BRITISH
COLUMBIA
The Best Place on Earth

General Disclaimer

Disclaimer of Liability

CWAP

WATERSHED ASSESSMENT FOR CHAPMAN CREEK AND GRAY CREEK, SECHELT, BC

Prepared for:
International Forest Products Ltd.,
Campbell River Operations

December, 2000

EBA Engineering Consultants Ltd.

EBA Engineering Consultants Ltd.

WATERSHED ASSESSMENT (CWAP) FOR CHAPMAN CREEK AND GRAY CREEK, SECHELT, BC

FINAL REPORT

Prepared by:

EBA ENGINEERING CONSULTANTS LTD.
Vancouver, B.C.

Submitted To:

INTERNATIONAL FOREST PRODUCTS LTD.
Campbell River, B.C.

Project No. 0801-00-81516

December, 2000

Sun Life Plaza, Suite 550, 1100 Melville Street, Vancouver, British Columbia V6E 4A6
Tel: (604) 685-0275 - Fax: (604) 684-6241 Internet: vancouver@eba.ca - Web Site: http//www.eba.ca

ACKNOWLEDGEMENTS

EBA would like to acknowledge the input and assistance of many individuals. Rob Hudson, of the Ministry of Forests Vancouver Forest Region Research Branch, provided equivalent clearcut area (ECA) values using a revised (regionalized) approach. Brian Lennan, provided assistance updating the sediment source inventory for Chapman Creek as part of his research project at BCIT, Environmental Engineering Program. Brian Carson, an independent consultant in Roberts Creek, provided much information based on several years of watershed monitoring and field observations. Bruce Thomson and Tanis Douglas of the Ministry of Environment, Lands and Parks, provided access to a large inventory of air photos and maps. Greg Allen, Interfor, completed the GIS mapping for the project. Jeff Pollock and Dennis Lozinsky, of Interfor, and Derrick Harbourne of the Ministry of Forests Sunshine Coast Forest District, provided many background assessment reports and unpublished file documents. Both Jeff Pollock, of Interfor, and Mike Younie, of the Ministry of Environment, Lands and Parks provided comments on the initial draft report.

EXECUTIVE SUMMARY

EBA Engineering Consultants Ltd. (EBA) were retained by International Forest Products Ltd. (Interfor) to conduct a Watershed Assessment Procedure (CWAP) for the Chapman Creek and Gray Creek Watersheds. The Chapman Creek and Gray Creek watersheds are critical to the Sunshine Coast Regional District (SCRD) community water supply system that delivers domestic water to 21,000 full time residents and an even greater number during summer months. The study streams are also important spawning streams for several species of anadromous salmon, steelhead and cutthroat trout.

The purpose of the CWAP is to assess the cumulative effects of past forest practices on the watershed and to provide recommendations for further development based on the results of the assessment. The CWAP follows guidelines of the *Coastal Watershed Assessment Procedure Guidebook*, Second Edition, April 1999.

The results of the watershed assessment are summarized as follows:

- there is no question that the watershed has been impacted by past forestry activities. Most of the impacts are related to mass wasting and are the result of large-scale progressive clearcutting, poor road construction and road maintenance practices, and severe ground and stream channel disturbance. Since the mid-1990s, extensive road deactivation activities have occurred. These activities, which include landslide rehabilitation and road stabilization, combined with natural recovery, have reduced the long-term risk of impact to water quality. Although Gray Creek has not experienced as many forestry-related landslides as Chapman Creek, both watersheds have experienced a dramatic recovery over the past decade.
- low flows between July and October are a major concern for both the SCRD and DFO. Chapman Creek is often not able to meet fisheries flow requirements downstream from the domestic water supply intake. Based on hydrometric data and theoretical hydrologic response, it is unlikely that low flows have been affected by forest harvesting activities in the watershed. The volume of water or the magnitude of peak flows is also not likely to be affected by the proposed development.
- approximately 165 ha are proposed for harvest in the Chapman Creek watershed and 78 ha are proposed for harvest in the Gray Creek watershed. Proposed harvesting will not significantly affect current Equivalent Clearcut Area (ECA) levels, which are currently 12% for Chapman Creek and 14.3% for Gray Creek (calculated using R. Hudson's Regional Method, 2000). Elevated ECAs in several sub-basins will limit future harvesting opportunities. Harvesting in sub-basins C3-1, C3-2, and C3-3 in the Chapman Creek watershed should not be considered until ECAs drop below 20%. Harvesting in sub-basins G1-2 and G1-5 in the Gray Creek watershed, a watershed that is less sensitive to peak flow effects, should not be considered until ECAs drop below 30%.

- the Chapman and Gray Creek mainstem channels, upstream from the intakes, are fairly steep, bouldery streams that are relatively confined. Although the channels have been disturbed in the past by landslides and by streamside harvesting, the channel morphology has noticeably recovered. Fine-textured sediments, delivered to the stream by discrete landslide events and by chronic erosion of exposed surfaces, are transported through the system quite quickly and contribute to short duration turbidity events.
- water quality concerns expressed by the SCRD are associated with turbidity, total organic carbon, and colour. Identified sources of turbidity include discrete sources such as landslides, chronic sources such as streambanks, and organic sources. If conducted in an appropriate manner, proposed harvesting and road building activities will not result in the incidence of landslides and they are unlikely to have an effect on chronic and organic sources of turbidity. By retaining vegetated buffers to all streams, lakes, and wetlands in the watershed, proposed harvesting activities are not expected to impact total organic carbon concentrations, and likewise, will not affect water colour.

On the basis of this study, it is concluded that limited forest harvesting activities can take place in both the Chapman Creek and Gray Creek watersheds without degrading water resource characteristics if conducted in a manner reflecting the sensitivity of the watershed. Both watersheds are heavily relied upon to supply a minimum quality and quantity of water that meets both public need for consumption as well as for valuable fish species present in the systems. Proposed harvesting operations must be sensitive to these values.

Recommendations for hazard mitigation are summarized as follows:

- minimize soil disturbance. Use harvesting methods compatible with terrain and soil conditions. Special precautions to minimize site degradation during forest development are recommended for:
  - organic soils, since organic material comprises a considerable proportion of the measured turbidity; and
  - silty-sand textured glaciofluvial moraine deposits, since these soils are most likely to have a high surface erosion potential.
- reduce the likelihood of initiating a landslide, or other mass wasting processes by:
  - completing terrain stability field assessments for cutblocks, roads, and excavated or bladed trails, on slopes greater than 50% regardless of terrain class, and where they are situated on Class III to V terrain;
  - limiting ECAs to 20% on areas located above Class IV and V terrain, where stability mapping is complete, or above slopes greater than 50%;
  - all new, or replaced, drainage structures must be designed for the 100-yr instantaneous peak flow. Use historic flow records to size culverts and/or use past performance of other culverts on the same stream to help determine size. On channels affected by debris flows, culvert design should be based on the maximum debris flow, rather than the peak water flow. During construction of all

  stream crossings, guidelines for drainage structures in community watersheds should be followed (Forest Practices Code, 1996);
  - assess all streams and gullies after harvesting for the removal of introduced debris, slash or soils; and
  - establish a regular maintenance plan for all drainage structures. Inspections should be conducted at least twice per year (prior to spring runoff and to fall rains) and after unusually heavy floods or extreme events.
- reduce the risk of introducing sediment to streams. Suggested means of reducing the risk are to:
  - Restrict activities to the dry season and follow rainfall shut-down guidelines during storms;
  - Install silt fencing, hay bales, detention ponds, or similar measures to reduce stream sedimentation at stream crossings during road construction; and
  - Grass seed exposed soil surfaces concurrently with road construction.
- maintain, or expand, the current water quality and quantity monitoring program at the SCRD water intake. Water quality parameters should include, but not necessarily be limited to: turbidity, total organic carbon, total suspended solids and should be recorded at least on a monthly basis during the wet season (November to June). Turbidity monitoring should also be undertaken on the stream receiving runoff from harvesting or road building activities.
- distribute copies of the Emergency Response Plan, developed for the IWMP document to all operators within the watershed; and
- ensure that a forested, windfirm riparian buffer (minimum width 20 m) be maintained along all perennial streams, wetlands and lakes.

DEFINITIONS

Throughout the text, the terms low, moderate, and high are used to describe the hazard associated with either current watershed condition, or with proposed forest harvesting and road building activities.

Hazard is the likelihood that proposed forestry activities would accelerate, or increase the magnitude and/or frequency of a specified parameter (i.e. peak flows, water quality, riparian and/or stream channel condition, landslide occurrence).

> **Low** – There is a low likelihood of an effect resulting from proposed activities. For example, proposed activities are not likely to have a noticeable effect on peak flows, rate of landslide occurrence, and/or stream channel condition. From the perspective of this watershed assessment, a low hazard implies that there is not likely to be a noticeable or measurable impact on water quality and/or quantity.
>
> **Moderate** – There is a moderate likelihood of an effect resulting from proposed activities. Proposed activities are likely to have a noticeable effect. A moderate hazard rating implies that effects on water quality and/or quantity may be noticeable or measurable but would likely be of a short-term duration and/or of a limited magnitude.
>
> **High** – There is a high likelihood of an adverse effect resulting from proposed activities. Proposed activities are likely to have a noticeable and significant effect. A high hazard condition implies that there would be a noticeable, perhaps chronic, impact to water quality and/or quantity. Activities expected to generate high levels of impact are not considered acceptable.

TABLE OF CONTENTS

Page

FIGURES

TABLES

APPENDICES

1.0 INTRODUCTION

1.1 Project Background and Rationale for Watershed Assessment

EBA Engineering Consultants Ltd. (EBA) were retained by International Forest Products Ltd. (Interfor) to conduct a Coastal Watershed Assessment Procedure (CWAP) for the Chapman Creek and Gray Creek watersheds. The study area includes the portion of each watershed upstream of the community water intake, and is shown in Figure 1.1. Authorization to carry out this work was provided by Mr. Jeff Pollock of Interfor on January 26, 2000.

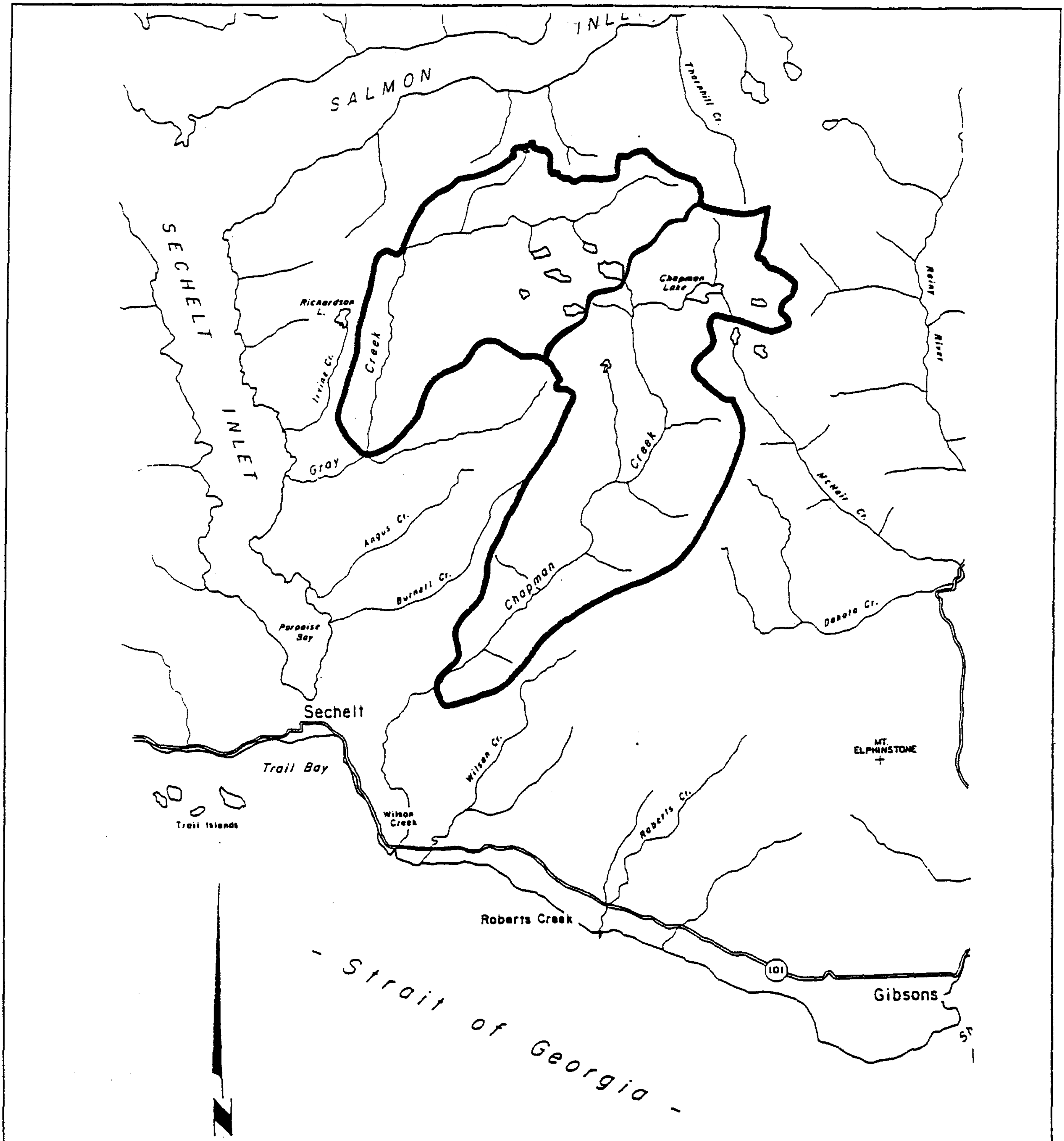
One of the first ever CWAPs was completed for the Chapman and Gray Creek watersheds by the BC Ministry of Forests (Hudson, et al., 1993). In 1994, a detailed hydrologic analysis was completed by Summit Environmental Consultants Ltd. (1997). A CWAP is considered valid for three years, thus the assessment presented here is an update of the previously completed CWAP.

1.2 Project Objectives and Approach

The purpose of the CWAP is to assess the cumulative effects of past forest practices on the watershed and to provide recommendations for further development based on the results of the assessment. The specific objectives of the watershed assessment are to determine:

- potential for changes in peak stream flows;
- potential for accelerated landslide activity;
- potential for accelerated surface erosion;
- channel bank erosion and changes to channel morphology as a result of logging the riparian vegetation;
- potential for stream channel changes;
- potential for impacts to water quality;
- results of past watershed restoration activities; and,
- interaction of all of these processes, an evaluation of which indicates the sensitivity of the watershed to further forest development.

The CWAP is made up of a review of watershed characteristics (Section 2.0), a summary of past and proposed forestry activities (Section 3.0), and an analysis of watershed effects. Methods used to complete the CWAP analysis are described in Section 4.0 and are comprised of an analysis of peak flow effects, a landslide hazard assessment, a channel assessment, and a riparian assessment. The results are detailed in Section 5.0 and summarized in Section 6.0 and can be used to provide rationale for forest development plan recommendations. Recommendations for hazard mitigation are provided in Section 7.0.



Map Source: Chapman and Gray Creeks Integrated Watershed Management Plan. 1998

EBA Engineering Consultants Ltd.

PROJECT: Watershed Assessment (CWAP) for Chapman and Gray Creeks, Sechelt

CLIENT: **International Forest Products Ltd.**

TITLE: Location of the Study Area

DATE: June, 2000
DWN.:
SCALE: unk.
FILE NO.: 0801-00-81516
FIGURE 1.1

1.3 Special Resource Concerns

The Chapman and Gray Creek watersheds provide domestic drinking water and fire protection to approximately 21,000 residents of the Sunshine Coast. Increasingly, water quality is a major concern for the community. The water quality parameters of concern identified by the Sunshine Coast Regional District (SCRD) are water colour, suspended solids, and turbidity. Past logging activity in the community watershed is seen as the cause for degraded water quality (B. Patrick, *pers. comm.*, 2000).

Chapman and Gray Creeks, downstream from the SCRD domestic water intakes, are also important spawning streams for several species of anadromous salmon, steelhead and anadromous cutthroat trout. Low flow periods, generally July to September, present high demands on the water supply and community water withdrawals during this period can conflict with downstream fisheries requirements. Forestry practices that affect the timing and duration of low flow periods are, therefore, a concern for both the SCRD and the Department of Fisheries and Oceans (DFO).

1.4 Watershed Advisory Committee Consultation

The Watershed Advisory Committee (WAC) is a technical group representing resource interests in the watershed that is assembled for the Chapman and Gray Creek CWAP. The initial WAC meeting took place on February 29, 2000 at the MOF District Office in Sechelt, BC.

Members of the WAC were asked to comment on the draft report. At a final WAC meeting, held on October 30, 2000 members discussed the results of the assessment.

A list of WAC Committee members and minutes of both WAC meetings are provided in Appendix A.

2.0 WATERSHED CHARACTERISTICS (CHAPMAN AND GRAY CREEKS)

The Chapman and Gray Creek watersheds are located on the Sechelt Peninsula near the community of Sechelt, BC (Figure 1.1). The Chapman Creek watershed, which drains south to Georgia Strait is the largest watershed on the Peninsula, with a drainage area of approximately 5,600 ha upstream from the SCRD intake. The Gray Creek watershed is approximately 4,333 ha upstream from the intake and drains west to Sechelt Inlet.

The headwaters of both watersheds are part of the Tethrahedron Plateau, an area designated as Provincial Park and situated at an elevation above 800 m. The plateau is characterized by many small wetlands and lakes between steep and short mountainous peaks. Chapman Creek has a total basin relief of 1700 m, while Gray Creek has a total relief of 1500 m. Both watersheds occupy elongate, steep sided valleys and incised deep deposits of till and glaciofluvial material in the middle to lower reaches.

2.1 Hydrology and Dominant Hydrologic Processes

Flow monitoring has been conducted on Chapman Creek since 1959 and is currently ongoing. Due to the installation and subsequent modification of the Sechelt domestic water intake, the Water Survey of Canada (WSC) hydrometric stations have moved locations several times during this period. They are all in the same general area with a similar catchment area. A list of hydrometric stations, their location, and period of operation, is provided in Table 2.1.

Table 2.1 List of Hydrometric Stations Operating on Chapman Creek

Station No.	Station Name	Location	Period of Operation	Agency
Stn. 08GA046	Chapman Ck. near Wilson Ck.	0.5 km upstream of mouth	1959-1970	Water Survey of Canada
Stn. 08GA060	Chapman Ck. above Sechelt Diversion	7 km upstream of mouth	1970-1988	Water Survey of Canada
Stn. 08GA078	Chapman Ck. below Sechelt Diversion	7 km upstream of mouth	1992-**current**	Water Survey of Canada
	Chapman Ck. at Fish Hatchery	2.5 km upstream of mouth	1996-**current**	Brian Carson, Carson Land Resources Mgmt. Ltd.

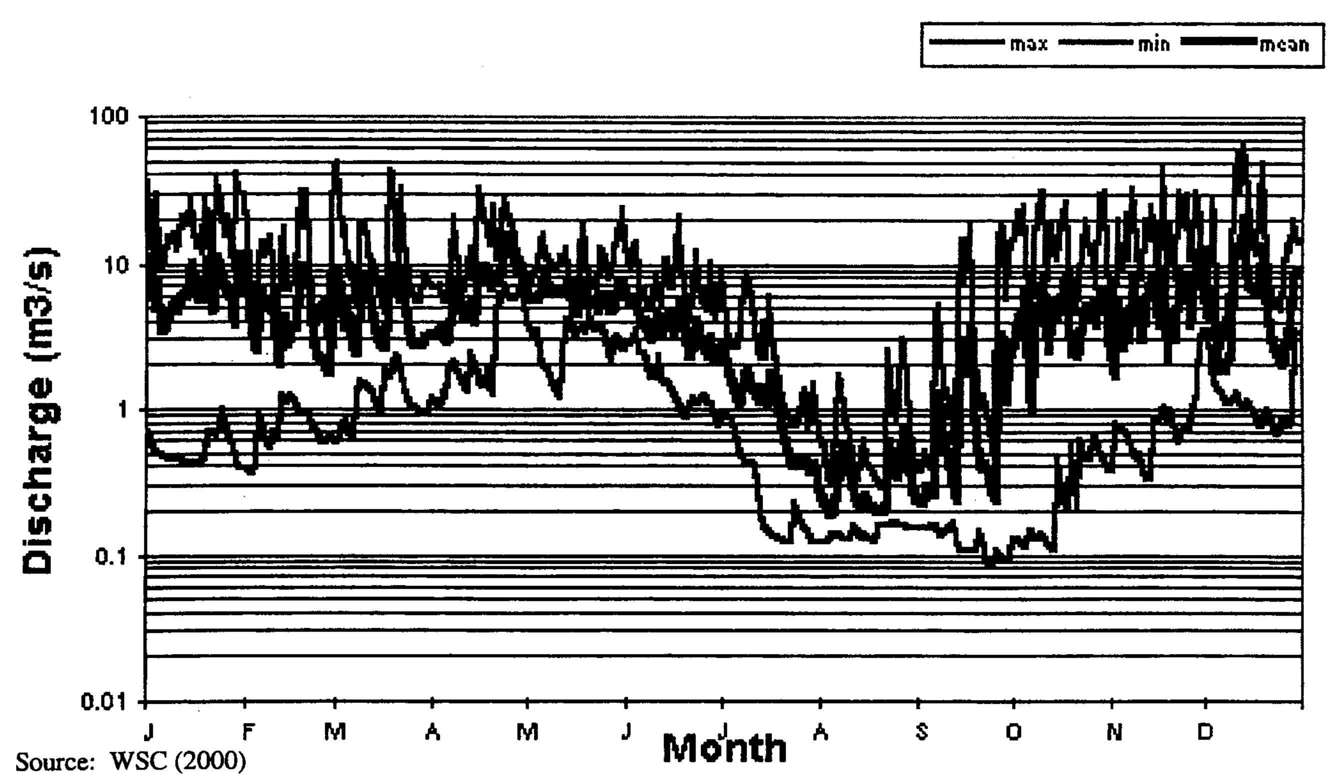
Characteristic climate and hydrology for the Chapman and Gray Creek watersheds are summarized in Chapman and Reksten (1991) using rainfall and discharge records between 1960 and 1988. More recent water quantity monitoring for the two watersheds has taken place in various forms since about 1992 and includes three years of continuous flow monitoring on Chapman Creek conducted by B. Carson (1999). There is no reliable flow data for Gray Creek.

Annual Hydrograph

The mean annual flow for Chapman Creek is approximately 4.53 m^3/s with peaks of about 50-60 m^3/s in the early winter and lows of 0.1-0.2 m^3/s in the late summer. The daily discharge hydrograph for WSC Station 08GA078 (Chapman Creek, below Sechelt Diversion) is presented as Figure 2.1.

Based on limited data, timing and volume of discharge for the Gray Creek watershed are considered to be comparable to that of Chapman Creek on a unit area basis (Carson, 1999).

Figure 2.1 Daily Discharge Hydrograph for WSC Station 08GA078 – Chapman Creek below Sechelt Diversion (1993-1998)



Source: WSC (2000)

Peak Flows

The records indicate that peak flows, generated by convective rain storms and/or snow melt can occur year-round. Annual peak flows are the largest, and occur most frequently during the winter months (December to March) as a result of rain or rain-on-snow events. In fact, 90% of the annual peak flow events recorded on Chapman Creek between 1960 and 1988 occurred between October and February (Chapman and Rekston, 1991). Only 7% of the annual peak flow events occurred as a result of summer rainstorms.

Between 1996-1999, there have been two major floods (Carson, 1999). A four-day storm, during which 94 mm of rain were recorded at the Chapman Creek hatchery, resulted in a peak flow of 90 m^3/s on March 18, 1997. On December 13, 1998, a rain-on-snow event contributed to peak flows of 95 m^3/s. Two peak flow events recorded in the past 30 years have had flows exceeding 100 m^3/s. These flows recorded in October, 1962 (193 m^3/s) and January, 1968 (160 m^3/s) are thought to have been associated with the failure of landslide debris dams. These flows were excluded from the flood frequency analysis but are 1.5 times the estimated 100-year peak daily flow (110 m^3/s) (Chapman and Rekston, 1991). The hydraulic design of drainage structures and in-stream works should consider the flashy hydrologic response and the risk of debris flood in the Chapman Creek basin.

Based on the data analysis presented by Chapman and Rekston, there is no clear indication that forest harvest activities have affected mean annual runoff in the Chapman Creek watershed. This is not unexpected as recent research by Ziemer (1998) indicates that the greatest effect of logging on streamflow peaks is to increase the size of the smallest peaks (i.e. 1 in 2 to 5-yr events) during the driest antecedent conditions, with the effect declining as storm size and watershed wetness increases. The effect on major floods (i.e. peak flows) is apt to be minor compared to the influence of rainfall and basin storage. The effect on peak flows is also more difficult to detect for coastal watersheds, where peak flows are generated by direct response to precipitation events.

A detailed and updated analysis of the timing and magnitude of peak flow events using the now-extended period of record may provide some useful information on the nature of peak flow events in the watershed.

Low Flows

Low flows in the study watersheds occur between early July and mid-October. The WSC hydrometric station, located below the SCRD intake on Chapman Creek (Figure 2.1) indicates that flows were less than 200 l/s (0.2 m^3/s) for most of the summer low flow period.

Watershed monitoring at low flow periods indicates that most of the surface water in Chapman Creek is generated from catchments with headwaters at elevations greater than 1000 m (Carson, 1999). These observations confirm the role of headwater wetland areas and lakes to provide water during periods of low flow. Water storage in these areas is dependent on seasonal snow pack accumulation. The timing and nature of low flow periods are, therefore, dependent upon annual variations in snow pack depth and spring temperatures.

Theoretically, forest harvesting increases soil moisture content by reducing transpiration rates. The corresponding effect is an increase in flows during the low flow period. This short-term effect should not, however, be interpreted as a hydrologic benefit of timber harvesting. Results from a limited amount of research, which addresses changes in low flows, range from no detectable effect to an increase in summer low flows (Rekston, 1991).

Watershed Response

In both basins, there is a strong relationship between precipitation and elevation, and the resultant runoff. Annual precipitation in both watersheds increases substantially with elevation due to the orographic uplift of frontal systems. For example, annual precipitation in the area varies from approximately 1350 mm near sea level to more than 3500 mm at high elevations (Chapman and Rekston, 1991). Because of steep slopes, precipitation inputs are quickly converted to runoff. Due to the resulting high runoff per unit area, the streams have a high capability to erode and transport material.

Response to rainfall and rain-on-snow melt in the fall/winter period is characterized as extreme peaks with a fast response time and short recession time. This illustrates the small role of floodplain storage. In the late spring, the hydrologic response to snow melt is characterized by sustained higher flows and a longer recession limb.

Carson (1999) states that watershed hydrologic response may have been impacted by forestry activities and that road deactivation efforts have not reduced the flashiness of the stream. Most deactivated roads, with the exception of those that have been fully recontoured, continue to intercept groundwater. Despite this, the present hydrology is not likely to degrade further with limited future development.

2.2 Geology, Geomorphology and Soils

The bedrock geology of Gray Creek and most of Chapman Creek is comprised of relatively erosion-resistant quartz diorite and granodiorite. The southeastern part and the headwaters of Chapman Creek appear to be underlain by thin bands of volcanic and sedimentary rock and related mafic intrusions of the Bowen Island Group (Friedman et al., 1976; Harris, 1986). These rocks tend to weather to fine-textured sands and silts that are more erodible.

Surficial deposits within low-elevation areas (areas below 200 m) are comprised of gravely beach materials deposited as a result of wave action and changing sea levels. Above this, glacial meltwaters during interglacial periods and during glacial retreat resulted in widespread sand and gravel deposits below 300 m elevation. Intermediate elevation areas along the lower reaches of Chapman and Gray Creeks are blanketed by sandy to gravely glaciofluvial, ice-contact, and morainal deposits (IWMP, 1998). In both watersheds, it is these mid-elevation glaciofluvial deposits that are sensitive to destabilization. Loss of root cohesion and mechanical disturbance due to forest harvesting has destabilized the oversteepened unconsolidated materials. Because the sediments are resting on slopes much greater than their stable angle of repose, it takes much longer for destabilized areas to recover. High elevation areas are covered by Vashon Drift comprised of glacial till, outwash and ice contact deposits, and post-glacial colluvium.

Humic gleysol soils predominate on poorly drained sites on the plateau and humic podzol soils predominate on well-drained sites. Humic soils have a considerable fraction of organic matter that is continuously being formed and destroyed by decomposition and mineralization. Podzols are typically acidic soils that have a leached horizon of iron, aluminum, and humus. Because of higher water tables and the absence of soil microorganisms, organic matter is not broken down as quickly as it would be for well-drained soils. In the Chapman and Gray Creek watersheds, this means that organic and clay colloids, aluminum, and iron compounds are common elements in the water supply and will characterize the natural water quality.

2.3 Water Quality

Water quality and quantity monitoring, initiated under Forest Renewal B.C., has occurred since 1994 and is currently on-going (Carson, 1999). Major findings of the monitoring program, as they may relate to the current watershed assessment are summarized as follows:

- Turbidity levels in Chapman Creek generally range from < 1 NTU in the summer months to peaks up to 50 NTU (Feb. 1997) in the high flow winter months. Threshold turbidity levels (7.5 NTU), which signal SCRD intake closure, have been exceeded on 12 occasions in 1996, 11 times in 1997, and 12 times in 1998. The relationship between turbidity and precipitation is not predictable due to the importance of antecedent watershed conditions such as soil moisture, rainfall, and discharge.

  Sources of turbidity identified by Carson (1999) in Chapman Creek are attributed to the following:

  - Discrete slope failures that produce extremely high, but short-lived turbidity events;
  - Chronic and periodically dominant sources of sediment that originate from the streambanks along the mainstem Chapman Creek between the old East Main crossing and the SCRD intake; and
  - Natural organic sources of turbidity that are more diffuse over the watershed.

- Turbidity levels in Gray Creek are, in general, less than for Chapman Creek. Grab samples indicate that turbidity ranges from < 1 NTU in the summer months to 6 NTU in the high flow winter months. Periodic monitoring indicates that occasional slope failures are the dominant source of turbidity, while the contribution of sediment from streambank sources is considerably less than for Chapman Creek.

- A considerable proportion of the turbidity is related to organics. Total Organic Carbon (TOC) is a measure of dissolved and particulate organic carbon, which is comprised of humic substances and partly degraded plant and animal materials. TOC concentrations at the Chapman Creek intake range from 1.3 mg/L at low flows to 5.9 mg/L at high winter flows. Gray Creek TOC concentrations are higher on average, ranging from 2.2 mg/L to 7.6 mg/L. Although there are currently no provincial drinking water criteria for TOC, the US EPA recently set 4 mg/L TOC as a limit to prevent the formation of trihalomethane, a harmful by-product of chlorination. Timing of TOC inputs is likely related to the seasonal storage and release of water from high elevation bogs. Potential sources of TOC identified by Carson (1999) include tributaries that drain the swampy and boggy plateau areas, deciduous leaf litter within the riparian zone, and soils.

- Drinking water from Chapman and Gray Creek is often described as "tea coloured". In Chapman Creek, true colour, which is a measure of the amount of dissolved colouring compounds (organic and inorganic) in water from which the turbidity has been removed, ranged from 5 TCU at low flow periods to 40 TCU during high flow periods in the winter. On Gray Creek just downstream from the intake true colour ranged from 10 TCU to 55 TCU. The provincial drinking water criterion for true colour is 15 TCU. Elevated colour may originate from the decomposition of naturally occurring organic matter (EPA, 1986) such as that which is present throughout the headwaters of both watersheds.

Water temperatures in Chapman Creek, monitored at the hatchery hydrometric station by B. Carson, appear to exceed provincial water quality criteria for aesthetics (15° C) and the maximum weekly average for spawning salmonids (8-10° C) in the summer months. Temperatures greater than 10°C were recorded from the beginning of June through to the end of September. In 1998, water temperatures exceeded 20° C for a short period in July.

2.4 Fisheries and Wildlife Characteristics

Fisheries distribution information is reported by EVS Environment Consultants Ltd. (1999). Chapman Creek supports five different species of anadromous fish (coho, pink, and chum salmon, steelhead and anadromous cutthroat trout) and resident populations of Dolly Varden char, cutthroat trout and rainbow trout. Gray Creek supports the same five anadromous fish species and resident rainbow trout and cutthroat trout. A series of waterfalls (9 m and 8 m high) limit the upstream migration of anadromous fish to the lower 6.6 km of Chapman Creek. A smaller velocity barrier limits chum and pink salmon to the lower 5.8 km of the creek. On Gray Creek, a series of impassible falls is located at approximately 1.2 km. These falls (2 m and 3 m high) form a barrier to all anadromous fish in Gray Creek.

In Chapman Creek, the chum salmon population recovered from a low of 50 adults in the late 1960s to peak at 3,500 adults in 1973-1974. Over the period 1994 to 1997, annual chum escapements averaged 388 fish (EVS Environment Consultants Ltd., 1999). Lower Chapman Creek presently supports an annual winter run of wild steelhead numbering 50-100 fish. Coho and pink salmon annual escapements average 594 and 475, respectively and these numbers appear to have increased from historic levels. Efforts by the Sunshine Coast Salmon Enhancement Society, which operates a hatchery at the lower end of Chapman Creek, have helped the recovery.

Annual escapement data indicates that in Gray Creek, the chum salmon population has dropped from highs of 3,500 and 3,000 adults in 1959 and 1968 to a low of 12 adults in 1996. There have been similar significant declines in pink and coho salmon escapements.

Through the Salmonid Enhancement Program (SEP), fish stocking was initiated in both watersheds around 1982. In Chapman Creek, the program included developing a hatchery, releasing an annual average of 4800 steelhead fry and smolts above (1988-1989) and below (1993-1995) the impassible falls. Coho smolts were released every year since 1992 and there were also a limited number of pink, chinook, and cutthroat trout releases into Chapman Creek. Chum, coho, and chinook salmon smolts have been released into Gray Creek under SEP since about 1982. Chapman Lake has been stocked with unreported numbers and species of trout and char. Tannis Lake and Batchelor Lake, in the Gray Creek watershed have been stocked with cutthroat trout.

Wildlife values in the Chapman and Gray Creek watersheds are not well understood due to the limited number of surveys. Documented wildlife species and watershed usage is provided in the IWMP report (1998). The watersheds appear to support low to moderate populations of Columbia black-tailed deer, black bear, cougar, and other fur bearing animals. Other wildlife known to use the watershed include: water fowl, gulls and shorebirds, raptors, upland game birds, woodpeckers, a variety of songbirds, small mammals, amphibians, and reptiles.

The low deer population is thought to have been negatively affected by past progressive clearcutting in the watershed and the lack of suitable winter range at low elevations because of dense second-growth. Large-scale clearcuts historically have a low edge:forest ratio and long dash distances to cover. Newly designed "large clearcuts" now introduce more edge than in the past (i.e. irregular boundaries, wildlife tree patches, etc.).

2.5 Water Requirements and Low Flow Concerns

The water intake on Chapman Creek is located approximately 7 kilometers upstream from the mouth. Throughout the year, the Sunshine Coast Regional District (SCRD) is licensed to use 27.63 million litres per day (312 l/s, or 0.31 m^3/s) from Chapman Creek. The maximum water requirements, which typically coincide with low flow periods in the late summer, are approximately 250 l/s (0.25 m^3/s). The fish hatchery, located downstream from the intake requires a non-consumptive volume of 60 l/s (0.06 m^3/s).

The Department of Fisheries and Oceans (DFO) has stated that during the summer low flow period, generally from July to October, the <u>preferable</u> minimum flow is 500 l/s (0.5 m^3/s). An <u>acceptable</u> minimum flow is 400 l/s (0.4 m^3/s). However, should this flow persist for more than 7 continuous days, additional water should be released from headwater storage to bring Chapman Creek flow back to the preferred 500 l/s. The <u>absolute lowest sustainable</u> rearing flow is 300 l/s (0.3 m^3/s). For fisheries reasons, DFO states that lower Chapman Creek flows should never fall below this discharge at any time of the year. DFO suggests that watershed storage and storage release strategies be planned so that the minimum flow never falls below this magnitude except in extreme drought and/or emergency situations (R. Eliasen, 2000).

Streamflow monitoring for the period of 1996 to 1998 has indicated that low-flow period discharge at the hatchery hydrometric station has ranged between 70 and 210 l/s.

Conflicting water requirements during periods of low flow have been a concern for the SCRD and DFO for some time. A "low flow agreement" has yet to be established between the SCRD and DFO. Plans to augment low flows in Chapman Creek include managing stored water in Chapman Lake. A proposal to construct a floating pump station on the lake has been presented to the SCRD and may be considered after alternative water supplies are investigated.

By way of a trigger valve, the water intake on Chapman Creek may be closed during turbidity events. The valve is closed when turbidity values reach 7.5 NTU and storage capabilities can supply up to 48 hours of water supply during the peak turbidity event.

Gray Creek is a backup water supply should the main intake on Chapman Creek be shut down or to supplement the supply during periods of low flow. The water intake on Gray Creek is located at the highway crossing approximately 4 kilometers upstream from the mouth. During periods of high consumption, Gray Creek may be drawn upon to augment the water supply. Gray Creek provides 3-5% of the total supply of water. The SCRD is licensed to 2.84 million litres per day (32 l/s) from Gray Creek. Flow monitoring in September, 1996 showed that the total flow in Gray Creek was less than 20 l/s, indicating that Gray Creek may not be able to provide licensed quantities at times of low flow (Carson, 1999).

3.0 PAST AND PROPOSED FORESTRY ACTIVITIES

3.1 Past Forest Harvest Activities

Although there has been no logging in the Chapman Creek watershed for the past 3 to 5 years, forestry activities have dominated other land use in the study area for over 60 years. In the 1950s, Timber Berth tenures which covered the mid-Chapman Creek valley were issued to Canadian Forest Products (Canfor) and MacMillan Bloedel Ltd. (IWMP, 1998). These areas in both watersheds have since reverted to the Crown and the remainder converted to Timber Licenses.

In 1967, a 10-year Timber Sale Harvest License was granted to consolidate operating areas for Jackson Bros. Logging Co. and the Burke Lumber Company in the Chapman Creek watershed. In 1972, a separate license was issued for Gray Creek. These were consolidated into one Forest License in 1987, and has been operated since 1990 by International Forest Products Limited (Interfor) (IWMP, 1998).

Current forestry activities in the watersheds are being conducted by the Ministry of Forests, Interfor, Weyerhaeuser (formerly MacMillan Bloedel) and Canfor on Crown and Private (Managed Tree Farm) Lands. Private land represents approximately 5% of the combined watershed area. The Chapman and Gray Creek watersheds make up part of the Sunshine Coast Timber Supply Area and the area contributes approximately 50,000 m^3 per year to the Annual Allowable Cut out of a total of 1.14 million m^3.

3.2 Watershed Restoration Activities

Road deactivation has been the dominant restoration activity in the Chapman and Gray Creek watersheds. A summary of road deactivation activities, provided in Table 3.1, indicates that 51 km of forest road have been deactivated since 1996. Between 1996 and 2000, Interfor, by means of Forest Renewal BC funding, spent over $1.1 million deactivating and rehabilitating roads and landslides. Historically, over 56 kilometers of road have been deactivated in the Chapman Creek watershed and over 23 kilometers of road have been deactivated in the Gray Creek watershed (total 79 km).

Table 3.1 - Total Length of Road Deactivated (1996-1999)

Year	Chapman Creek	Gray Creek	Amount Spent
1996	21.26 km	6.86 km	$823,203
1997	7.62 km		$207,243
1998	10.85 km		$77,702
1999	4.51 km		$20,560
TOTAL	44.24 km	6.86 km	$1,128,708

Road deactivation and gully rehabilitation activities completed over the past four years and documented in Watershed Restoration Summary Reports, included the following:

- light, moderate, and heavy fill pullback (with end haul);
- rock wall construction;
- french drain and cross-drain construction;
- remove woody debris from fill material;
- bioengineering of the sand gully located at km 15.4-15.6 on the East Main Rd. and construction of a catch basin for material ravelling from the slopes (in 1997 the catch basin filled within 4 months of being cleared indicating an on-going maintenance requirement);
- rebuilding the gully crossing located at km 20.5 on the East Main Rd.;
- installing a locked gate at km 9 on the East Main Rd. and block access on the E400 road system to restrict access into the watershed (1998);
- rehabilitating a rock quarry at km 8.5 on the East Main Rd. including planting with approximately 65 conifer seedlings (1999);
- hand and helicopter spread grass seeding (general mix #2 and alpine mix #5) selected by biogeoclimatic zone. Helicopter seeding was spread by a dry seed dispersal hopper at a rate of 200 kg/ha.; and
- fertilization (slow release NPK 18-18-18) of 9.1 ha of seeded areas by helicopter at a rate of 150 kg/ha (1999).

Rehabilitation activities have targeted several landslides in the Chapman Creek watershed. Bioengineering structures and a debris catch basin were installed on the 'sand gully' failure, and work was completed on a large ravelling cutslope adjacent to the sand gully. Several road cuts on the East Main were planted as bioengineering demonstration projects. In 1999, bioengineering was completed on a dry, ravelling slide upstream from the upper bridge crossing on Chapman Creek by the Sechelt First Nation crew under the direction of the Ministry of Environment, Lands and Parks (T. Douglas, *pers. comm.*, 2000). Approximately 0.2 ha were treated. Based on the recent completion of many projects, a means of project monitoring and maintenance is recommended.

Fish habitat restoration activities in Chapman Creek include the following (T. Douglas, *pers. comm.*, 2000):

- in 1993, five "Newbury"-riffles were constructed along the lower Chapman Creek to raise the profile of stream that had degraded since the overflow channel was cut off. The uppermost riffle was designed to raise the profile of the stream 1.5 m to the natural profile.
- in 1995, a small groundwater-fed channel was constructed near the fish hatchery, located on lower Chapman Creek (Reach 1b); and

- in 1999, a 400 m long channel was constructed upstream from the fish hatchery, near the airfield, on lower Chapman Creek (Reach 1c).

3.3 Proposed Forest Harvest and Road Building

In the Chapman Creek watershed, Interfor proposes five (5) cutblocks and Weyerhauser proposes eight (8) cutblocks, representing a total gross area of 163.5 ha (2.9% of total watershed area over 5 years, or 0.58% per year). Interfor proposes six (6) cutblocks in Gray Creek, representing a total gross area of 76.1 ha (1.8% of total watershed area over 5 years, or 0.4% per year). For perspective, these proposed rates of harvest are significantly lower than the 1% per year specified in recommendations made by the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound. Cutblock information is summarized in Table 3.2.

Interfor has made a significant investment in the engineering, silviculture and terrain assessments associated with these cutblocks. Weyerhauser has completed terrain mapping in the proposed areas, but have not completed other engineering or silviculture assessments.

Weyerhauser intends to develop proposed cutblocks in a "socially-sensitive" manner and has implemented variable retention harvest practices and narrow, low impact roads in the Mount Elphinstone and Malibu areas (B. Wriglesworth, *pers. comm.*, 2000). Interfor has stated that harvesting activities associated with the proposed cutblocks will take into account (J. Pollock, *pers. comm.*, 2000):

- appropriate harvest systems (i.e. aerial, high-lead or ground-based) on a site specific basis;
- the stand level biodiversity, by way of leaving >17% standing timber within the blocks;
- Interfor's target of using alternative systems (varying degrees and types of retention) on 40% of its cutblocks; and
- restricting harvesting to less than 20 ha per year (to address social concerns with rate of harvest).

In the Chapman Creek watershed, a total of 14.4 km of road are proposed for construction and reconstruction. This includes 3 km of new road to access proposed blocks on the east side of the watershed and 11.4 km of new and reconstructed road within the E300 road system. In the Gray Creek watershed, a total of 2.8 km of road are proposed for reconstruction, including a 2 km section of the Richardson Mainline, and 4 km of new road is proposed.

Table 3.2 - Proposed Forest Harvest in Chapman and Gray Creek Watersheds

Opening #	Sub-Basin	Gross Area (ha)	Mid-Point Elevation	Licensee
Chapman Creek				
167	C2	10.1	1020 m	Interfor
169	C2	7.7	1000 m	Interfor
	C3	6.7	1000 m	Interfor
172	C2	12.1	1050 m	Interfor
	C3	15.7	1050 m	Interfor
203	C3	5.2	1120 m	Interfor
204	C2	2.1	830 m	Interfor
	C3	13.2	830 m	Interfor
330	C3	12.6	340 m	Weyerhaeuser
21	C3	5.9	720 m	Weyerhaeuser
22	C3	1.8	940 m	Weyerhaeuser
23	C3	23.2	1000 m	Weyerhaeuser
24	C3	19.9	1040 m	Weyerhaeuser
	C3-3	1.3	1040 m	Weyerhaeuser
40	C3	6.4	1120 m	Weyerhaeuser
43	C3	13.4	650 m	Weyerhaeuser
44	C3	6.2	800 m	Weyerhaeuser
TOTAL		**163.5 ha**		
Gray Creek				
120	G1-6	12.6	1020 m	Interfor
148	G1-6	37.2	830 m	Interfor
178	G1-4	7.7	700 m	Interfor
180	G1-4	1.0	600 m	Interfor
	G1-6	2.6	600 m	Interfor
174	G1-3	2.8	1020 m	Interfor
	G1-4	0.4	1020 m	Interfor
176	G1-6	11.8	1040 m	Interfor
TOTAL		**76.1 ha**		

4.0 CWAP METHODS

This CWAP follows guidelines of the *Coastal Watershed Assessment Procedure Guidebook*, Second Edition, April 1999. A more detailed description of assessment procedures is outlined below.

4.1 Sub-Basin Delineation

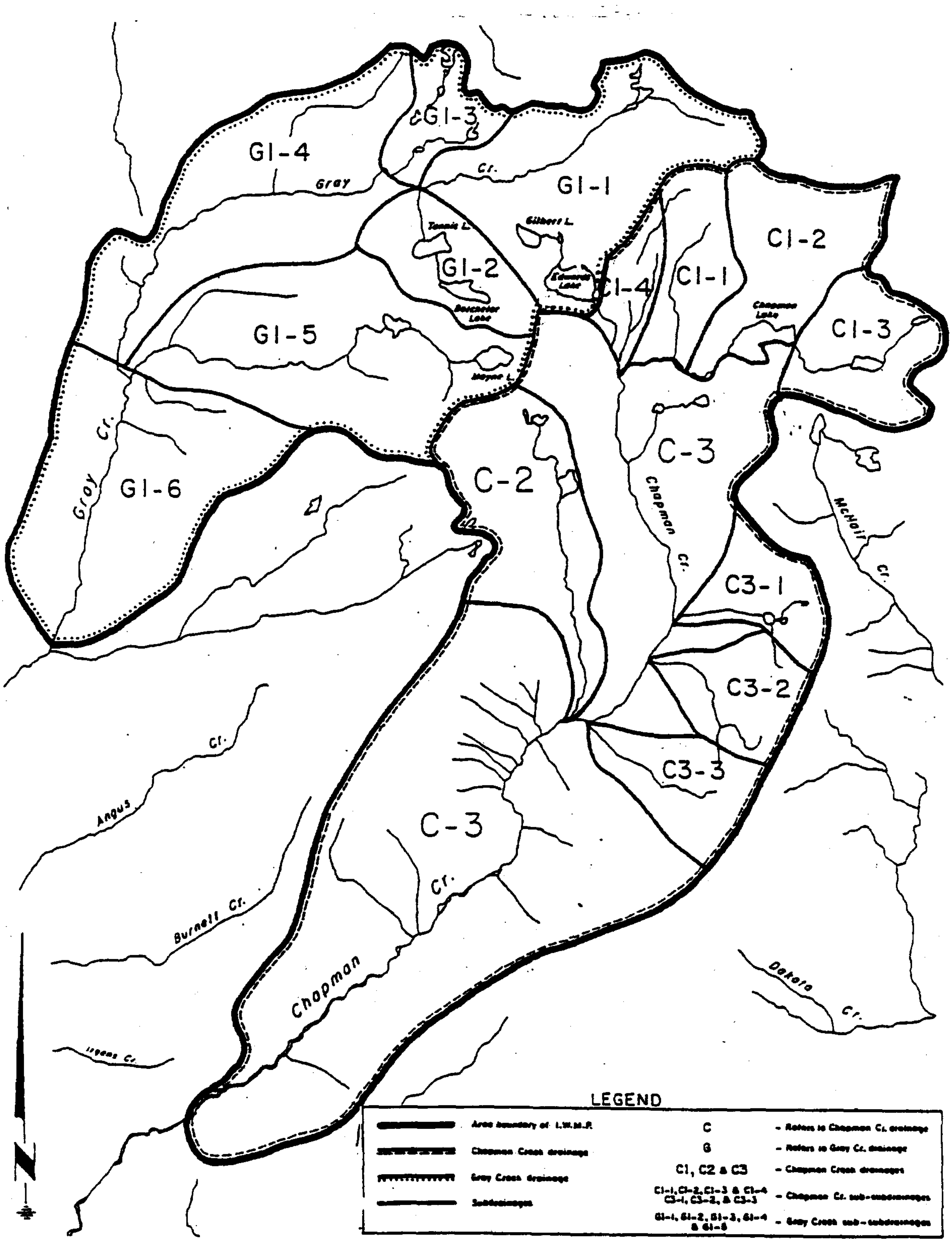
Sub-basins boundaries used for the Cumulative Effects Analysis (1993) and for the Hydrological Assessment (Summit, 1997) were used for this assessment with a minor difference (Figure 4.1). The difference between the sub-basins of this and previous assessments is that Edwards Lake is included as part of the Gray Creek watershed, whereas it was previously split between the Gray and Chapman Creek watersheds. The SCRD operates an outlet valve on Edwards Lake that allows a diversion of water to the Chapman Creek watershed. The valve has operated only once (1998) since it was constructed and is not considered fully functional. Because of its limited use, it was not included as part of Chapman Creek.

4.2 Peak Flow and Hydrologic Recovery Analysis

To determine the cumulative hydrologic effect of past forest harvest and road construction, an analysis of peak flow and hydrologic recovery was conducted. Forest harvesting and road construction tends to produce higher water yield, and earlier and higher peak flows. In general, the hydrologic effect of forest harvesting, which uses tree height and stocking as an indicator, is reduced as trees grow. This reduction is termed "hydrologic recovery".

Stand heights, projected to January 1999, are reported in the most recent forest inventory database (FIP file) provided by the Ministry of Forests, Powell River. It was found that because of a computer modeling error, projected tree heights were underestimated. For this reason, projected tree heights in the Chapman and Gray Creek watersheds were recalculated by EBA using a computer model called TIPSY (Ministry of Forests, 1997, Version 2.1e).

Hydrologic recovery attributed to stand regeneration is expressed as the equivalent clearcut area (ECA) index. By current methods, ECA index values are related to tree height as shown in Table 4.1. Using the ECA index, harvested areas are "reduced" by that amount of recovery. For example, if the average canopy height in a 100 ha cutblock is 4 m, the equivalent clearcut area is 75 ha (100 ha less 25% hydrologic recovery). The relationship between canopy height and hydrologic recovery, determined by Rob Hudson (MOF) from recent research is illustrated in Figure 4.2 for Gray Creek and Chapman Creek. These recovery curves indicate that the interim method underestimates hydrologic recovery of all stand heights in Gray Creek and mid-elevation (300-800 m) stands in

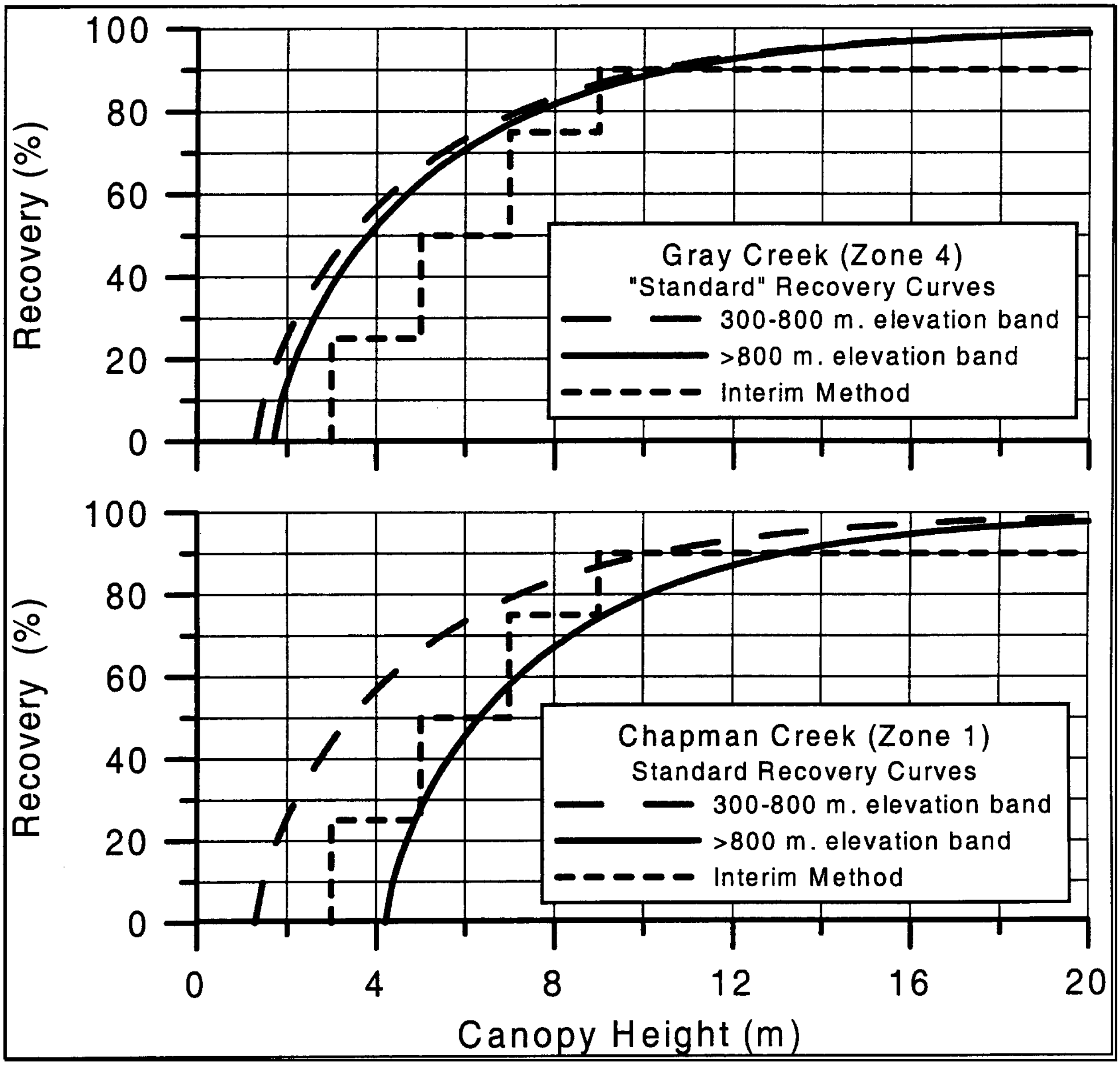


Modified From: Chapman and Gray Creeks Integrated Watershed Management Plan, 1998

EBA Engineering Consultants Ltd. eba	PROJECT: Watershed Assessment (CWAP) for Chapman and Gray Creeks, Sechelt
CLIENT: International Forest Products Ltd.	TITLE: Sub-Basin Delineation

DATE: June, 2000	DWN.:	SCALE: unk.	FILE NO.: 0801-00-81516	FIGURE 4.1

Figure 4.2 Hydrologic Recovery Curves for Gray Creek and Chapman Creek



From: Rob Hudson, Ministry of Forests, Vancouver Region (unpublished data)

Chapman Creek. The interim method, however, overestimates recovery of stands in the upper elevation band (>800 m) (R. Hudson, unpublished data).

Table 4.1 - Equivalent Clearcut Area (ECA) Index (Interim Method, 1999)

Stand Height (m)	ECA Index, or Hydrologic Recovery
0 to 3 m	0%
3 to 5 m	25%
5 to 7 m	50%
7 to 9 m	75%
9 m +	90%

Peak flows in the two watersheds are dominated by rain and rain-on-snow processes and these processes occur most frequently between 300 m and 800 m elevation. This elevation band is usually defined the "rain-on-snow elevation band". Theoretically, cutblocks and roads in this elevation band have a more pronounced effect on peak flows and clearcut areas have, in previous watershed assessments, been weighted by a factor of 1.5 to account for the greater effect.

For this watershed assessment all clearcut areas in the rain-on-snow elevation band were weighted by a factor of 1.5. This is considered a relatively conservative approach since peak flows are not the primary mechanism for watershed change in the Chapman and Gray Creek watersheds. In the Chapman Creek watershed sedimentation and direct channel disturbance from past forestry activities has been the dominant mechanism of watershed disturbance. In the Gray Creek watershed, the watershed has shown little evidence that it has been impacted by elevated peak flows.

Comparison with 1994 ECA Calculations

A hydrologic analysis was completed for the Chapman/Gray Chart Area in 1997 (Summit Environmental Consultants Ltd., 1997). For the assessment ECA values were calculated to the end of 1994.

While general comparisons are possible, there are some considerable differences in assessment methodologies that preclude direct comparison. Namely, the 1997 assessment was completed for the Interfor Chart Areas only, while the 1999 assessment was completed for the entire watershed upstream of the SCRD intakes.

4.3 Sediment Source Survey and Landslide Hazard Assessment

The intent of a sediment source survey is to identify and characterize the significance of forestry-related sources of sediment and to determine the hazard of future landslide occurrence. The sediment source survey was completed by the following methods:

- Information Review - Previously completed inventories and assessments provide the foundation for this component of the watershed assessment. An inventory of historic landslides completed by Bruce Thomson in 1987 was incorporated in the assessment. The inventory was completed using air photos dated between 1945 and 1988 and the results are included on the enclosed map (see Map). Reconnaissance-level terrain and terrain stability mapping, for which no formal fieldwork was completed, was reviewed and incorporated in the assessment (Maynard, 1995).
- Air Photo Review - 1996 1:5,000 scale and 1998, 1:20,000 scale air photos were reviewed to identify recent landslides. Communication with individuals familiar with the watershed was also completed to identify more recent slides, or expansion of existing slides.
- Helicopter and Field Assessment – A low-level helicopter overview flight was conducted to examine landslides in the basin and to provide judgement as to the level of existing impact and the potential for future impact.

4.4 Stream Channel Assessment

The purpose of the reconnaissance-level stream channel assessment is to determine post-harvest stability and sensitivity along the mainstem alluvial reaches of Chapman and Gray Creeks. The assessment is comprised of the following methods:

- Information Review – A comparative channel assessment was completed by E. Karanka in 1974. Stream channel characteristics are summarized in the Hydrologic Analysis completed by Summit Environmental (1997) and in the Level 1 Fish Habitat and Riparian Assessment (EVS Environment Consultants, 1999). Another relevant source of information is unpublished work by Dan Hogan, MOF. Mr. Hogan conducted a stream channel assessment using the 1970 video-photographs used by Karanka and compared these to photos obtained in 1997.
- Reach Break Analysis - The mainstem channel of Chapman Creek is subdivided into reaches and sub-reaches.
- Air Photo Review - Historic (1946, 1967, and 1982) air photos were used to document channel disturbance, the location of major sediment sources, and the location of disturbed riparian areas. Air photos were used to evaluate trends in channel stability and to consider the sensitivity and/or susceptibility to channel change.
- Field Assessment – An overview field assessment was conducted along selected reaches to investigate channel conditions and probable causes for disturbance.

Results of the channel assessment, including a reach-by-reach description of channel type and extent of disturbance, are tabulated. Historical channel changes and trends in channel stability are described. A hazard evaluation of each reach prepared as part of the channel assessment will be considered in the preparation of management recommendations.

4.5 Riparian Assessment

An assessment of the role of riparian vegetation in providing channel stability and structure was completed. A review of historic air photos will determine how this role has been affected by previous logging in the Chapman and Gray Creek watersheds.

Methods to conduct an overview-style riparian assessment were as follows:

- Information Review – A primary source of information for this component was the riparian assessment (RAPP) recently completed for the Chapman Creek watershed by EVS Environment Consultants (1999).
- Air Photo Review – The results of the previously completed RAPP are used in combination with a review of historic (1946, 1967, and 1982) and recent (1998) air photos to identify logged riparian areas. The CWAP will determine the effectiveness of second-growth forest in providing stable channel banks, stream cover, and future large-woody debris recruitment.
- Field Assessment – An overview field assessment of logged alluvial reaches was completed in concert with the stream channel assessment.

The results of the riparian assessment include an evaluation of impact related to the loss of riparian vegetation. Recommendations for protection in areas of proposed logging are provided.

5.0 RESULTS

5.1 Peak Flow and Hydrologic Recovery Analysis Results

5.1.1 Historic Equivalent Clearcut Area (ECA)

To provide an estimate of historic ECA in the Chapman and Gray Creek watersheds, the cumulative area logged is summarized by decade (see Figures 5.1 and 5.2). The results indicate that over 2000 ha, or 36% of the total watershed area, have been logged in the Chapman Creek watershed. The majority of this was logged in the 1970s. It should be noted that the lower Chapman Creek valley was logged prior to the earliest air photos (1948) but because the trees have reached a certain age and height class, the forest is not inventoried as having been logged. The total area (approximately 280 ha) would be considered 90% recovered from a hydrological perspective and would, therefore, have an ECA of 28 ha (or 0.5% of the total watershed area). The amount is considered negligible from a hydrologic perspective and is not included in the analysis.

Approximately 2200 ha, or 51% of the Gray Creek watershed has been logged. In Gray Creek, 58% of the total area logged was logged between 1970 and 1990.

To estimate historic ECA values for each watershed, conservative growth rates (0.4 m/year) were applied such that the ECA was reduced over time to reflect forest recovery. Historic ECAs for both watersheds are shown in Figure 5.3. The results indicate that, for Chapman Creek, ECAs have never exceeded 15% in any single decade and that the peak ECA (15%) was recorded in the 1980s. For Gray Creek, the peak ECA (28%) was also recorded in the 1980s.

5.1.2 Current Equivalent Clearcut Area and Proposed Changes

Current equivalent clearcut area (ECA) calculated for the Chapman and Gray Creek watersheds is summarized in Tables 5.1 and 5.2 by sub-basin and elevation band. ECA results are shown for two different methods, the Interim Method as per the CWAP Guidebook (1999) and the Regional Approach proposed and calculated by Rob Hudson, MOF.

The results indicate that the current equivalent clearcut area (ECA) for the Chapman Creek watershed is between 12% and 16.4%, depending on the method of calculation. ECAs for each individual sub-basin in the watershed range from 0% in sub-basin C1-2, located in the Tetrahedron Provincial Park and 32.3% for sub-basin C3-2. The current ECA for the Gray Creek watershed is between 14.3% and 22.8%, depending on the method of calculation. ECAs for each

Figure 5.1 - Historic Forest Harvest Activities in the Chapman Creek Watershed

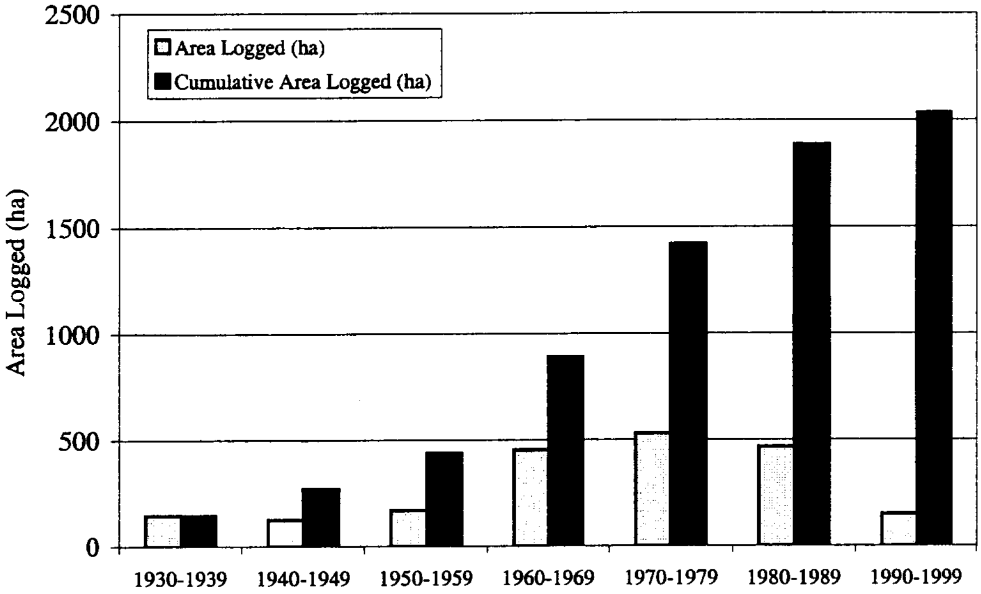


Figure 5.2 - Historic Forest Harvest Activities in the Gray Creek Watershed

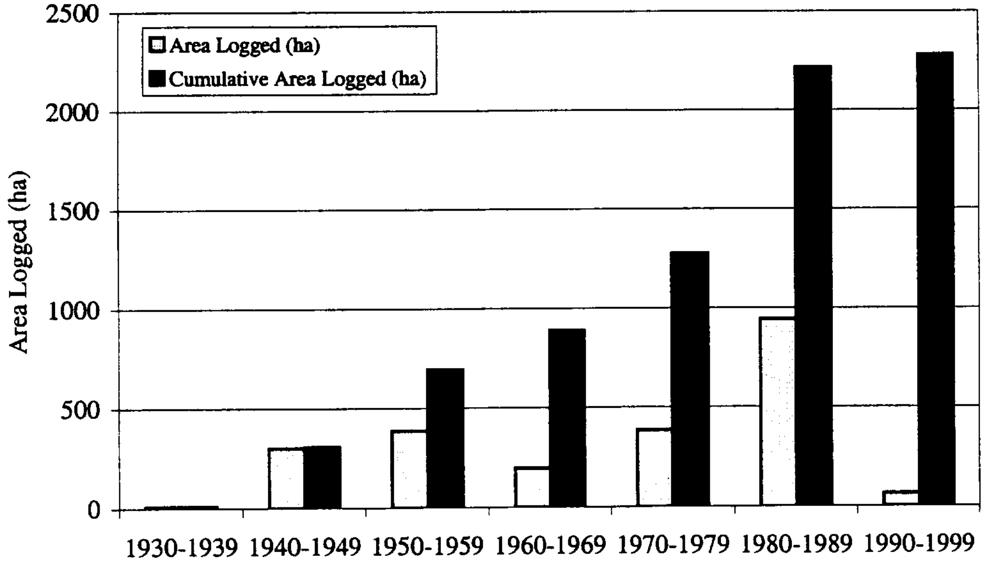


Figure 5.3 - Historic Equivalent Clearcut Area (%) for the Chapman and Gray Creek Watersheds

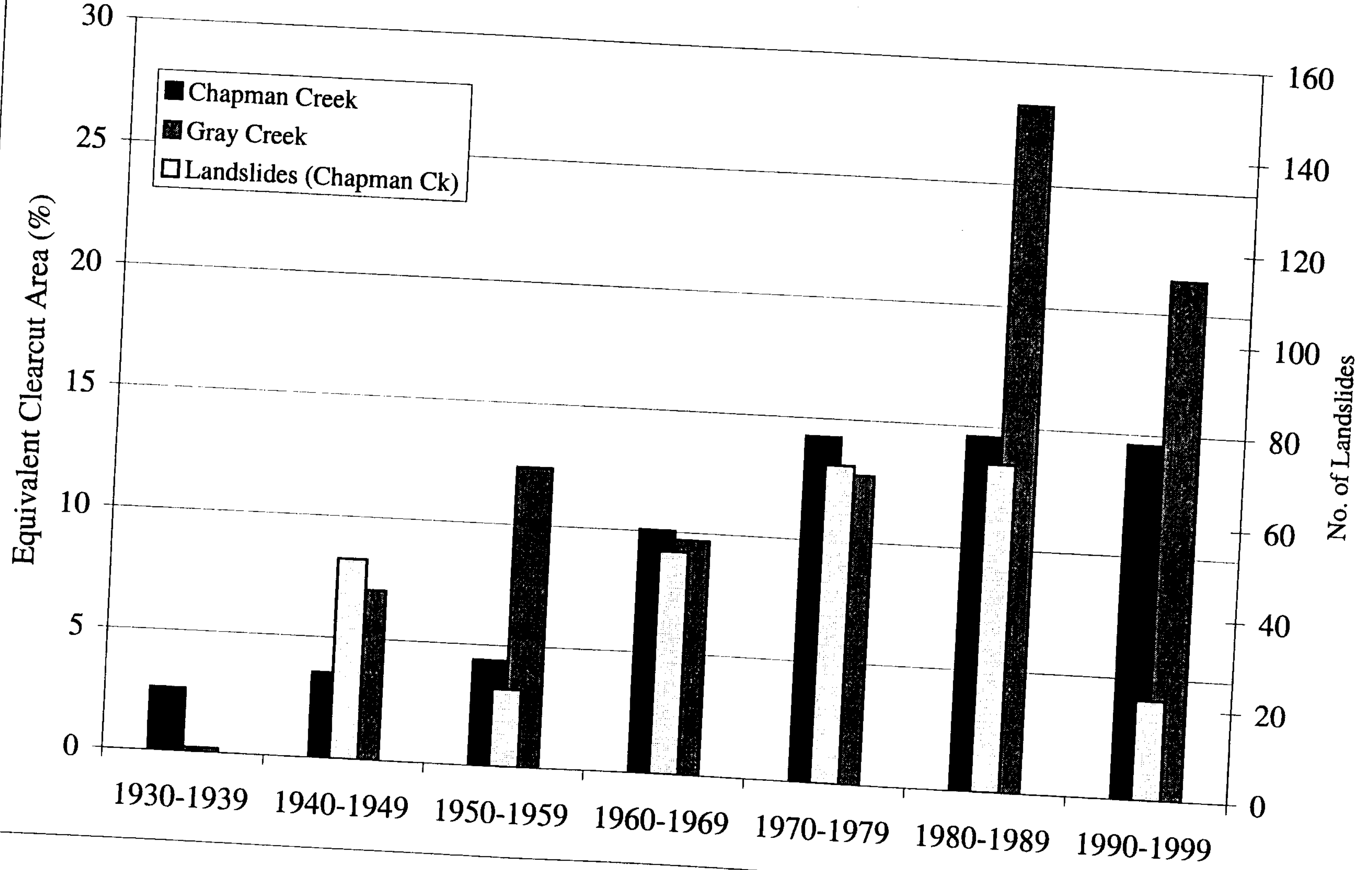


Table 5.1 Equivalent Clearcut Area (ECA) for the Chapman Creek Watershed

				Interim Method [1]	Regional Method [2]	Proposed Change [3]
Sub-Basin	**Elevation Band**	**Basin Area (ha)**	**% Logged**	**Weighted ECA (%)**	**ECA (%)**	**ECA (%)**
C1-2	800+	604.0	0.8	0.1	0.0	0.0
C2	300-800			1.1	-	
	800+			7.1	-	
	Total	616.0	22.8	8.1	8.2	32 ha; 5.2%
C3	0-300			1.0	-	
	300-800			7.9	-	
	800+			9.9	-	
	Total	3647.0	45.7	18.8	14.2	147 ha; 4.0%
C3-1	300-800			0.4	-	
	800+			24.7	-	
	Total	332.0	57.8	25.1	24.7	0.0
C3-2	300-800			1.0	-	
	800+			27.0	-	
	Total	172.7	37.4	28.0	32.3	0.0
C3-3	300-800			0.8	-	
	800+			20.3	-	
	Total	229.0	36.5	21.1	22.5	0.0
TOTAL		5600.7	34.1	**16.4**	**12.0**	**179 ha; 3.2%**

Notes:

[1] - Interim Method as per CWAP guidebook (FPC, 1999). Weighting factor (1.5) applied to 300-800 m elevation band.

[2] - ECA calculations completed by Rob Hudson, MOF using Regional Method (unpublished)

[3] - Proposed changes based on 2000-2004 Forest Development Plan (Interfor)

Table 5.2 Equivalent Clearcut Area (ECA) for the Gray Creek Watershed

Sub-Basin	Elevation Band	Basin Area (ha)	% Logged	Interim Method [1]	Regional Method [2]	Proposed Change [3]
				Weighted ECA (%)	ECA (%)	ECA (%)
G1-1	800+	880.5	18.2	16.2	13.9	-
G1-2	800+	241.5	50.8	30.1	25.1	-
G1-3	800+	206.6	47.1	22.0	14.5	2.8 ha; 1.4%
G1-4	300-800			3.2	-	
	800+			13.4	-	
	Total	1013.2	75.7	16.5	8.8	13.5 ha; 1.3%
G1-5	300-800			2.3	-	-
	800+			29.5	-	-
	Total	1113.3	61.0	31.8	20.5	-
G1-6	0-300			0.1	-	-
	300-800			14.3	-	
	800+			8.9	-	
	Total	877.8	53.7	23.3	10.2	79.5 ha; 9.1%

Total Watershed (u/s intake)	4332.9	53.2	**22.8**	**14.3**	**95.7 ha; 2.2%**

Notes:

[1] - Interim Method as per CWAP guidebook (FPC, 1999). Weighting factor (1.5) applied to 300-800 m elevation band.

[2] - ECA calculations completed by Rob Hudson, MOF using Regional Method (unpublished)

[3] - Proposed changes based on 2000-2004 Forest Development Plan (Interfor)

- Cutblock areas proposed within the rain-on-snow elevation band (300-800 m) are weighted by a factor of 1.5

individual sub-basin range from 8% in sub-basin G1-4 to 31.8% in sub-basin G1-5.

Where peak flows are a concern, ECAs greater than 20% are considered to be high. Where the effect of elevated peak flows is not apparent, higher ECAs may be attained with minimal effect on peak flows. In Chapman Creek, sub-basins C3-1, C3-2 and C3-3 have ECAs greater than 20% and in Gray Creek, sub-basins G1-2 and G1-5 have ECAs greater than 30%. There are currently no cutblocks proposed in these sub-basins and it is recommended that harvesting be postponed until the above-mentioned sub-basin ECA levels are less than 20% for the Chapman Creek watershed and 30% for the Gray Creek watershed.

Two scenarios are presented for both watersheds to the year 2004; a "no logging" scenario and a "proposed logging" scenario (see Tables 5.3 and 5.4). Over the next five years (2000-2004) the total (weighted) ECA in Chapman Creek will naturally reduce from 16.4% to 11.3%. The area proposed for harvest in the Chapman Creek watershed is 163.5 ha. Of this, 30.5 ha are situated in the rain-on-snow elevation band and are, therefore, weighted by a factor of 1.5. If the total area is logged, the ECA would increase by 179 ha, or 3.2%. This value takes into consideration the on-going natural recovery of harvested stands.

In the Gray Creek watershed the total (weighted) ECA will naturally recover from 22.8% to 15% over the next five years if no logging were to proceed. The proposed forest harvesting in the Gray Creek watershed represents an ECA increase of 95.7 ha, or 2.2%. Proposed logging will have the largest effect on ECAs in the G1-6 sub-basin of Gray Creek. In G1-6 the proposed harvest presents 79.5 ha, or 9.1% of the total sub-basin area.

Current ECA levels are not considered to be elevated. Because historic ECA levels which have been characteristically higher, have not resulted in an appreciable effect on peak flows, it is considered likely that the proposed harvesting activities will not significantly increase peak flows. A more intensive analysis is required to be able to understand whether there has been a historic effect on smaller (i.e. 5 to 10-yr) peaks. Due to the incidence of forestry-induced slope instability, it is determined that slopes draining onto potentially unstable terrain, or onto slopes that are more vulnerable to surface erosion, are more sensitive to changes in the surface or subsurface flow regime. In such situations, target ECA levels should be much lower. A general guideline is that the ECAs should not exceed 20% of the contributing area above these sensitive slopes.

Table 5.3 - ECA Changes in the Chapman Creek Watershed

	1999		2004 (no logging scenario)		2004 (proposed logging scenario)	
Canopy Height and Hydrologic Recovery	**Area Logged (ha)**	**ECA[1] (ha) (% of total watershed area)**	**Area Logged (ha)**	**ECA (ha)**	**Area Logged (ha)**	**ECA (ha)**
0-3 m (0%)	337	388 (7%)	0	0	164	179
3-5 m (25%)	160	123 (2.2%)	337	291	337	291
5-7 m (50%)	384	201 (3.6%)	160	82	160	82
7-9 m (75%)	268	75 (1.3%)	384	101	384	101
9+ (90%)	1000	128 (2.3%)	1268	158	1268	158
TOTAL	**2149**	**915 (16.4%)**	**2149**	**632 (11.3%)**	**2313**	**811 (14.5%)**

[1] – ECA calculated using Interim Method (1999)

Table 5.4 - ECA Changes in the Gray Creek Watershed

	1999		2004 (no logging scenario)		2004 (proposed logging scenario)	
Canopy Height and Hydrologic Recovery	**Area Logged (ha)**	**ECA[1] (ha) (% of total watershed area)**	**Area Logged (ha)**	**ECA (ha)**	**Area Logged (ha)**	**ECA (ha)**
0-3 m (0%)	382	398 (9.2%)	0	0	76	96
3-5 m (25%)	191	144 (3.3%)	382	299	382	299
5-7 m (50%)	468	247 (5.7%)	191	96	191	96
7-9 m (75%)	288	73 (1.7%)	468	124	468	124
9+ (90%)	960	126 (2.9%)	1248	129	1248	129
TOTAL	**2289**	**988 (22.8%)**	**2289**	**648 (15%)**	**2365**	**744 (17.2%)**

[1] – ECA calculated using Interim Method (1999)

5.1.3 Peak Flow Effects of Road Deactivation

Roads alter watershed hydrology by intercepting and concentrating surface and groundwater flows and by reducing infiltration on compacted surfaces. A high density of roads will contribute to higher and faster peak flows. Road deactivation reduces the density of roads and attempts to re-establish natural drainage patterns. The magnitude of the reduced hydrologic effect depends on initial terrain conditions and the level of deactivation completed (i.e. constructing cross-ditches versus recontouring the slope).

Road deactivation activities have dramatically reduced road densities in the Chapman Creek watershed (Table 5.5). Several sub-basins (i.e. C3-1, G1-2, G1-4, G1-5, and G1-6) have had road densities greater than 2 km/km^2. Through deactivation, the density of roads in the Chapman Creek watershed has been reduced from about 1.67 km/km^2 to approximately 0.67 km/km^2. In the Gray Creek watershed, where fewer roads have been deactivated, the density of roads is 1.56 km/km^2, down from 2.10 km/km^2. Several sub-basins in Gray Creek (G1-2 and G1-4) currently have elevated road densities.

Although reduced, the hydrologic effect of forestry roads in the watershed has not been totally eliminated. This is due to the varying levels of deactivation and the permanence associated with some terrain modifications (i.e. large exposed cutslopes).

Proposed road building activities will temporarily elevate road densities as road deactivation is proposed within the period of the 5-year forest development plan. Currently there are no roads proposed in sub-basins with elevated road densities. If proposed in the future, it is recommended that existing roads in the sub-basin are assessed and deactivated prior to construction.

Table 5.5 - Road Densities Before and After Road Deactivation

Sub-Basin	Total Length of Roads (km)	Road Density (km/km^2) (before deactivation)	Length of Non-Deactivated Roads (km)	Current Road Density (km/km^2)
		Chapman Creek		
C3	71.9	1.97	31.3	0.86
C3-1	7.5	2.27	0.3	0.09
C3-2	2.0	1.18	0.1	0.06
C3-3	3.3	1.44	1.5	0.66
C2	8.8	1.42	4.2	0.68
TOTAL	**93.5**	**1.67**	**37.3**	**0.67**
		Gray Creek		
G1-1	10.2	1.16	6.0	0.68
G1-2	9.1	3.76	6.7	2.77
G1-3	2.4	1.16	2.4	1.16
G1-4	27.9	2.75	27.6	2.72
G1-5	23.5	2.11	11.9	1.07
G1-6	18.0	2.05	13.0	1.48
TOTAL	**91.1**	**2.10**	**67.6**	**1.56**

5.2 Sediment Source Survey and Landslide Hazard Assessment

5.2.1 Landslides in the Chapman Creek Watershed

A total of 274 landslides have been identified in the Chapman Creek watershed. Of these, 252 slides are dated between 1946 and 1984 using air photos. Twenty-two (22) slides, identified as part of this assessment, occurred between 1984 and 2000. All slides are identified on the enclosed map (see Map).

Each individual slide is classified in terms of slope, surficial material, location, land use, vegetation status, sediment delivery, and terrain stability class. A detailed inventory is provided in Appendix B and a summary of slides is presented in Table 5.6.

Table 5.6 - Summary of Landslides in the Chapman Creek Watershed

Total No. of Landslides	274
Total No. of Forestry-Related Landslides	225 (82%)
Total No. of Forestry-Related Slides that have Directly, or Indirectly Impacted a Stream	78

Based on the inventory of landslide characteristics, the following interpretations are made with respect to landslide occurrence in the Chapman Creek watershed:

- 225, or 82%, of the identified slides were identified as having initiated within a clearcut or along a road. Most of the identified slides were not directly attributed to the loss of slope support or road fill failure, as is often the case for forestry-related slope failures, but the majority appear to have been associated with the failure of drainage structures;
- 78 forestry-related landslides directly, or indirectly impacted a stream;
- the highest frequency of landslides occur in silty-sand till materials; and
- landslide slopes are most often between 70 and 80%. However, 71 landslides, for which soil textures are typically silty sand to sandy gravel, have slopes less than 60%. This indicates that some lower-gradient slopes are potentially unstable.

From a water quality perspective, the largest historic sediment-related impacts in the Chapman Creek watershed have been the chronic and severe landsliding associated with roads and cutblocks located on the highly unstable glaciofluvial moraine deposits in sub-basin C-3. The fine sand materials are clearly visible at a site, known as the "sand gully", at about 15.5 km along the East Main Road.

A 1.1 km section of the Old Canfor road situated upstream from the SCRD intake, is also identified as a source of sediment to Chapman Creek. Along this section of private road there are several large, chronic instabilities in fine-textured glaciolacustrine sediments. The road was built before 1948 and is currently a popular recreational trail. It is believed that deactivation would be difficult, expensive and would result in sedimentation over the short-term. Considering that most sediment that contributes to elevated turbidity is derived from the streambanks, the relative reduction in turbidity at the SCRD intake would not likely be significant. Other options to reduce sediment delivery to the stream (i.e. revegetation of slide paths) could be considered but are not expected to reduce the likelihood of larger-scale slope failures.

Since the mid-1980s landslide activity has slowed in proportion to the decreased forestry activities. In this period several older slides have extended and others continue to ravel as an ongoing source of sediment. Water quality monitoring has determined that landslides contribute to occasional and short-lived periods of high turbidity concentrations (Carson, 1999). In the past 3 to 5 years, road deactivation has addressed drainage problems and has reduced the threat of long-term instability. Revegetation of exposed soil surfaces has also reduced the risk of long-term impact on water quality. Based on these results the current landslide hazard level for the Chapman Creek watershed is considered to be low.

5.2.2 Landslides in the Gray Creek Watershed

A summary of sediment source survey results for the Gray Creek watershed is provided in Table 5.7 and a detailed inventory is provided in Appendix B. Overall, Gray Creek has not had the same sort of terrain response to past forestry activities as Chapman Creek. Forest harvest activities in Gray Creek have been predominantly located on the stable plateau areas.

Table 5.7 - Summary of Landslides in the Gray Creek Watershed

Total No. of Landslides	28
Total No. of Forestry-Related Landslides	12 (43%)
Total No. of Forestry-Related Slides that have Directly, or Indirectly Impacted the Stream	10

A total of twenty-eight (28) landslides were identified in the Gray Creek watershed. Natural slides are short streambank failures along the mainstem, or sidewall failures along tributary channels. It is not clear whether streambank logging in the past may have contributed to their occurrence. There are 12 (43%) forestry-related (road or clearcut) landslides, 3 of which originate from the deactivated 100 Road system on the upper left bank of Gray Creek upstream from the intake.

For each identified slide, the current risk of impact was estimated on the basis of the current state of revegetation and the connectivity to the mainstem creek. The results indicate that there are 12 low risk slides, 14 moderate risk slides, and 2 high risk slides. The two high risk slides (S27 and S28) are relatively unvegetated debris slides situated downslope from the mainline road in the upper watershed. The slides, located along a relatively incised reach of Gray Creek, expose sandy moraine materials. Approximately 3 km of the 100 Road system are considered to be high risk. Additional deactivation is proposed for the roads that were deactivated in 1992 (W. Keddy, *pers. comm.*, 2000).

5.2.3 Soil Surface Erosion Potential

Surface erosion is the detachment, entrainment and transport of mineral soil by running water and this process is accelerated after vegetation has been removed and mineral soil has been exposed. Factors that affect surface erosion potential are soil texture, soil moisture, soil structure, permeability, soil thickness, slope steepness, slope position, abundance of seepage and catchment area. The rate of erosion is also affected by the extent of compaction of the soil as well as the amount of cementation and alteration of the soil.

In general, steeper slopes on long, uniform slopes with a shallow water table have a higher potential for surface erosion than short, shallow slopes. Soil textures that have a higher potential for surface erosion include non-cohesive silt to silt loam, and sandy loam to sand.

Surface erosion potential mapping has not been completed for the Chapman or Gray Creek watersheds. It is, however, required for all community watersheds where logging is proposed by June 15, 2000 under the Forest Practices Code. In both watersheds, silty-sand textured glaciofluvial material, which is common along the middle elevation zones, is vulnerable to surface erosion. Special precautions to minimize site degradation during forest development are recommended.

5.2.4 Landslide Hazard Potential Associated with Proposed Cutblocks

Potential clearcut landslide and stream impact rating were derived for each cutblock identified on the forest development plan. The ratings are derived from the terrain and terrain stability maps. Where detailed terrain stability field assessments (TSFAs) have been completed, revised ratings are provided. The results are summarized in Table 5.8.

TSFAs provide a site-specific assessment of landslide hazard potential and were completed for Blocks 172 and 204 in Chapman Creek (T. Lewis, 1996a and 1996b). Both assessments concluded that there is a low hazard of post-logging instability and provide recommendations for road construction.

Table 5.8 Potential Landslide Hazard Rating for Proposed Blocks

Opening #	Potential Clearcut Landslide Rating*	Potential Stream Impact Rating*	Potential Landslide Hazard Rating
Chapman Creek			
167	very low	low	very low
169	very low	low to high	very low to moderate
172	very low	low to high	low**
203	low to moderate	low to high	low to **high**
204	very low, low, moderate	high	low**
330	very low	low	very low
21	very low	low	very low
22	very low	low	very low
23	very low	low	very low
24	very low	low	very low
40	low to moderate	low to high	low to **high**
43	high	high	**high**
44	high	high	**high**
Gray Creek			
120	very low	low	very low
148	very low to high	low to moderate	very low to **high**
178	moderate to high	low	low to moderate
180	very low to low	moderate	low
174	very low	low	very low
176	very low to low	low	very low

* Ratings from D. Howes stability mapping

** Terrain stability field assessments completed by T. Lewis (1996a and 1996b)

Under the Forest Practices Code, TSFAs are completed for cutblocks and roads located on Class IV and V terrain. Using these guidelines TSFAs would be completed for some or all of Opening No.'s 203, 40, 43, and 44 in Chapman Creek and Opening No. 148 in Gray Creek.

In a watershed such as Chapman Creek where significant disturbance has been caused by landslides, it is recommended that harvesting be managed to a low risk of slope failure. This would mean completing TSFAs on Class III to V terrain, and for slopes greater than 50%, to ensure a low likelihood of failure throughout the block. Detailed field assessments will provide specific recommendations for block layout and road design to minimize the likelihood of slope instability or sedimentation to streams.

5.3 Channel Assessment Results

5.3.1 Reach Break Analysis

Reach breaks used for other assessments of Chapman Creek and Gray Creek were used, and further subdivided for this assessment (see enclosed Map). Longitudinal profiles of the mainstem channels are provided in Figure 5.4.

Channel substrates downstream from the SCRD intake are typically cobble, boulder, and gravel, however there are short sections of stream dominated by bedrock. Above the intake, Chapman Creek has downcut through thick deposits of glaciofluvial and glacial till, resulting in oversteepened valley scarps and narrow terraces along the valley sides (Maynard, 1995). The floodplain of Chapman Creek is narrow, which means that the stream is highly connected with slope processes above the channel. Tributary streams of Chapman Creek are steep (gradient > 60%) and bouldery.

Similar to Chapman Creek, the middle and lower reaches of Gray Creek are incised into glaciofluvial and till deposits. The channel is relatively steep and confined by steep slopes through the middle reaches. Stream gradient and hillslope connectivity decrease along the upper reaches as Gray Creek extends towards the Tetrahedron plateau.

A summary of reach characteristics for Chapman and Gray Creeks is provided in Table 5.9. The reach characteristics include approximate channel width and gradient, channel type and pattern, hillslope-channel coupling and riparian vegetation characteristics.

5.3.2 Historic Air Photo Assessment

Air photos ranging from 1946/47 to 1998 were compared to provide an assessment of past channel changes. A similar comparison was completed by D. Hogan, Ministry of Forests (unpublished data) who compared channel conditions in 1997 to the conditions reported by E. Karanka (1974) using low-level helicopter imagery.

Figure 5.4 Longitudinal Profiles of Chapman and Gray Creek

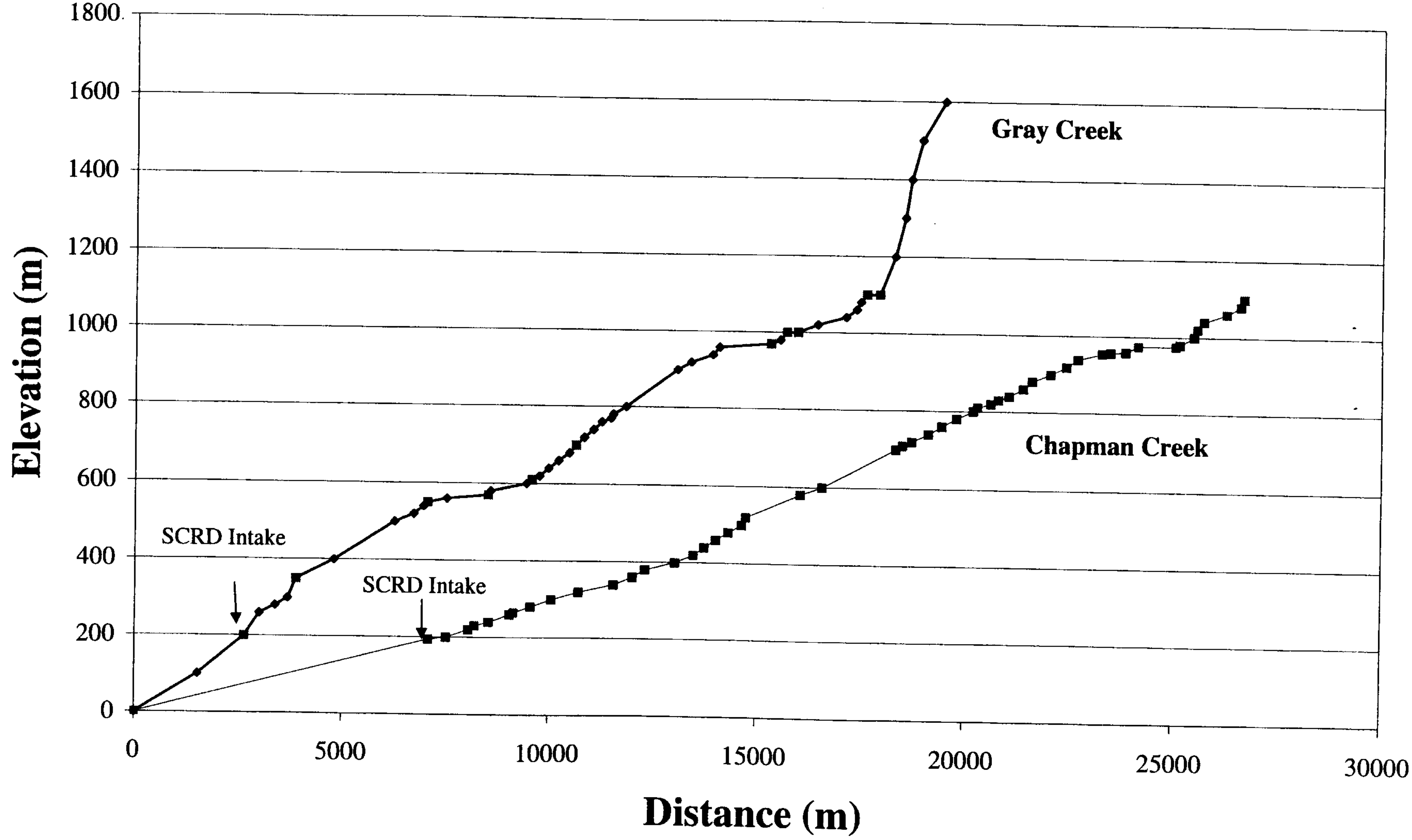


Table 5.9 Reach Characteristics for Chapman and Gray Creeks

Reach No.	Length (m)	Approx. Width (m)	Avg. Gradient (%)	Channel Type and Pattern	Hillslope-Channel Coupling	Riparian Vegetation Type & Stand Structure	Riparian Logging (y/n)	Role of Riparian Vegetation on Stability
Chapman Creek								
1a	860	20	<2%	RPg - sinuous	None, incised in fan	Mixed/Deciduous - Young Forest/Pole Sapling	private land dev.	moderate to high
1b	720	20	<2%	RPc - sinuous	None, incised in fan	Mixed/Deciduous - Young Forest/Pole Sapling	private land dev.	moderate
1c	1000	20	<2%	RPg/c - sinuous	Direct	Mixed/Deciduous - Young Forest/Pole Sapling	private land dev.	low
1d	1137	20	<2%	RPc /R - sinuous	Direct	Mixed/Deciduous - Young Forest/Pole Sapling	private land dev.	low
2	1744	15	2	RPc to CPb - sinuous	Direct	Mixed/Deciduous - Young Forest	yes	low
3	770	15	5	RPc/R - sinuous	Direct	Deciduous/Mixed - Pole Sapling/Young Forest	yes (partial)	low
4a	2100	20	4	RPc - sinuous	Direct	Mixed/Deciduous - Young Forest/Pole Sapling	y (RB - pre-1946) (LB- more recent)	moderate
4b	960	25	4	CPb - sinuous to braided	Direct	Mixed	yes	moderate
4c	4160	20	4	RPc/b / R - sinuous	Direct	Mixed	y (pre-1946)	moderate to high
5a	1290	15	8	RPc/b - sinuous	Direct	Mixed/Coniferous	y (pre-1982)	moderate
5b	1265	25-50	5	RPc/b - sinuous	Direct	Mixed	y (pre-1967)	high
5c	2490	30	5	RPc/b - sinuous	Direct	LB- Coniferous; RB - Deciduous	y (pre-1967)	moderate to low
5d	1800	15-20	6	RPc/b - sinuous	Direct	Coniferous - Young Forest	y (pre-1982)	moderate to low
5e	505	20	4	RPc/b - sinuous	Direct	Coniferous - Mature Forest	y (pre-1982)	low
5f	2500	15	5	RPc/b - sinuous	Direct	Coniferous - Mature Forest	no	low
6a	800	variable	2	marshy	None	Coniferous - Mature Forest	no	low
6b	Chapman Lake		-	CHAPMAN LAKE		Coniferous - Mature Forest	no	low
6c	417		6			Coniferous - Mature Forest	no	low
7a	215		17			Coniferous - Mature Forest	no	low
7b	lake		4			Coniferous - Mature Forest	no	low
7c	420		10			Coniferous - Mature Forest	no	low
7d	556					Coniferous - Mature Forest	no	low
7e	460					Coniferous - Mature Forest	no	low
7f	580					Coniferous - Mature Forest	no	low
Gray Creek								
1		10-15	3	RPg/c to CPb - sinuous	Direct	Mixed - young forest	yes (pre 1950)	high
2a		20	5	CPb - sinuous	Direct	Mixed - young forest	yes (1980s)	moderate
2b		15	5	CPb - sinuous	Direct	Mixed - young forest	yes	moderate
3a		15	8	RPg/c-w - sinuous to braided	Direct	Deciduous - young forest	yes	moderate to high
3b		15	8	RPc/b - sinuous to braided	Direct	Deciduous - young forest	yes	moderate
4a		10-15	10	SPb/r - sinuous	Direct	Mixed - young forest	no	moderate to high
4b		15-20	8	RPc/b to CPb - sinuous	Direct	Mixed - young forest	yes	low to moderate
5		10-15	7	RPg-w - sinuous to braided	Direct to Indirect	Coniferous - Mature Forest	no	low

Note: Reach characteristics are based on 1996 air photos (approx. 1:5,000 scale) and are, therefore, approximate.

Bankfull Width - the width of the water surface at bankfull stage which occurs just prior to flooding when the brim-full channel overflows with no banks exposed (Hogan, et al, 1996)

Channel Type -
RPg - gravel, riffle-pool
RPc - cobble, riffle-pool
CPb - boulder, cascade-pool
SP - step-pool
/R - bedrock substrate

Hillslope-Channel Coupling - indicates the connectivity between the hillslopes and the channel. Coupling may be direct, indirect or none,

LWD - Large wood depending on the width of the floodplain.

Chapman Creek

The earliest available air photos for Chapman Creek (1946) indicate that, at that time, streambank logging had occurred in the lower watershed, above and below the current location of the SCRD intake. Yarding across Chapman Creek, up steep valley slopes, and along tributary gullies for short distances, had induced some soil disturbance and slope failures. Streambank disturbance and logging of riparian vegetation resulted in lateral instability immediately upstream from the old Canfor Road bridge (in Reach 4a). The upper extent of valley logging in 1946 was just upstream from Reach 4c/5a (approx. 2.6 kilometers upstream from the intake). At this time there was no forestry activity in the upper watershed and the incidence of naturally occurring landslides was low.

By 1967, logging had proceeded to mid-elevations of the Chapman Creek watershed, including the E300 Road area. Road and cutblock related landslides, including the large "sand gully" failure, are now clearly visible on the air photos. Many of the landslides directly impacted Chapman Creek. Streambank logging and channel disturbance occurred along Reaches 5b and 5c.

The 1982 air photos indicate that although harvesting has generally avoided areas which are now designated protected (Tethrahedron Provincial Park), extensive forest harvest in the upper watershed has now occurred. Landslides in the E300 Road area have extended. Some channel reaches, particularly at the lower end of the watershed appear have started to stabilize, but upper reaches, adjacent to more recent logging, appear to be disturbed and slightly widened but not highly aggraded.

In 1996, 1:5,000 scale low-level air photos were flown along the mainstem channel of both watersheds. These photos indicate that the Chapman Creek mainstem channel appears to be greatly recovered and stabilized. Many streamside sediment sources are now revegetated and riparian vegetation, where it was previously cleared, has recovered as stands dominated by deciduous trees and shrubs, or mixed deciduous and coniferous vegetation. Vegetated mid-channel and lateral bars within the channel also indicate an increased stabilization. By this time, road deactivation and landslide rehabilitation activities had addressed road-related slides along Reaches 5a-d, previously logged to the streambank.

Direct sediment delivery to Chapman Creek in the past has resulted in localized channel aggradation. Since the channel is generally confined between steep valley slopes, there is little room for lateral channel movement, so much of the very coarse sediment remains in place. Due to the high stream energy, fine-textured sands and silts are easily transported downstream.

Gray Creek

The earliest air photos (1947) show that forest harvesting along Gray Creek extended from the mouth of the creek to the middle reaches (approx. 3.4 km upstream from the water intake). No riparian buffer was retained. Several landslides occurred along the steep glaciofluvial terrace slopes, contributing sediment directly to the creek. Stream channel disturbance, attributed to skidding logs across the stream, was fairly localized and had resulted in some local channel aggradation. The upper watershed was unlogged in 1947 and the channel appeared stable at this time.

Between the mid-1940s and the early 1970s, forest harvest activities extended to include much of the upper (plateau) portion of the watershed and often included riparian forest. Logging activities within the upper watershed have resulted in few channel and sediment impacts. This may be attributed to short, low gradient slopes and thin soils in the upper watershed. Compared to Chapman Creek there have been much fewer road and gully landslides. Appropriate road construction, combined with more-stable slopes, contributes to the improved watershed condition.

The low-level 1996 air photos indicate that the logged areas adjacent to the creek, upstream from the water intake, have recovered. However, recent slope failures from the 100 series road system above the left bank have resulted in direct sediment impacts. The 1996 air photos also indicate that the G1-5 sub-basin is a significant contributor of flow and is also a source of sediment to Gray Creek. ECA values are high (31%) in this sub-basin and landslides originating from cutblocks and roads along this tributary have contributed to the sediment load of Gray Creek.

5.3.3 Channel Stability Assessment

For each reach, sediment supply phase and notable sediment sources are identified. Lateral stability, trends in channel stability, and the role of riparian vegetation on stability are interpreted. An overall rating of channel stability is then provided and summarized in Table 5.10. The results indicate that downstream from the SCRD intake on Chapman Creek, the channel is stable with a considerable number of streambank sediment sources where the stream has deeply incised glaciofluvial and glaciolacustrine sediments. Upstream from the intake, reaches 4a to 5e (total length of 14.6 km) appear to have a slightly aggraded condition (A1). For these reaches, the aggraded condition may be attributed to past sediment inputs from local sources and direct streambank

Table 5.10 Channel Stability Assessment for Chapman and Gray Creeks

Reach No.	Channel Type and Pattern	Sediment Supply Phase and Notable Sediment Sources	Lateral Stability	Role of Riparian Vegetation on Stability	Trends in Channel Stability	Current Channel Stability Rating	Channel Sensitivity to Hydrologic Changes
Chapman Creek							
1a	RPg - sinuous	depositional, streambank sed sources	dyking limits streambank erosion	moderate to high	increase in stability	D1	moderate to high
1b	RPc - sinuous	depositional, streambank sed sources	stable (streambank sources of sediment)	moderate	increase in stability	S	low
1c	RPg/c - sinuous	depositional, streambank slides and sed sources	relatively stable (streambank sources of sediment)	low	increase in stability	S	low
1d	RPc /R - sinuous	transport	stable	low	no change	S	low
2	RPc to CPb - sinuous	depositional and transport	stable, bedrock control	low	no change	S	low
3	RPc/R - sinuous	transport	stable, bedrock control	low	no change	S	low
4a	RPc - sinuous	transport	moderately stable, minor areas of channel widening and deposition	moderate	slight decrease in stability	A1	low
4b	CPb - sinuous to braided	depositional	moderately stable, some historical channel disturbance	moderate	increase in stability	A1	low
4c	RPc/b / R - sinuous	depositional	moderately stable, past disturbance	moderate to high	increase in stability	A1	moderate
5a	RPc/b - sinuous	depositional, major sed. sources on left bank	laterally unstable since early 1980s, disturbed stone lines and pools	moderate	increase in stability	A1	low
5b	RPc/b - sinuous	depositional, sand gully and slides from RB	moderately unstable, channel widening, channel disturbance in 1960s	high	increase in stability	A1	moderate
5c	RPc/b - sinuous	depositional, road-related sed sources	moderately stable, some channel widening, becoming more stable	moderate to low	slow stabilization	A1	moderate
5d	RPc/b - sinuous	depositional, tributary sed. sources and streamside sources	moderately stable, some channel widening and lateral instability	moderate to low	increase in stability	A1	low
5e	RPc/b - sinuous	depositional	moderately stable, vegetated bars indicates recovery	low	increase in stability	A1	low
5f	RPc/b - sinuous	depositional	stable	low	stable	S	low
6a	marshy	wetland	stable	low	stable	S	low
6b	CHAPMAN LAKE	-	-	-	-	-	-
Gray Creek							
1	RPg/c to CPb - sinuous	depositional, streambank sed sources	moderately stable	high	stable	S	low, relatively confined by stable banks
2a	CPb - sinuous	transport, road-related slides on left bank	moderately stable	moderate	increasing stability	S	low
2b	CPb - sinuous	transport	moderately stable	moderate	increasing stability	S	low
3a	RPg/c-w - sinuous to braided	depositional	stable	moderate to high	increase in stability	S	low
3b	RPc/b - sinuous to braided	depositional	stable	moderate	increase in stability	S	low
4a	SPb/r - sinuous	depositional	stable	moderate to high	stable	S	low
4b	RPc/b to CPb - sinuous	depositional, tributary sed. sources and streambank instability	stable	low to moderate	stable	S	low
5	RPg-w - sinuous to braided	depositional, low-gradient	stable	low	stable	S	low

Note: Channel characteristics are based on 1996 air photos (approx. 1:5,000 scale) disturbance, and is less likely to be attributed with cumulative hydrologic effects of upslope harvesting.

Observed disturbance indicators that are typical of slightly aggraded boulder cascade-pool stream channels include: disturbed stone lines and infilled pools, and a lack of functioning woody debris. These reaches have exhibited significant increases in stability from a severely disturbed, or highly aggraded, state. Channel conditions, observed in Chapman Creek, confirm the results of previous assessments that indicate that stream stabilization over the past 25 years has resulted in a reduced bar extent, increased number and depth of pools, restructured stone lines, and revegetation of diagonal riffles and streambanks (D. Hogan, unpublished data).

The results of the channel assessment, summarized in Table 5.10, for Gray Creek indicate that the channel is relatively stable. Channel disturbances, for Gray Creek, have never been as extensive as for Chapman Creek. This may be attributed to the much lower degree of sedimentation from adjacent hillslopes and the smaller amount of streamside logging activity in the past.

Stream channel sensitivity, or susceptibility to disturbance is an estimate of the likely effect of peak flow changes or sediment input. It is an assessment that is based on the past stream channel response to forest harvest activities and stream channel characteristics such as gradient, substrate and streambank composition. For example, low-gradient reaches on floodplains comprised of loose, unconsolidated sands and gravels are more sensitive to changes and hydrology and/or sediment load. It is estimated that both Chapman Creek and Gray Creek are not particularly sensitive to hydrologic or sedimentation changes due to stream gradient, substrate materials and degree of confinement. Chapman and Gray Creeks are fairly steep, bouldery streams that are relatively confined. Past sediment inputs are typically coarse-textured and have resulted in localized aggradation of the channel. Fine-textured sediments such as fine sand, silt and clay wash out fairly quickly, resulting in minimal disturbance to channel morphology.

5.3.4 Channel Impact Potential Associated with Proposed Cutblocks

The channel impact potential is the likelihood that proposed harvesting would result in changes in stream channel morphology. For this assessment the stream impact potential is the combination of the Sedimentation Hazard (determined in Section 5.2) and the sensitivity of the mainstem channel, downstream from the proposed blocks, to hydrologic change or sediment inputs. The potential for stream channel impacts on Chapman and Gray Creek, resulting from each individual proposed cutblock is found to vary and effects are more likely to be apparent along reaches with a higher susceptibility to disturbance.

Due to the low sensitivity of downstream reaches, the stream impacting potential is high only for individual cutblocks, or in most cases small portions of the proposed cutblock, that are situated in areas having a high landslide hazard potential. Opening No.'s 203, 40, 43, and 44 in Chapman Creek and Opening No. 148 in Gray Creek have the potential to impact downstream reaches, therefore TSFAs are recommended. Management considerations should ensure that potential sediment routings to the stream are minimized.

5.4 Riparian Assessment Results

Results of the riparian assessment indicate where past riparian logging has occurred and where it has resulted in channel impacts. Impacts related to the loss of vegetation in the riparian management areas, as defined by the Forest Practices Code, include a loss of streambank stability, sedimentation, and a diminished supply of large woody debris for fish and wildlife.

Results of a riparian assessment completed for Chapman and Gray Creeks by EVS Environment Consultants (1999) are summarized as follows:

- twenty-one (21) impact sites were identified on Chapman Creek and two (2) impact sites were identified on Gray Creek. Riparian impacts were identified as landslides, bridge crossings, and streambank erosion;
- site-level rehabilitation prescriptions were developed for eight (8) sites on Chapman Creek and two (2) sites on Gray Creek;
- in 1999, bioengineering was completed for one (0.2 ha) site along Chapman Creek upstream from the upper bridge crossing. Work priority should be reevaluated for other identified sites for which prescriptions were developed.

In addition to these above-mentioned impacts, logging in riparian areas may impair riparian function, or the ability to provide: large woody debris, stream shading, channel stability, and wildlife and general biodiversity attributes. Using air photos and forest cover maps, harvested areas are identified and categorized by vegetation type based on the structural stage of the stand and the tree type.

The results of the assessment are summarized in Table 5.11 and provided in detail in Appendix C. The results indicate that all sub-basins of Chapman Creek and all but sub-basins G1-1 and G1-2, located in the Tetrahedron Provincial Park have a high degree of past riparian logging (i.e. > 40% of total stream length has been logged). A total of 16.9 km (72%) of the total length of stream within the Chapman Creek watershed, and 11.5

km (64%) of stream within the Gray Creek watershed has been historically logged to the streambank. Much of the logged areas have now recovered and stands have reached the young-forest structural stage that is typical of young second growth forest. These stands typically lack old growth forest characteristics and, thus are somewhat limited in providing wildlife and general biodiversity attributes. However, the second-growth stands do provide cover and streambank stability.

Where logging has occurred more recently (pre-Code), riparian areas where logging has occurred remain impacted. Table 5.11 indicates the length of stream where current riparian function is limited according to 1996 and 1998 air photos. These are areas where the riparian forest is considered to be at a pole-sapling or young-forest structural stage and/or where streambank disturbances have resulted in a loss of riparian function.

The results indicate that along the Chapman Creek mainstem, there is 3.8 km of impacted riparian vegetation. One short section (1 km) is situated on the lower Chapman Creek in the vicinity of the SCRD intake and is associated with nearby land clearing, roads, and intake structures. The remaining 2.8 km of impacted riparian forest are located at the upper reaches of Chapman Creek and are associated with streambank/hillslope failures and pre-Code (circa 1980s) logging. Streambank logging along the tributary streams in the upper Chapman Creek watershed has impacted the forest and has contributed to several slope and gully failures. The forest along these tributaries, logged in the 1980s, is recovering.

Based on this and previous assessments of riparian impacts in the study watersheds, there may be opportunities to enhance old growth attributes in the riparian reserve zone. Detailed riparian assessments should be considered for approximately 17 km of Chapman Creek and 11.5 km of Gray Creek.

5.4.1 Riparian Impact Potential Associated with Proposed Cutblocks and Roads

The riparian impact potential is the relative likelihood that activities proposed under the current development plan and regulated by the Forest Practices Code Act will impact riparian vegetation. Riparian management area (RMA) width is determined by the stream class, which is dependent on width and varies from S1 to S4 in a community watershed.

In most cases there is little potential for riparian impact where proposed blocks lie outside the RMA. There is a moderate potential for riparian impact where proposed logging crosses or is immediately adjacent to a stream, lake, or wetland. Field verification and detailed (1:5,000 scale) mapping of each cutblock to identify and classify all affected water courses and to ensure that RMA widths meet FPC requirements.

To ensure long-term stability of the RMA, it is recommended that windthrow assessments be completed before harvesting in the Riparian Management Zone. It is also recommended that narrow road widths be constructed when crossing riparian areas.

Table 5.11 - Riparian Logging in Chapman and Gray Creek Watersheds

Watershed – Sub-Basin	**Stream Length where past logging did not meet current RMA requirements (km)**	**Stream Length where current* riparian function is limited**
	Chapman Creek	
C-3	11.3 km	3.7 km
C-2	1.6 km	1.3 km
C3-1	1.1 km	1.1 km
C3-2	1.5 km	1.6 km
C3-3	1.4 km	1.5 km
Total Chapman Creek	16.9 km	9.2 km
	Gray Creek	
G1-1	0 km	0 km
G1-2	0 km	0 km
G1-3	0.4 km	0.4 km
G1-4	4.2 km	0.9 km
G1-5	3.0 km	0.3 km
G1-6	3.9 km	0.9 km
Total – Gray Creek	11.5 km	2.5 km

* Note: Riparian vegetation assessment is based primarily from 1996, 1:5,000 scale air photos

6.0 SUMMARY OF RESULTS

6.1 Watershed Report Card

A Watershed Report Card is prepared for each watershed (Table 6.1 and 6.2). The report card summarizes some of the key measures of watershed condition and provides a summary assessment of hazard level for peak flow, sedimentation, channel impact, and riparian impact.

Table 6.1 - Chapman Creek Watershed Report Card

	Current Condition (2000)	**Proposed Condition (FDP)**
Equivalent Clearcut Area (%) (Interim Method, 1999)	16.4%	14.2%
Length of road and total road density (km, km/km^2)	37.3 km, 0.67 km/km^2	37.3 km, 0.67 km/km^2
PEAK FLOW HAZARD	**LOW**	**LOW**
Length of deactivated road (km)	56 km (60%)	70.4 km
Total number of forestry-related landslides	225	-
Total number of landslides, point source of sediment that have directly impacted the stream	78	-
Length of High Hazard Road	1.1 km	-
LANDSLIDE HAZARD	**MODERATE**	**LOW**
Length of mainstem stream with disturbed stream channel (km, %)	14.6 km	-
STREAM CHANNEL IMPACT HAZARD	**MODERATE**	**LOW**
Length of mainstem stream with impacted, non-functional riparian forest (km, %)	9.2 km	-
RIPARIAN IMPACT HAZARD	**MODERATE**	**LOW**

Table 6.2 - Gray Creek Watershed Report Card

	Current Condition (2000)	**Proposed Condition (FDP)**
Equivalent Clearcut Area (%) (Interim Method, 1999)	22.8%	16.8%
Length of road and total road density (km, km/km^2)	67.6 km, 1.56 km/km^2	69.7 km, 1.62 km/km^2
PEAK FLOW HAZARD	**LOW**	**LOW**
Length of deactivated road (km)	23.5 km	-
Total number of forestry-related landslides	12	-
Total number of landslides, point source of sediment that have directly impacted the stream	10	-
Length of High Hazard Road	3 km	-
LANDSLIDE HAZARD	**LOW**	**LOW**
Length of mainstem stream with disturbed stream channel (km, %)	0 km	-
STREAM CHANNEL IMPACT HAZARD	**LOW**	**LOW**
Length of mainstem stream with impacted, non-functional riparian forest (km, %)	2.5 km	-
RIPARIAN IMPACT HAZARD	**LOW**	**LOW**

6.2 Conclusions

Based on the results of the watershed assessment, the hydrological risks of future harvesting and road construction are concluded as follows:

- there is no question that the watershed has been impacted by past forestry activities. Most of the impacts are related to mass wasting and are the result of large-scale progressive clearcutting, poor road construction and maintenance, and severe ground and stream channel disturbance. Since the mid-1990s extensive road deactivation activities have occurred. These activities, including the revegetation of sediment contributing landslides and road stabilization, combined with natural recovery, have reduced the long-term risk of impact to water quality. Although Gray Creek has not experienced the same sort of terrain hazard response from past forestry activities as Chapman Creek, both watersheds have experienced a dramatic recovery over the past decade.

- low flows between July and October are a major concern for both the SCRD and DFO. Chapman Creek is often not able to meet fisheries flow requirements downstream from the domestic water supply intake. It is very unlikely that flow volumes have, in the past, been affected by forest harvesting activities in the watershed. Nor is the volume of water or the magnitude of peak flows likely to be affected by the proposed development.

- approximately 165 ha are proposed for harvest in the Chapman Creek watershed and 78 ha are proposed for harvest in the Gray Creek watershed. Proposed harvesting will not significantly affect current Equivalent Clearcut Area (ECA) levels, which are currently 12% for Chapman Creek and 14.3% for Gray Creek (calculated using R. Hudson's Regional Method, 2000). Elevated ECAs in several sub-basins will limit future harvesting opportunities. Harvesting in sub-basins C3-1, C3-2, and C3-3 in the Chapman Creek watershed should not be considered until ECAs drop below 20%. Harvesting in sub-basins G1-2 and G1-5 in the Gray Creek watershed should not be considered until ECAs drop below 30%.

- the Chapman and Gray Creek mainstem channels, upstream from the intakes, are fairly steep, bouldery streams that are relatively confined. Although the channels have been disturbed in the past by landslides and by streamside harvesting, the channel morphology has noticeably recovered. Fine-textured sediments, delivered to the stream by discrete landslide events and by chronic erosion of exposed surfaces, are transported through the system quite quickly and contribute to short duration turbidity events.

- water quality concerns expressed by the SCRD are associated with turbidity, total organic carbon, and colour. Identified sources of turbidity include discrete sources such as landslides, chronic sources such as streambanks, and organic sources. Mitigating activities proposed in this watershed assessment, combined with those required under the Forest Practices Code, will reduce the likelihood for landslides. Proposed harvesting and road building activities would not likely have an effect on chronic and organic sources of turbidity. By retaining vegetated buffers to all streams, lakes, and wetlands in the watershed, proposed harvesting activities are not expected to impact total organic carbon concentrations, and likewise, will not affect water colour.

On the basis of this study, it is concluded that limited forest harvesting activities can take place in both the Chapman Creek and Gray Creek watersheds without degrading water resource characteristics if conducted in a manner reflecting the sensitivity of the watershed. Both watersheds are heavily relied upon to supply a minimum quality and quantity of water that meets both public need for consumption as well as for valuable fish species present in the systems. Proposed harvesting operations must be sensitive to these values.

To minimize deleterious impacts on the water resource, recommendations for hazard mitigation, provided below, must be followed as part of the Forest Development Plan approval process.

7.0 FOREST DEVELOPMENT PLAN RECOMMENDATIONS

7.1 Recommendations for Hazard Mitigation

Forestry activities in the Chapman and Gray Creek watersheds are legislated by the Forest Practices Code. Should a higher-level plan, such as the IWMP, be approved then specific management practices not included in the Code may be adopted. Based on the requirements for a clean water supply, combined with heightened community involvement, there is a necessity to adopt practices beyond that which is required under the Code, provided there is some rationale for additional requirements.

Recommendations for hazard mitigation are summarized as follows:

- minimize soil disturbance. Use harvesting methods compatible with terrain and soil conditions. Special precautions to minimize site degradation during forest development are recommended for:
  - organic soils, since organic material comprises a considerable proportion of the measured turbidity; and
  - silty-sand textured glaciofluvial moraine deposits, since these soils are most likely to have a high surface erosion potential.
- reduce the likelihood of initiating a landslide, or other mass wasting processes by:
  - completing terrain stability field assessments for cutblocks, roads, and excavated or bladed trails, on slopes greater than 50% regardless of terrain class, and where they are situated on Class III to V terrain;
  - limiting ECAs to 20% on areas located above Class IV and V terrain, where stability mapping is complete, or above slopes greater than 50%;
  - all new, or replaced, drainage structures must be designed for the 100-yr instantaneous peak flow. Use historic flow records to size culverts and/or use past performance of other culverts on the same stream to help determine size. On channels affected by debris flows, culvert design should be based on the maximum debris flow, rather than the water flow. During construction of all stream crossings guidelines for drainage structures in community watersheds should be followed (Forest Practices Code, 1996);
  - assess all streams and gullies after harvesting for the removal of introduced debris, slash or soils; and
  - establish a regular maintenance plan for all drainage structures. Inspections should be conducted at least twice per year (prior to spring runoff and to fall rains) and after unusually heavy floods or unexpected events.
- reduce the risk of introducing sediment to streams. Suggested means of reducing the risk are to:
  - Restrict activities to the dry season and follow rainfall shut-down guidelines during storms;

    - Install silt fencing, hay bales, detention ponds, or similar measures to reduce stream sedimentation at stream crossings during road construction; and
    - Grass seed exposed soil surfaces concurrently with road construction.
- maintain the current water quality and quantity monitoring program at the SCRD water intake. Water quality parameters should include, but not necessarily be limited to: turbidity, total organic carbon, total suspended solids and should be recorded at least on a monthly basis during the wet season (November to June). Turbidity monitoring should also be undertaken on the stream receiving runoff from harvesting or road building activities.
- distribute copies of the Emergency Response Plan, developed for the IWMP document to all operators within the watershed; and
- ensure that a forested, windfirm riparian buffer (minimum width 20 m) be maintained along all perennial streams, wetlands and lakes.

To further mitigate the risk of on-going forest harvest activities recommended restoration opportunities are identified. These include:

- conduct a systematic inspection and complete maintenance activities on several bioengineering projects in the Chapman Creek watershed.
- complete landslide rehabilitation prescriptions for two slides located along upper Gray Creek; and
- complete road deactivation prescriptions for the 100 Road system in the Gray Creek watershed.

7.2 Recommendations for CWAP Update

Under the Forest Practices Code, it is recommended that if forest development activities proceed in the Chapman and Gray Creek watersheds, the CWAP should be updated every three years. If no additional development occurs within the three year period then it is recommended that the watershed assessment be updated only when it is again proposed (i.e. on the 2005-2010 development plan). The update will provide a watershed status report and will provide an opportunity to re-evaluate the potential effects of proposed development activities.

7.3 Recommendations for Further Research

Data gaps, identified by the watershed assessment, provide opportunities for further research and would provide additional detailed information that would be useful for on-going watershed management. Suggested opportunities include:

- develop an effectiveness monitoring program to determine the relative success of road deactivation and landslide rehabilitation activities;
- conduct a detailed and updated analysis of the timing, magnitude, and nature of peak flow events and of smaller (5 to 10-yr flows) events using the extended period of

record. It may also be useful to include a comparison of flows in an adjacent and similar watershed;

- complete soil surface erosion hazard potential mapping, and interpret the "potential for landslide debris to enter streams" and the "risk of sediment delivery to streams" as required under the Forest Practices Code; and
- continue the water quality and quantity monitoring program.

8.0 CLOSURE

Services performed by EBA for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practising under similar conditions in the jurisdiction in which the services are provided. Professional judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the results, comments, recommendations, or any other portion of this report.

Respectfully submitted,

EBA ENGINEERING CONSULTANTS LTD.

Prepared by:

J.A. CLARKE
25319
12/12/00

Jennifer Clarke

Jennifer Clarke, M.Sc., P.Geo.
Geomorphologist

Reviewed by:

Brian Adeney, P.Eng
Senior Water Resources Engineer

\\VAN1\DATA\0801-FOR\PROJECTS\2000\00-81516\report\final - diskette\81516-CHAPMAN-GRAY-CWAP-FINAL.doc

REFERENCES:

Carson, B. 1999. Cumulative Summary Report – Watershed Monitoring Program for Chapman and Gray Creek (1995 through 1999). Submitted to International Forest Products Ltd. April, 1999. Roberts Creek, B.C.

Chapman, A. and D. Rekston. 1991. Chapman Creek Hydrology – Data Summary and Analysis. Ministry of Environment, Water Management Division, Hydrology Section. Victoria.

EPA, 1986. Quality Criteria for Water:1986. U.S. Environmental Protection Agency, Off. Water Regulations and Standards. Washington, DC, 41 p.

EVS Environment Consultants Ltd. 1999. Chapman/Gray Creek – Overview Fish Habitat and Riparian Assessment. Prepared for the Ministry of Environment, Lands and Parks, Surrey. February, 1999. North Vancouver, BC.

Forest Practices Code. 1995. Riparian Management Area Guidebook. Forest Practices Code. Ministry of Forests and Ministry of Environment, Lands and Parks. Victoria, BC.

Forest Practices Code. 1996. Community Watershed Guidebook. Forest Practices Code. Ministry of Forests and Ministry of Environment, Lands and Parks. Victoria, BC.

Friedman, R.M., J.W.H. Monger and H.W. Tipper. 1990. Age of the Bowen Island Group, Southwestern Coast Mountains, British Columbia. Canadian Journal of Earth Sciences, Vol. 27, pp. 1456-1461.

IWMP. 1998. Chapman and Gray Creeks Integrated Watershed Management Plan. Prepared by the Chapman and Gray Creeks Integrated Watershed Management Planning Team.

Karanka, E.R. 1974. Channel Morphology and Processes of Chapman Creek. E.L.U.C. Secretariat, Resource Analysis Unit, Victoria, British Columbia.

Lewis, T. 1996a. Proposed Area 204, Chapman Creek, Sechelt Operation. TSA Report prepared on September 27, 1996 for International Forest Products, Sechelt. Courtenay, B.C.

Lewis, T. 1996b. Proposed Area 172, Chapman Creek, Sechelt Operation. TSA Report prepared on September 30, 1996 for International Forest Products, Sechelt. Courtenay, B.C.

Maynard, D. 1995. Terrain, Terrain Stability and Sedimentation Potential Mapping of the Chapman / Gray Creek Chart Area. Prepared for International Forest Products Ltd., Sechelt. D. Maynard and Associates Ltd. January, 1995. North Vancouver, BC.

MELP, 1998. Guidelines for Interpreting Water Quality Data. Version 1.0. Prepared by Ministry of Environment, Lands and Parks, LandData BC, Geographic Data BC for the Land Use Task Force. Resource Inventory Committee. Victoria, BC.

MELP. 1995. Approved and Working Criteria for Water Quality: 1995. Water Quality Branch, Environmental Protection Department. Victoria, BC.

Ministry of Forests. 1997. Table Interpolation Program for Stand Yields (TIPSY) Computer Program. Developed by MOF Research Brnach. Victoria, British Columbia.

Ministry of Forests. 2000. Sunshine Coast Timber Supply Area Timber Supply Review. Data Package. May, 2000.

R. Eliasen. 2000. Watershed Assessment (CWAP) for Chapman and Gray Creeks, Sechelt, BC. (letter to EBA Engineering as feedback to draft CWAP report). Prepared by Richarg Eliason, Habitat Engineering Technologist, Department of Fisheries and Oceans. Letter dated: November 3, 2000. Nanaimo, British Columbia.

Rekston, D.E. 1991. Hydrologic Impacts of Land-Use Change. In: C.H. Coulson (ed.) Manual of Operational Hydrology in British Columbia. BC Ministry of Environment, Water Management Division. pp. 207-234.

Summit Environmental Consultants Ltd. 1997. Hydrologic Analysis for the Chapman/Gray Chart Area. Volume 1: Text. Prepared for: International Forest Products Ltd. Vernon, B.C.

Thomson, B. 1987. Chapman Creek Landslide Inventory. Ministry of Environment, Lands and Parks. Victoria, BC.

Ziemer, R.R. 1998. Proceedings of the Conference on Coastal Watersheds: The Caspar Creek Story. May 6, 1998. Ukiah, California. General Technical Report PSW GTR-168. Pacific Research Station, Forest Service, USDA. Albany, California.

\\VAN1\DATA\0801-FOR\PROJECTS\2000\00-81516\report\final - diskette\81516-CHAPMAN-GRAY-CWAP-FINAL.doc

EBA Engineering Consultants Ltd.

December 12, 2000 EBA File: 0801-00-81516

International Forest Products Ltd.
#371 – 1180 Ironwood Road
Campbell River, British Columbia
V9W 5P7

Attention: Jeff Pollock, R.P.F. Area Engineer

Dear Mr. Pollock;

Re: Watershed Assessment (CWAP) for Chapman and Gray Creeks, Sechelt, B.C.

EBA Engineering Consultants Ltd. (EBA) is pleased to submit the final watershed assessment (CWAP) report for Chapman and Gray Creeks. Copies of the final report were distributed to all members of the Watershed Advisory Committee (WAC).

We trust that this now satisfactorily completes the project. It has been a pleasure working with you on this interesting project and we look forward to working together again in the future.

Yours truly,

EBA ENGINEERING CONSULTANTS LTD.

Jennifer Clarke

Jennifer Clarke, M.Sc., P.Geo.
Geomorphologist

cc. See distribution list attached.

Sun Life Plaza, Suite 550, 1100 Melville Street, Vancouver, British Columbia V6E 4A6
Tel: (604) 685-0275 - Fax: (604) 684-6241 Internet: vancouver@eba.ca - Web Site: http//www.eba.ca

Distribution List:

Jeff Pollock, R.P.F., Area Engineer
International Forest Products Ltd.
#371 – 1180 Ironwood Road
Campbell River, B.C.
V9W 5P7

Bob Patrick
Sunshine Coast Regional District
P.O. Box 800
Sechelt, B.C.
V0N 3A0

Keith Julius, Resource Officer
Sechelt Indian Band
P.O. Box 740
Sechelt, B.C.
V0N 3A0

Barry Miller, R.P.F.
Ministry of Forests,
Sunshine Coast Forest District
7077 Duncan Street
Powell River, B.C.
V8A 1W1

Derek Harbourne
Ministry of Forests,
Sunshine Coast Forest District
7077 Duncan Street
Powell River, B.C.
V8A 1W1

Scott Babakaiff, M.Sc., P.Geo.
Ministry of Environment, Lands and Parks
10470 – 152nd Street
Surrey, B.C.
V3R 0Y3

Drew Brayshaw, M.Sc. G.I.T.,
Water Resource Specialist
Water Management Branch
Ministry of Environment, Lands and Parks
46360 Airport Road
Chilliwack, B.C.
V2P 1A5

Blair Wriglesworth, R.P.F., Area Engineer
Weyerhaeuser, Stillwater Division
#201 – 7373 Duncan Street
Powell River, B.C.
V8A 1W6

Richard Eliasen
Department of Fisheries and Oceans
3225 Stephenson Point Road
Nanaimo, B.C.
V9T 1K3

Tim Adams
Coast Garibaldi Health
P.O. Box 1040
Sechelt, B.C.
V0N 3A0

Dave Nansen
Department of Fisheries and Oceans

APPENDIX A – Watershed Advisory Committee Meeting Minutes

Chapman/Gray Creeks Watershed Assessment (February 29, 2000)

Location: Ministry of Forests, Sunshine Coast Forest District,
Sechelt Field Office,
1975 Field Road, Sechelt, B.C..

Date: February 29, 2000

Start: 09:40 hrs.
Recorder: Barry Miller
Participants:

Mike Younie, Water Resource Specialist,	- Ministry of Environment, Lands and Parks; Water Management
Dave Crosby, Infrastructure Services,	- Sunshine Coast Regional District
Paul Thompson, Planner,	- Sunshine Coast Regional District
Blair Wriglesworth, Forester,	- Weyerhaeuser Company Limited, Stillwater Timberlands
Keith Julius, Resource Officer	- Sechelt Indian Government
Jeff Pollock, Area Engineer,	- International Forest Products Limited
Gerhard Pokrandt, Operations Manager	- International Forest Products Limited
Richard Eliasen	- Fisheries and Oceans Canada
Dave Nanson	- Fisheries and Oceans Canada
Jennifer Clarke	- EBA Engineering Consultants Ltd.
David Marquis	- EBA Engineering Consultants Ltd.
Barry Miller, Planning Forester	- Ministry of Forests, Sunshine Coast Forest District
Regrets	
Tim Adams, Environmental Health Officer	- Coast Garibaldi Health
Derrick Harborne, WRP Technician	- Ministry of Forests

1. **Introductions:** - made as per the above list of participants.

2. **WAP General Information:**

Mike Younie provided background information and justification for the 'watershed assessment procedure:

- The Coastal Watershed Assessment Procedure (CWAP) is a requirement under the Forest Practices Code.

to riparian recovery. RE and DN ask about alder stability vs. coniferous. This, and riparian management to promote conifer growth preferentially over alder, is discussed by all at some length. SB asks about water temperature. JC indicates there is little or no data but that she does not expect it to be a serious issue. RE notes that storage in the upper drainages (= lakes) controls temperature and minimizes variability.

12. JC introduces recommendations for hazard mitigation if harvesting is to occur – generally speaking these recommendations are "Code-plus", that is, more restrictive/intensive in nature than the FPC. Notes that the IWMP suggests TSFA's should be done on slopes >45%; she is suggesting 50% as a threshold primarily because few slides have been observed on slopes less steep than this. Recommends that the overdue surface erosion potential mapping be completed to current standards before any potential harvesting takes place, that ECAs be limited to 20% above that all drainage structures be designed for 100-year floods. RE notes that culverts that can pass 100-year floods may nevertheless become blocked by debris during smaller events and wash out. DB enquires about the 20% ECA recommendation – JC clarifies that this applies to each microcatchment above a terrain class IV or V polygon, so the sequence would be:
    - propose block above unstable polygon
    - determine catchment above unstable polygon
    - determine ECA for catchment
    - determine effect on ECA from proposed block
    - approve proposed block or not based on effect on ECA.

13. JC outlines recommendations for sediment control. DN asks about reserve zones on S5, S6 streams - JC notes that due to CWS status, minimum stream class is S4. S4 streams under the code have 20m RMZ, no RRZ; JC's recommendations include some reserve zone (site-specific determination) for perennial S4's (this is a Code-plus requirement.)

14. JC circulates updated Emergency Contact List for review and possible revision.

15. General discussion begins. BP asks about water quality & flow data – what is its source, who collects? Brian Carson has collected this data in the past & is still doing so; JC used data up to 1999. Again it was recommended that Brian Carson be retained for monitoring water characteristics, and in this discussion it was recommended that he address temperature and organic characteristics of the two watercourses (Chapman and Gray Creeks drainages). Sampling site is near hatchery, 7km downstream of SCRD intake. BP indicates he believes low flow data is of questionable validity, due to distance from SCRD intake and that Water Survey Gauge does not accurately record low flows, instead they are estimated below 15 cfs. Discussion of past vs. current locations of SCRD intake and Water Survey of Canada gauging site.

16. DH provides update on Watershed Restoration activities. Currently funded through FRBC, but funding is in flux. In the 2000-01 fiscal year, all Vancouver Forest Region watersheds are analysed together for prioritisation, whereas previously this was done by district. MELP and DFO are driving the assessment of which watersheds to target, the major criteria are WQ and fish habitat. If neither is threatened, there is little money for more upslope work or road deactivation. That said, however, most of the restoration work which needed to be done in Chapman & Gray has been done, and monitoring of its effectiveness is

- The 1995 Coastal Watershed Assessment Procedure Guidebook has been replaced with an April 1999 revision.
- The recommendations generated by a CWAP are operational in nature, intended to assist industrial licencees conduct operations in ways that will not jeopardize water characteristics (quality, quantity and timing of flows).
- The CWAP has 6 components;
  1. The watershed advisory committee
  2. Compilation of existing information --- by the hydrologist
     e.g. - aerial photography, topographic maps, forest development plan maps, forest cover maps and reports (to assist with determination of equivalent clearcut area <ECA>), terrain instability reports, etc.
  3. Field assessment --- by the hydrologist
     - peak flows and hydrological recovery
     - sediment source survey
     - reconnaissance channel assessment procedure
     - riparian assessment
  4. Watershed report card --- by the hydrologist
     - % of watershed harvested, corrected for ECA
     - ECS by important elevation bands
     - total road density (km/km2)
     - length of road as High sediment source
     - number of landslides entering streams
     - length of road on unstable terrain
     - etc.
  5. Watershed report --- by the hydrologist
     - a characterization of the watershed, specific recommendations and conclusions
  6. Forest development plan recommendations --- by the hydrologist

3. Background Information:

A. Sunshine Coast Regional District (SCRD) - by Dave Crosby and Paul Thompson

1. Future Water Consumption / Treatment

The new Board of Directors for the Sunshine Coast Regional District passed a motion (copy attached) in January (of this year) declaring that the Board is 'not in favour of logging in designated community watersheds or watershed reserves'.

Mike Younie explained that a "watershed reserve" is a designation under the Land Act that triggers a referral process of any proposed industrial development to various parties for review and recommendation. The "watershed reserve" designation is not a protection from industrial activity.

The Chapman Creek drainage services 85% of the SCRD, including some of the water requirements of Gibsons. Earl's Cove and Irvine's Landing have independent water supplies. At times, during the summer months when there is an increase in population on the "Sunshine Coast", Gray Creek is drawn upon to augment supply of water to residents living in Sechelt, Sandyhook and Tuwanek. Gray Creek provides 3% to 5% of the total Chapman/Gray Cks. water delivery.

The SCRD's Infrastructure Services Department recommended to the Board of Directors that a floating pump station be established on Chapman Lake in order to meet peak demands.
B.C. Parks was supportive of the recommendation, saying that Chapman Lake and the area immediately surrounding the lake could be withdrawn from the Tetrahedron Park and established as another form of reserve in which water infrastructure development would be permitted. However, the Board had directed the Infrastructure Services Department to consider other options (e.g. alternative sources of water) but has not put this project on hold.

Richard Eliasen expressed his consternation that a "low flow agreement" has yet to be established between the SCRD and the DFO (Department of Fisheries and Oceans). Richard stated that after 9 years of negotiations with the SCRD agreement has not been reached --- a "low flow agreement" is essential, and the pump would provide the necessary water. As it stands now, the SCRD is open to charges under the federal Fisheries Act.

2. Recent Water Quality

Water quality appears to have somewhat improved over the past years since the FRB (Forest Renewal B.C.) works were initiated and the SCRD installed a turbidity control valve on the Chapman Creek intake. Dave Marquis and Mike Younie stated that the CWAP should address the FRBC works and their effects on water characteristics.

Turbidity, consisting of both sediment and organics, is still a problem that is worse during November storm events as well as during spring melts. A turbidity control valve at the intake shuts off water during periods of high turbidity which can last up to 12 hours. Storage of water at this time of year is approximately 2 days. Fortunately, turbidity events don't occur during the summer when the demand for water is at its highest --- the storage tank (with its limited capacity) would never be able to meet demand should a summer turbidity event occur.

A membrane-type filtering system, provided for a few months on a trial basis by Dayton and Knight Ltd., seemed to be quite successful; however, the cost was prohibitive. This technology may be considered for inclusion in the next 10 year waterworks update that is scheduled for 2000-2001.

The Infrastructure Services Committee of the SCRD will be looking at updating the SCRD's 10-Yr. Waterworks Plan.

It was noted that a mountain bike trail, running through private land held by Canadian Forest Products, was contributing silt (and at times a significant amount of silt) into Chapman Creek. **(Action:** EBA will address this issue in the CWAP.)

B. International Forest Products -by Jeff Pollock and Gerhard Pokrandt

1. Proposed Forest Development

All the cutblocks on Interfor's Chapman / Gray Cks. Forest Development Plan (FDP) are Category I ("Information) blocks only at this time. Within the Gray Creek drainage there are 6 blocks proposed, totalling 78 hectares in size and 50,000 m3 in volume. Associated with these cutblocks are 2 ½ km of reconstruction-road and 3 km of new road. In the Chapman Creek drainage 4 cutblocks are located at higher elevation, while a 5th cutblock is situated at lower elevation in the drainage. These 5 Chapman Ck. Blocks total < 70 hectares and approximately 50,000 m3 in volume. 5 km of reconstruction-road and 5 km of new road are associated with these cutblocks. To date Interfor has made a significant investment in the engineering, silviculture and terrain assessments associated with these Chapman / Gray Creeks cutblocks.

Harvesting activities associated with these blocks will take into account;

- appropriate harvest systems (i.e. aerial, high-lead or ground-based) on a site specific basis,
- the stand level biodiversity, by way of leaving >17% standing timber,
- Interfor's target of using alternative systems (varying degrees, and types of retention) on 40% of its cutblocks,
- restricting harvesting to less than 20 hectares per year (to address social concerns with rate of harvest, even if the CWAP's ECA indicates that greater than 20 ha per year could be harvested).

2. Upslope Watershed Restoration - by Jeff Pollock and Derrick Harborne (Derrick was not present due to illness)

Extensive upslope restoration works have addressed primarily road deactivation / rehabilitation and slide stabilization. These works have been very effective in helping to stabilize sideslopes in the watersheds. This effectiveness has been reflected in the improved quality and flow characteristics of both Chapman and Gray Creeks.

C. Weyerhaeuser Company Limited - by Blair Wriglesworth

1. Proposed Development

While Weyerhaeuser has 75 hectares in proposed cutblocks within the Chapman Ck. drainage, little engineering work has been done to date; however, terrain mapping has been done. 50 hectares are on fairly flat ground, while the remaining 25 hectares are on steep ground and would be harvested by helicopter. Weyerhaeuser is not in any big rush to develop these blocks, but it should be understood by everyone that while the development of even one cutblock doesn't produce a lot of revenue for Weyerhaeuser, it does generate considerable economic gain for the community (i.e. direct employment as well as associated secondary business).

Weyerhaeuser is confident that it can develop its cutblocks in a 'socially sensitive' manner, as witnessed by the company's variable retention harvesting practices (and associated narrow, low impact roads) in the Mount Elphinstone and Malibu (in Jervis Inlet) areas. In addition, Weyerhaeuser is well aware that in community watersheds, water characteristics (quality, quantity and timing of flows) are the number one priority.

D. B.C. Environment - Mike Younie

1. Riparian Restoration

Mike Younie suggested that the SCRD Board of Directors might be interested in a field trip to view some of the local, current harvesting practices as well as FRBC funded watershed restoration works. Both Dave Crosby and Paul Thompson said that Board members would probably take up the offer; however, they cautioned that the Board appears to have its mind made up to oppose any harvesting within community watersheds or water reserves. Keith Julius indicated that he and representatives of the Sechelt Indian Government would be interested in taking part in the field trip. Several members of the CWAP Advisory Committee indicated that they would be interested in the field trip. Dave Marquis offered to present a slide show of FRBC works within the Chapman / Gray Cks. drainage, during an office session of the field trip. (**Action:** Mike Younie will send out a formal invitation to the SCRD Board of Directors, offering a tour of local, current harvesting practices as well as FRBC funded watershed restoration works. Mike will follow-up with an advisement to CWAP Advisory Committee members on whether or not the tour will take place, as well advisement of tour arrangements if the tour goes ahead.)

(There was some discussion around the issue of interest by the SCRD Board of Directors in a Community Forest. Mike Younie noted that there is some political will to pursue this issue; also pointing out that there would likely be more of an appetite for harvesting in a community watershed when the drinkers of the water are the tenure holder <of the Community Forest>.)

2. Water Quality Monitoring

Mike Younie briefly summarized the FRBC restoration works, which have focused on;

- improving fish habitat,
- how riparian areas functioned, and then how to improve their structure,
- assessment and establishment of large woody debris in water courses,

- assessment of roads and the deactivation / stabilization of roads no longer required, and
- assessment and stabilization of slides.

The water quality monitoring program (also funded by FRBC) was established to assess improvements to water quality resulting from the above listed FRBC works; this water quality monitoring program continues to assess the impacts of FRBC works on water quality.

E. Fisheries and Oceans Canada - Richard Eliasen

1. Fish Resources

Richard once again expressed his consternation with the difficulty he has had over the past many years to reach a low-flow agreement with the SCRD. This agreement is absolutely essential to the well being of fish stocks in the Chapman Gray Creeks drainage. In addition to the 'adequate water flow' aspect of an agreement is the very critical issue of stream temperature.

Richard pointed out that the IWMP document provide the technological framework to maintain appropriate flows (quantity and timing) as well as water quality. In addition, from a fish management perspective, much of the FRBC works have contributed toward assurance of good quality water, so vital to fish stocks. Richard said he was not opposed to logging in the Chapman / Gray Cks. watershed, but would like to see the logging done to the standards detailed in the IWMP document.

David Marquis noted that a large percentage (99%) of the problems in the watershed have been addressed by FRBC; these being problems caused for the most part by past harvesting practices that were the 'standard of the day'. While harvesting as per the Code has yet to be tried in the watershed, the Code isn't foolproof and there may be problems; however, the rate & systems of harvesting, as well as road construction techniques of the past will no longer be practiced, providing some assurance that the magnitude of problems resulting from past practices will not be repeated.

F. Sechelt Indian Government - Keith Julius

Keith Julius advised that the Chapman Creek drainage was originally the Sechelt Indian Band's, but that the drainage had been taken over by the Union Steamship Lines. At present the Band uses water from the Chapman / Gray Creeks drainage, by way of an agreement with the SCRD in which the Band receives its water free of charge.

Keith Julius pointed out that the Sechelt Indian Band was involved in the FRBC works conducted in the Chapman / Gray Creeks drainage. The bioengineering stablilization works on many of the slide tracks were very successful.

It was pointed out by Keith that he was attending this Advisory Committee meeting with a primary purpose to listen and observe, and then report back to the Sechelt Indian Government.

G. Coast Garibaldi Health Unit Tim Adams was not present

Dave Crosby pointed out that the Health Unit Officers are always very concerned with water quality.

4. Delineate Watershed and Sub-Basin Boundaries --- EBA Engineering Ltd.

Jennifer Clarke advised that EBA Engineering Ltd. (EBA) proposed to use the boundaries that were used in past assessments, these boundaries co-inciding closely with those of the IWMP study area. The only exception would be the placement of Edwards Lake into the Gray Creek drainage instead of the Chapman Creek drainage, since the waters of Edwards Lake naturally flow more into Gray Ck. than into Chapman Ck. Thesubasin boundaries will be those used in the past CWAP and the IWMP. Jennifer pointed out that the 'Summit' report done for Interfor was more of a hydrology report than a CWAP.

5. WAP (Watershed Assessment Procedure) Report Objectives --- Mike Younie and EBA Engineering Ltd.

Jennifer Clark stated that the initial step in the CWAP process will be compilation of the great amount of existing data on the watersheds --- this information available from both industry and various government agencies. The old CWAP was a number crunching exercise that didn't always address the 'critical issues' in a drainage. Mike Younie pointed out that the old CWAP could produce a low ECA (Effective Clearcut Area) for a watershed (based on the number of roads, cutblocks and other factors); and while this ECA may be quite appropriate for a watershed with steep relatively unstable terrain, the ECA was for too restrictive for a watershed on flatter more forgiving land. Jennifer pointed out that while the new CWAP would utilize some of the same indicator values (i.e. numbers of proposed cutblocks, roads, etc.), the new CWAP would focus on determining the critical issues and problems within the drainage, then make educated decisions on how these issues / problems should be managed for (e.g. if sedimentation is a problem, then target management of the sediment sources).

Water characteristics (quality, quantity and timing of flows) would closely studied above the intakes, as well as below the intakes (or water characteristics critical for fish stocks). In addition, above the intakes other factors that will be studied include riparian areas, hydrological effects of logging, ECA, the rate of hydrological recovery, peak flows, etc..

The "Summit Report", done for Interfor in 1997, determined that within the Chapman / Gray Creeks drainages critical ECAs were between 20% and 40%. These critical ECAs being the levels of 'clearcut area' above which there could be an adverse effect on the hydrological stability of a sub-basin or the entire watershed. EBA will take into consideration the findings of the Summit Report.

Jennifer explained how harvesting has a different effect on hydrological stability, depending on the elevation at which the harvesting takes place. Between 300 and 800 metres exists a 'transient zone' which is subject to 'rain on snow' events. Hydrological stability is very sensitive to harvesting within this zone. Therefore, the ECAs associated with this zone will be weighted by a factor of 1.5. The work done by Rob Hudson will be very helpful in assessments made on this zone.

Other categories of information that will be taken into account include:
- sediment source surveys done by Bruce Thompson and Interfor,
- terrain hazard assessments done by Denny Maynard (helicopter assessment of new slides will also be made),
- channel assessments (i.e. sensitivity of channels to change, as well as the ability of the channels to recover), and
- riparian assessment (i.e. how riparian vegetation has changed over time; how logging has affected riparian vegetation and how the second growth has become established).

Jennifer pointed out that there will be limited field confirmation in light of the considerable amount of work already completed within the watershed.

In conclusion, Jennifer stated that EBA would be considering;
- proposed development in light of what past development has produced, with a focus on the levels of risk current harvesting practices will present to areas with higher instabilities,
- trends in water conditions,
- riparian conditions,
- block specific recommendations, and
- road specific recommendations.

Mike Younie suggested that EBA also look at deciduous stands and their potential contribution of organics to the water supply. Mike pointed out that Brian Carson has already done some work in this field. David Marquis advised that most organics in this Chapman / Gray drainage originate from the high elevation lakes, with only a minor amount of organic contribution form the riparian deciduous trees.

Jennifer advised that a draft report would be issued by mid to late April, two weeks prior to the final meeting of the Advisory Committee, in order that committee members have a chance to review the document and provide feedback.

6. Emergency Contact List: - Mike Younie

Mike Younie reviewed and revised contacts on the Emergency page of the IWMP document.

7. Cost Sharing Between Forest Companies

Mike Younie advised Interfor and Weyerhaeuser to develop a cost sharing agreement for the CWAP.

Adjournment: 12:40 hrs.

Watershed Assessment of Chapman & Gray Creek Community Watersheds Final Meeting

10:00 AM, Monday, October 30, 2000
Ministry of Forests Sechelt District Office
1975 Field Rd, Sechelt BC, 740- 5005

Recorders: Barry Miller and Drew Brayshaw

Participants
Scott Babakaiff, Ministry of Environment (SB)
Drew Brayshaw, Ministry of Environment (co-chair) (DB)
Jennifer Clarke, EBA Engineering Ltd. (JC)
Richard Eliasen, Fisheries & Oceans Canada (RE)
Derrick Harborne, Watershed Restoration Program (DH)
Barry Miller, Ministry of Forests (co-chair) (BM)
Dave Nansen, Fisheries & Oceans Canada (DN)
Bob Patrick, Sunshine Coast Regional District (BP)
Jeff Pollock, International Forest Products Ltd. (JP)

Regrets
Tim Adams, Coast Garibaldi Health Unit
Keith Julius, Sechelt First Nation
Blair Wriglesworth, Weyerhaeuser

1. Meeting commences 10:30 AM

2. DB briefly recaps CWAP general information and objectives for the benefit of those new to the process.

3. JC introduces her report and distributes prepared material on her presentation[1]. Briefly compares and contrasts Chapman and Gray Creeks. Forestry-related impacts to Chapman Creek are primarily related to landsliding on steep glaciofluvial slopes in which surficial material directly enters the creek. In Gray Creek, there is greater slope stability, and less landsliding and sedimentation; this means peak flows are potentially more important, but impacts from peak flows have not been noticed. JC states that she believes that proposed forest harvesting can take place, if her recommendations are followed, without further adverse impacts to the creeks.

4. BP notes that SCRD shuts down intake on Chapman when turbidity at intake exceeds 7.5 NTU, and that currently the intake shuts down 11-12 times a year due to high turbidity. Discussion of sources of turbidity – organic vs. non-organic, and unresolved question of sources of organics (in form of high total organic carbon (TOC) values). At lower elevation in Chapman Creek, the old Canadian Forest Products' road is a chronic source of turbidity.

---

[1] In general, information contained in Jennifer's report is not recapitulated herein.

WRP has funded turbidity monitoring since 1995, and the Sunshine Coast Regional District (SCRD) may have turbidity monitoring records prior to 1995.

5. JC discusses hydrology of Chapman & Gray. Notes that long-term hydrologic data on Gray Cr. is limited but enough exists to say it behaves similarly to Chapman. Discusses ECAs for the creeks and compares ECAs derived from the 'interim method' (in CWAP guidebook) to those derived using unpublished work of R. Hudson, based on research carried out in Gray Cr.

6. BP questions applicability of ECA measurement with respect to other values such as wildlife habitat. Asks about reliability of Hudson's work – notes it is unpublished research. DB clarifies that ECA is only used to discuss potential impacts on peak flows, and assesses hydrological recovery only.

7. DN questions JC's conclusion that current and proposed forest harvesting has had no impact on peak flows. JC displays charts and graphs (hydrologic data from stream gauging, etc.) which provide evidence supporting her conclusion.

8. JC presents data on landsliding in Chapman and Gray Creeks. DB asks about forestry related slides – how many are road failures vs. non-road related. JC indicates most forestry-related failures are road-related, caused not by failure of fill prisms but inadequate drainage control –this is summarised in Appendix B.

9. BP asks about the relative sensitivity of the two creeks to landsliding. Notes that of 225 forestry related slides in Chapman, 78 directly impacted the stream (about 35%) whereas in Gray, 10 of 12 (83%) forestry related slides directly impacted the creek. Asks if this means that landslides in Gray are potentially more hazardous than in Chapman and that therefore it is a misnomer to state that Gray is more stable than Chapman? JC clarifies – notes that 36% of Chapman has been logged, and 85% of total slides in watershed are forestry related, whereas 51% of Gray has been logged but only 43% of slides are forestry related – much higher proportion of slides are forestry related in Chapman than Gray. But in Chapman, there is more unstable terrain not directly connected to the creek, so proportion (not actual number) of slides reaching creek is lower. In Gray, most sensitive slopes are directly linked to creek, hence high proportion of slides impacting creek, but total impact (effect of all slides) is much lower in Gray than Chapman – 10 vs. 78 impact creek.

10. JC presents stream channel assessment data. Chapman disturbed in 1980's, stabilising. Gray's channel not disturbed noticeably. Introduces reach-profiling data, based on unpublished work by Dan Hogan, showing sediment sources and sinks along reach profiles (coarse and fine sediment supply and routing). Essentially, coarse sediment enters the stream, moves a short distance, and is stopped by low-gradient reaches. Fine sediment enters the stream and moves a much greater distance.

11. JC presents riparian assessment. Clarifies that "currently impaired" reaches have vegetation less than 5m high, sparse, shrubby, disturbed or a combination of the above. RE asks about slow recovery of riparian. JC indicates most reaches currently impaired are in upper watershed (where climatic conditions produce slower growth hence slower recovery), also there are not as many sources of CWD recruitment (higher upstream), which contributes

still ongoing. At this point it looks like the remaining work will proceed as long as Interfor chooses to fund it – and remaining work must be completed by the end of 2004. So hopefully, the remaining restoration work will be completed.

17. BP asks about the meanings of terms such as "high", "moderate", "low" as used in Jennifer's report – what is their specific meaning. JC indicates she has tried to minimize those terms in her report where possible. DB indicates that the FPC uses qualitative terms in many cases to lump together varying numerical probabilities for the purpose of recommending procedures – for instance, a range of hazards expressed as a % of an event occurring may be classified as "high" and then recommendations may be given for high hazard areas – for instance Terrain Class V is "Very High" risk of landsliding post-harvesting – thus the qualitative phrases have actual meaning under the Code. DB will forward the relevant website address for the Code to BP.

18. BP and RE discuss low flows in Chapman Creek. There is still no agreement over low flows between SCRD and DFO. Both BP and RE wish to address this issue. RE made the point that his recommended low-flow of 5% average flow, is ½ the amount normally recommended by DFO. BP said he would do what he could to facilitate the completion of a low-flow agreement. RE stated that if a low-flow agreement were not in place by next summer, he would be compelled to pursue legal action through Crown prosecution. RE will discuss further with BP and Seig L. Discussion of the apparently contradictory flow requirements stated in the first paragraph of the section "Water Requirements" on p.8 of the report. RE will review the numbers in this paragraph and provide corrected numbers to JC.

19. DB asks BP about the turbidity shut off threshold values. SCRD intake shuts off at 7.5 NTU. DB has been informed that provincial standards are 5 NTU for the intake and 1NTU for treated water in the distribution system. BP will consult with MoH on this issue.

20. BP asks about the access control boulders being moved on the Chapman – McNair divide. DH will discuss with Mike Whitehouse the potential for replacing the access boulders (now moved out of the way by persons unknown) with a gate. BM discusses the history of previous gates in the area being destroyed, keys going missing and so on.

21. SB complements JC on the quality of her report. JC indicates that final comments on the report should be forwarded to her by November 10th.

22. Recommendations
    - the recommendations contained in the CWAP document
    - a low-flow agreement be established between the Federal Department of Fisheries and Oceans and the Sunshine Coast Regional District
    - a gate be established to replace the, now defunct, boulder barricade to entrance into the east side of the Chapman Creek drainage.
    - FRBC funding be used to continue Brian Carson's monitoring program
    - Brian Carson's monitoring program be expanded to include water temperature, organic characteristics and low flow volumes
    - effectiveness monitoring of landslide stabilisation success, and
    - maintenance of landslide stabilisation works.

23. Meeting adjourned – 1:00 PM

APPENDIX B - Chapman Creek Sediment Source Inventory

Landslide Identification No.	Type of Landslide	Characteristics of Landslide Initiation Points						Vegetation Status	Entered Stream or Gully	Approx. Landslide Area (ha)	Sediment Delivery	Risk of Sediment Impact
		Average Slope (degrees)	Materials (Origin)	Texture of Materials	Location	Land Use	Slide Aspect					
46 - 1a	S	***21***	F	sg	E	N	SSE	54	S	0.01	direct	HIGH
46 - 1b	S	***21***	F	sg	E	N	S	54	S	0.01	direct	HIGH
82 - 2a	S	***32***	F	sg	E	C	SE	18	S	0.004	direct	HIGH
80 - 2b	S	***20***	F	sg	E	C	SE	18	S	0.005	direct	HIGH
76 - 2c	S	***18***	F	sg	E	C	SE	24		0.0025	direct	HIGH
76 - 2d	S	***26***	F	sg	E	C	SSW	24		0.003	direct	HIGH
82 - 3	S	***12***	M	sg	E	C	SE	-16	V	0.06	direct	
56 - 4	S	***27***	F	zs/sg	E	C	E	-9		0.016	direct	
76 - 5	S	***12***	M	zs	O	R	E	24	V	0.0105	direct	
46 - 6	S	***11***	A	zs	O	R	ESE	-22	S	0.0075	direct	
46 - 7	T	***14***	M	zs	E	C	ESE	-26	VS	0.026	direct	
84 - 8*	S	8	F	zs/sg	O	N	SE	-15		0.015	none	
46 - 9a*	S	40	F	zs/sg	E	C	SE	-28		0.015	none	
46 - 9b*	S	40	F	sz/sg	E	C	SE	-28		0.015	none	
64 - 10*	T	38	M	xrs	H	C	SSE	-27	V	0.38	indirect	
64 - 11*	T	55	M	r	H	C	SSE	-27	V	0.045	indirect	
46 - 12	T	***18***	A	g/zs	O	R	SE	-27	S	0.072	direct	
76 - 13*	S	39	M	zs/sg	H	N	SSE	-18		0.045	none	
46 - 14*	T	42	M	zs/sg	O	C	SSE	-34		0.03	direct	
46 - 15*	T	37	LG	zs/sg	H	C	SSE	-34	V	0.24	direct	
46 - 16	T	***23***	M	sg	H	C	SSE	-27	V	0.25	direct	
64 - 17	S	***37***	F	sg/zs	0	R	ENE	36		0.03	direct	
76 - 18*	T	30	F	sg/zs	0	R	NE	24	VS	0.056	direct	
50 - 19*	T	32	F	sg/zs	0	R	NE	40	VS	0.048	direct	
64 - 20	T	***36***	A	sg/zs	O	R	ENE	-29	VS	0.018	none	
50 - 21*	S	30	F	sg/zs	0	R	NE	50	V	0.01	indirect	
64 - 22*	T	39	FG	sg/zs	G	C	NNE	36	VS	0.008	indirect	
64 - 23*	T	31	M	rzs	G	C	NNE	-16	VS	0.044	indirect	
64 - 24*	T	32	FG	rzs	H	C	ENE	36	VS	3.15	direct	HIGH
64 - 25	S	34	FG	sgz	S	C	SSE	36	VS	0.25	indirect	HIGH

Inventory updated from Thomson (1987) by Brian Lennon, BCIT
Refer to LEGEND provided on Page 10 for an explanation of abbreviations

APPENDIX B - Chapman Creek Sediment Source Inventory

Landslide Identification No.	Type of Landslide	Characteristics of Landslide Initiation Points						Vegetation Status	Entered Stream or Gully	Approx. Landslide Area (ha)	Sediment Delivery	Risk of Sediment Impact
		Average Slope (degrees)	Materials (Origin)	Texture of Materials	Location	Land Use	Slide Aspect					
64 - 26	S	34	FG	sg/zs	S	C	SSE	36	VS	0.50	indirect	HIGH
64 - 27a*	T	30	FG	sg/zs	O	C	SE	-16	VS	0.042	direct	
64 - 27b*	T	***34***	C	sg/zs	S	C	SSE	-16	VS	0.02	direct	
64 - 28	T	***32***	A	sg/zs	S	R	ESE	-16	VS	0.036	direct	
84 - 29*	T	12	FG	sg/zs	S	C	SSE	-16	VS	0.0135	direct	
64 - 30	T	***25***	M	zs	H	C	E	-16	V	0.01	direct	
64 - 31	T	***29***	M	zs	H	C	ENE	-30	V	0.01	direct	
80 - 32*	T	31	M	zsg	O	C	ESE	20	V	0.85	direct	
78 - 33	T	***34***	A	zsg	H	R	SE	22	V	0.021	indirect	
78 - 34	T	***34***	M	zsg	S	C	SE	22	V	0.015	indirect	
64 - 35	T	***20***	A	sg	S	R	SE	-28	V	0.048	direct	
64 - 36	S	***20***	FG	sg	O	C	SE	-30		0.018	direct	
64 - 37	S	***23***	FG	sg	O	C	SE	-19	V	0.064	none	
78 - 38*	T	33	FG	sg	H	R	SE	-16	V	0.06	direct	
64 - 39	S	***30***	F	sg	H	C	SE	-25	V	0.012	direct	
78 - 40	T	***29***	F	sg	H	C	SE	-18	VS	0.03	direct	
67 - 41	T	***29***	F	sg	H	C	SE	-29	VS	0.04	direct	
67 - 42	T	***25***	F	sg	S	C	SE	-29	VS	0.081	direct	
75 - 43	T	***23***	M	sg	O	C	SE	-16	V	0.72	direct	
76 - 44	T	28	M	zgs	C	C	SE	25	V	0.45	direct	
67 - 45	T	***30***	M	zgs	H	C	SE	-27	V	0.024	none	
67 - 46	T	***31***	M	zgs	H	C	ESE	-27	V	0.01	none	
67 - 47	T	***31***	M	zgs	H	C	SE	-27	V	0.03	none	
80 - 48*	T	28	M	zs	O	C	SE	20	VS	0.125	indirect	
80 - 49*	T	28	M	zs	0	C	SE	20	VS	2.00	direct	
67 - 50	S	***23***	M	zgs	C	C	SE	-24	V	0.021	none	
76 - 51*	T	33	M	zgs	S	C	ESE	-16	V	0.023	none	
76 - 52*	T	37	M	zgs	S	C	SE	-16	V	0.315	none	
76 - 53*	T	32	M	zgs	O	C	SE	-16	V	0.013	none	
84 - 54*	S	23	M	zs	O	C	SE	16		0.017	none	
67 - 55*	T	30	M	zgs	O	C	SE	-16	V	0.16	indirect	

Inventory updated from Thomson (1987) by Brian Lennon, BCIT
Refer to LEGEND provided on Page 10 for an explanation of abbreviations

APPENDIX B - Chapman Creek Sediment Source Inventory

Landslide Identification No.	Type of Landslide	Characteristics of Landslide Initiation Points						Vegetation Status	Entered Stream or Gully	Approx. Landslide Area (ha)	Sediment Delivery	Risk of Sediment Impact
		Average Slope (degrees)	Materials (Origin)	Texture of Materials	Location	Land Use	Slide Aspect					
76 - 56	T	23	M	zgs	O	C	SE	24*	VS	0.91	direct	
67 - 57	T	***32***	M	zsg	H	C	SE	-27	V	0.046	none	
67 - 58	S	***21***	M	sg	O	C	SE	-26		0.007	none	
75 - 59*	T	***25***	M	zgs	O	C	SE	-16	V	0.18	indirect	
75 - 60*	T	25	M	zgs	O	C	SE	25*	V	0.497	indirect	
75 - 61	T	***24***	M	zgs	O	C	SE	25	V	0.014	indirect	
67 - 62*	T	25	M	zgs	C	C	SE	-16	V	0.16	indirect	
75 - 63	T	***30***	M	zgs	C	C	SE	25*	V	0.09	indirect	
75 - 64*	T	24	M	zgs	O	C	SE	25	V	0.09	indirect	
80 - 65*	T	***25***	M	zgs	O	C	SE	18	V	0.081	indirect	
78 - 66*	T	22	M	zgs	O	C	SE*	22*	V	0.24	direct	
84 - 67*	T	34	M	zs	S	C	SSE	-16	V	0.04	indirect	
84 - 68*	T	29	M	zs	C	C	SE	-16	V	0.02	indirect	
67 - 69*	S	32	M	zs	S	C	SW	33	V	0.006	indirect	
67 - 70*	S	34	M	zs	C	C	SSW	-16	V	0.024	none	
75 - 71	T	34	M	zs	O	C	SSW	-16	V	0.16	indirect	
80 - 72*	S	45	A	zs/x	O	R	S	-16		0.045	none	
82 - 73*	T	***23***	M	zs/x	S	C	SSW	18	S	0.015	indirect	
80 - 74*	T	23	M	zs/r	S	C	E	20	S	0.015	indirect	
80 - 75*	T	25	M	zs/r	S	C	E	20	VS	0.015	indirect	
84 - 76*	T	25	M	zs/r	S	C	E	16	VS	0.008	indirect	
80 - 77*	T	23	M	zs/r	S	C	E	20	S	0.006	indirect	
78 - 78*	T	31	M	zs/r	S	C	SSW	22	VS	0.009	indirect	
80 - 79*	T	28	M	zs/r	S	C	SSW	20	S	0.009	indirect	
80 - 80*	T	42	M	zs/r	S	C	SSW	20	S	0.009	indirect	
78 - 81*	T	35	M	zs/x	S	C	ESE	22	VS	0.15	indirect	
75 - 82	S	***35***	M	zsg	O	R	S	-16		0.0075	direct	
75 - 83*	S	35	LG	zs	O	R	SE	-16		0.0075	direct	
75 - 84*	S	40	M	zgs	O	C	SE	-16		0.005	direct	
82 - 85*	S	40	LG	zs	O	C	SE	-16		0.0425	direct	
84 - 86*	S	45	LG	zs	O	C	SE	-16		0.0075	direct	

Inventory updated from Thomson (1987) by Brian Lennon, BCIT
Refer to LEGEND provided on Page 10 for an explanation of abbreviations

APPENDIX B - Chapman Creek Sediment Source Inventory

Landslide Identification No.	Type of Landslide	Characteristics of Landslide Initiation Points						Vegetation Status	Entered Stream or Gully	Approx. Landslide Area (ha)	Sediment Delivery	Risk of Sediment Impact
		Average Slope (degrees)	Materials (Origin)	Texture of Materials	Location	Land Use	Slide Aspect					
67 - 87*	S	44	M	gzs	O	C	SSE	33		0.045	direct	MODERATE
80 - 88*	S	45	M	zs/xg	O	C	SE	20		0.056	direct	MODERATE
80 - 89*	S	47	C	x/zs	S	R	SE	20		0.01	direct	
80 - 90*	S	47	C	x/zs	S	R	SE	20		0.0075	direct	
67 - 91*	S	33	C	x/zs	O	C	SSE	33		0.021	direct	HIGH
80 - 92	S	33	M	zs	O	C	SE	20		0.014	direct	HIGH
80 - 93*	S	33	M	zs	O	C	SE	20		0.014	direct	HIGH
80 - 94*	S	33	M	zs	O	C	SE	20		0.08	direct	MODERATE
82 - 95*	S	34	LG	zs	O	N	ENE	18	S	0.0015	direct	HIGH
84 - 96*	S	25	M	zs	O	N	ENE	-16	S	0.0021	none	
84 - 97*	S	28	M	g	S	N	NE	16	S	0.003	none	
84 - 98*	S	33	M	g	O	N	NE	-16	S	0.012	direct	MODERATE
82 - 99	S	***35***	M	sg/z	O	N	NE	-16		0.006	direct	
84 - 100*	T	44	M	sg/z	H	C	NE	-16	VS	0.035	direct	
67 - 101*	T	9	FG	sg/z	S	N	ESE	-16		0.021	direct	
57 - 102*	S	42	FG	sg/z	O	N	ENE	-16	S	0.35	direct	
46 - 103*	S	32	FG	sg/z	O	N	ENE	54	S	0.035	direct	
67 - 104*	S	32	FG	sg/z	O	N	NE	33	S	0.03	direct	HIGH
67 - 105*	S	20	FG	sg/z	O	N	NE	33	S	0.03	direct	HIGH
46 - 106*	S	22	FG	sg/z	O	N	E	54	S	0.03	direct	HIGH
67 - 107	S	***26***	M	sg/z	O	N	E	33	S	0.03	direct	MODERATE
67 - 108	S	***25***	M	sg/z	O	N	E	33	S	0.03	direct	MODERATE
57 - 109	S	***23***	M	sg/z	O	N	ESE	43	S	0.01	direct	MODERATE
76 - 110	S	***46***	M	zs	O	N	WSW	-16		0.055	direct	
76 - 111	S	***43***	M	zs	O	N	WSW	43	S	0.024	direct	MODERATE
84 - 112*	S	42	M	zs	O	C	SW	16	V	0.028	direct	MODERATE
84 - 113*	S	37	M	zs	O	C	SW	16		0.04	direct	MODERATE
84 - 114*	S	36	M	zs	O	C	SW	16	V	0.38	direct	MODERATE
78 - 115*	S	38	A	zs	C	R	SW	22	V	0.064	indirect	
80 - 116*	S	36	M	zs	O	C	SSW	22		0.024	indirect	
78 - 117	S	***36***	M	zs	O	C	SSW	22		0.025	indirect	

Inventory updated from Thomson (1987) by Brian Lennon, BCIT
Refer to LEGEND provided on Page 10 for an explanation of abbreviations

APPENDIX B - Chapman Creek Sediment Source Inventory

Landslide Identification No.	Type of Landslide	Characteristics of Landslide Initiation Points						Vegetation Status	Entered Stream or Gully	Approx. Landslide Area (ha)	Sediment Delivery	Risk of Sediment Impact
		Average Slope (degrees)	Materials (Origin)	Texture of Materials	Location	Land Use	Slide Aspect					
78 - 118*	S	36	M	zs	H	C	SSW	22		0.064	indirect	
76 - 119*	T	38	A	zs	O	R	SW	24	VS	0.039	direct	HIGH
80 - 120*	T	38	A	zs	O	R	W	20	VS	0.006	indirect	
78 - 121*	S	35	A	zs	S	R	WSW	22	V	0.009	indirect	
76 - 122*	T	31	A	zs	S	R	SW	25	VS	0.056	direct	HIGH
50 - 123	T	***28***	M	zs	S	N	SSE	-30	VS	0.004	indirect	
57 - 124	S	***45***	M	x/zs	S	N	SSE	-36	V	0.008	indirect	
57 - 125*	T	39	M	x/zs	H	N	SW	43	V	0.25	direct	HIGH
57 - 126	T	***32***	R	x	H	N	S	-16	V	0.014	none	
46 - 127	S	***39***	M	x/zs	S	N	SW	-27	V	0.012	indirect	
50 - 128	S	***27***	M	zs/sr	S	N	SW	-30	VS	0.009	indirect	
76 - 129*	T	28	A	zs	O	R	SW	24	VS	0.02	indirect	
84 - 130*	T	30	M	zs/sr	O	C	SW	16	VS	0.006	indirect	
84 - 131*	S	***45***	M	zs	O	C	SSW	-16	V	0.003	none	
46 - 132*	F	***43***	R	x/zs	O	N	SSW	-37		0.03	none	
84 - 133*	T	31	M	zs	O	C	SW	16	V	0.10	indirect	HIGH
80 - 134*	T	30	M	zs	O	C	SW	20	V	0.112	direct	HIGH
84 - 135*	S	44	A	r	O	R	SW	16		0.0165	none	
84 - 136*	T	31	M	zs	S	C	SW	-16	V	0.06	indirect	MODERATE
84 - 137*	S	30	LG	zs	O	C	WSW	-16	V	0.02	indirect	
80 - 138*	S	30	LG	zs	O	C	WSW	-16		0.03	indirect	
75 - 139	T	30	C	sx	O	R	WSW	-16	V	0.021	indirect	
80 - 140*	S	25	F	zs	O	C	WSW	-16		0.024	indirect	
78 - 141*	S	34	LG	zs/z	O	C	WSW	-16	V	0.012	direct	
75 - 142*	T	36	A	zs/z	O	R	WSW	-16	VS	0.039	direct	HIGH
75 - 143	T	36	A	zs/z	H	R	WSW	25	V	0.054	direct	HIGH
75 - 144*	S	38	A	zs/z	C	R	WSW	25	V	0.45	direct	HIGH
84 - 145	S	31	M	zs/z	O	C	W	-16		0.024	direct	
84 - 146*	S	31	M	zs/z	O	C	W	-16		0.0405	direct	
84 - 147*	S	31	M	zs/z	O	C	W	-16		0.015	direct	
76 - 148*	S	31	LG	zs/z	O	C	W	-16		0.009	direct	

Inventory updated from Thomson (1987) by Brian Lennon, BCIT
Refer to LEGEND provided on Page 10 for an explanation of abbreviations

APPENDIX B - Chapman Creek Sediment Source Inventory

Landslide Identification No.	Type of Landslide	Characteristics of Landslide Initiation Points						Vegetation Status	Entered Stream or Gully	Approx. Landslide Area (ha)	Sediment Delivery	Risk of Sediment Impact
		Average Slope (degrees)	Materials (Origin)	Texture of Materials	Location	Land Use	Slide Aspect					
80 - 149	S	***27***	M	zs	S	C	S	20	S	0.0625	indirect	
84 - 150	T	***40***	M	zs	S	C	SE	16	VS	0.002	indirect	
80 - 151*	S	31	M	zs	O	C	SSW	20		0.03	none	
80 - 152*	S	38	M	zs	O	C	SW	16		0.018	none	
80 - 153	S	43	M	zs	S	C	SE	16	V	0.006	indirect	
76 - 154*	S	47	M	zs	S	C	SE	24	V	0.009	indirect	
46 - 155	S	40	M	zs	S	N	SW	-16	V	0.03	indirect	
80 - 156*	T	47	A	zs	H	R	SSW	20	VS	0.56	direct	HIGH
76 - 157*	S	40	M	zs	O	C	SW	25	VS	0.02	indirect	
78 - 158*	S	42	M	zs	S	C	SW	22	V	0.008	indirect	
80 - 159	S	***34***	M	rsz	O	R	NNW	-16		0.012	none	
84 - 160	S	***27***	M	sr	S	C	NNW	-16	V	0.03	indirect	
84 - 161	S	***27***	M	sr	S	C	N	-16	V	0.03	indirect	
84 - 162*	T	***27***	M	zs	O	C	WNW	-16	V	0.045	direct	
78 - 163*	S	31	M	zs	O	R	W	22		0.025	indirect	
76 - 164*	S	31	M	zs	O	C	W	-16		0.06	indirect	
76 - 165	T	31	A	zs	S	R	W	-16	V	0.132	none	
76 - 166	S	31	M	zs	O	C	NW	-16	V	0.07	none	
84 - 167	T	32	M	zs	O	C	NW	16	V	0.08	indirect	
84 - 168*	T	32	M	zs	O	C	NW	16		0.184	indirect	
76 - 169*	S	34	M	zs	O	C	WNW	-16	V	0.10	indirect	
84 - 170*	T	35	M	zs	H	N	WNW	-16	V	0.35	direct	
75 - 171*	S	38	F	zs	S	C	W	-16	V	0.02	direct	
84 - 172*	F	28	M	zs	C	C	WSW	-16	V	0.0225	direct	
78 - 173*	S	35	M	zs/rsg	O	R	NW	-16		0.03	direct	
75 - 174*	T	42	A	zs	O	R	WNW	25	VS	0.0315	direct	MODERATE
75 - 175*	T	42	A	zs/rsg	O	R	WNW	25	VS	0.04	direct	HIGH
84 - 176	S	40	M	zs/rsg	O	C	WNW	-16		0.02	direct	MODERATE
67 - 177	S	40	M	zs/rsg	O	C	NW	-16	VS	0.02	direct	
75 - 178*	S	40	A	zs/rsg	C	R	NW	-16	S	0.0175	direct	HIGH
78 - 179*	S	38	A	zs/rsg	O	R	NW	-16	V	0.02	direct	HIGH

Inventory updated from Thomson (1987) by Brian Lennon, BCIT
Refer to LEGEND provided on Page 10 for an explanation of abbreviations

APPENDIX B - Chapman Creek Sediment Source Inventory

Landslide Identification No.	Type of Landslide	Characteristics of Landslide Initiation Points						Vegetation Status	Entered Stream or Gully	Approx. Landslide Area (ha)	Sediment Delivery	Risk of Sediment Impact
		Average Slope (degrees)	Materials (Origin)	Texture of Materials	Location	Land Use	Slide Aspect					
75 - 180*	T	39	A	zs/rsg	O	R	NW	-16	VS	0.0175	direct	HIGH
75 - 181*	S	40	A	zs/rsg	O	R	NW	-16		0.105	direct	
80 - 182	S	***27***	M	zs/rsg	E	C	N	-16		0.09	direct	
75 - 183	T	***38***	A	zs/rsg	H	R	NW	25	VS	0.021	direct	
78 - 184	S	***36***	M	zs/rsg	S	C	WSW	-16	V	0.055	indirect	
78 - 185	S	***36***	M	rsz	S	C	W	-16	VS	0.035	indirect	
75 - 186	S	37	A	zs/rsg	O	R	NW	24	S	0.0675	direct	HIGH
46 - 187	S	***38***	M	zs/rsg	O	N	NW	54	S	0.06	direct	
75 - 188	T	***23***	M	zs/rsg	E	C	NNW	-16	V	0.03	direct	
75 - 189	T	***27***	M	zs/rsg	C	C	NW	25	VS	0.05	indirect	
76 - 190	T	***24***	M	zs	C	C	NW	24	VS	0.07	indirect	
84 - 191*	S	31	M	zs	O	C	N	16	V	0.018	none	
84 - 192*	S	30	A	zs	O	R	WNW	-16		0.036	none	
75 - 193	S	***25***	F	sg/zs	E	C	NW	-16	V	0.012	none	
75 - 194	S	***25***	F	sg/zs	E	C	NW	-16		0.01	none	
67 - 195	S	***31***	F	sg/zs	E	C	SW	-16		0.03	direct	
67 - 196	S	***30***	F	sg/zs	E	C	SW	-16		0.0175	direct	
64 - 197	T	***36***	F	sg/zs	H	C	W	-32	VS	0.04	direct	
76 - 198	T	***27***	M	zs	O	C	NW	-16	V	0.065	direct	
64 - 199	T	***36***	F	sg/zs	H	C	WNW	-29	VS	0.09	direct	
64 - 200	T	***27***	F	sg	H	C	NW	-26	V	0.084	direct	
64 - 201	T	***35***	F	sg	H	C	W	-28	V	0.225	direct	
76 - 202*	T	26	M	xzs	H	C	W	-16	VS	0.06	direct	
67 - 203	T	***27***	M	xzs	O	C	WNW	-27	VS	0.12	direct	
75 - 204	S	***27***	M	xzs	S	C	W	-21	VS	0.07	direct	
57 - 205	T	***28***	M	xzs	H	C	WNW	-16	VS	1.50	direct	
46 - 206	T	***34***	M	xzs	S	C	WNW	-36	VS	0.12	direct	
64 - 207	T	***33***	M	xzs	C	C	WNW	-28	VS	0.50	direct	
50 - 208	T	***24***	M	xzs	S	C	NW	-36	VS	0.14	direct	
46 - 209	T	***18***	F	sg	O	C	NNW	-34		0.021	none	
46 - 210	S	***18***	M	gsz	O	C	NW	-34		0.03	direct	

Inventory updated from Thomson (1987) by Brian Lennon, BCIT
Refer to LEGEND provided on Page 10 for an explanation of abbreviations

APPENDIX B - Chapman Creek Sediment Source Inventory

Landslide Identification No.	Type of Landslide	Characteristics of Landslide Initiation Points						Vegetation Status	Entered Stream or Gully	Approx. Landslide Area (ha)	Sediment Delivery	Risk of Sediment Impact
		Average Slope (degrees)	Materials (Origin)	Texture of Materials	Location	Land Use	Slide Aspect					
46 - 211	T	***21***	M	zs	O	C	NW	-20		0.18	indirect	
50 - 212	T	***25***	M	zs/r	H	C	NNW	-32	V	0.75	direct	
46 - 213	T	***16***	M	zs/sg	S	C	NNW	-16		0.245	indirect	
46 - 214	T	***22***	M	zs/sg	S	C	WSW	-27	VS	0.042	indirect	
56 - 215	T	***22***	M	zs/sg	S	C	SW	-25	V	0.042	indirect	
46 - 216	T	***16***	M	zs/sg	S	C	NNW	-26	VS	0.10	direct	
46 - 217	T	***23***	M	zs/sg	S	C	NNW	-26	VS	0.03	indirect	
46 - 218	T	***16***	M	zs/r	S	C	NW	-26	VS	0.65	direct	
76 - 219*	S	28	M	zs/g	O	R	WNW	-20	S	0.09	direct	
56 - 220*	S	37	A	zs/g	O	R	WNW	-40	S	0.15	direct	
46 - 221	T	***9***	A	sg	H	R	NW	-26	V	0.176	direct	
84 - 222*	S	25	A	zgs	O	R	ESE	16	V	0.009	none	
84 - 223*	S	25	A	zgs	O	R	SE	16	V	0.0135	none	
57 - 224*	T	***40***	C	x	H	C	SSE	-34	V	0.114	none	
67 - 225	T	***43***	M	zs	H	N	SE	33	V	0.002	indirect	
80 - 226	S	***36***	M	zs/rsg	O	C	N	-16	V	0.06	indirect	
64 - 227	T	***28***	M	sg/zs	H	C	NE	-32	V	0.04	none	
64 - 228	T	***40***	FG	sg/zs	S	C	NNE	-32	V	0.006	indirect	
46 - 229	F	***20***	R	a	E	N	S	54		0.35	none	
46 - 230	F	***27***	R	a	E	N	SW	54		0.195	none	
46 - 231	F	***16***	R	a	E	N	SW	54		0.15	none	
46 - 232	F	***22***	R	a	E	N	SW	54		1.20	none	
46 - 233	F	***25***	R	a	E	N	ESE	54	V	0.225	none	
46 - 234	F	***40***	R	zs/x	E	N	SSE	54		0.40	none	
46 - 235	F	***40***	R	zs/x	E	N	SSE	54		0.24	none	
46 - 236	F	***37***	R	zs/x	E	N	ENE	54	V	0.5	none	
46 - 237	F	***40***	R	ax	E	N	SW	54		0.12	none	
46 - 238	F	***28***	R	ax	S	N	SW	54		0.4	none	
46 - 239	F	***28***	R	ax	S	N	SW	54		0.075	none	
46 - 240	F	***28***	R	ax	E	N	NW	54		0.65	none	
46 - 241	F	***27***	R	ax	E	N	NW	54		0.39	none	

Inventory updated from Thomson (1987) by Brian Lennon, BCIT
Refer to LEGEND provided on Page 10 for an explanation of abbreviations

APPENDIX B - Chapman Creek Sediment Source Inventory

Landslide Identification No.	Type of Landslide	Characteristics of Landslide Initiation Points						Vegetation Status	Entered Stream or Gully	Approx. Landslide Area (ha)	Sediment Delivery	Risk of Sediment Impact
		Average Slope (degrees)	Materials (Origin)	Texture of Materials	Location	Land Use	Slide Aspect					
46 - 242	F	***35***	R	ax	E	N	WSW	54		0.2	none	
46 - 243	F	***34***	R	ax	E	N	WSW	54		1.20	none	
46 - 244	F	***34***	R	ax	E	N	WSW	54		1.44	none	
46 - 245	F	***31***	R	ax	E	N	SW	-37		0.15	none	
46 - 246	F	***25***	R	xzs	E	N	NNW	-16		0.03	none	
98 - 247	T	***34***	A	x/zs	C	R	SW	2	V	0.005	none	
98 - 248	T	***33***	M	x/zs	C	C	SW	2	V	0.006	none	
98 - 249	T	***34***	M	x/zs	C	C	SW	2	V	0.018	indirect	
98 - 250	T	***26***	M	zs/sr	C	R	SW	2	VS	0.015	indirect	
98 - 251	T	***18***	M	zs	O	C	S	2		1.00	none	
98 - 252	S	***29***	M	zs	O	R	WNW	2	S	0.024	direct	
98 - 253	S	***19***	C	sr	O	R	SE	2		0.09	none	
98 - 254	T	***13***	M	zs/r	C	C	N	2	VS	0.16	direct	MODERATE
98 - 255	T	***10***	M	zs	C	R	NW	2	VS	0.072	direct	MODERATE
98 - 256	T	***19***	M	r/s	C	C	W	2	VS	0.18	direct	HIGH
98 - 257	T	27	M	zs	O	C	WNW	2	S	0.60	direct	MODERATE
98 - 258	S*	34	M	gsz	O	R	NW	2		0.27	direct	MODERATE
98 - 259	S	32	M	zs/rsg	C	C	WNW	-2	VS	0.14	direct	HIGH
98 - 260	S	***34***	M	zs/x	O	C	S	2		0.056	none	
95 - 261	S	32	FG	sg/zs	O	R	ENE	5		0.09	indirect	
95 - 262	S	32	FG	sg/zs	O	R	ENE	5		0.3835	indirect	
95 - 263	S	33	FG	zsg	O	R	NE	5		0.25	direct	
95 - 264	S	33	FG	zsg	O	R	NNE	5		0.01	none	
95 - 265	T	20	M	zsg	C	R	SSE	5	S	0.225	direct	
96 - 266	S	***37***	M	zs/sg	C	R	NW	4	V	0.07	indirect	
96 - 267	T	***27***	M	xzs	C	C	W	4	S	0.0825	direct	HIGH
96 - 268 - 869	T	***12***	M	sg	S	C	SE	4	S	0.05	direct	MODERATE

Total area affected in hec 36.93

Inventory updated from Thomson (1987) by Brian Lennon, BCIT
Refer to LEGEND provided on Page 10 for an explanation of abbreviations

APPENDIX B - Chapman Creek Sediment Source Inventory

Legend (modified and expanded after Thomson(1987))

Landslide Id. No.: 76 - 2b* - 76 = year of photo, 2b = slide number, * = field inspection completed (by Thomson),

Terrain Polygon Number: - 1139 or 52, 53, 4: 1139 = terrain polygon numbers from Maynard (1995)
52/131 = NTS map sheet 92G 052 (or 53 or 42) / terrain polygon 131 after Thomson, (1987, 1988)

Type of Landslide: T = debris flow - rapid flow of muddy mixture of water, soil, rock and organic material in a channel (stream or gully)
S = slide - slow to rapid movement of water saturated unconsolidated soils, base materials and organics along a fracture plain.
F = rock fall - a mass of disintegrating bedrock detached from a steep slope and falling and rolling downslope to rest at angle of repose.

Average Slope Angle (degrees): ***27 = measured from 1:20,000 scale topographic map***
31 = measured in field

Materia M = glacial till
FG = glaciofluvial silts to gravels
LG = glaciolacustrine materials
F = fluvial materials
C = colluvium
R = bedrock
A = anthropogenic materials (road fill etc.)

Texture: a = blocks
g = gravels
r = rubble
s = sands
x = angular fragments
z = silts

Examples of Textural Combinations
(proportional amounts increase to the right)
zsg = silty sandy gravels
gs = gravelly sands
sg/zs = sandy gravels interlayered with or overlying silty sands
xzs = angular fragments in silty sands

Topographic Location of Landslide at Initiation Point: H = gully headwall
O = open slope
S = gully sidewall
E = escarpment face
C = gully channel

Land Use C = clearcut
N = natural
R = road

Vegetation Status: -12 = landslide vegetated as of May 2000, (12 years since first regrowth notice on aerial photographs)
+34 = landslide remains unvegetated as of May 2000 (34 years that slide has remained unvegetated since first noted on aerial photographs)

Entered Stream or Gully: S = landslide debris entered a stream
V = landslide debris entered a gully
VS = landslide debris entered both gully and stream
blank = landslide debris did not enter either a gully or stream

Sediment Delivery (at time of failure) direct = sediment deposited directly into Chapman Creek
indirect = sediment deposited into a tributary or gully
none = sediment is not deposited into any stream or gully, but remains on the slope or floodplain

Current Risk of Sediment Impact to Chapman Creek:

HIGH High risk of sediment impact to Chapman Creek
Criteria: direct connectivity, slope > 20 degrees, currently unvegetated, and comprised of clay, silt, sand and fine gravel.

MODERATE Moderate risk of sediment impact to Chapman Creek
Criteria: indirect connectivity (narrow valley bottom provides buffer), slope > 20 degrees, comprised of silts, sands and fine and coarse gravels

LOW Low risk of sediment impact to Chapman Creek
Criteria: indirect to no connectivity, fully or partially vegetated or scoured to bedrock

APPENDIX B - Gray Creek Sediment Source Inventory

Slide Id. No.	Type	Texture	Materials	Land Use	Vegetation Status	Sediment Delivery	Current Risk of Sediment Impact
S1	S	silt & sand	M	C	PART	Direct	Moderate
S2	F	silt & sand	M	R	PART	Direct	Moderate
S3	F	silt & sand	M	R	PART	Direct	Moderate
S4	F	silt & sand	M	R	FULL	Direct	Low
S5	F	silt & sand	M	C	FULL	Direct	Low
S6	F	silt & sand	M	R	FULL	Direct	Low
S7	S	silt & sand	M	C	FULL	Indirect	Low
S8	S	silt & sand	M	C	FULL	Indirect	Low
S9	S	mixed fragments - silt & sand	M	N	UNK	Direct	Low
S10	S	mixed fragments - silt & sand	M	N	UNK	Direct	Low
S11	S	mixed fragments - silt & sand	M	N	UNK	Direct	Low
S12	S	mixed fragments - silt & sand	M	N	UNK	Direct	Low
S13	S	mixed fragments - silt & sand	M	N	UNK	Direct	Low
S14	S	gravel	M	N	UNK	Direct	Low
S15	F	gravel	M	C	FULL	Direct	Low
S16	S	gravel	M	N	PART	Direct	Moderate
S17	S	rubble - silt & sand	M	N	UNK	Indirect	Moderate
S18	S	rubble - silt & sand	M	N	UNK	Indirect	Moderate
S19	S	rubble - silt & sand	M	N	UNK	Indirect	Moderate
S20	S	silt & sand	M	N	NONE	Indirect	Moderate
S21	S	angular colluvium	C	N	NONE	Indirect	Moderate
S22	S	silt & sand	M	N	NONE	Indirect	Moderate
S23	S	silt & sand	M	N	NONE	Indirect	Moderate
S24	S	silt & sand	M	N	NONE	Indirect	Moderate
S25	S	angular colluvium	C	N	NONE	Indirect	Moderate
S26	S	sand & gravel	M	R	UNK	Direct	Moderate
S27	S	sand & gravel	M	R	NONE	Direct	High
S28	S	sand & gravel	M	R	NONE	Direct	High

Type of Landslide: S - Debris slide
F - Debris Flow
Materials: M - Moraine
C - Colluvium
Land Use: C - Clearcut
R - Road
N - None, natural
Vegetation Status: UNK - unknown, not visible on air photos
PART - partially vegetated
FULL - fully vegetated

APPENDIX C - Riparian Assessment of Chapman Creek

Reach No.	Segment No.	Stand Structure	Riparian Vegetation	Crown Closure	Harvesting/Restocking History	Disturbances
1a			Dr(MbHw)			private land/development
1b			Dr(MbHw)			
1c			Dr(MbHw)			
1d			FdDrHw			
2	R1	YFc	Fd(DrHw)	4	Logged 1960	powerline crossing
	R2	YFc	Dr	2	Logged 1992 (currently NSR)	old road crossing
	L1	YFc	CwHw(Fd)	4		
	L2	YFd	Dr	2		
3	R3	YFc	FdHw(Cw)	3	Logged 1992 (currently NSR)	nearby gravel pit
	L3	YFc	FdHw(Cw)	2		
4a	R4	YFc	FdHw(Cw)	3		SCRD intake access road
	L4	YFc	CwFd(Dr)	2	Logged (NSR)	old road crossing
	L5	PSd	DrHw	2	Logged (NSR)	
	L6	YFc	CwFd(Dr)	2		
	L7	YFc	CwFd(Dr)	3		
4b	R4	YFc	FdHw(Cw)	3	Logged	
	L8	YFc	FdHw(Dr)	3	Logged	
4c	R5	YFc	HwFd(Cw)	3	Logged 1946	old road parallels ck
	R6	YFc	HwFd(Cw)	3	Logged 1946	LB sed. source
	R7	YFc	HwFd(Dr)	2	Logged 1946	
	L9	YFd	DrFd(Cw)	3	Logged 1946	recent slide from mainline
	L10	YFc	HwFd(Cw)	3	Logged 1946	
	L11	YFd	DrFd	3	Logged 1946	
	L12	YFc	HwFd(Dr)	3	Logged 1946	
5a	R7	YFc	HwFd(Dr)	2	Logged 1946	slides (RB)
	L12	YFc	HwFd(Dr)	3	Logged 1946	older slides, now reveg.
	L13	YFc	HwBa(Cw)	3	Logged 1958; Planted 1966	
5b	R7	YFc	HwFd(Dr)	2	Logged 1946	areas of disturbance adj. Ck
	R8	YFd	Dr(Hw)	2	Logged 1958	disturbance, deciduous veg
	R9	YFc	HwBa(Cw)	1	Logged 1965-70; Planted 1979	deciduous regen on dist areas
	L14	YFd	DrHw	2		
5c	R9	YFc	HwBa(Cw)	1	Logged 1965-70; Planted 1979	
	R10	YFc	BaHw(Cw)	1	Logged 1965-70, Planted 1972	decidous along RB
	R11	YFc	BaCw(Hw)	3	Logged 1984	slow to recover
	L14	YFd	DrHw	2		
	L15	YFc	HwBa(Cw)	1	Logged 1970	sev major sed sources
	L16	YFc	CwBa	1	Logged 1970	sev major sed sources
	L17	YFc	CwFd	2	Logged 1984	slow to recover
5d	R12	YFc	FdHw(Ba)	2		thin buffer
	R13	YFc	BaHw	2		thin buffer
	L17	YFc	CwFd	2	Logged 1984	thin, discontinuous buffer
	L18	YFc	BaHw	2		adequate buffer
5e	R14	YFc	HwYcBa	3		none
	L19	YFc	HwYcBa	3		none
5f	R14	YFc	HwYcBa	3		none
	L19	YFc	HwYcBa	3		none

Note: Primary source of information from EVS Environmental Consultants Ltd. report (1999) and 1996 1:5,000 scale air photos

APPENDIX C - Riparian Assessment of Gray Creek

Reach No.	Segment No.	Stand Structure	Riparian Vegetation	Crown Closure	Harvesting/Restocking History	Disturbances
1	R1	YFd	MbDrFd	3		nearby development
	R3	YFc	MbDrFd	3		
	L1	YFd	FdHCw	3		
	L2	YFc	FdH	3		
2a	R4	YFc	Fd(CwHw)	3	Logged 1985; Planted 1986	
	L3	YFc	Fd(Dr)	3	Logged 1982; Planted 1984	several road slides
2b	R5	YFc	FdHw(Dr)	3	Logged 1945	
	R6	YFm	FdDr(Cw)	3		
	L4	YFc	FdHw(Dr)	3	Logged 1945-52	
3a	R7	YFc	HwBa	4		
	L5	YFc	HwBa(Cw)	4		
	L6	YFm	HwDr	4		powerline closeby
3b	R8	YFc	HwCwBa(Dr)	3		dom by deciduous veg
	L6	YFm	HwDr	4	Logged 1944-49	
	L7	YFc	HwCwBa	3	Logged 1950-53	dom by deciduous veg
4a	R9	YFc	BaHwCw	3		
	L7	YFc	HwCwBa	3	Logged 1950-53	
	L8	YFc	HwBa(Cw)	3		
4b	R9	YFc	BaHwCw	3	Logged 1949-53	
	R10	YFc	HwYcBa	4	Logged 1980-83	small buffer, non-functioning
	L8	YFc	HwBa(Cw)	3	Logged 1954	
	L9	YFc	HwYcBa	4	Logged 1980; Planted 1982	deact road crossing
5	R10	YFc	HwYcBa	4	Logged 1980-83	buffer to creek
	L9	YFc	HwYcBa	4	Logged 1980; Planted 1982	

Note: Primary source of information from EVS Environmental Consultants Ltd. report (1999) and 1996 1:5,000 scale air photos

Appendix D – Emergency Contact List

This list of emergency contact names and numbers will be provided to all contractors or other personnel working in the Chapman and Gray Creek community watersheds.

General Manager SCRD Infrastructure Services – Sieg Lehmann	885-2261 (bus.)
	885-9364 (home)
Administrative Assistant SCRD Infrastructure Services – Dave Crosby	885-2261 (bus.)
	885-6465 (home)
SCRD Utilities Supervisor – Don Gare	885-2261 (bus.)
	885-0862 (bus.)
Medical Health Officer – Dr. Paul Martiquest	885-5600
Environmental Health Officers –	
Bob Weston (Gibsons)	886-5614 (bus.)
	885-3736 (home)
Jim Brookes (Gibson)	886-5600
Tim Adams (Sechelt)	885-5164
Bill Purtell (Sechelt)	885-5164
Medical Clinic (Sechelt)	885-2257
Hospital (Sechelt)	885-2224
R.C.M.P. Sechelt	885-2266
Gibsons	886-2245
Provincial Emergency Program – Duty Officer	1-800-663-3456
Sunshine Coast Emergency Program – Bob Stubbings (Coordinator)	885-0738 (bus.)
	886-1559 (home)
	740-9391 (pager)
Regional District Chairperson	885-2261 (bus.)
BC Parks – Al Jenkins	885-9019 (bus.)
	885-3774 (home)
	898-3678 (District Office)
Ministry of Forests – Sechelt Field Office	741-5004
MOF Fire Line	740-5008