harrison River Salmonid Spawning Distribution 1967

SPAWNING DISTRIBUTION OF SALMON IN THE MAINSTREAM OF THE HARRISON AND STAVE RIVER DURING NOVEMBER AND DECEMBER 1967

INTRODUCTION AND OBJECTIVES:

Information on the spawning distribution of salmon at The Harrison and Stave Rivers was collected as part of a larger program designed to determine the biological characteristics of the major chum salmon populations of the Fraser River system.

In the swim surveys conducted on the Harrison and Stave Rivers our primary concern was with the question of whether chum salmon utilized the mainstem of those rivers and, if so, where and to what extent. Of particular interest were those portions of the mainstem that could not be examined from the water surface because of the depth and turbidity of the river. Another objective of the survey was to determine the spacial interrelationship of spawning salmon in the main channels of the streams.

METHOD:

The survey employed two divers and one surface helper who also acted as recorder. The divers proceeded on roughly parallel courses downriver and surfaced frequently to relay information to the recorder in the accompanying boat. Data on the number and species of salmon observed, the consistency and type of bottom material, bottom topography and water depths were marked on an aerial map. Several sweeps over the same stretch of river ensured reasonably adequate coverage of the area.

AREA OF OPERATION:

The swim surveys in the Harrison River covered the distance from the mouth of Morris Slouth to the Highway Bridge, and in the Stave River from the Ruskin Power Dam to a point approximately 1 mile downstream from it.

RESULTS

(1) Harrison River

a) Chum Salmon

It was found that generally the mainstem was not utilized for spawning by chum salmon in the period and the area covered by the surveys with the exception of three localities. They were:

1. 1. The area roughly outlined by a series of pilings adjoining to and upstream from a defunct log dump on the right bank.

2. A narrow strip adjacent to the right bank with an average width of 50 ft. extending from the log dump to the mouth of a slough approximately 2,000 ft. downriver. Spawning in this area occurred from the shore to a depth of approximately 7 ft.

3. A very small, shallow water area in the immediate vicinity of an Indian graveyard on the left bank with a linear extent of approximately 200 ft.

Judging from the location of these chum spawning sites it is conceivable that they may be influenced by ground water seepage.

b) Spring and Pink Salmon

On November 8 and 9 Spring spawning was observed in a stretch of river extending from the mouth of a side channel above Smokehouse Slough to a point downstream approximately two-thirds of the distance of the rapids. The water depth in this area ranged from 7 - 12 ft. and Springs were observed spawning across the entire width of the stream down to approximately the upstream termination of the pilings. From this point downstream spawning was compressed into the right half of the river. In the vicinity of the pilings Springs were noted to spawn in bottom material ranging from 3 to 10 inches in diameter and in estimated velocities of 4 - 5 ft./sec. Movement of gravel in the lower 1/3 of the rapids and in the river bend pointed to an instability of the bottom and therefore was devoid of spawners. The current velocity in this stretch was estimated at 6 ft/sec. The relatively densely spawned area above the upper end of the pilings was characterized by highly uneven bottom contours. Traverse ridges of clean, medium sized gravel followed one another in close succession and the trough-like depressions between the ridges acted as catch basins for fines. Springs spawned on the gently inclined upstream aspects of the gravel folds whose downstream faces dropped relatively abruptly into the fine filled hollows. This wide, furrowed area was also occupied by the few remaining pink salmon observed at the time of the survey.

Spring spawning also occurred in small isolated localities in the vicinity of the log dump and in a small area below the river bend.

Two sweeps over the Spring and Pink spawning area on November 24 established the absence of all fish.

c) Sockeye

On November 8 and 9 sporadic sockeye spawning was noted just off an island at the upstream end of the pilings and at the mouth of a side channel on the left bank

(2) Stave River

On November 23 a swim survey of the Stave River revealed the main body of spawners to be concentrated in the upper 1400 ft of the main channel.

DISCUSSION:

Spawning distribution is governed by variables such as the size of the spawning population, water levels, flows, and the condition of the spawning beds. Therefore the pattern of distribution established in this year's surveys does not necessarily conform to that found in other years. However, previous years' observations indicate that chum salmon tend to use the same general areas in successive years. For example, chum salmon are found in the vicinity of the log dump and along the shoreline downstream from it every year. These areas are used almost exclusively by a late spawning segment of the Harrison River population during the period from approximately the end of November to the middle of January.

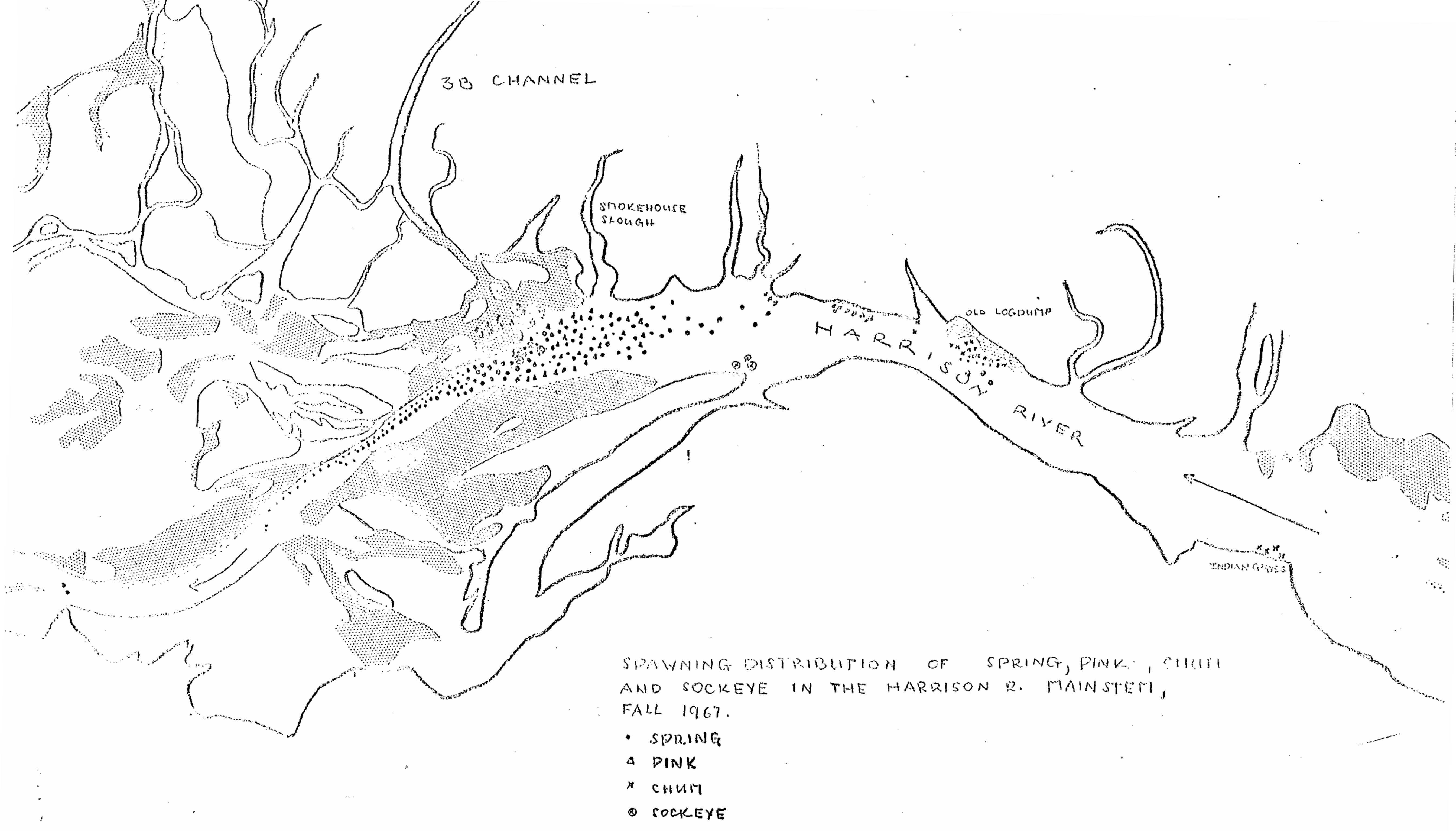
An example of the possible effect of escapement size on the spawning distribution is illustrated by the observation of spawning chum in the shore area below the mouth of Morris Creek last year when the chum population of the Harrison River was estimated at 160,000 and the absence of spawners in the same area this year when the total escapement was estimated at 55,000. The river bottom of the mainstem supporting no spawning showed relatively low contours and a compacted consistency. In these unproductive areas the bottom consisted of algae covered gravel embedded in a matrix of hardened fine material.

The absence of chum salmon in the Spring and Pink spawning area of the mainstem indicates that the specific environmental condition favoured by the Harrison River chum salmon are not found at this site. It appears that the race might show a preference for seepage water fed sloughs and side channels. However, the presence of seepage water is not a necessary requirement for they will spawn in side channels fed by main river water provided the velocities and gravel conditions are suitable to them. In a backwater channel with varying local velocities the first arriving chums show a preference for the highest velocity sites (riffle areas).

The relative advantages of spawning in seepage water fed channels in terms of reproductive efficiency are obvious.

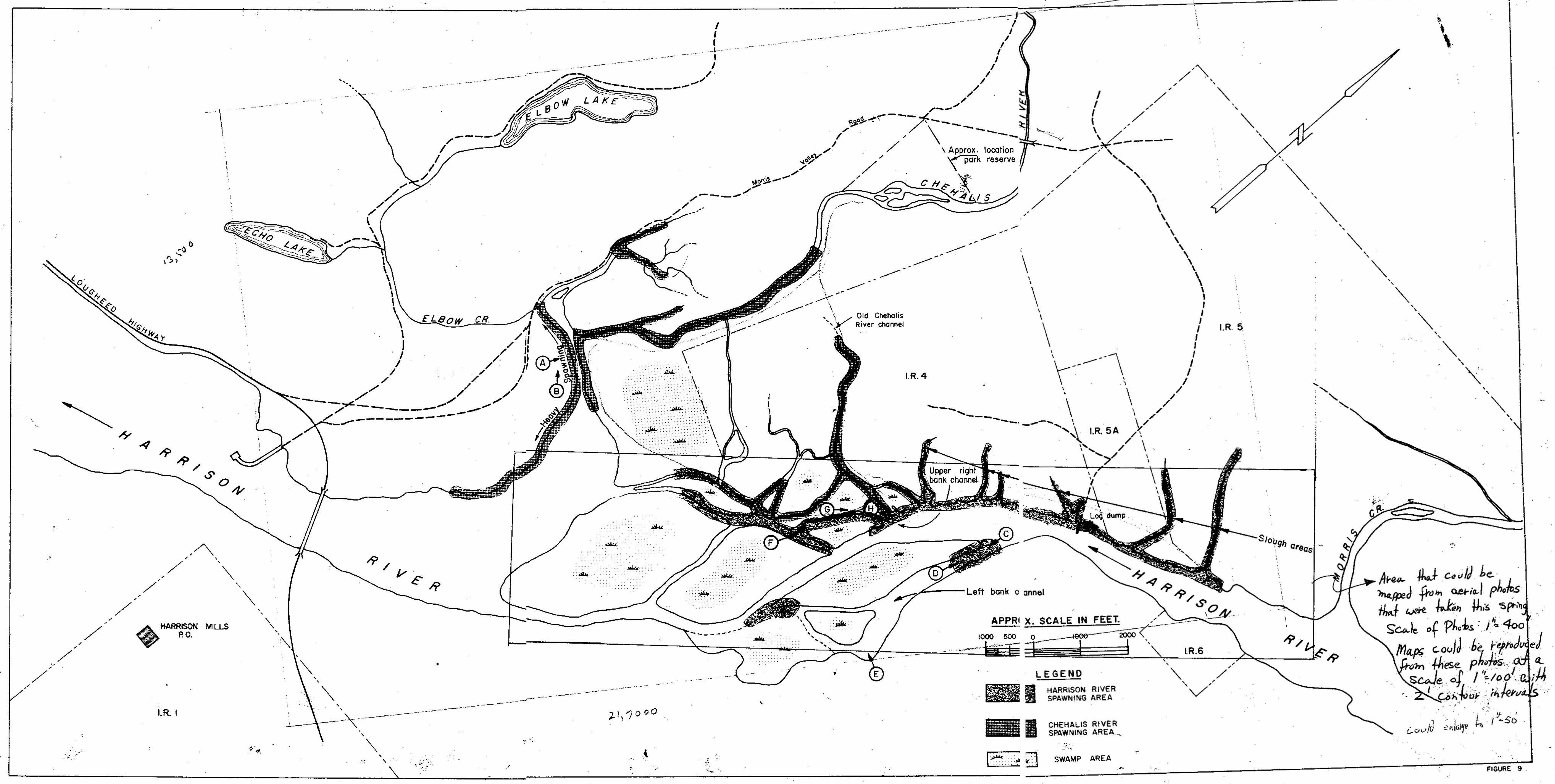
In the Stave River the densest chum spawning was observed in an area adjoining the precipitous cutbank of an island. The influence of seepage water on this site was not excluded.

K. Dietz



SPAWNING DISTRIBUTION OF SPRING, PINK, CHUM AND SOCKEYE IN THE HARRISON R. MAINSTEM, FALL 1967.

APPENDIX 6 Undated map of Harrison River Chum Spawning Distribution



The Harrison and Chehalis River Chum Salmon Spawning Areas