Western Forest Products Inc.

Nootka Region

Tree Farm Licence 19
Watershed Indicators

Forest Investment Account Project #6649012
Investment No. COTFL196649

March 2008

Prepared by:

Glynnis Horel, P. Eng.
G.M. Horel Engineering Ltd.
2639 Barnes Road, Nanaimo, B.C. V9X 1N3
Phone: (250) 722-7166 Email: oesl@shaw.ca

Western Forest Products Inc.
Nootka Region
TFL 19 Watershed Indicators Project

Table of Contents

Western Forest Products Inc.
Nootka Region
TFL 19 Watershed Indicators Project

Appendix C	Map atlas	*separate document*
	Map 1	-- Biogeoclimatic Zones
	Map 2	-- Bedrock Geology
	Map 3	-- Steep Slopes and Watershed Units
	Map Set 4	-- Era of Road Construction
	Map Set 5	-- Road Stability Hazard, Deactivation Status, Landslides
	Map Set 6	-- Stream Channel Types
	Map Set 7	-- Riparian Function -- Left Bank
	Map Set 8	-- Riparian Function -- Right Bank
	Map Set 9	-- Riparian Vegetation -- Left Bank
	Map Set 10	-- Riparian Vegetation -- Right Bank
	Map Set 11	-- Potential sites for riparian assessment
	Map Set 12	-- Potential sites for instream assessment

1.0 INTRODUCTION

This project was initiated by Western Forest Products Inc. (WFP) to provide the basis for physical watershed assessment and to develop indicators for watershed units on Tree Farm Licence 19 (TFL 19). The project area comprises 176,081 ha; this includes timber licences (726 ha) in the lower Oktwanch watershed formerly managed with TFL 37. See Figure 1.

The objectives are:

- To propose indicators for tracking the effectiveness of forest management strategies, and indicators for Sustainable Forest Management of watersheds;

- To identify candidate sites for possible riparian and instream restoration projects;

- To characterize physical watershed conditions as the basis for developing forest management stategies. (The management strategies are not part of this project.)

In 2005-2006 WFP and FIA cost-shared a project on TFL 19 that developed the following watershed-related inventories (FIA Project No. 6448006, report data March 31, 2006):

- Stability hazard ratings for all road segments with a moderate or higher hazard of fillslope instability;
- Sediment delivery potential to fish for road segments with a moderate or higher stability hazard rating;
- Stream channel type (alluvial, semi-alluvial, nonalluvial) and streams on alluvial fans, for all streams in WFP's GIS inventory;
- Riparian condition and function for alluvial and semi-alluvial streams that are not S6's;
- A landslide inventory (paid for by WFP) from airphotos, satellite imagery and event reports.

This project did the following:

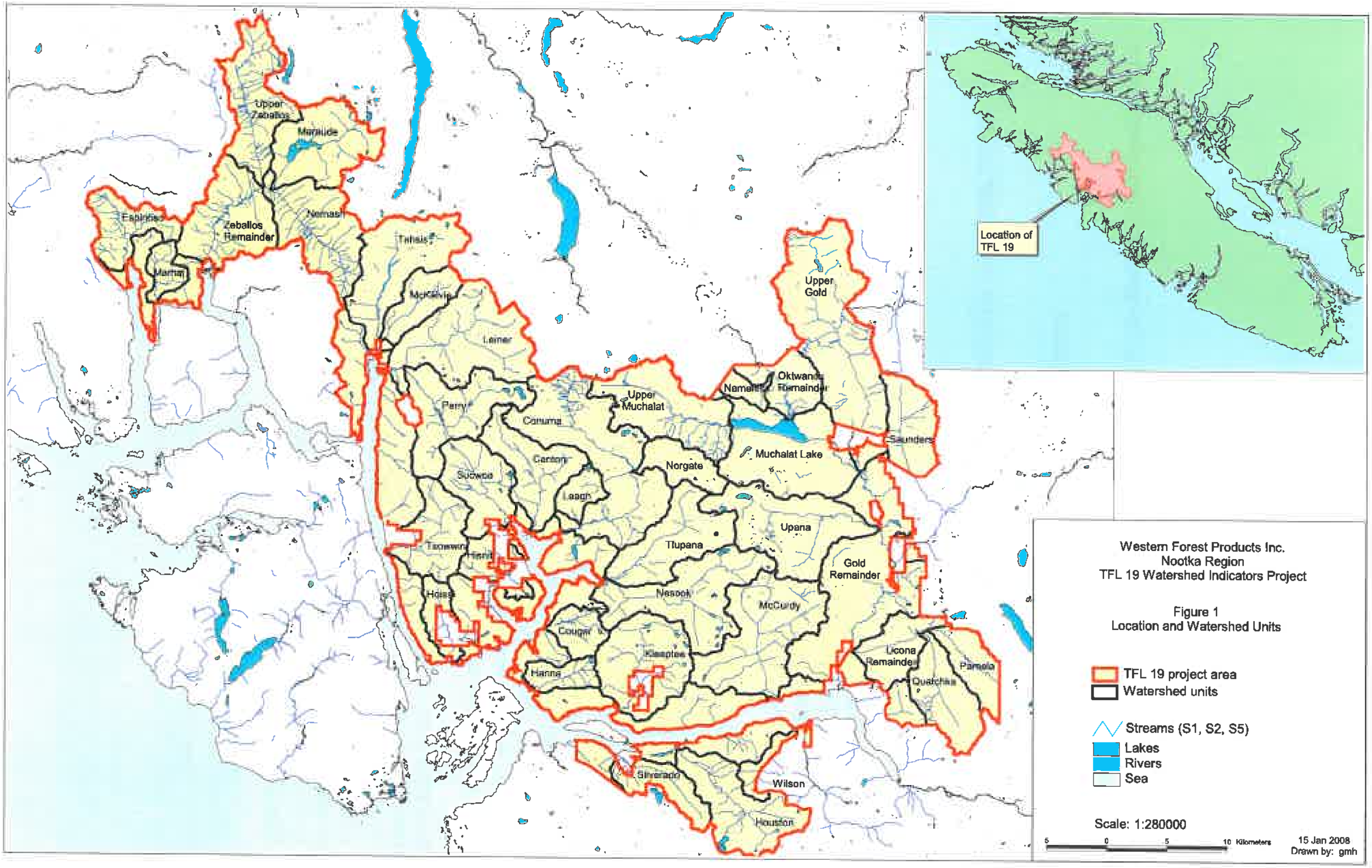
1. From inventories developed in the previous project, and existing reports and information, compile watershed data for all primary and local watersheds in the project area larger than 1,000 ha.

2. From this data, develop subjective factors to rank watershed sensitivity, watershed disturbance, and risk.

3. From the above information, identify current trends in watershed condition, sensitive areas in each watershed, and key concerns for watershed management.

4. Select indicators to track ongoing forest management practices, and to track long term Sustainable Forest Management objectives for watershed condition.

5. Using the above inventory information and other WFP spatial data, select criteria and identify candidate sites for riparian assessments and instream restoration.



Western Forest Products Inc.
Nootka Region
TFL 19 Watershed Indicators Project

Figure 1
Location and Watershed Units

2.0 INFORMATION AVAILABLE

The following information was used in this project.

- 1995 black and white airphotos;
- 2004 and 2005 satellite image;
- Digital inventory data as of May 2007 from WFP's Geographic Information System (GIS) including:
    - TRIM (20 m) contours,
    - Water features including streams and lakes,
    - Harvesting history,
    - Terrain stability mapping,
    - Slopes steeper than 60% (generated by WFP from TRIM DEM),
    - Tenure,
    - Roads.
- Inventory data developed in the 2006 project.

The following information was available from public sources:

- Bedrock geology mapping at 1:250,000 scale.
- Biogeoclimatic mapping.
- Environment Canada precipitation data.

3.0 STUDY AREA

For the purpose of this project, primary watersheds are those that drain directly into the sea. Regional watersheds are large primary watersheds. Major basins within a regional watershed that drain directly into the mainstem of the regional watershed are called local watersheds. The east part of TFL 19 (29% of the TFL area) is in the Gold River regional watershed. All of TFL 19 drains to the west side of Vancouver Island. This part of the west coast of Vancouver Island is deeply transected by inlets. There are many small primary watersheds. Climate and hydrology in many of these watersheds is probably influenced by proximity to the ocean; that is, even at mid elevation bands, winter snowpacks are likely to be of short duration.

Elevation in the study area ranges from sea level to 1875 m at the upper drainage divide between the Zeballos watershed (Nomash basin) and the Woss watershed (tributary to the Nimpkish). At low elevations, biogeoclimatic zones ranges from very dry maritime (CWH xm2) along the Gold River valley floor to southern very wet hypermaritime (CWH vh1); and to windward moist maritime (MHmm1) and alpine (AT p) at higher elevations. See Map 1. Environment Canada climate stations in the vicinity of the project area record the climate data given in Table 1.

Table 1
Climate Summary
Environment Canada AES Climate Stations

	Nootka Light Station	Tahsis	Zeballos	Conuma R. Hatchery	Gold R. Townsite
Elevation	16 m	5 m	7 m	12 m	140 m
Period of record	1978-2002	1952-1988	1955-1993	1989-2002	1966-2002
Mean annual rainfall	3260 mm	3252 mm	3790 mm	3610 mm	2701 mm
Mean annual snow	17.6 cm	38.3 cm	33.1 cm	41.6 cm	115.1 cm
Mean annual precipitation	3278 mm	3311 mm	3830 mm	3720 mm	2812 mm
Maximum 1-day rain	210 mm 06-Nov-78	245 mm 30-Oct-81	141 mm 18-Nov-61	244 mm 22-Dec-94	188 mm 07-Nov-95
Maximum 1-day snow	26.6 cm 09-Jan-80	19.0 cm 22-Feb-82	19.1 cm 05-Mar-56	53.2 cm 31-Dec-96	51.8 cm 03-Jan-78
Mean annual temperature	10.1 C	NA	NA	NA	9.2 C
Maximum temperature	34 C 13-Aug-02	31 C (7 occurrences)	NA	NA	39 C 09-Aug-81
Minimum temperature	-10 C 02-Feb-89	-10 C (2 occurrences)	NA	NA	-19.0 C 28-Jan-80

These stations are at low elevations; precipitation is known to increase with elevation in coastal watersheds. In TFL 19, annual precipitation likely ranges from 2800 mm in the lower Gold River valley to about 4000 mm at the upper elevations. All of TFL 19 is in Snow Zone 1 and drains to the west side of Vancouver Island. This is the wettest zone on the windward side of coastal B.C. (Hudson 2004).

Over half of TFL 19 is in steep terrain (Table A5, Map 3); most watersheds have steep mid and upper slopes. Several watersheds rise to alpine areas with rockslides and avalanche tracks. Lower and mid valley slopes are typically till-blanketed; mid and upper slopes have varying colluvial veneers and blankets. The larger valley floors have significant alluvial deposits. There are also occurrences of deep glaciofluvial deposits along the larger valleys and at some valley confluences.

Valley orientation and drainage patterns are strongly influenced by bedrock structure. The most extensive bedrock units in the study area are Karmutzen volcanics and granitic rocks of the Island Intrusions. Along the west side of the TFL there are bands of Parsons Bay and Quatsino formation containing limestone beds that may have karst features; in a few places elsewhere there are also limestone beds of the Buttle Lake group. See Map 2.

4.0 NOVEMBER 2006 STORMS

In November 2006 severe storms struck Vancouver Island that caused widespread flooding, landslides and windthrow. A total of 102 events were identified in TFL 19 from this storm. Of these, 18 originated in unharvested natural timber; however, most natural events were not reported and there were many torrents in existing natural slide tracks. Of the landslides identified, 72 occurred at harvested cutblocks; 45 were at postCode blocks, 27 were at preCode blocks. Twelve slides originated at roads; two of these were from postCode roads.

Watershed units in TFL 19 affected by these landslides (natural or development related) were Saunders, Nameless, Oktwanch Remainder, Twaddle and Waring Creeks in Upper Gold River, Hisnit, McCurdy, Tlupana, Silverado, McKelvie (only natural landslides), Tsowwin, and Wilson (landslide in BCTS area). See Table A4.

5.0 METHODS

There are no Resource Inventory Steering Committee (RISC) standards for the indicators developed in this project, or for inventories done in the 2006 project. This is an overview or planning-level assessment; the inventories were based on airphoto interpretation and GIS data. No site assessments were carried out. Definitions for the inventories are in Appendix B. Criteria for indicators developed for this project are described in subsequent sections of this report. A map atlas accompanying this report displays key attributes from the inventory data.

A helicopter reconnaissance of TFL 19 was done in June 2007 to update the landslide inventory, to check stream channel types and to identify impacts to stream channels from the November 2006 storms.

6.0 WATERSHED INDICATORS – DISCUSSION

To be practicable for ongoing forest management, indicators must be readily tracked by spatial analyses. As well, to the extent possible, they should be directly measurable, and should make maximum use of data that is routinely available for forest management or can be easily acquired.

Gustavson and Brown (2002) propose 15 strategic and watershed-level indicators.

Strategic:

- Road density
- Road density on steep slopes
- Road-stream crossing density on forest land
- Road-stream crossing density on forest land on steep slopes
- Equivalent clearcut area (ECA)
- Riparian disturbance
- Salmon escapement
- Fish species at risk

Watershed level:

- Landslide area density
- Temperature
- Turbidity
- Habitat complexity
- Riparian disturbance

- Resident fish populations
- Benthic macroinvertebrate diversity.

This project focuses on indicators for physical watershed condition. Ecological indicators (temperature, turbidity, habitat complexity, resident fish populations, and macroinvertebrate diversity) are not within the scope of this project. While habitat complexity is not directly assessed in this project, some inferences can be made from stream channel type and riparian condition. For example, an alluvial stream with unlogged riparian forest could be expected to have greater habitat complexity than a nonalluvial stream; or than an alluvial stream where the riparian forest has been logged and has inadequate riparian forest to supply large wood debris (LWD) or limit channel bank erosion (CBE).

Most of the above strategic-level physical indicators are the same or similar to report card factors from the original Coastal Watershed Assessment Procedure (BC Ministry of Forests, 1995).

The attraction of report card style indicators is that they can be readily compiled by spatial data analyses with little or no professional assessment or judgment applied. However, this significantly limits the validity of this type of indicator. While these indicators are helpful, they do not eliminate the need for professional judgment to interpret existing watershed conditions and trends.

A limitation of all spatial analyses is the accuracy and completeness of the spatial data set.

Road density

Simple road density (total road length per area of watershed) does not distinguish between roads that are overgrown relative to those that are in active use; roads that have been deactivated or remediated from roads that have not; or roads built before the Forest Practices Code (FPC) from those built under FPC standards. These are important factors for road stability and stream crossings; and consequently for the influence of roads on watershed and stream conditions. As well, spatially-calculated road density is a function of how many roads are recorded or retained in a digital road inventory. For example, some operations delete from the inventory some or all of the nonstatus roads (roads not under Road Permit), such as roads that have been permanently deactivated. Other operations retain in the inventory all roads that have been mapped from the earliest records. Calculated road density will vary considerably depending on the data management approach being employed.

This project compiles the following data for roads (Table A1):

* Total length of roads with moderate or higher stability hazard (Section 3.2)
* Total length of roads with moderate or higher stability hazard that have not been permanently deactivated.
* Length of road on steep terrain, separately for preCode and postCode roads.
* Landslides per km of road built on steep terrain, separately for preCode and postCode roads.

Streams

Crossing density and length of stream disturbance are highly sensitive to the scale and intensity of stream mapping. Gustavson and Brown do not specify stream size or stream order to be considered. For example, WFP's stream inventories include many streams that are not in the 1:20,000 TRIM map base; so comparison of stream crossing densities from WFP's inventories to those based on the TRIM map base would be misleading. The scale and intensity of stream mapping also vary from area to area within WFP operations depending on where the stream inventory has been enhanced through site-level planning or specific mapping projects. As an illustration, in the combined area of TFL 6 and TFL 39 Block 4 the density of mapped streams in the inventory was 2.8 km/km^2; in TFL 37, the mapped stream density was 4.5 km/km^2; and in TFL 19 the mapped stream density is 2.6 km/km^2. This may partly reflect different actual stream density but more likely is a function of the mapping. This illustrates the difficulty with comparing indicators between operating areas.

Riparian vegetation has both geomorphic and ecological functions related to streams. Assessing ecological function is beyond the scope of this report. In certain channel types, the riparian forest has an important role in maintaining channel integrity and structure. This in turn affects the physical quality of habitat in these streams. Further, the influence of riparian disturbance varies with channel type. Where stream banks are in erodible alluvial deposits, the riparian forest is critical to maintain channel stability, whereas confined channels with nonalluvial banks do not become unstable following logging. LWD is important for channel structure in alluvial and many semi-alluvial streams. In small upland streams subject to gully processes, LWD may form steps, creating channel roughness and limiting sediment transport. In larger nonalluvial streams, LWD usually has limited to no function. LWD may cause forced morphologies where jams develop at choke points or individual logs wedge across a channel; these are transient features that degrade rapidly when the wood is dislodged or breaks down.

Riparian disturbance is typically taken to be the length of stream channel logged. This by itself is not a good indicator because it does not reflect the role of LWD and bank vegetation as it relates to stream sensitivity. This project compiles riparian data relating to physical channel condition as follows:

* For alluvial and semi-alluvial streams, length of stream channel with inadequate riparian forest on one or both sides to supply functioning large wood debris (LWD).
* For alluvial streams, length of stream channel with inadequate riparian forest on one or both sides to control stream bank erosion and maintain channel stability. This is indicated from airphoto evidence that the channel appears overwidened or its position is unstable relative to the expected predisturbance condition.

Note that the first indicator, ability of riparian forest to supply functioning LWD, does not mean that there is adequate LWD in the channel. This cannot be determined in an overview level assessment; it requires field review. In field reviews of streams in second growth, it is common to find that streams continue to be deficient in functioning LWD long after the adjacent forest has trees of sufficient size to supply it, because the trees are not falling into the streams. Streams where the riparian zone was logged under preCode forest practices may be deficient in LWD, for any of three reasons:

* The trees in the riparian zone are mainly alder as opposed to conifers; or
* The trees in the riparian zone are mainly conifers but have not yet reached sufficient size to supply functioning LWD; or
* The trees in the riparian zone are mainly second growth conifers and of sufficient size, but are not falling into the streams.

The age of the riparian forest is an important factor when considering restoration projects to place LWD in streams, because if the adjacent forest has trees of adequate size and type to eventually replenish LWD, long-term maintenance of LWD in streams is more likely to be successful.

Equivalent Clearcut Area (ECA)

ECA is often taken to be an indicator of stream flow change related to forest harvesting. This is true only in specific research watersheds for which stream flows have been correlated to ECA. Even in these watersheds, the relationship between stream flow and ECA varies widely between watersheds. ECA is in fact an indicator of how a regenerating forest compares to a natural forest with respect to snowpack development and rainfall interception (Hudson and Horel 2007). It is determined by applying hydrologic recovery models to individual harvested stand areas, and cumulating these stand areas for the total watershed. Vegetation cover is only one factor affecting stream flow response. Others include:

- Nonforest area,
- Topographic relief,
- Soil depth and permeability (e.g., macropores),
- Bedrock permeability (especially karst, if present),
- Water storage (lakes, wetlands, icefields, late-persisting snowpacks),
- Regional climate,
- Dominant peak flow regime (snow melt, rain, rain-on-snow),
- Nonforest development (agriculture, urban, industrial),
- Artificial flow controls or diversions, extraction of groundwater or surface water.

Changes in stream flows are of interest for two reasons. One is the potential physical effects on channel characteristics. The second reason is the potential effect on fish and aquatic ecosystems of changes such as magnitude and timing of flow events. Low flows are often recognized as a limiting habitat condition in stream systems. The effects on aquatic ecosystems of peak flow increases or shifts in timing are not well understood. Ecosystem effects of changes in peak flows are beyond the scope of this project. This project considers the potential physical effects of changes in stream flows on channel characteristics.

Recent work by Chapman (2003), and Alila and Schnorbus (2005), suggests that in rain-dominated coastal watersheds, peak stream flows are either not significantly affected by ECA (Chapman), or are only significantly affected for low return period events (Alila and Schnorbus). These events are unlikely to cause perceptible channel change.

Where peak flow regimes have a significant rain-on-snow component, flows are likely to be more significantly affected by forest harvesting in the rain-on-snow zone, depending on the importance of forest cover relative to other watershed characteristics.

Where peak flow regimes are dominated by spring snowmelt events, particularly in watersheds with low relief, the influence of forest cover removal on stream flows can cause large changes in peak stream flows (Forest Practices Board 2007). Snow-dominated peak flow regimes tend to be an interior, rather than coastal, condition.

The potential for channel change from increased peak flows depends on the type and sensitivity of the channel. Changes in stream flows have the potential to initiate a response in alluvial streams where channel morphology is dominated by flood events. Nonalluvial streams with erosion-resistant banks and coarse (cobble-boulder-bedrock) substrates are not sensitive to peak flow increases. Large alluvial streams with broad floodplains and cobble-boulder substrates have low sensitivity, except to severe storms, because they have a large capacity to handle overflow and store sediment. Streams that are potentially sensitive to peak flow increases would be smaller alluvial streams especially those with gravel-sand substrates and channel banks; or semi-alluvial streams with erodible banks in fine-textured materials such as sandy or silty glaciolacustrine deposits or sandy glaciofluvial deposits.

Channel form and condition in coastal watersheds are typically dominated by physical processes such as landslides, erosion, riparian logging along erodible channels, and loss or removal of large wood debris (LWD) from within channels. Potential channel changes from changes in peak flows are usually not significant relative to changes caused by these other physical processes. Even in small alluvial streams, potential changes from altered stream flows have far less effect on channel condition than changes caused by, for example, loss of LWD.

Understanding stream flow response to harvesting is important when evaluating watershed sensitivity and effects of forest development. In coastal watersheds, current science suggests that ECA is a poor indicator of watershed condition. By itself it has no physical significance to watershed condition and is not an indicator of potential channel disturbance. Indicators that reflect physical hillslope processes, channel sensitivity and riparian condition are more directly relevant to watershed and stream condition.

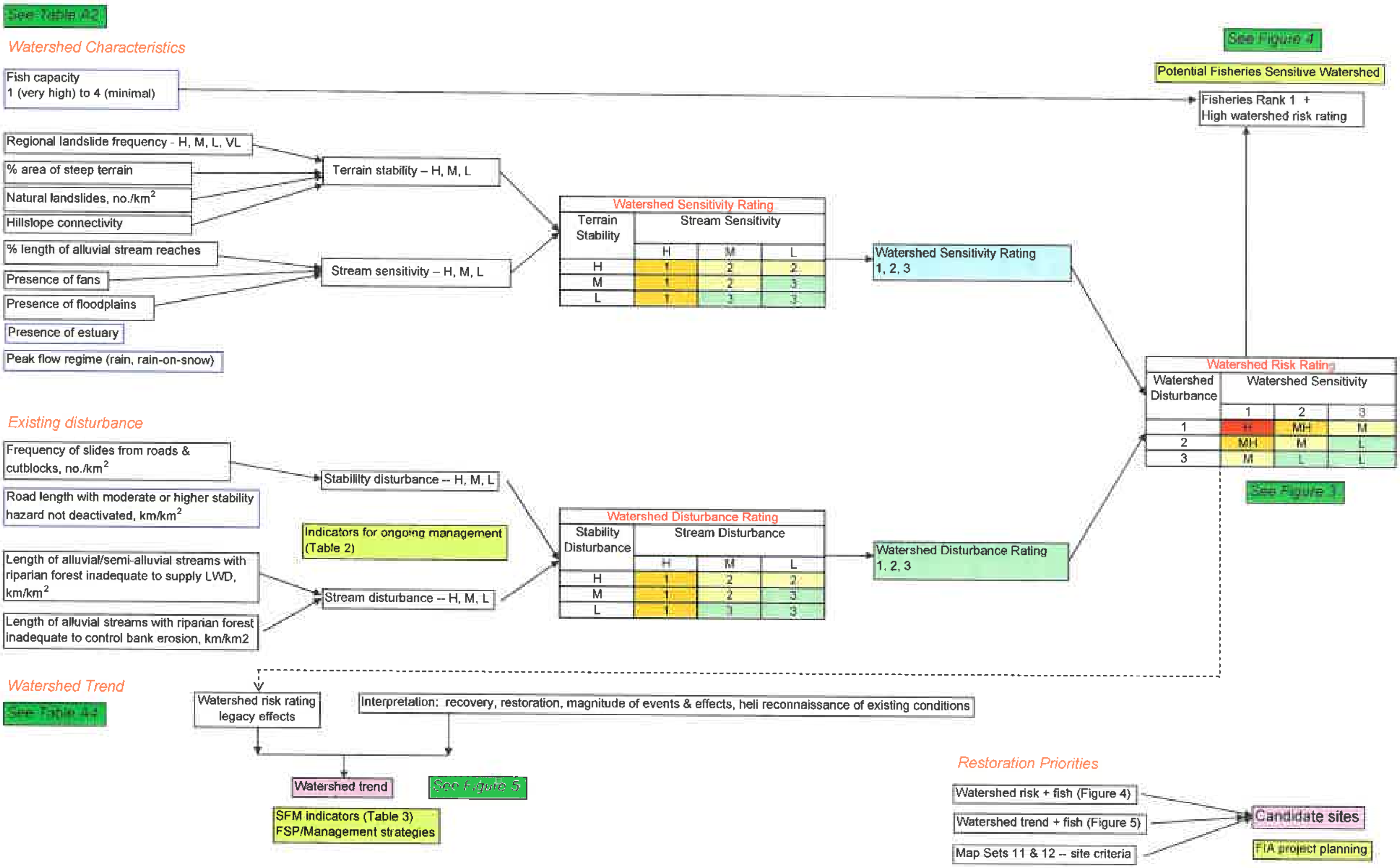
7.0 WATERSHED RISK RATINGS

Figure 2 illustrates the process for assigning watershed risk levels based on sensitivity and disturbance. Figure 3 is a visual presentation of these ratings for TFL 19 watershed units, as described below.

7.1 Watershed Data

Table A1 (Appendix A) summarizes watershed data for 38 watershed units in TFL 19.

Figure 2 -- Watershed Risk Rating & Watershed Trend



Landslides are reported separately for preCode and postCode roads and cutblocks to allow the effect of changed management practices to be examined.

The data in Table A1 reflect legacy effects from historic practices, recent events, and existing potential hazards. Legacy effects include landslides from preCode roads and cutblocks; and inadequate riparian forest to control channel bank erosion (CBE), or supply large wood (LWD).

Potential hazards include areas of steep terrain logged since 1995. These areas may be vulnerable to further open-slope landslides, which may be a consideration in risk management for future harvesting on steep slopes. Road length of moderate or higher hazard that is not deactivated indicates the potential for possible future landslides, and is a consideration for risk management of road maintenance.

Number of landslides per 100 ha logged in steep terrain helps to predict the probable occurrence of landslides for new cutblocks in the same area; and to evaluate how well steep terrain is being managed.

7.2 Subjective Ratings for Sensitivity, Disturbance and Risk

Subjective ratings for watershed sensitivity, disturbance and risk are given in Table A2.

These ratings are derived from the data in Table A1, and provide an interpretation of the data. Some judgment is applied in assigning risk ratings from the numerical data.

Watershed characteristics describe the inherent physical character of a watershed and its sensitivity to disturbance. These ratings allow the relative sensitivity of watersheds to be characterized by the same criteria whether they are undeveloped or have been disturbed. These characteristics do not change with time although for example, variations in natural landslide frequency might occur through time.

Watershed disturbance ratings primarily reflect legacy effects of historic practices. Going forward, they can be tracked to monitor watershed recovery and the effects of changed management practices.

For watershed units that are only partly in WFP tenure, data and ratings for WFP's portion of the unit may not reflect the condition of the entire watershed unit. Note also that there are several units that are portions of drainage areas: Oktwanch Remainder, Gold Remainder, Ucona Remainder, Zeballos Remainder.

Most ratings and indicators in this project are similar to indicators used in TFL 6 and TFL 39 Block 4; and to TFL 37 which is adjacent to TFL 19 (ref. FIA projects 6549006, 6561023 and 6654004). They may not be applicable outside this region of Vancouver Island.

7.2.1 Watershed characteristics

The watershed sensitivity rating is based on terrain stability and stream sensitivity (Table A2, Figure 2). Criteria for the ratings were selected from a review of data for watersheds

Figure 3
TFL 19 Watersheds by Risk Category
(From Figure 2 & Table A2)

Criteria for sensitivity & disturbance ratings are in Table A2, Appendix A.

Watershed Sensitivity Rating			
1	Oktwanch-Rem., Pamela, Conuma, Espinosa, Sucwoa, Tahsis, Zeballos-Rem.	U. Gold, Houston, Tlupana, Tsowwin	U. Muchalat, Kleeptee, Canton
2		Saunders, Nameless, Hanna, Hisnit, Hoiss, Perry, Mamat, U. Zeballos	Muchalat L., Quatchka, Ucona-Rem., Upana, Gold-Rem., Leagh, Leiner, Silverado, McKelvie CWS, Maraude, Nomash
3	McCurdy, Wilson		Norgate, Cougar, Nesook
	1	2	3

Watershed Disturbance Rating

Blue text -- CWAP completed previously.
Watershed sensitivity: 1 - most sensitive, 3 - least sensitive
Watershed disturbance: 1 - most disturbed, 3 - least disturbed

Risk category	
(pink)	High
(orange)	Moderately high
(yellow)	Moderate
(green)	Low

See Figure 2

Note: WFP has only a portion of some of the watersheds, and the ratings are determined only for WFP's areas. The ratings could change if determined over the entire watershed.

where conditions were documented in watershed assessments, or known from other work. As noted, these may not be applicable outside the region.

Terrain Stability Rating

Factors considered in assigning the terrain stability rating are regional landslide frequency, area of the watershed in steep terrain, occurrence of natural landslides, and hillslope connectivity to the mainstem.

Regional landslide frequency is defined in WFP's draft Terrain Risk Management Strategy (TRMS) and in their Terrain Management Code of Practice (TMCOP) based on occurrence of landslides in logged steep terrain as indicated in the following table. Where landslide inventory data are not available, or the number of events is too few for the frequency to be meaningful, annual precipitation or biogeoclimatic zones are used here to estimate the probable frequency.

Very low	<1 slide per 100 ha logged in steep terrain	-
Low	1-<3 slides per 100 ha logged steep terrain	<2000 mm/year
Moderate	3-5 slides per 100 ha logged steep terrain	2000-3000 mm/year
High	>5 slides per 100 ha logged steep terrain	>3000 mm/year

For the purpose of this project, "steep terrain" is the combined area of Class 4 and 5, plus slopes steeper than 60% that fall outside these terrain stability polygons (Map 3).

Relative terrain vulnerability is rated as follows:

Low	Steep terrain area =<10% of watershed area
Moderate	Steep terrain area 10-30% of watershed area
High	Steep terrain area >30% of watershed area

Because of the extensive steep terrain in TFL 19, most watershed units rank high for terrain vulnerability.

Hillslope connectivity is represented by the percent of mainstem length with a runout slope adjacent to the stream. In Table A2, yes (Y) indicates that runout slopes are present for 50% or more of the mainstem length. No (N) indicates that runout slopes are either absent, or present for less than 50% of the mainstem length. A runout slope is considered to be lower valley slopes or fans at least 150 m long with a slope gradient of less than 30% (based on Horel 2007). The presence of lakes, wetlands and other features can also influence connectivity or sediment transport.

In assigning the terrain stability rating, some judgment is applied to weighing the above factors.

Stream Sensitivity Rating

Stream sensitivity ratings are based on channel sensitivity, present of floodplains and presence of fans. Since alluvial streams are more sensitive than other channel types, the proportion of alluvial streams in a watershed reflects the overall stream sensitivity.

Because stream mapping in TFL 37 was to a higher intensity than in TFL 6 & TFL 39 Block 4, the channel sensitivity criteria from the TFL 6 & TFL 39 Block 4 did not apply well to the TFL 37 project. The stream mapping in TFL 19 is similar to that of TFL 6 & TFL 39 Block 4.

For this project, the criterion used to reflect relative channel sensitivity is the density of alluvial streams per unit watershed area. The density of alluvial S1, S2 and S3 streams is also noted but was not used as a sensitivity criteria; it does, however, give a sense of the potential sensitivity of fish streams. Some watersheds have considerable lengths of alluvial channels that are not fish streams.

The presence of floodplains with channel migrations zones reflects the potential for channel instability to occur following harvesting. For the purpose of this project, the presence of floodplains wider than three channel widths are noted (as estimated from airphotos). Similarly, fans have the potential to destabilize following harvesting of the fan surface or increased sediment delivery to the fan. Contemporary fans are those formed by the current fluvial regime. There are other fans that were formed during deglaciation and are no longer fluvially active. At some, the stream subsequently downcut through the fan and formed a second, lower fan which is the contemporary fan. Determination of active and inactive fans, and the active portion of floodplains, needs to be made in an onsite assessment. In this overview-level project, no distinction is made between active and inactive fans.

The presence of an estuary or delta is also noted. Estuaries do not relate to stream sensitivity but are relevant to site-level risk management of FRPA values.

The criteria for rating channel sensitivity are as follows:

Low	Density of alluvial streams: <0.20 km/km^2
Moderate	Density of alluvial streams: 0.20 - <0.25 km/km^2
High	Density of alluvial streams: >=0.25 km/km^2

The stream sensitivity rating considers channel sensitivity, floodplains and fans. Sensitivity is strongly weighted to the presence of a floodplain with a channel migration zone. Where floodplains of significant extent are present, the sensitivity rating is high.

Watershed Sensitivity Rating

The watershed sensitivity rating is determined from the terrain stability rating and the stream sensitivity rating as follows:

Watershed Sensitivity Rating				
		Stream Sensitivity Rating		
		H	M	L
Terrain Stability Rating	H	1	2	2
	M	1	2	3
	L	1	3	3

Hydrologic Change

Because ECA does not have direct physical significance to watershed or stream condition, it is not proposed as an indicator. It is nevertheless important to understand stream flow regimes and the factors affecting stream flow response, when developing watershed management strategies.

The rain-on-snow zone in coastal watersheds is usually taken to be the zone from 300 to a transition elevation of 800 m, 900 m or 1,000 m depending on the region. Transient snow is also affected by proximity to the ocean, especially on the west side of Vancouver Island where long inlets influence temperature and precipitation on the adjacent slopes. For this project, assumptions of peak flow regimes (rain, rain-on-snow) were based on proximity to the ocean and extent of the MHmm1 zone in the watershed units.

Table A2 notes watersheds where bedrock units might include limestone with karst features. Karst development can profoundly affect stream flow regimes because of the high bedrock permeability associated with subsurface solution channels. Where there is a significant component of subsurface flow in solution cavities, stream flow changes from forest harvesting are less likely to affect flow in surface channels. Map 2 shows bedrock geology in the project area, including bedrock units with limestone beds that might have karst development.

Karst features are known to be present in this region. As noted above, other factors such as presence of lakes and wetlands, and other watershed characteristics also have an important influence on the peak flow regime.

7.2.2 Watershed disturbance

The following conditions were considered in assigning a watershed disturbance rating:

* Frequency of landslides from roads and cutblocks
* Length of stream channels with inadequate riparian forest to provide LWD
* Length of stream channels with inadequate riparian forest to control bank erosion and maintain channel stability (CBE). This is from airphoto evidence of channel instability or overwidening.

Stability Disturbance Rating

The stability disturbance ratings were based on landslides from roads and cutblocks as follows:

Stability disturbance rating:	Low	Moderate	High
Slides from roads and cutblocks	<0.5 slides/km^2	0.5-1.0 slides/km^2	>1.0 slides/km^2

Road stability hazard is not incorporated into the stability disturbance rating because it represents potential hazard rather than actual disturbance; but is a consideration for risk-managing of road inspections and maintenance.

Potential stability disturbance:	Low	Moderate	High
Road length with moderate or higher stability hazard not deactivated	<0.25 km/km^2	0.25-0.5 km/km^2	>0.5 km/km^2

Stream Disturbance Rating

Disturbance levels were assigned as follows:

Disturbance level:	Low	Moderate	High
Riparian forest inadequate for LWD	<0.20 km/km^2	>0.20 km/km^2	
Riparian forest inadequate for channel bank erosion* (CBE)	<0.05 km/km^2	0.05-0.10 km/km^2	>0.10 km/km^2

*Typically indicates existing channel instability.

The higher of the two ratings was used as the stream disturbance rating. Disturbance ratings are weighted towards streams with floodplains where channels have become unstable as a result of riparian logging (CBE). In large streams this instability can persist for many decades until a mature forest of conifers is re-established in the floodplain. While landslides can severely impact streams, channel instability from riparian logging in a large floodplain can be far more persistent than impacts to streams from landslides, and so is given more weight in this rating system.

Watershed Disturbance Rating

The watershed disturbance rating is determined from the stability disturbance and stream disturbance ratings as follows:

Watershed Disturbance Rating				
		Stream Disturbance Factor		
		High	Moderate	Low
Stability Disturbance Rating	High	1	2	2
	Moderate	1	2	3
	Low	1	3	3

7.2.3 Watershed risk rating

Figure 3 shows the watersheds in the project area by risk category. Watershed risk is determined from the watershed sensitivity rating and the watershed disturbance rating

(Figure 2). Watershed risk ratings are used for comparisons between watersheds and to identify impacts of past development practices.

Watershed Risk Rating				
		Watershed Disturbance Rating		
		1	2	3
Watershed Sensitivity Rating	1	High	Moderately high	Moderate
	2	Moderately high	Moderate	Low
	3	Moderate	Low	Low

The highest sensitivity watersheds are those with floodplains where the stream has a channel migration zone and could become unstable if the riparian zone is logged. The highest risk watersheds are watersheds of this type where channel instability has actually occurred as a result of riparian logging and the channels are not yet stable.

8.0 FISHERIES RANK

Relative fisheries values are considered together with watershed risk (Figure 4), to assist in prioritizing watersheds for restoration work, and for on-going management strategies. Fisheries rank for each watershed is given in the tables in Appendix A.

This is a simple ranking meant for comparing the relative fisheries capacity between watersheds. It is not intended for site-level risk management. The rankings are primarily subjective; approximate criteria are as follows:

0	No data	
1	High to very high capacity. Large or potentially large anadromous runs	At least 5 km fish access up from ocean and >2 km of alluvial channels in the anadromous reaches.
2	Moderate anadromous capacity or important resident fishery.	2-5 km anadromous access and >1 km of alluvial channels.
3	Small but significant anadromous capacity or some resident fish.	<2 km anadromous access or <1 km of alluvial channels.
4	Limited fish capacity. Few resident or anadromous fish.	<0.5 km anadromous access.

Hatcheries, enhancement activities and community water supply areas are not accounted for in the rankings. These aspects, as well as species at risk or other focus species, are considered separately in site-level risk management.

Dave Clough provided fish information and a review of fisheries rankings for watershed units in the project area. See Table A3.

9.0 FISHERIES SENSITIVE WATERSHEDS (FSW)

The intent of the approach described in this project is that all watersheds are evaluated in a consistent manner, and are managed according to the specific sensitivities and key

Figure 4
TFL 19 Watershed Risk & Fish Rank

(Watershed risk from Figure 3 & Table A2)

Factors for risk ratings are in Table A2; Fish rank is in Table A3, Appendix A.

Watershed Risk Rating

High	Oktwanch-Rem., Conuma, Tahsis, Zeballos-Rem.	Sucwoa	Pamela, Espinosa	
Moderately high	U. Gold, Tlupana, Tsowwin	Houston		
Moderate	U. Muchalat, Kleeptee, Perry, Canton	Hisnit, Hoiss, McCurdy, U. Zeballos	Heber, Hanna, Mamat, Wilson	Nameless
Low	Muchalat L., Ucona-Rem., Gold-Rem.	Upana, Leiner, Maraude, Nomash	Quatchka, Leagh, Norgate, Nesook, Silverado, McKelvie	Cougar
	1	2	3	4

Fish Rank

Fisheries rank:

0	No data
1	High to very high fish capacity; large or potentially large anadromous runs.
2	Important resident fishery or moderate anadromous capacity.
3	Small but significant anadromous capacity; or some resident fish.
4	Limited fisheries capacity. Few resident or anadromous fish.

-- Watershed risk rating and fish rank can be used in conjunction with Map Sets 11 & 12 to prioritize candidate sites for restoration projects.

-- Watershed risk rating and fish rank serve GAR (2004) S. 14 and VILUP (2000) S. 8 which set objectives for sensitive watersheds with high fish values.

concerns in each watershed, rather than singling out individual watersheds for management focus.

However, there are specific objectives for watersheds with high sensitivity and high fish values in S. 14 of the Government Actions Regulation (2004) and in S. 8 of the Vancouver Island Land Use Plan (VILUP, 2000). The assessment methods here address these regulatory requirements.

Watersheds with a fisheries rank of 1, with high sensitivity, and with significant disturbance still apparent are shown on Figure 4. These are:

* Oktwanch
* Tahsis
* Conuma
* Zeballos Remainder

Only a portion of the Oktwanch watershed is in TFL 19; the entire watershed should be taken into account when assigning watershed sensitivity, disturbance and risk ratings.

Candidate FSW's in TFL 19 should be considered along with other candidate watersheds in the broader region.

The final determination of a fisheries sensitive watershed must be based on a detailed watershed assessment that includes field verification of stream conditions, as well as more specific fish information.

Watershed disturbance ratings can change over time as watersheds recover. This means that a fisheries sensitive watershed designation could be dropped once disturbance has recovered to an acceptable level.

10.0 WATERSHED CONDITION AND TRENDS

Figure 5 illustrates watershed trends relative to fisheries rank; Figure 6 is a spatial display of watershed trend. Table A4 describes the physical character of the watersheds, summarizes assessments and special initiatives, identifies sensitive areas and key concerns, and indicates the current watershed trend. This information provides the basis for selecting management strategies for individual watersheds.

Watershed trend is an interpretation of current watershed condition based on the data (Table A1), risk ratings (Table A2), and on changes apparent from airphotos, satellite imagery, and observed during the helicopter reconnaissance. It considers the legacy effects of preCode management practices, recovery that has taken place, risk reduction measures that have been implemented, and recent disturbances. These considerations account for the difference between the watershed risk shown on Figures 3 and 4, and the trend shown on Figure 5.

Legacy effects (which include riparian harvesting, cross stream yarding, logging of unstable terrain, and road construction practices that resulted in landslides and erosion) are

Figure 5
TFL 19 Watershed Trends
(from Table A4)

Watershed Trend				
D. Highly disturbed	Oktwanch-Rem., Tahsis	McCurdy	Wilson	
C. Moderately disturbed; or improving but still of concern	Conuma, Tsowwin, U. Gold	Hisnit, Hoiss, Houston, Sucwoa	Saunders, Pamela	Nameless
B. Improving, may have sites that are still disturbed	U. Muchalat, Canton, Kleeptee, Perry, Tlupana, Zeballos-Rem.	Upana, Maraude, U. Zeballos, Nomash	Espinosa, Mamat	
A. Stable OR consistent with natural	Muchalat Lake, Ucona-Rem., Gold-Rem.	Leiner	Quatchka, Norgate, Leagh, Hanna, Nesook, Silverado, McKelvie	Cougar
	1	2	3	4

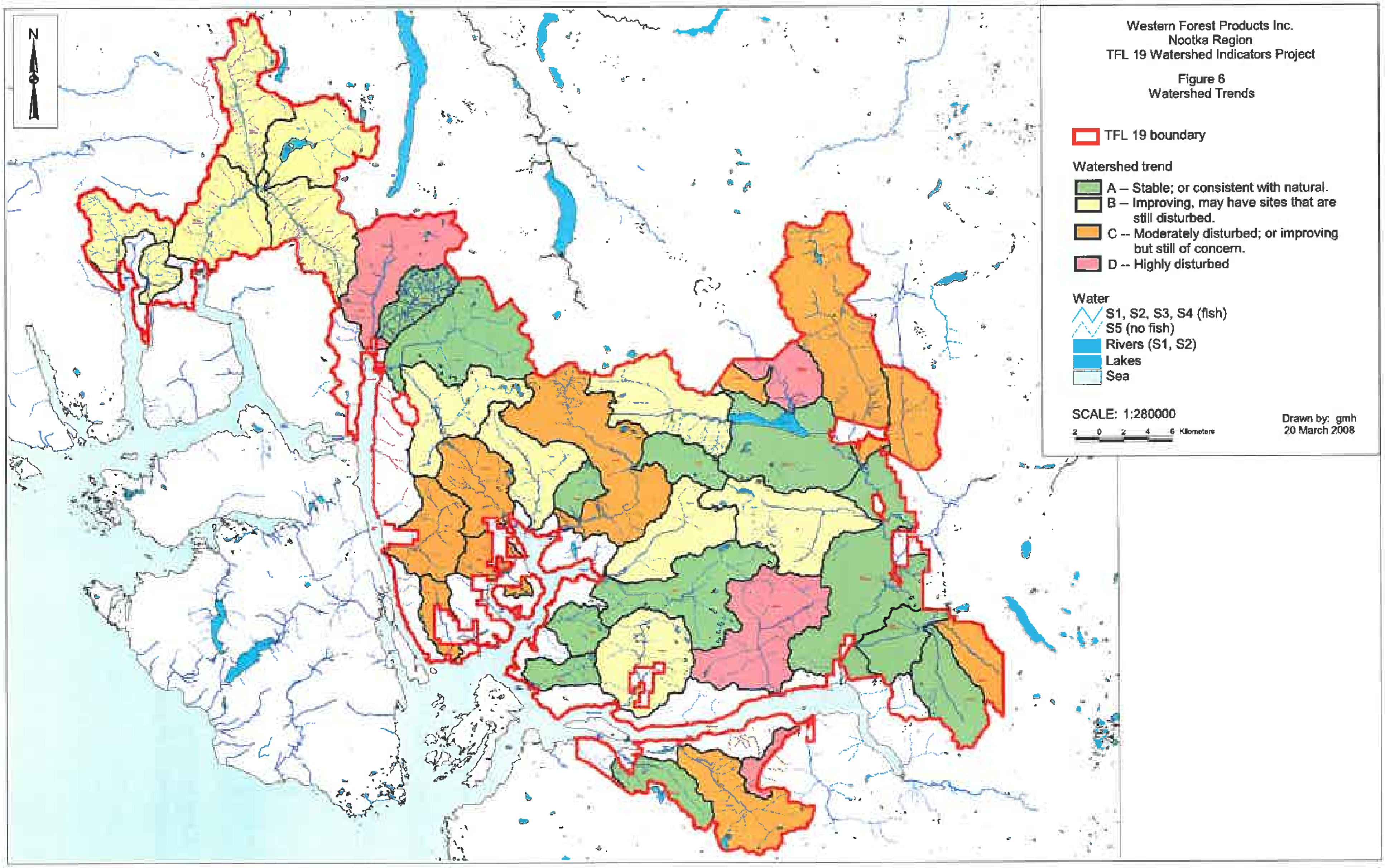
Fish Rank

Blue text -- CWAP done previously

Fisheries rank:

0	No data
1	High to very high fish capacity; large or potentially large anadromous runs.
2	Important resident fishery or moderate anadromous capacity.
3	Small but significant anadromous capacity; or some resident fish.
4	Limited fisheries capacity. Few resident or anadromous fish.

-- Watershed trends are the basis for proposed SFM watershed indicators; and for on-going management strategies.


N
Western Forest Products Inc.
Nootka Region
TFL 19 Watershed Indicators Project
Figure 6
Watershed Trends
TFL 19 boundary
Watershed trend
A – Stable; or consistent with natural.
B – Improving, may have sites that are still disturbed.
C -- Moderately disturbed; or improving but still of concern.
D -- Highly disturbed
Water
S1, S2, S3, S4 (fish)
S5 (no fish)
Rivers (S1, S2)
Lakes
Sea
SCALE: 1:280000
2 0 2 4 6 Kilometers
Drawn by: gmh
20 March 2008

indicated by the data, but subsequent recovery and mitigation are not fully apparent and require interpretation.

For example, older landslides may be partly or completely revegetated and not producing sediment; a few may still be experiencing mass wasting. Recent landslides are likely to be active sediment sources. Specific events such as a single large landslide can significantly impact a watershed and may be not be apparent in the indicators, whereas a number of small vegetated landslides may yield a high stability hazard but may have effectively recovered as sediment sources.

Data on past road-related landslides do not reflect subsequent risk reduction that has been done through deactivation. Indicators for stream disturbance do not reflect restoration works to replace LWD and recreate channel structure. Restoration projects have been undertaken in TFL 19 but except for road deactivation, details of the restoration works were not available for this project.

In addition to tracking indicators, periodic field reviews of watershed conditions are needed to check for responses to management practices and natural events.

11.0 WATERSHED INDICATORS

Indicators are used to monitor watershed recovery from legacy impacts, to monitor the effectiveness of current management strategies, and to track progress toward Sustainable Forest Management objectives.

11.1 Indicators for On-going Forest Management

Table 2 gives monitoring intervals, objectives and thresholds for proposed indicators for TFL 19 watersheds. Statistical sampling or analysis is not proposed because the indicators are based on complete inventory information which is intended to be updated at the intervals indicated. These indicators are intended to guide on-going forest management as well as to track progress toward Sustainable Forest Management objectives (section 11.2).

In addition to tracking watershed data, watershed and stream conditions should be reviewed using new aerial photography or other high resolution imagery every ten years; and/or by helicopter overviews if extreme storms or large landslides occur.

Indicators with three-year monitoring intervals reflect processes that are evident over fairly short time intervals. Indicators with ten-year monitoring intervals reflect processes that take place over longer time intervals. For example, watersheds exhibiting channel disturbance from landslides, such as scoured or aggraded channels, may be expected to show improvement in channel condition over about ten years. Watersheds with floodplains that have experienced channel instability and loss of LWD, and have regenerated primarily to alder, may take many decades to approach a predisturbance condition, because this may require re-establishing mature conifers in the riparian zone.

Table 2 -- Proposed indicators, monitoring intervals and thresholds for on-going forest management

	Indicator	Reason	Interval to re-measure	Targets & Thresholds
A.	*Landslides -- objective: To prevent material adverse effects on water quality, fish habitat, timber and long-term soil productivity caused by development-related landslides.*			
1.	*Potential stability hazards -- these represent vulnerability to future instability* Area (ha) of steep terrain logged in last 10 years (rolling time interval)	Limits may be set for individual watersheds in management strategies. Track effectiveness of these strategies to manage steep terrain.	Every 3 years	Measure together with No. 3.
2.	Road length of moderate or higher stability hazard not deactivated	Potential hazard, ongoing management of road systems	Every 3 years	Include in risk management of road system
3.	*Landslide occurrence* No. of landslides per 100 ha logged in steep terrain harvested in last 10 years (rolling time interval) -- measured over total TFL 19.	Track how well steep terrain is being managed, & how well TSA's predict instability.	Every 3 years	Maintain low frequency of landslides in harvested steep terrain (<2 slides/100 ha logged steep) over all TFL 19.
4.	No. of landslides per km of road on steep terrain, constructed since 1995 -- measured over total TFL 19.	Track the performance of road construction on steep terrain	Every 3 years	Maintain low frequency of landslides from new roads constructed on steep terrain (<0.1 slides/km) over all TFL 19.
5.	Total number of landslides from roads and cutblocks per watershed area (no./km^2) in last 10 years (rolling time interval) -- for each watershed.	Track significance of development-related landslides at watershed scale.	Every 3 years	If >0.05 slides/km^2, OR after extreme storm, review channel conditions to assess impacts.
B.	*Stream channels -- objectives: To maintain functioning riparian forests needed for stream channel integrity, and to allow continued recovery of riparian forests with preCode legacy impacts*			
6.	*Riparian condition (by watershed)** Length (km) of alluvial & semi-alluvial streams with inadequate riparian forest to supply LWD.	Track recovery of riparian forest.	Every 10 years	Continual decline in riparian forest inadequate for LWD.
7.	Length of alluvial & semi-alluvial streams per watershed area with inadequate riparian forest to supply LWD (km/km^2)	Track significance of riparian function at watershed scale.	Every 10 years	Long term decline to <0.01 km/km^2
8.	Length (km) of alluvial streams with inadequate riparian forest to control bank erosion (CBE).	Track recovery of riparian forest.	Every 10 years	Continual decline in riparian forest inadequate for CBE.
9.	Length of alluvial streams per watershed area with inadequate riparian forest to control bank erosion (km/km2)	Track significance of riparian function at watershed scale.	Every 10 years	Long term decline to <0.01 km/km^2

*Recovery of riparian forest to a large degree depends on growth of trees (especially conifers), which can take many years to achieve adequate riparian function.

11.2 Indicators for Sustainable Forest Management Objectives

The proposed indicator for this objective is the number of watershed units that exhibit a target watershed condition relative to the total number of watershed units. (The indicator could also be expressed as an area ratio). It is proposed that the target condition be to have all watershed units in the bottom two trend categories shown on Figure 5. These are:

A – Stable, or consistent with natural.
B – Improving, may have sites that are still disturbed.

Progress toward the SFM objective would be demonstrated by watershed units dropping down the trend categories in Figure 5. Table 3 indicates estimated time intervals for TFL 19 watershed units to improve by one trend category.

12.0 FUTURE RESTORATION PROJECTS

Map Sets 11 and 12 (see map atlas), and Figures 4 and 5, can be used to prioritize watersheds for restoration works and to select sites for the following:

- Riparian assessments
- Assessments for instream treatments.

Note that trends and risk ratings displayed in Figures 4 and 5, and Table A2, do not indicate whether or not there are sites suitable for restoration within the watershed unit. Therefore, Figures 4 and 5 have to be considered together with Map Sets 11 and 12 to select candidate sites for assessment. Some high priority watersheds may not have sites suitable for restoration.

In addition, assessments and works already completed need to be considered along with the information from this project. Information on existing stream and riparian restoration was not available fro this project. A compilation of existing restoration works, including spatial data for the locations, would be helpful.

Restoration projects such as improving fish access at road crossings cannot be identified from the overview-level information in this project; but the fish ranking can help to prioritize watersheds for this type of work.

Priority watersheds

Watershed sensitivity, trend and fish rank (Figures 4 and 5) suggest that sites in the following units should be highest priority for assessment:

- Tahsis
- Oktwanch Remainder
- Conuma
- Upper Gold
- Tsowwin

Nevertheless, sites in lower priority watershed units should not be ruled out if restoration measures would have a high likelihood of success with significant benefits to fish

Table 3 -- Proposed SFM Indicator and Targets

Long Term SFM objective : all watershed units to be in the bottom 2 trend categories (A, B) in Figure 5:
A - Stable; or consistent with natural
B - Improving, may have sites that are still disturbed
Indicators in Table 2 provide measurements for management strategies to meet this objective.

Indicator : proportion of watershed units that are in the target condition (A,B)

Current condition:

No. of watershed units in categories A & B =25/46 (54%)
Area of watershed units in categories A & B = 98,171 ha/152,637 ha (64%)

Forecast for watersheds in trend categories C & D

Watershed units now in categories C, D	Fish rank	Current trend (Figure 5/Table A4)	Nature of main disturbance	Estimated time to improve to next trend category
Oktwanch Remainder	1	D -- Highly disturbed	Unstable alluvial channel from riparian logging	50 years
Tahsis	1	D -- Highly disturbed	Unstable alluvial channel from riparian logging*	50 years
McCurdy	2	D -- Highly disturbed	Scoured channel from landslides	10 years
Wilson	3	D -- Highly disturbed	Scoured channel from landslides (BCTS)	10 years
Conuma	1	C -- Improving but still of concern	Unstable alluvial channel from riparian logging*	30 years
Tsowwin	1	C -- Moderately disturbed	Scoured channels (nonalluvial) & aggraded channels (alluvial) from landslides	10 years
Upper Gold	1	C -- Improving but still of concern	Unstable alluvial channel from riparian logging*	20 years
Hisnit	2	C -- Moderately disturbed	Aggraded fans from landslides	20 years
Hoiss	2	C -- Moderately disturbed	Aggraded channels from landslides	10 years
Houston	2	C -- Improving but still of concern	Unstable alluvial channel from riparian logging*	20 years
Sucwoa	2	D -- Improving but still of concern	Unstable alluvial channel from riparian logging*	20 years
Saunders	3	C -- Moderately disturbed	Aggraded channels from landslides	10 years
Pamela	3	C -- Improving but still of concern	Unstable alluvial channel from riparian logging*	20 years
Nameless	4	C -- Moderately disturbed	Channels on fan widened from riparian logging & aggraded from landslides (mostly natural)*.	10 years

* may be potential to accelerate recovery somewhat with riparian treatments targeted at conversion of alders to conifers; or increased growth rate of conifers. Riparian assessments would be needed to determine feasibility of these measures.

production. Reaches proposed for restoration should be evaluated with respect to channel stability, because restoration efforts are more likely to be successful where channels are stable or trending toward stability

Criteria for riparian assessments (Map Set 11)

Reviews of habitat improvement projects have concluded that the most effective long term solution for mitigating historic logging impacts is to re-establish riparian vegetation communities to something approaching their pre-disturbance condition (Hartman and Miles, 1995). In TFL 19 many alluvial valley flats have come back largely to alder, which does not provide durable LWD and does not provide as effective a root network to resist channel bank erosion as do conifers. In particular, a long term supply of functioning LWD is required for pre-disturbance channel structure to become re-established in alluvial and semi-alluvial streams. This project proposes that riparian assessments be targeted at increasing the mix of conifers in the predominantly deciduous riparian zones.

In some restoration projects, riparian treatments have included spacing and treating existing conifers to promote tree growth and increased tree diameters. The intent is to accelerate the rate at which the conifers will reach sufficient size for improved ecological function as well as for channel bank erosion and LWD supply. While this work meets the objective of targeting conifer development in riparian zones, it is proposed here that treatment of deciduous stands to increase the mix of conifers be a higher priority than treating existing conifer stands, because these latter sites are already predominantly conifers. Nevertheless, conifer treatments should not be ruled out if other aspects of a site warrant a high priority for this work.

Using the overview inventories from the 2005-2006 project, potential sites for riparian assessments are identified based on the following criteria:

- Riparian class: S1, S2 or S3
- Channel type: alluvial or semi-alluvial
- Riparian vegetation type: primarily deciduous (D) or mixed conifer and deciduous (M)
- Age of riparian forest: Age class 3 (minimum 20 years) or older

Map Set 11 displays stream reaches that meet these criteria. These sites should be field checked to confirm whether or not they are suitable for riparian assessment.

This information should be considered together with any existing assessments as well as site-specific fisheries information, to prioritize stream reaches for riparian assessment.

Criteria for instream sites (Map Set 12)

Experience has demonstrated that instream work such as placement of LWD is more likely to be successful if it is "in sync" with the adjacent riparian forest; that is, the riparian zone has trees of sufficient size to replenish LWD. Field reviews of streams in second growth forests typically find that, even where the second growth stands have trees of sufficient size for LWD, the streams are deficient in LWD because the trees are not falling into the streams. These are favourable sites for placement of LWD, because the adjacent forest will over time replenish the LWD. Further, experience has indicated that small streams with gentle gradients are likely to have a higher success rate than larger, higher energy streams (Hartman and Miles, 1995). Most main channels of large streams are not considered desirable for instream works and are not included in potential sites for this work.

Potential candidate sites for instream work are identified based on the following criteria:

- Riparian class: S1, S2, S3 (excluding main channels of large streams).
- Channel type: alluvial or semi-alluvial
- Riparian condition: adequate to supply LWD on at least one bank. For small streams this is assumed to be mixed or coniferous stands at least 40 years old; for large streams this is assumed to be mixed or coniferous stands at least 60 years old.

Map Set 12 displays stream sections meeting these criteria. Because of the extensive steep terrain in TFL 19, there are few areas with a significant extent of small low gradient streams. Many of the sites that meet the above criteria are in mainstem channels; these may not be suitable for instream work. As with candidate sites for riparian assessments, the sites should be field checked. This information should be considered together with fish ranking or site-specific fisheries data and any existing site assessments, to prioritize sites for development of prescriptions.

Road deactivation

Considerable road deactivation has already been done in TFL 19. The 2006 project identified priority road sections for field assessments for deactivation. The road stability hazard ratings, along with landslide and terrain information can also assist with risk-based road maintenance planning.

13.0 COMMENT ON FINDINGS

Table A5 allows a comparison to be made of the influence on landslide occurrence of changed management practices (preCode vs postCode). The frequency of landslides on roads constructed before 1995 was 1.0 slides per km of road built on steep terrain. Roads built 1995 and later have experienced 0.02 slides per km of road built on steep terrain. The frequency of landslides in cutblocks harvested before 1995 was 3.9 slides per 100 ha logged on steep terrain; in postCode cutblocks, it is 1.1 slides per 100 ha logged on steep terrain. These figures include the November 2006 events. While it might be argued that postCode roads and cutblocks have not yet been fully tested, it is apparent that the occurrence of landslides from both postCode roads and cutblocks is significantly reduced, and in the case of roads, the incidence of landslides has improved by two orders of magnitude.

Glynnis Horel, P. Eng.

March 20, 2008

References

Alila, Y. and M. Schnorbus. 2005. *Hydrologic Decision Making Tools for sustainable Forest Management in Rain Dominated Coastal BC Watersheds.* Forest Investment Account, Forest Science Program. Project Y051293.

BC Forest Practices Board. 2007. The Effect of Mountain Pine Beetle Attack and Salvage Harvesting on Streamflows. FPB/SIR/16

BC Ministry of Forests. 1995, rev. 1999. *Coastal Watershed Assessment Procedure Guidebook, Interior Watershed Assessment Procedure Guidebook.* 2nd ed. BC Ministry of Forests. Forest Practices Code of British Columbia Guidebook. [web]

Chapman, A. 2003. *Long-Term Effects of Forest Harvest on Peak Streamflow Rates in Coastal BC Rivers.* Forestry Innovation Investment. Forintek Canada Corporation Project R2003-0119.

Gustavson, K. and D. Brown. 2002. *Monitoring Land Use Impacts on Fish Sustainability in Forest Environments.* Ministry of Sustainable Resource Management, Aquatic Information Branch.

Hartman, G. F. and M. Miles. 1995. *Evaluation of Fish Habitat Improvement Projects in B.C. and Recommendations on the Development of Guidelines for Future Work.* Report prepared for B.C. Min. of Environment, Lands and Parks, Fisheries Br., Victoria, B.C. 40 p.

Horel, G. 2006. *Summary of landslide occurrence on northern Vancouver Island.* Streamline Watershed Management Bulletin 10(1):1–9.

Horel, G. 2007. *Overview-level Landslide Runout Study.* Streamline Watershed Management Bulletin 10(2):15-24.

Horel, G. 2007. *Watershed Indicators, Tree Farm Licence 6 and Tree Farm Licence 39 Block 4,* Western Forest Products Inc., North Vancouver Island Region. Forest Investment Account Projects 6549006 and 6561023.

Hudson, R. and G. Horel. 2007. *An operational method of assessing hydrologic recovery for Vancouver Island and south coastal B.C.* Research Section, Coast Forest Region, B.C. Ministry of Forests, Nanaimo, B.C. Technical Report TR-0**/2007.

Hudson, R. 2000. *Assessing Snowpack Recovery of Watersheds in the Vancouver Forest Region.* Research Section, Coast Forest Region, B.C. Ministry of Forests, Nanaimo, B.C. Technical Report TR-004/2000.

APPENDIX A

Tables

Notes on Tables -- TFL 19:

Digital GIS data for this project including forest cover, harvested areas, roads, streams, water bodies, contours, tenure, terrain stability, slopes >60% and orthophoto provided by Western Forest Products Inc.

1.	GIS roads and harvested blocks to 2006.
2.	Landslide inventory based on 1995 airphotos, 2004 satellite image; and event reports to June 2007.
3.	"Steep terrain" includes the combined area of Class 4 and 5; and slopes steeper than 60%.
4.	Total harvest area and steep terrain logged include harvesting up to 60 years old.
5.	Natural landslides include rockslides in alpine areas. Fully forested old naturals are not included in occurrence of natural landslides (no./km^2), Table A2. Natural landslides after 2004 have not all been reported in event reports.
7.	Riparian condition assessed for alluvial and semi-alluvial streams other than S6's.
8.	CBE= riparian forest on one or both banks inadequate to control channel bank erosion.
9.	CBE+LWD= riparian forest on one or both banks inadequate both for channel bank erosion and supply of large wood debris.
10.	LWD= riparian forest on one or both banks inadequate to supply functioning LWD to channel. (Note - this does not mean channel is deficient in LWD; or if riparian forest deemed adequate, does not mean there is adequate LWD in the channel.)
11.	R = rain-dominated peak flow regime
12.	ROS = probable rain-on-snow peak flows
13.	PreCode and postCode roads were determined by whether or not they were visible on the 1995 airphotos. If visible, they were assumed to be preCode. If not visible, they were assumed postCode.
14.	Stream lengths for large streams (polygons) in Table A1 were determined as half the length of the polygon perimeter. This introduces an error which would be significant for short wide stream polygons.
15.	Roads do not include paved highways.
16.	Pre 1995 and post 1995 harvest areas determined from year of harvest in logging coverage and forest cover.

Table A1

TFL 19 Watershed Planning Units

Regional watershed:	Gold											NONE				
Watershed:	Heber	Muchalat		Oktwanch		Ucona			Upana	U. Gold	Gold Rem.	Canton	Conuma			Cougar
Basin:	Saunders	Muchalat L.	U. Muchalat	Nameless	Oktwanch-Rem	Pamela	Quatchka	Ucona-Rem					Conuma	Leagh	Norgate	
Total Area, ha	4,020	6,900	5,351	786	4,567	4,167	3,460	11,054	6,219	23,407	10,938	3,873	9,178	1,178	1,968	1,497
WFP area, ha	2,981	6,731	5,351	732	2,270	2,158	3,460	2,503	6,219	9,895	9,535	3,873	9,178	1,178	1,968	1,497
WFP area, km^2	29.8	67.3	53.5	7.3	22.7	21.6	34.6	25.0	62.2	98.9	95.4	38.7	91.8	11.8	19.7	15.0
WFP percent of total drainage area	74%	98%	100%	93%	50%	52%	100%	23%	100%	42%	87%	100%	100%	100%	100%	100%
Fisheries Rank	3	1	1	4	1	3	3	1	2	1	1	1	1	3	3	4
Harvest history - WFP area - to 2006																
Total harvested area, ha	836	2,257	923	354	1,052	794	1,044	484	1,699	4,292	2,611	728	1,393	37	344	585
Area harvested before 1995, ha	369	1,733	701	246	834	647	883	214	1,289	3,511	2,062	478	598	2	78	329
Area harvested 1995 and later, ha	467	524	222	108	219	147	161	271	410	781	549	250	795	35	266	256
Total steep terrain (Class 4&5 + >60%)	1,300	2,506	2,704	200	1,100	1,246	2,014	1,144	3,125	4,183	4,271	2,269	4,830	733	806	905
Steep terrain logged before 1995, ha	47	462	172	63	203	104	223	14	355	486	334	108	111	1	14	142
Steep terrain logged 1995 and later, ha	167	208	105	27	87	66	80	55	209	269	65	60	322	12	141	139
Roads - to 2006																
Total road length, km	52	123	55	19	51	38	42	31	93	204	153	42	96	3	21	33
Total length M, MH, H stability hazard, km	13	25	6	6	8	9	9	4	19	24	15	3	12	0	6	4
Length M, MH, H hazard not perm. deactivated	11	16	5	6	5	7	8	4	9	13	9	2	11	0	6	2
Roads on steep terrain built before 1995, km	4	11	3	1.5	10	5	3	0	11	16	11	3	2	0	0.5	5
Roads on steep terrain built 1995 and later, km	8	11	6	0.8	3	1	3	4	10	5	3	2	17	0	8	6
Landslides - to Sep 2007																
Slides originating at roads:																
No. of slides at roads built before 1995	3	22		2	9	5	3	2	6	23	8	2	0		3	
No. of slides/km of road on steep terrain <1995	0.9	1.9	0.0	1.4	0.9	1.0	1.0	66.7	0.5	1.4	0.7	0.7	0.0	0.0	6.7	0.0
No. of slides at roads built 1995 or later													1			
No. of slides/km of road on steep terrain >=1995	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0
Slides originating in harvested cutblocks:																
No. of slides in pre-1995 cutblocks	10	6	3	5	7	5	12		12	31	0	9	6		1	2
No. of slides per 100 ha logged in steep terrain, logged before 1995	21.5	1.3	1.7	8.0	3.4	4.8	5.4	-	3.4	6.4	-	8.4	5.4	-	7.2	1.4
No. of slides in 1995 and later cutblocks	7	1			1			1	4	3	1	1	2			
No. of slides per 100 ha logged in steep terrain, logged 1995 and later	4.2	0.5	-	-	1.1	-	-	1.8	1.9	1.1	1.5	1.7	0.6	-	-	-
Slides from cutblocks logged >= 1995, no./km^2 (WFP area)	0.23	0.01	-	-	0.04	-	-	0.04	0.06	0.03	0.01	0.03	0.02	-	-	-
Slides originating in unharvested timber:																
Fully forested old naturals	2	2	18		6	12	16	1	18	12	9	2	6	4	1	1
No. of slides occurring pre1995, visible in forest cover	7	4	21	5	7	20	15	1	20	35	13	22	38	3		5
No. of slides occurring 1995 and later	3				1		1			6	1	10		1		
Streams																
Total length of mapped streams, km	82	122	150	15	59	81	103	50	171	312	238	132	243	26	33	34
Length alluvial channels, km	7	15	23	1.2	15	10	1.7	4.0	14	28	20	9	25	0.5	2.7	1.3
% of total stream length	8%	12%	15%	8%	25%	12%	2%	8%	8%	9%	8%	7%	10%	2%	8%	4%
Length semi-alluvial channels, km	2	7	6	0.0	1.0	6	9	9	15	18	27	8	13	0.0	2.3	2.9
% of total stream length	2%	6%	4%	0%	2%	7%	9%	17%	8%	6%	11%	6%	6%	0%	7%	9%
Length nonalluvial channels, km	72	100	120	14	43	66	92	37	141	266	190	115	205	25	28	30
% of total stream length	88%	82%	80%	92%	73%	81%	89%	74%	83%	85%	80%	87%	84%	98%	85%	88%
Length channels in wetland, km	1.3	0.0	0.0	0.0	0.5	0.0	0.0	0.2	0.7	0.0	1.2	0.0	0.0	0.0	0.0	0.0
% of total stream length	2%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Riparian condition (alluvial & semi-alluvial only)																
Length assessed, km	9.0	25.6	27.0	1.2	16.1	15.5	11.8	13.7	30.9	49.6	48.0	17.7	39.5	0.5	5.0	4.0
Length CBE, km	0	0	0	0	0	0	0	0	0	0	2.7	0.5	0	0	0	0
Length CBE+LWD, km	1.0	3.0	2.3	1.0	5.0	3.2	0.4	0.0	2.1	1.8	0.4	0.5	10.6	0.5	0.0	0.0
Length LWD, km	3.4	7.0	7.0	0.2	10.0	7.0	7.9	3.1	11.8	17.1	12.0	7.5	8.0	0.0	0.3	3.0

WFP area does not include portions of watersheds in TFL37 or in forest licence

Table A1

TFL 19 Watershed Planning Units

Regional watershed:	NONE																
Watershed:	Espinosa	Hanna	Hisnit (Deserted)	Hoiss	Houston	Kleeptee	Leiner		Mamat	McCurdy	Nesook		Silverado	Sucwoa	Tahsis		Tsowwin
Basin:							Leiner	Perry			Nesook	Tlupana			McKelvie	Tahsis	
Total Area, ha	2,725	1,364	2,030	1,508	4,831	5,296	6,736	4,897	1,104	6,943	6,134	4,590	2,280	3,596	2,174	5,504	3,592
WFP area, ha	2,723	1,364	1,336	1,046	4,831	4,782	6,727	4,897	1,104	6,943	6,134	4,590	2,092	3,518	2,171	5,445	3,345
WFP area, km^2	27.2	13.6	13.4	10.5	48.3	47.8	67.3	49.0	11.0	69.4	61.3	45.9	20.9	35.2	21.7	54.4	33.5
WFP percent of total drainage area	100%	100%	66%	69%	100%	90%	100%	100%	100%	100%	100%	100%	92%	98%	100%	99%	93%
Fisheries Rank	3	3	2	2	2	1	2	1	3	2	3	1	3	2	3	1	1
Harvest history - WFP area - to 2006																	
Total harvested area, ha	1,150	457	290	256	1,753	1,030	180	1,358	503	2,366	1,576	1,367	299	1,674	-	99	1,245
Area harvested before 1995, ha	909	328	69	-	1,468	265	30	1,204	359	1,661	596	897	-	1,577	-	77	1,015
Area harvested 1995 and later, ha	241	129	220	256	285	765	150	155	144	705	979	470	299	97	-	22	230
Total steep terrain (Class 4&5 + >60%)	1,555	561	645	485	2,041	2,078	4,337	2,822	735	3,239	2,963	2,427	1,271	1,500	1,415	3,185	1,722
Steep terrain logged before 1995, ha	305	71	12	-	471	48	9	334	152	539	169	280	-	380	-	4	256
Steep terrain logged 1995 and later, ha	121	30	45	62	103	200	53	95	102	256	437	209	95	24	-	11	105
Roads - to 2006																	
Total road length, km	45	28	22	17	77	78	20	62	27	104	94	78	15	83	0.6	7	63
Total length M, MH, H stability hazard, km	8	3.8	1.6	1.5	14	6.2	2.7	13	8	26	14	15	0.7	10	0	0.8	12
Length M, MH, H hazard not perm. deactivated	8	3.0	0.6	1.4	8	5.9	1.1	3	8	24	15	14	0.7	7	0	0.4	6
Roads on steep terrain built before 1995, km	4	2.5	1.2	0.0	10	3.6	2	10	6	10	9	9	0	9	0	0.8	8
Roads on steep terrain built 1995 and later, km	6	0.9	2	2.0	1.9	8	2.9	1.3	6	5	13	8	2	1	0	0	1
Landslides - to Sep 2007																	
Slides originating at roads:																	
No. of slides at roads built before 1995	13	1			10	4		8	3	22	7	13		12		2	14
No. of slides/km of road on steep terrain <1995	3.2	0.4	0.0	0.0	1.0	1.1	0.0	0.8	0.5	2.1	0.8	1.4	0.0	1.3	0.0	2.5	1.7
No. of slides at roads built 1995 or later			1														
No. of slides/km of road on steep terrain >=1995	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slides originating in harvested cutblocks:																	
No. of slides in pre-1995 cutblocks	3	6	1	0	14	2		27	2	16	8	8	0	15			21
No. of slides per 100 ha logged in steep terrain, logged before 1995	1.0	8.4	8.2	-	3.0	4.1	-	6.1	1.3	3.0	4.7	2.9	-	4.0	-	-	8.2
No. of slides in 1995 and later cutblocks			3	2						5	2	3	1	1			6
No. of slides per 100 ha logged in steep terrain, logged 1995 and later	-	-	5.7	3.2	-	-	-	-	-	2.0	0.5	1.4	1.1	4.3	-	-	5.7
Slides from cutblocks logged >= 1995, no./km^2 (WFP area)	-	-	0.22	0.19	-	-	-	-	-	0.07	0.03	0.07	0.05	0.03	-	-	0.18
Slides originating in unharvested timber:																	
Fully forested old naturals	31	2	8	6	6	10	7	12	7	12	6	5	12	10	4	8	9
No. of slides occurring pre1995, visible in forest cover	10	1	5	1		16	48	35	5	11	6	18	15	19	23	47	3
No. of slides occurring 1995 and later	3					2		3		2		1	1		1	3	
Streams																	
Total length of mapped streams, km	90	38	30	26	96	87	192	149	32	163	104	79	55	128	74	145	112
Length alluvial channels, km	13	3.6	2.8	2.6	14	8	11	10	1.5	8	7	14	3.8	18	3.4	23	8
% of total stream length	14%	9%	9%	10%	15%	9%	6%	7%	5%	5%	6%	18%	7%	14%	5%	16%	7%
Length semi-alluvial channels, km	2.8	4.3	2.3	2.2	9	10	10	8	5	13	15	4.5	3.9	5	4.5	3.6	5
% of total stream length	3%	11%	8%	8%	9%	11%	5%	5%	15%	8%	14%	6%	7%	4%	6%	2%	5%
Length nonalluvial channels, km	75	31	25	21	73	70	172	131	26	141	83	60	47	105	67	119	98
% of total stream length	83%	79%	83%	82%	76%	80%	89%	88%	81%	86%	80%	76%	86%	82%	89%	82%	88%
Length channels in wetland, km	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% of total stream length	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Riparian condition (alluvial & semi-alluvial only)																	
Length assessed, km	15.6	7.9	5.2	4.7	23.3	17.0	20.6	17.9	6.0	23.8	20.8	20.3	7.6	23.0	9.2	25.5	13.2
Length CBE, km	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.0	0
Length CBE+LWD, km	4.9	0.1	0.0	0.0	4.6	2.9	0.6	1.6	0.5	0.7	1.6	3.6	0.5	4.3	0.0	8.7	1.3
Length LWD, km	9.4	6.1	1.4	0.5	11.1	4.2	1.0	8.5	4.0	10.8	4.9	7.3	1.0	8.5	0.0	7.2	5.4

WFP area does not include portions of watersheds in TFL37 or i

Table A1

TFL 19 Watershed Planning Units

Regional watershed:	NONE				
Watershed:	Wilson	Zeballos			
Basin:		Maraude	Nomash	U.Zeballos	Zeballos-Rem.
Total Area, ha	1,637	4,791	4,899	4,754	4,882
WFP area, ha	788	4,791	4,899	4,754	4,830
WFP area, km^2	7.9	47.9	49.0	47.5	48.3
WFP percent of total drainage area	48%	100%	100%	100%	99%
Fisheries Rank	3	2	2	2	1
Harvest history - WFP area - to 2006					
Total harvested area, ha	320	106	1,331	1,103	1,493
Area harvested before 1995, ha	272	67	1,094	858	1,118
Area harvested 1995 and later, ha	48	39	237	245	376
Total steep terrain (Class 4&5 + >60%)	296	2,670	3,005	2,215	2,792
Steep terrain logged before 1995, ha	118	10	192	198	381
Steep terrain logged 1995 and later, ha	9	7	106	99	192
Roads - to 2006					
Total road length, km	21	6	55	71	81
Total length M, MH, H stability hazard, km	9	0.2	10	9	19
Length M, MH, H hazard not perm. deactivated	8	0.2	7	7	11
Roads on steep terrain built before 1995, km	5	0.2	6	6	15
Roads on steep terrain built 1995 and later, km	0.3	0.4	3	5	3
Landslides - to Sep 2007					
Slides originating at roads:					
No. of slides at roads built before 1995	6		6	4	12
No. of slides/km of road on steep terrain <1995	1.2	0.0	1.0	0.7	0.8
No. of slides at roads built 1995 or later			1		
No. of slides/km of road on steep terrain >=1995	0	0	0.3	0	0
Slides originating in harvested cutblocks:					
No. of slides in pre-1995 cutblocks	4		8	10	11
No. of slides per 100 ha logged in steep terrain, logged before 1995	3.4	-	4.2	5.1	2.9
No. of slides in 1995 and later cutblocks			1		4
No. of slides per 100 ha logged in steep terrain, logged 1995 and later	-	-	0.9	-	2.1
Slides from cutblocks logged >= 1995, no./km^2 (WFP area)	-	-	0.02	-	0.08
Slides originating in unharvested timber:					
Fully forested old naturals		7	30	26	42
No. of slides occurring pre1995, visible in forest cover		43	49	25	44
No. of slides occurring 1995 and later			2	1	1
Streams					
Total length of mapped streams, km	15	138	180	141	175
Length alluvial channels, km	0.2	7	8	13	23
% of total stream length	1%	5%	4%	9%	13%
Length semi-alluvial channels, km	2.6	6	8	7	1.7
% of total stream length	17%	4%	4%	5%	1%
Length nonalluvial channels, km	12	125	164	121	151
% of total stream length	81%	90%	91%	86%	86%
Length channels in wetland, km	0.0	0.0	0.0	0.0	0.0
% of total stream length	0%	0%	0%	0%	0%
Riparian condition (alluvial & semi-alluvial only)					
Length assessed, km	2.5	13.2	16.0	22.5	24.4
Length CBE, km	0	1.4	0	0	2.8
Length CBE+LWD, km	0.0	0.0	2.5	2.4	4.3
Length LWD, km	1.7	0.0	8.5	10.4	11.8

WFP area does not include portions of watersheds in TFL37 or i

Table A2

TFL 19 Watershed Planning Units

Regional watershed:	Gold											NONE			
Watershed:	Heber	Muchalat		Oktwanch		Ucona			Upana	U. Gold	Gold Rem.	Canton	Conuma		
Basin:	Saunders	Muchalat L.	U. Muchalat	Nameless	Oktwanch-Rem	Pamela	Quatchka	Ucona-Rem					Conuma	Leagh	Norgate
Total Area, ha	4,020	6,900	5,351	786	4,567	4,167	3,460	11,054	6,219	23,407	10,938	3,873	9,178	1,178	1,968
WFP area, ha	2,981	6,731	5,351	732	2,270	2,158	3,460	2,503	6,219	9,895	9,535	3,873	9,178	1,178	1,968
WFP area, km^2	29.8	67.3	53.5	7.3	22.7	21.6	34.6	25.0	62.2	98.9	95.4	38.7	91.8	11.8	19.7
WFP percent of total drainage area	74%	98%	100%	93%	50%	52%	100%	23%	100%	42%	87%	100%	100%	100%	100%
Watershed Characteristics															
Fisheries Rank	3	1	1	4	1	3	3	1	2	1	1	1	1	3	3
Terrain Stability															
Regional landslide frequency	H	M	M	H	M	H	H	M	M	H	M	H	H	H	H
Total steep terrain (Class 4&5 + >60%)	1,300	2,506	2,704	200	1,100	1,246	2,014	1,144	3,125	4,183	4,271	2,269	4,830	733	806
% of WFP area	44%	37%	51%	27%	48%	58%	58%	46%	50%	42%	45%	59%	53%	62%	41%
Relative terrain vulnerability	H	H	H	M	H	H	H	H	H	H	H	H	H	H	H
Occurrence of natural landslides, no./km^2	0.34	0.06	0.39	0.68	0.35	0.93	0.46	0.04	0.32	0.41	0.15	0.83	0.41	0.34	0.00
Runout slopes >50% of mainstem length	Y	Y + lake	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y
Terrain stability rating	H	M	M	H	M	H	H	M	M	H	M	H	H	H	M
Streams															
Alluvial streams per watershed area, km/km^2	0.22	0.22	0.43	0.16	0.64	0.46	0.05	0.16	0.23	0.28	0.21	0.24	0.27	0.04	0.14
Total length S1, S2 and S3 streams, km	10	19	24	1	17	15	10	18	25	50	51	13	39	2	0.3
Alluvial length S1, S2 and S3 streams, km	7	12	17	1	14	9	1	4	11	25	18	6	20	0.5	0.3
% alluvial stream length S1, S2 & S3	67%	62%	72%	100%	82%	59%	12%	23%	42%	49%	35%	50%	51%	25%	100%
Alluvial S1,S2,S3 per watershed area, km/km^2	0.23	0.18	0.32	0.16	0.63	0.41	0.04	0.17	0.17	0.25	0.19	0.17	0.21	0.04	0.01
Channel sensitivity	M	M	H	L	H	H	L	L	M	H	M	M	H	L	L
Presence of estuary											Y	Y	Y		
Presence of floodplains >3 channel widths			Y		Y	Y			short	short	short	Y	Y		
Presence of contemporary fans	small	small	Y	Y	Y	Y	small		Y	small	small		Y	Y	
Sensitivity to riparian logging (fan, floodplain)	M	M	H	M	H	H	L	L	M	H	M	H	H	M	L
Stream sensitivity rating	M	M	H	M	H	H	L	L	M	H	M	H	H	M	L
Watershed sensitivity rating	2	2	1	2	1	1	2	2	2	1	2	1	1	2	3
Hydrologic Change															
Probable peak flow regime (R, ROS)	R, ROS	R, ROS	R, ROS	R, ROS	R, ROS	R, ROS	R, ROS	R	R, ROS	R, ROS	R, ROS	R, ROS	R, ROS	R	R, ROS
Possible karst (uTrp, uTrq, uTrkq, CPB)	N	N	Y	N	small	N	N	N	Y	small	N	N	small	small	Y
Disturbance Indicators															
Terrain Stability -- cutblocks and roads															
Total no. of slides from roads and cutblocks	20	29	3	7	17	10	15	3	22	57	9	12	9	0	4
no./km^2 of watershed area	0.7	0.4	0.1	1.0	0.7	0.5	0.4	0.1	0.4	0.6	0.1	0.3	0.1	0.0	0.2
Relative frequency	M	L	L	H	M	M	L	L	L	M	L	L	L	L	L
Slides in road/cutblocks, no./km^2	0.23	0.01	0.00	0.00	0.04	0.00	0.00	0.04	0.06	0.00	0.01	0.03	0.02	0.00	0.00
Roads M, MH, H hazard not perm. deactivated, km	11	16	5	6	5	7	8	4	9	13	9	2	11	0	6
Roads M, MH, H not deact. - km/km^2	0.38	0.24	0.10	0.76	0.23	0.32	0.22	0.16	0.15	0.13	0.09	0.06	0.12	0.03	0.30
Relative road stability hazard	M	L	L	H	L	M	L	L	L	L	L	L	L	L	M
Stability disturbance rating	M	L	L	H	M	M	L	L	L	M	L	L	L	L	L
Streams															
Total CBE, km/km^2	0.03	0.04	0.04	0.13	0.22	0.15	0.01	0.00	0.04	0.02	0.03	0.03	0.12	0.04	0.00
CBE disturbance level	L	L	L	M	H	H	L	L	L	L	L	L	H	L	L
Total LWD, km/km^2	0.1	0.1	0.1	0.0	0.4	0.3	0.2	0.1	0.2	0.2	0.1	0.2	0.1	0.0	0.0
LWD disturbance level	L	L	L	L	M	M	M	L	M	M	L	M	L	L	L
Stream disturbance rating	M	L	L	M	H	H	M	L	M	M	L	M	H	L	L
Watershed disturbance rating	2	3	3	2	1	1	3	3	3	2	3	3	1	3	3
Watershed risk	M	L	M	M	H	H	L	L	L	MH	L	M	H	L	L

WFP area does not include portions of watersheds in TFL37 or in forest licence

Unclassified streams are assumed to be S3 if alluvial, semi-alluvial or wetland; and S6 if nonalluvial

Ratings in red text were adjusted based on visual observations of channel condition during 2007 heli recon.

Table A2

TFL 19 Watershed Planning Units

Regional watershed:	NONE																
Watershed:	Cougar	Espinosa	Hanna	Hisnit	Hoiss	Houston	Kleeptee	Leiner		Mamat	McCurdy	Nesook		Silverado	Sucwoa	Tahsis	
Basin:				(Deserted)				Leiner	Perry			Nesook	Tlupana			McKelvie	Tahsis
Total Area, ha	1,497	2,725	1,364	2,030	1,508	4,831	5,296	6,736	4,897	1,104	6,943	6,134	4,590	2,280	3,596	2,174	5,504
WFP area, ha	1,497	2,723	1,364	1,336	1,046	4,831	4,782	6,727	4,897	1,104	6,943	6,134	4,590	2,092	3,518	2,171	5,445
WFP area, km^2	15.0	27.2	13.6	13.4	10.5	48.3	47.8	67.3	49.0	11.0	69.4	61.3	45.9	20.9	35.2	21.7	54.4
WFP percent of total drainage area	100%	100%	100%	66%	69%	100%	90%	100%	100%	100%	100%	100%	100%	92%	98%	100%	99%
Watershed Characteristics																	
Fisheries Rank	4	3	3	2	2	2	1	2	1	3	2	3	1	3	2	3	1
Terrain Stability																	
Regional landslide frequency	M	M	M	H	M	M	M	H	H	M	M	M	M	H	H	H	H
Total steep terrain (Class 4&5 + >60%)	905	1,555	561	645	485	2,041	2,078	4,337	2,822	735	3,239	2,963	2,427	1,271	1,500	1,415	3,185
% of WFP area	60%	57%	41%	48%	46%	42%	43%	64%	58%	67%	47%	48%	53%	61%	43%	65%	59%
Relative terrain vulnerability	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
Occurrence of natural landslides, no./km^2	0.33	0.48	0.07	0.37	0.10	0.00	0.38	0.71	0.78	0.45	0.19	0.10	0.41	0.76	0.54	1.11	0.92
Runout slopes >50% of mainstem length	N	Y	N	Y	N	Y	Y	N	Y	N	N	N	Y	N	Y	N	Y
Terrain stability rating	M	M	M	M	M	M	M	H	H	H	M	M	M	H	H	H	H
Streams																	
Alluvial streams per watershed area, km/km^2	0.08	0.47	0.26	0.21	0.24	0.29	0.16	0.16	0.20	0.14	0.12	0.11	0.31	0.18	0.51	0.16	0.42
Total length S1, S2 and S3 streams, km	0.1	5	4	6	4	13	13	11	14	5	14	14	14	4	21	74	17
Alluvial length S1, S2 and S3 streams, km	0.1	2	3	2	3	9	5	4	6	2	3	3	10	2	17	3	13
% alluvial stream length S1, S2 & S3	100%	43%	69%	39%	66%	66%	36%	38%	43%	32%	23%	21%	69%	35%	78%	5%	75%
Alluvial S1,S2,S3 per watershed area, km/km^2	0.01	0.08	0.20	0.18	0.26	0.18	0.10	0.06	0.13	0.14	0.05	0.05	0.22	0.07	0.47	0.16	0.24
Channel sensitivity	L	H	H	L	M	H	M	L	M	L	L	L	H	L	H	L	H
Presence of estuary	N	Y	Y	Y	N	N	Y	Y		Y	N	Y		Y	Y		N
Presence of floodplains >3 channel widths		Y	small			Y	Y	Y	Y	small			Y		Y		Y
Presence of contemporary fans	small	Y		Y		Y	Y		Y		small		Y	small	Y	Y	Y
Sensitivity to riparian logging (fan, floodplain)	L	H	M	M	M	H	H	H	H	M	L	L	H	M	H	M	H
Stream sensitivity rating	L	H	M	M	M	H	H	M	M	L	L	L	H	L	H	M	H
Watershed sensitivity rating	3	1	2	2	2	1	1	2	2	2	3	3	1	2	1	2	1
Hydrologic Change																	
Probable peak flow regime (R, ROS)	R	R	R	R	R	R	R, ROS	R, ROS	R, ROS	R	R, ROS	R, ROS	R, ROS	R	R, ROS	R, ROS	R, ROS
Possible karst (uTrp, uTrq, uTrkq, CPB)	N	N	N	Y	small	N	N	N	Y	N	N	N	small	Y	Y	N	Y
Disturbance Indicators																	
Terrain Stability -- cutblocks and roads																	
Total no. of slides from roads and cutblocks	2	16	7	5	2	24	6	0	35	5	43	17	24	1	28	0	2
no./km^2 of watershed area	0.1	0.6	0.5	0.4	0.2	0.5	0.1	0.0	0.7	0.5	0.6	0.3	0.5	0.0	0.8	0.0	0.0
Relative frequency	L	M	M	L	L	M	L	L	M	M	M	L	M	L	M	L	L
Slides in postCode cutblocks, no./km^2	0.00	0.00	0.00	0.22	0.19	0.00	0.00	0.00	0.00	0.00	0.07	0.03	0.07	0.05	0.03	0.00	0.00
Roads M, MH, H hazard not perm. deactivated, km	2	8	3.0	0.6	1.4	8	5.9	1.1	3	8	24	15	14	0.7	7	0	0.4
Roads M, MH, H not deact. - km/km^2	0.15	0.30	0.22	0.04	0.13	0.17	0.12	0.02	0.06	0.68	0.35	0.24	0.31	0.03	0.19	0.00	0.01
Relative road stability hazard	L	M	L	L	L	L	L	L	L	H	M	L	M	L	L	L	L
Stability disturbance rating	L	M	M	M	M	M	L	L	M	M	M	L	M	L	M	L	L
Streams																	
Total CBE, km/km^2	0.00	0.18	0.01	0.00	0.00	0.10	0.06	0.01	0.03	0.04	0.01	0.03	0.08	0.02	0.12	0.00	0.18
CBE disturbance level	L	H	L	L	L	L	M	L	L	L	L	L	M	L	H	L	H
Total LWD, km/km^2	0.2	0.3	0.4	0.1	0.0	0.2	0.1	0.0	0.2	0.4	0.2	0.1	0.2	0.0	0.2	0.0	0.1
LWD disturbance level	M	M	M	L	L	M	L	L	M	M	M	L	M	L	M	L	L
Stream disturbance rating	M	H	M	M	M	M	M	L	M	M	H	L	M	L	H	L	H
Watershed disturbance rating	3	1	2	2	2	2	3	3	2	2	1	3	2	3	1	3	1
Watershed risk	L	H	M	M	M	MH	M	L	M	M	H	L	MH	L	H	L	H

WFP area does not include portions of watersheds in TFL37 or i

Unclassified streams are assumed to be S3 if alluvial, semi-alluv

Ratings in red text were adjusted based on visual observations c

Table A2

TFL 19 Watershed Planning Units

Regional watershed:	NONE					
Watershed:	Tsowwin	Wilson	Zeballos			
Basin:			Maraude	Nomash	U.Zeballos	Zeballos-Rem.
Total Area, ha	3,592	1,637	4,791	4,899	4,754	4,882
WFP area, ha	3,345	788	4,791	4,899	4,754	4,830
WFP area, km^2	33.5	7.9	47.9	49.0	47.5	48.3
WFP percent of total drainage area	93%	48%	100%	100%	100%	99%
Watershed Characteristics						
Fisheries Rank	1	3	2	2	2	1
Terrain Stability						
Regional landslide frequency	H	M	H	H	H	H
Total steep terrain (Class 4&5 + >60%)	1,722	296	2,670	3,005	2,215	2,792
% of WFP area	51%	37%	56%	61%	47%	58%
Relative terrain vulnerability	H	H	H	H	H	H
Occurrence of natural landslides, no./km^2	0.09	0.00	0.90	1.04	0.55	0.93
Runout slopes >50% of mainstem length	Y	N	lake	Y	N	Y
Terrain stability rating	H	M	M	H	H	H
Streams						
Alluvial streams per watershed area, km/km^2	0.24	0.02	0.16	0.16	0.27	0.47
Total length S1, S2 and S3 streams, km	14	4	3	18	11	15
Alluvial length S1, S2 and S3 streams, km	8	0	2	6	5	11
% alluvial stream length S1, S2 & S3	53%	5%	51%	35%	46%	76%
Alluvial S1,S2,S3 per watershed area, km/km^2	0.23	0.02	0.04	0.13	0.10	0.24
Channel sensitivity	M	L	L	L	H	H
Presence of estuary	Y	Y			N	Y
Presence of floodplains >3 channel widths	Y					Y
Presence of contemporary fans	small	small	Y	Y	Y	Y
Sensitivity to riparian logging (fan, floodplain)	H	L	M	M	M	H
Stream sensitivity rating	H	L	M	M	M	H
Watershed sensitivity rating	1	3	2	2	2	1
Hydrologic Change						
Probable peak flow regime (R, ROS)	R	R	R, ROS	R, ROS	R, ROS	R
Possible karst (uTrp, uTrq, uTrkq, CPB)	Y	N	small	Y	Y	Y
Disturbance Indicators						
Terrain Stability -- cutblocks and roads						
Total no. of slides from roads and cutblocks	41	10	0	16	14	27
no./km^2 of watershed area	1.2	1.3	0.0	0.3	0.3	0.6
Relative frequency	H	H	L	L	L	M
Slides in post-Code cutblocks, no./km^2	0.10	0.00	0.00	0.02	0.00	0.10
Roads M, MH, H hazard not perm. deactivated, km	6	8	0.2	7	7	11
Roads M, MH, H not deact. - km/km^2	0.18	1.01	0.00	0.14	0.14	0.24
Relative road stability hazard	L	H	L	L	L	L
Stability disturbance rating	H	H	L	L	L	M
Streams						
Total CBE, km/km^2	0.04	0.00	0.03	0.05	0.05	0.15
CBE disturbance level	L	L	L	M	M	H
Total LWD, km/km^2	0.2	0.2	0.0	0.2	0.2	0.2
LWD disturbance level	M	M	L	M	M	M
Stream disturbance rating	M	H	L	M	M	H
Watershed disturbance rating	2	1	3	3	2	1
Watershed risk	MH	M	L	L	M	H

WFP area does not include portions of watersheds in TFL37 or i

Unclassified streams are assumed to be S3 if alluvial, semi-alluv

Ratings in red text were adjusted based on visual observations c

Table A3 -- Fish Ranking -- TFL 19 Watershed Units *(compiled by D. Clough)*

WATERSHED	WATERSHED CODE	BASIN	AREA (ha)	FISH RANK	SPECIES PRESENT	COMMENTS/ Known Barrier Location	REF*
Canton	930-539800		3873	1	CH,CO,CH,PK,CT	BARRIER APPROX 5KM UPSTREAM	1
Conuma	930-538500	Leagh	1178	3	CH,CO,CM,ST,RB	RES RB UPSTREAM TO 1.0KM ABOVE HATCHERY INTAKE	1
Conuma	930-538500-10300	Norgate	1968	3		Headwaters likely have cutthroat	100
Conuma	930-538500-46800		9178	1	CH,CM,DV,RB,PK,ST	COHO TO 5.5KM, RES DV, RB ABOVE	1
Cougar	930-530500	Tlupana Inlet	1497	4		BARRIER NEAR MAINLINE, NO FISH ABOVE	6
Deserted (Hisnit)	930-548100		2030	2	SK,CH,CO,PK,CM	salmon throughout main drainage, alluvial inflow with floodplain	8
Espinoso			2725	3	CO,CM,CT,PK	BARRIER APPROX 1.1KM FROM MOUTH	1
Gold	930-511600	Remainder	10938	1	ALL SALMON	Mainstem Gold,	1
Hanna	930-525200		1364	3	CO,CT,CM	BARRIER APPROX 1.4KM FROM MOUTH	11
Heber	930-511600-24900	Remainder	2215	1	SST,WST,CT,CM,CH,DV,CO	BARRIER FALLS AT 0.9KM	1
Heber	930-511600-24900	Saunders	4020	3	SST,WST,RB,DV,CT	BARRIER FALLS AT 4.0KM FROM CONF. RES fish ABOVE	12
Hoiss	930-556300		1508	2	CO,CM,PK,CT,DV	BARRIER APPROX 1.6KM FROM MOUTH, RES DV ABOVE	13
Houston	930-497700		4831	2	CO,CM,PK,CT	BARRIER APPROX 150M FROM MOUTH, RES CT ABOVE	1
Kleeptee	930-521000		5296	1	PK,CO,CH,CH,ST,CT	BARRIER FALLS APRROX 3.6KM FROM OCEAN, RES CT ABOVE	15
Leagh			1178	4	CT/CO	Short access to hatchery intake then no fish	16
Leiner	930-567600	Perry	4897	1	CO,CH,CM,PK,CT	first barrier at 4km passable	1
Leiner	930-567600-14900-99100		6736	2	CH,CT		1
Mamat	930-599200	Zeballos	1104	3	CO,CH,CT	BARRIER APPROX 1.5KM RES CT ABOVE	17
McCurdy	930-514500	Muchalat Inlet	6943	2	ST,RB,CM,CO	COHO TO 3.2KM, ST TO APPROX 10KM	18
Upper Muchalat	930-511600-42100	Upper Muchalat	5107	1	SK,CO,CH,RB,ST,CM,CT	From Gold to Lake	1
Muchalat Lake	930-511600-42100	Muchalat	7144	1	SK,CO,CH,RB,DV,ST	BARRIER APPROX 7KM ABOVE LAKE RES CT ABOVE	19
Nesook	930-534200-06000	Tlupana	4590	1	CO,CM,CT	BARRIER APPROX 8.5KM FROM MOUTH, res Rb above	20
Nesook	930-534200		6134	3	CT	less than 1km anad, RES CT ABOVE BARRIER	21
Oktwanch	930-511600-42100-30700	Nameless	786	4		STEEP REACH , NO FISH IN HEADWATER	100
Oktwanch		Remainder	4567	1	SK,CO,CH,RB,DV,ST	NO BARRIER THRU TFL	1
Oktwanch	930-511600-42100-30700	U. Oktwanch	1785	1	CO,RB,DV,ST	ABOVE TFL MAP, SALMON CONTINUE IN ALLUVIAL TO 17KM	1
Silverado	930-494700		2280	3	CO,CM,CT	BARRIER APPROX 750M FROM MOUTH	1
Sucwoa	930-540600		3596	2	CH,CO,CH,CT,PK,	BARRIER APPROX 4.5KM UPSTREAM	1
Tahsis	930-569100-09400	McKelvie	2174	3	CO,CM,CT,DV	BARRIER APPROX 900M FROM CONFLUENCE	1
Tahsis	930-569100		5504	1	CH,CM,CO,PK,ST		1
Tsowwin			3592	1	CH,PK,CM,CO,ST	FALLS at approx 10k PASSABLE TO ST	22
Ucona	930-511600-06900	Pamela	4167	3	RB,CT		23
Ucona	930-511600-06900-24000	Quatchka	3460	3	RB,CT		24
Ucona	930-511600-06900-21100	Remainder	2582	1	CO,CH,ST,DV,CT	BARRIER APPROX 4KM FROM MOUTH. RES CT,RB ABOVE	1
Upana	930-511600-31700		6219	2	ST, CT,RB,DV	FALLS APPROX 500M UPSTREAM OF CONF. LAKE STOCKED	200
Upper Gold	930-511600		10362	1	CO,ST,RB	sthd refuge habitat	1
Wilson			1637	3	CO,CM,CT	SHORT ACCESS FROM OCEAN	200
Zeballos		Maraude	4791	2	RB,DV		200
Zeballos		Nomash	4899	2	RB,DV,ST,CO		200
Zeballos		Remainder	3789	1	ALL SALMON	BARRIER removed at 2.0KM, 30 km access FROM MOUTH	200
Zeballos		Upper Zeballos	4754	2	RB,DV,ST,CO		200

By D.R. Clough using G. Horel FishRank Methodology - Jan. 28, 2008

*See Appendix B for reference list.

DEFINITIONS
Fish ranking: 1 -- High to very high fish capacity; large or potentially large anadromous runs. 2 -- Important resident fishery or moderate anadromous capacity. 3 -- Small but significant anadromous capacity; or some resident fish. 4 -- Limited fisheries capacity. Few resident or anadromous fish.
Fish Species: CH = chinook salmon CM = chum salmon CO = coho salmon SO =sockeye salmon PK = pink salmon KO = kokanee ST = steelhead trout CT = cutthroat trout RB = rainbow trout DV = Dolly Varden char
Anad = anadromous Res = resident

Table A4

Watershed trends and management strategies

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Saunders (Heber)	3	Stream reaches aggraded from Nov 2006 slides & from previous events.	CWAP 1997. Sustainable Forest Management Report 2004. Semi-permanent & permanent road deactivation.	Elongate E-W trending drainage with low drainage divide at north end. Single dominant mainstem; mainly V-shaped valley, broadening at upper end of valley. Narrow valley floor; mainstem includes alluvial reaches with limited channel migration zones, semi-alluvial reaches & nonalluvial reaches. Asymmetric valley; west side has short, uniform moderate to steep slopes with short tributary streams in gullies. East side has several small tributary valleys with entrenched streams; moderate to steep slopes. Hillslopes moderately well connected to streams; limited runout slopes except at top end of valley. One small fan in upper drainage. A few small headwater ponds near upper drainage divide on west side; no other lakes. Natural landslides (old & recent); 19 slides from cutblocks including 9 from postCode blocks; 3 slides from preCode roads. Alluvial reaches are aggraded from sediment from slides (natural & development-related).	Alluvial reaches of mainstem.	Terrain stability. Slides in postCode blocks.
Muchalat Lake & lower Muchalat River	1	Stable	Sustainable Forest Management Report 2003 rev 2004. Semi-permanent & permanent road deactivation.	Unit includes slopes draining directly into Muchalat Lake & Muchalat River below lake. Does not include Upper Muchalat which drains into the upstream end of the lake; or Oktwanch, which drains into the north side of the lake. See below for those units.		
				North side of lake west of Oktwanch R.: slopes mainly steep, fairly uniform with minor gullied areas, entrenched nonalluvial streams. Small tributary drainage west part of area has V-shaped valley with entrenched nonalluvial stream & small fan at lakeshore, one old natural slide. One landslide at postCode block; several slides from Muchalat Main along lakeshore. North side east of Oktwanch R: moderate to steep slopes with entrenched nonalluvial tributaries, one natural slide area in steep upper valley wall, one slide in preCode block. No other lakes on north side of Muchalat L.		Road fill stability along Muchalat Main.
				South side of Muchalat Lake: Irregular moderate to steep terrain with entrenched nonalluvial streams in small tributary drainages. A few old landslides from preCode roads, one slide from preCode block, one from postCode block. Irregular terrain provides some runout zones. No-Name Lake is largest tributary drainage: Valley form is irregular with lake in centre of basin and two headwater tributaries; lower channel is entrenched nonalluvial; alluvial reach upstream of lake; small headwater lakes this drainage.	Small fans at lakeshore, alluvial streams on valley floor east end of lake.	Road maintenance on fans. Harvesting adjacent to alluvial streams.
				Lower Muchalat River: Drains from outlet of Muchalat Lake. Confined semi-alluvial to partially confined alluvial channel, limited channel migration zones, stable channel position; slopes between lower Muchalat & Gold Rivers are gentle to moderate with steeper sections at escarpments; no landslides.	Alluvial reaches of mainstem.	Harvesting adjacent to alluvial streams.
				South side of lower Muchalat River: Irregular moderate to steep terrain; mainly entrenched nonalluvial streams; alluvial reaches on valley floor draining into east end of Muchalat Lake. Slides from preCode roads. Irregular terrain & valley floor east end of lake provide some runout zones. Largest tributary is Cypress Creek: Oblong valley with moderate to steep slopes, mainly V-shaped valley form with mid-basin area of U-shaped valley & gentle lower slopes; 4 old slides from preCode roads, 3 from preCode blocks; mainstem & tributary creeks mainly confined to entrenched nonalluvial; alluvial reach & two small fans in mid-basin; small headwater lake at top of mainstem; a few ponds in upland terrain at top of valley slopes.	Alluvial reaches & small fans in mid basin of Cypress Creek, alluvial streams at east end of Muchalat Lake.	Road maintenance on fans. Harvesting adjacent to alluvial streams. Terrain stability.
Upper Muchalat	1		Sustainable Forest Management Report 2003 rev 2004. Semi-permanent & permanent road deactivation.	Unit comprises area draining into west end of Muchalat Lake: Two headwater basins & main valley of upper Muchalat River.		

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Upper Muchalat (cont'd)		Some alluvial reaches & fans still appear widened from riparian harvesting.		North Fork of upper Muchalat R.: Extensive steep slopes along valley sides; avalanche tracks & some natural slides including rockslides in upper valley walls. No road or cutblock slides. Entrenched nonalluvial tributary creeks in steep-sided V-shaped valleys. Upper basin has V-shaped to narrow U-shaped valley form with confined to entrenched nonalluvial & semi-alluvial reaches; hilslopes generally well connected to stream. Several small headwater lakes, the largest is Margot L. (13 ha). Mid part of basin has flat to gently sloping valley floor with extensive glaciofluvial deposits; several small fans on north side, mainly alluvial mainstem (~3 km reach) -- these provide some runout slopes. Considerable natural bedload from natural slides & avalanches. Some channel widening in alluvial reach & on fans from preCode logging on N side of channel. Lower basin has confined to entrenched nonalluvial to semi-alluvial mainstem; irregular terrain on lower slopes provides some runout slopes.	Alluvial reaches of mainstem. Fans on main valley floor.	Terrain stability. Harvesting, road building, road maintenance on fans. Harvesting adjacent to alluvial streams.
		Stable		South Fork of upper Muchalat R.: V-shaped to narrow U-shaped valley form; steep sidewalls with avalanche tracks & some natural slides including rockslides from upper valley walls. No road or cutblock slides; minor development to date. Low drainage divide at west end of basin. Mid & upper basin has mainly nonalluvial stream with a few short semi-alluvial & alluvial reaches. Valley floor widens in lower basin; stream is semi-alluvial & partially confined alluvial; several small fans on south side of basin;	Alluvial reaches (limited).	Terrain stability.
		Consistent with natural (natural floodplain activity)		Main valley south of confluence of headwater basins (Muchalat River): Moderate to steep, irregular valley slopes with entrenched nonalluvial tributary creeks. Frequent old natural slides, mainly gully sidewalls & headwalls. Three slides from preCode blocks; none from roads. Broad irregular main valley floor with partially confined to unconfined alluvial stream; areas of wide flooplain. Irregular lower slopes & floodplain provide runout slopes. Most of floodplain has not been logged; alluvial channel in good condition; natural floodplain activity from natural high bedload from headwater sources. A few short sections where preCode blocks bordered N side of channel; possible minor widening at these sections.	Floodplains, alluvial channels.	Harvesting on floodplains & adjacent to alluvial streams. Terrain stability.
Nameless (Oktwanch)	4	Some sediment from natural torrents in Nov 2006 storm. Minor channel widening still evident on fan.	CWAP 1997, update 1998. Overview & Level 1 Fish Habitat Assessment 1997. Construction Report, Off-Channel Projects & Mainstem Bank Protection 2001. Sustainable Forest Management Report 2004. Semi-permanent road deactivation.	Slightly asymmetric V-shaped valley form with moderate to steep valley slopes & nonalluvial mainstem entrenched in steep-sided inner gorge. Entrenched nonalluvial tributary creeks on adjacent valley slopes. No lakes or water storage. Hillslopes well connected to streams; few runout slopes. Several old natural landslides in gully sidewalls & headwalls, and several natural slide tracks torrented in Nov 2006 storm; 2 slides from preCode roads, 5 slides in preCode blocks. Alluvial fan where stream outlets onto main Oktwanch valley floor; aggradation & minor widening of channel from preCode logging on fan, now mostly aldered. Probable increased sediment to fan from torrents in natural slide tracks in headwater area.	Fan.	Terrain stability. Harvesting, road building, road maintenance on fan.
Oktwanch Remainder	1	South half of mainstem still highly unstable. Tributaries aggraded from Nov 2006 storms.	CWAP 1997, update 1998. Overview & Level 1 Fish Habitat Assessment 1997. Construction Report, Off-Channel Projects & Mainstem Bank Protection 2001. Sustainable Forest Management Report 2004. Semi-permanent & permanent road deactivation.	Unit includes the portion of the Oktwanch watershed in TFL 19 excluding Nameless Creek drainage -- this is the lower valley draining into Muchalat L. & adjacent slopes. Extensive steep slopes on east side of valley with nonalluvial tributary creeks entrenched in gullies & V-shaped valleys. West side of valley has oderate to steep gullied slopes with entrenched nonalluvial streams. Natural landslides in upper valley walls & gully sidewalls; slides from preCode roads & blocks; 4 slides in postCode blocks. Several large slides from storms of Nov 2006; heavy sediment load in tribuary creeks from these events. Unit has broad valley floor with alluvial mainstem. Upper half of mainstem has single uniform channel & stable position; adjacent terraces may be glaciofluvial. Lower half of mainstem is unconfined in broad floodplain; has been destabilized by preCode riparian logging & is still highly unstable with inadequate riparian forest to maintain channel stability or provide functioning LWD. Fans where tributary creeks enter main valley floor; channels on fans generally stable but adjacent riparian forest inadequate to provide LWD.	Oktwanch floodplain, alluvial streams, fans.	Harvesting, road maintenance on fan. Harvesting on floodplain & adjacent to alluvial streams. Terrain stability -- slides in postCode blocks. Stability of preCode roads on steep slopes.

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Pamela (Ucona)	3	Improving but significant sections of alluvial mainstem still appear aggraded & widened.	CWAP 1996, updates 2001, 2004. Semi-permanent & permanent road deactivation.	Elongate basin draining northwestward into Ucona R. Lower (N.) half is in TFL 19. Lower (N end) of basin has irregular moderate terrain with a confined to entrenched semi-alluvial mainstem; a few small upland lakes & ponds; several slides from U-22 (preCode) along inner gorge that entered mainstem; several slides in logged gullies in preCode blocks. Rest of basin has narrow U-shaped valley form with narrow band of gentle to moderate lower slopes, extensive steep mid & upper slopes rising to narrow rounded ridgetops at drainage divide. One small upland lake (5 ha) in upper basin. Frequent old natural slides in steep mid & upper valley slopes; one slide from postCode block, 2 slides from preCode roads. Variable valley floor with alluvial mainstem; aggraded and widened from preCode riparian logging; alder riparian bands suggest improvement but still appears overwidened. CWAP identifies eroding glaciofluvial terrace as significant sediment source also. Several fans along valley floor; channels generally stable. Valley floor & fans provide narrow runout zones along much of alluvial mainstem.	Floodplains, alluvial channels, fans.	Terrain stability. Harvesting on floodplain & adjacent to alluvial streams. Harvesting, road building, road maintenance on fans. Stability of U22 Road along lower gorge.
Quatchka (Ucona)	3	Generally stable; some reaches appear slightly aggraded (partly natural).	CWAP 1996, updates 2001, 2004. Semi-permanent & permanent road deactivation.	Oblong basin parallel to Pamela that also drains northwestward into Ucona R. Narrow U-shaped valley with extensive steep slopes & frequent old natural slides, mainly in upper valley slopes; entrenched nonalluvial tributary creeks. Two small upland lakes west side of basin. Narrow valley floor, mainstem mainly confined semi-alluvial, some short alluvial reaches with limited channel migration zones. Hillslopes generally well connected to mainstem; small fans along valley floor provide local runout zones. Hanging valley tributary on east side of basin; short alluvial reach in upper valley. Three slides from preCode roads; 11 slides in preCode blocks.	Alluvial reaches (limited).	Terrain stability.
Ucona Remainder	1	Stable	CWAP 1997, updates 2001, 2004. Semi-permanent & permanent road deactivation.	Unit comprises remainder of Ucona watershed within TFL 19 that is outside of Pamela & Quatchka basins; mainly comprises small tributaries & slopes draining directly into Ucona River below Kunlin Lake. North part of unit has irregular moderate terrain; one slide from preCode road, no other slides; some low-gradient upland headwater streams (alluvial or semi-alluvial), the rest are confined to entrenched nonalluvial; a few small headwater ponds. The rest of the unit has steep terrain with steep gradient entrenched nonalluvial tributary creeks in V-shaped valleys or gullies; one slide from preCode road, one slide from postCode block, one old natural slide & one slide that appears fresh on 1995 airphoto. Mainstem through this unit is nonalluvial or semi-alluvial entrenched in a canyon; rugged stable channel with limited bedload transport. Some sloughs in canyon sidewalls. Short alluvial reach just below lake is more of a pond. Mainstem is sediment supply-limited; Kunlin Lake restricts sediment transport from watershed upstream of lake.	Few sensitive areas.	Terrain stability.
Upana	2		CWAP 1997, update 2001. Semi-permanent & permanent road deactivation.	Upana River drains eastward into Gold River. The largest tributary is Magee Creek, draining northward & entering Upana River at the lower third of the Upana mainstem.		
		Improving. Channel on fan still overwidened.		Magee Creek: Valley form is narrow U-shape with extensive steep slopes above valley floor. Single dominant mainstem, no lakes. Hillslope creeks & headwater tributaries are entrenched nonalluvial in steep V-shaped gullies. Hillslopes generally well connected to mainstem; one small fan on west side of valley floor. Most of mainstem is confined semi-alluvial with short alluvial reach mid-basin. Lower 1.1 km of channel is alluvial, bottom 600 m above Upana confluence is on alluvial fan formed where Magee Creek valley opens onto Upana valley floor. Channel position on fan appears stable but has widened & aggraded from riparian logging & from sediment sources upstream. Numerous natural landslides (old & recent), several natural slide tracks torrented during Nov 2006 storm. Three slides from preCode roads, 8 slides from preCode blocks, 2 from postCode blocks. Significant natural sediment load in stream, has been increased by development-related slides & riparian logging on fan. Riparian alder bands on fan suggest channel stability is improving but still appears aggraded & overwidened.	Alluvial stream & fan in lower basin.	Terrain stability, slides in postCode blocks. Road maintenance on fan.

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Upana (cont'd)		Improving, alluvial reaches of Upana channel still widened & aggraded.		Rest of Upana: Upper half of watershed is asymmetric; most of the drainage area is on the south side. There are several upland lakes & numerous small headwater ponds; the largest is Upana Lake (40 ha) at the top of the Upana mainstem. Terrain on the south side is moderate to steep & irregular with few natural landslides & one from a postCode block; there are a few low-gradient upland streams (alluvial or semi-alluvial), most are nonalluvial. North side of the upper watershed has steep slopes with short steep nonalluvial tributary creeks; a few old natural slides at gully headwalls, one slide in a preCode block, one in a postCode block; hillslopes this area generally well connected to mainstem. Mainstem in upper half of watershed mainly confined semi-alluvial & nonalluvial with a few short alluvial reaches, mainly at inlet & outlet of Upana L. Mid part of watershed (from ~1.5 km above Magee confluence to ~2.2 km below confluence) has broad valley floor with alluvial mainstem. Adjacent valley slopes are steep with confined to entrenched nonalluvial tributary creeks. There are a few old natural slides & one from a preCode block. Downstream of the Magee confluence, Upana River has widened & aggraded from riparian logging & from sediment from Magee Creek; floodplain vegetation suggests channel is improving but 1.1 km of this reach still appears overwidened.	Alluvial reaches of Upana R. & floodplain.	Harvesting on floodplain & adjacent to alluvial streams. Sediment from Magee Creek basin.
Upper Gold	1		CWAP 1997. Sustainable Forest Management Report 2004. Semi-permanent & permanent road deactivation.	Unit comprises the Gold River watershed area within TFL 19 upstream of the Muchalat R. confluence; includes Twaddle & Waring basins, & Gold River downstream of the Twaddle confluence.		
		Generally consistent with natural (natural slide activity); one reach still widened from riparian logging.		Twaddle R.: Drains SSE into Gold R. Valley form is slightly irregular, broad U-shape becoming slightly narrower near S. end. Broad valley floor; low drainage divide to White R. at N. end of basin. Lower slopes are moderate with numerous small fans. West side, & east side S. of lake, have steep dissected upper slopes with natural slide areas & avalanche tracks; west side at & above lake has moderate to steep slopes with a few natural slides. Regular natural slide activity in steep gullied slopes; several natural debris torrents occurred in Nov 2006 storms; fresh sediment evident on fans & at roads. Four slides from preCode roads, 6 slides in preCode blocks. Fans & valley floor provide runout zones along most of mainstem. Mainstem mostly alluvial; significant natural sediment load from natural slides & avalanches; reach near S. end of basin below confluence with tributary valley is widened & aggraded; sediment mostly from natural slide areas in tributary drainage; channel widening appears aggravated by riparian logging.	Alluvial streams & fans.	Harvesting on floodplains & adjacent to alluvial streams. Road maintenance on fans. Terrain stability.
		Streams aggraded from November 2006 storms.		Waring Creek: Drains SSE into Gold R. below Twaddle confluence. Asymmetric valley with mainstem along east side of basin, 2 tributary drainages on west side. Main valley has narrow U-shaped valley form with narrow valley floors & steep dissected slopes. Hillslopes moderately well connected to channels; limited runout zones on lower slopes. Mainstem mainly semi-alluvial & alluvial with limited channel migration zones. North tributary has V-shaped valley with steep gradient nonalluvial stream; S. tributary has narrow U-shaped valley with alluvial & semi-alluvial stream. Natural landslide & avalanche tracks in upper valley slopes, fairly active; 4 slides from preCode roads, 8 slides in preCode blocks, 4 slides in postCode blocks. Several natural slides & 6 of the cutblock slides occurred in Nov 2006 storm. Channels aggraded from Nov 2006 landslides. Significant natural sediment from slides & avalanches but increased by development-related slides.	Alluvial streams.	Terrain stability, slides in postCode blocks.

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Upper Gold (cont'd)		Alluvial reach at top end of Gold R channel improving but still appears widened, aggraded.		Rest of Upper Gold: Broad U-shaped valley form with irregular valley floor, extensive till & glaciofluvial deposits on valley floor & lower slopes. Steep dissected upper valley slopes with some natural landslide areas in upper valley walls; several slides from these areas in Nov 2006 storms blocked roads. In this unit: 15 slides from preCode roads, 13 slides in preCode blocks, 4 slides in postCode blocks. Extensive moderate lower slopes with irregular terrain provide runout slopes along most of valley. Most of Gold R. channel through this unit is confined semi-alluvial or nonalluvial. The top 2 km is alluvial & most of this reach has widened & aggraded from riparian logging & upstream sediment sources; vegetation indicates channel is improving but is still overwidened. Bottom 3.9 km (above confluence with Muchalat) is also alluvial; adjacent terraces may be glaciofluvial; channel is uniform & position is stable.	Alluvial reaches.	Harvesting next to alluvial reaches. Terrain stability upper valley slopes.
Gold Remainder		Generally stable. Top 2.4 km of Gold River channel still overwidened & marginally unstable.	CWAP 1997. Semi-permanent & permanent road deactivation.	This unit comprises the main Gold River valley below the Muchalat R. confluence, southward to the ocean at Muchalat Inlet. Upper part of unit from Muchalat R. southward to ~2.5 km south of Heber R.: broad valley with extensive irregular moderate terrain on the lower & mid slopes. The top ~2.4 km of the Gold River mainstem has a partially confined to unconfined alluvial channel in a broad floodplain with alluvial & glaciofluvial terraces; this reach has experienced widening, aggradation & channel instability from preCode riparian logging. Vegetation indicates that channel stability is improving but is still overwidened, aggraded & marginally unstable. There are a few slides from preCode roads along terrace escarpments along this reach. Downstream of this reach to the south end of this valley form, Gold R. has a confined to entrenched nonalluvial & semi-alluvial channel with a stable channel position. At the south end of this area there is a 1.8 km alluvial reach; channel position is stable; adjacent terraces may be glaciofluvial. North of Heber R., tributary creeks have alluvial & semi-alluvial channels on the lower slopes & entrenched nonalluvial channels on the steep upper slopes. South of Heber R. in the moderate terrain on the east side of Gold R. there are several small lakes. South of Upana R. on the west side of Gold R., the upper valley slopes have extensive steep terrain dissected by entrenched nonalluvial streams; there are natural slides in the upper valley walls & several old slides from preCode roads. At ~2.5 km south of the Heber confluence, the valley narrows to a steep-sided V-shaped valley form with an entrenched nonalluvial to semi-alluvial mainstem in an inner gorge; & steep-gradient entrenched nonalluvial tributary creeks. There are few roads other than the highway. This valley form extends to ~2.7 km from the ocean, where the valley opens out to a floodplain with an alluvial stream; this reach has tidal influence. Approximately half the floodplain area was developed for the pulp mill site.	Alluvial reaches.	Terrain stability, especially west side S. of Upana R. Harvesting on floodplains next to alluvial reaches.
Canton		Improving; some reaches of mainstem still overwidened & aggraded.	Some semi-permanent & permanent road deactivation.	Watershed drains southward into Head Bay of Tlupana Inlet; comprises a short main valley & two headwater tributaries, the largest extends northwest from the confluence; the smaller tributary extends northeast. Main valley generally U-shaped, valley walls rise to narrow rounded ridgetops. East valley slopes are steep with short entrenched step-gradient nonalluvial tributary creeks & old natural landslides (mainly rockslides); west valley slopes are moderate to steep with mainly nonalluvial tributary creeks, a few lower gradient semi-alluvial upland streams. Lower part of main valley has broad floodplain with alluvial mainstem, fan delta & estuary at outlet; channel has widened & aggraded from preCode riparian logging; alder bands indicate channel stability is improving, still overwidened & aggraded in a few places. Upper part of main valley is narrower & variable; mainstem has confined semi-alluvial & partially confined alluvial reaches. One slide from preCode cutblock, 2 slides from preCode roads. Abundant natural sediment supply from headwater valleys especially west valley.	Floodplain in main valley, alluvial streams in main valley & east tributary; estuary.	Terrain stability, especially west headwater valley; slides in postCode blocks. Harvesting on floodplains & adjacent to alluvial streams.

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Canton (cont'd)				West (main) headwater valley has U-shaped valley form, colluvial aprons & cones flanking steep dissected hillslopes with natural landslides & avalanche tracks including some large rockslides; 3 slides from preCode blocks, 3 slides from postCode blocks. Mainstem mainly confined semi-alluvial & nonalluvial, a few short alluvial reaches. Hillslopes moderately well connected to channel; colluvial aprons & fans provide some runout slopes. East headwater valley has U-shaped valley form with steep irregular upper slopes, steep nonalluvial tributary creeks,avalanche tracks & a few natural landslides. Lower part of mainstem is entrenched nonalluvial & semi-alluvial; mid & upper mainstem is semi-alluvial & alluvial in narrow valley floor. Alluvial reaches appear slightly aggraded & widened in places, probably from preCode riparian logging.		
Conuma (except Leagh & Norgate)	1	Alluvial reaches of the Conuma mainstem are still overwidened & aggraded & have unstable channel sections.	CWAP 2000, update 2005. Semi-permanent & permanent road deactivation.	Drains westward into Tlupana Inlet at Moutcha Bay; large estuary at outlet. The lower 7 km of the Conuma valley trends approximately east-west; the north side has steep bedrock slopes with several natural active rockslides & steep-gradient nonalluvial tributary creeks. The south side has irregular moderate to steep terrain & a few upland ponds. The lower valley for 4.6 km above the estuary has a broad floodplain & unconfined to partially confined alluvial mainstem that experienced channel instability, widening & aggradation from preCode riparian logging. Alder bands suggest channel stability is improving but much of this reach is still overwidened & aggraded, some sections are still unstable. The floodplain is widest at the outlet, becoming narrower upstream. From 4.6 to 7 km the valley bottom is narrow & irregular; the mainstem is confined to entrenched semi-alluvial & nonalluvial. Irregular slopes & floodplain provide runout zones along this portion of the mainstem. The mid valley, from 7 km to the Norgate confluence at 10 km, the valley trends north-south; the upper valley above the Norgate confluence to the top of the mainstem trends northwest-southeast. The midvalley has a narrow irregular valley floor; adjacent slopes are irregular & mainly steep with a few old natural slides; there are small fans where tributary drainages enter the main valley floor. The mainstem is mostly confined semi-alluvial & nonalluvial, with a 0.8 km alluvial reach where the valley widens locally. This reach has widened & aggraded from riparian logging on the east side. Hillslopes moderatelly well connected to stream except at local widening. The upper valley above the Norgate confluence has a wider but variable valley floor; adjacent slopes are somewhat irregular but generally steep with entrenched nonalluvial tributary creeks, several old natural landslides in the upper valley walls, 6 slides from preCode blocks, 1 slide from a postCode block & 1 slide from a postCode road. There are 3 upland lakes in the upper slopes above the Norgate confluence, the largest is Leighton Lake (25 ha). There are several small fans where tributaries enter the main valley. The top of the Conuma mainstem branches into 3 headwater tributaries that extend into high-elevation steep alpine terrain with avalanche tracks & numerous active natural landslides including large rockslides; a few small alpine headwater lakes. The mainstem in the upper valley includes alluvial, semi-alluvial & nonalluvial reaches. The alluvial reaches have experienced channel widening & aggradation where they have been logged on the northeast side of the channel. In particular, a 2.2 km alluvial reach & floodplain in the vicinity of the Norgate confluence has experienced channel widening, instability & aggradation from riparian logging on the northeast side. Development-related landslides may have contributed to channel sediment but overall volume would be low compared to abundant natural sediment supply from the headwater basins. Variable valley floor provides some runout slopes.	Alluvial reaches of mainstem, floodplain, fans, estuary.	Harvesting on floodplains, fans & adjacent to alluvial streams. Terrain stability, particularly above Norgate confluence.

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Leagh (Conuma)	3	Stable; channel on fan still widened & aggraded.	Leagh Creek Water Quality Monitoring project 2004. Leagh Creek Channel Assessment 2002. CWAP 2000, update 2005 (Conuma). Hatchery at stream outlet.	Basin drains southward into Conuma R. ~1.8 km above Moutcha Bay. Basin has V-shaped to narrow U-shaped valley form & curved valley alignment. Valley sides have extensive steep slopes; a few old natural landslides in upper valley walls; entrenched steep-gradient nonalluvial mainstem with steep nonalluvial tributary creeks; upland lake (10 ha) at top of headwater tributary. Hillslopes well connected to mainstem. Low drainage divide at top end of basin. New road over drainage divide from upper Conuma valley; only development to date in this basin are recent blocks near drainage divide. Fan at outlet onto Conuma valley floor, hatchery is on fan. Channel on fan appears widened & aggraded from riparian logging (*also noted in Leagh Creek channel assessment report*).	Fan.	Terrain stability. Hatchery facilities occupy significant part of fan surface. Road maintenance on fan.
Norgate (Conuma)	3	Stable	CWAP 2000, update 2005. Some semi-permanent & permanent road deactivation.	Basin drains westward into Conuma R. in mid portion of Conuma watershed. Valley alignment generally east-west; slightly curved. Short alluvial reach on main Conuma valley floor; otherwise lower valley (bottom 2.7 km) has V-shaped valley form with steep slopes & entrenched high-energy nonalluvial channel in inner gorge; 3 landslides from preCode roads. Rest of basin has irregular valley form & more variable slopes, generally steeper slopes S. side; 1 old natural landslide, 1 from preCode block; streams generally nonalluvial; a few alluvial & semi-alluvial reaches.	Short alluvial reach on main Conuma valley floor.	
Cougar	4	Stable	CWAP 1996, updates 1999 & 2004. Semi-permanent & permanent road deactivation.	Approximately round watershed draining westward into Tlupana Inlet; small fan at outlet. Dendritic drainage pattern with branching tributaries, irregular terrain with extensive steep slopes. A few natural landslides including rockfalls near upper drainage divide; 2 slides in preCode blocks. Most streams are confined nonalluvial; mainstem has entrenched sections; a few lower gradient semi-alluvial & alluvial reaches (nonfish); overall channel sensitivity is low (CWAP).	Small fan; campground on fan.	
Espinosa	3	Improving; alluvial mainstem still appears overwidened.	Semi-permanent & permanent road deactivation.	Unit drains southward into north end of Espinoza Inlet; comprises main valley & one significant tributary basin on east side. There is an estuary at the outlet; alluvial mainstem & floodplain extends 0.5 km upstream; alluvial channel here is stable, adjacent regen is inadequate to provide LWD. Above 0.5 km to 1.2 km, the watershed has an irregular valley form with ridged to hummocky terrain in the lower valley & steep upper slopes; confined to entrenched semi-alluvial mainstem & nonalluvial tributary creeks. Above 1.2 km the valley broadens out & the mainstem is partially confined to unconfined alluvial in a variable width floodplain. Valley slopes are steep with entrenched nonalluvial tributary creeks & numerous natural landslides including a few recent ones; 2 slides from preCode blocks, 5 slides from preCode roads. Several fans where tributary gullies open onto the main valley floor. Much of the upper alluvial mainstem has experienced minor widening & aggradation from preCode riparian logging; regen along most of this reach is of inadequate size to provide LWD. East tributary: Irregular valley form; extensive steep slopes with step nonalluvial tributary creeks; mainstem mostly confined to entrenched nonalluvial with a few semi-alluvial & alluvial reaches (nonfish); small fan at outlet onto Espinosa valley floor. A few old natural landslides, 8 slides from preCode roads, 1 slide from a preCode block. Streams generally low sensitivity.	Alluvial streams, fans, estuary. FN village at estuary.	Harvesting on floodplain & adjacent to alluvial streams. Road maintenance on fans. Stability of preCode roads on steep terrain.

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Hanna	3	Generally stable. Sediment diminishing from slides along inner gorge.	CWAP 1997, update 2001. Semi-permanent & permanent road deactivation.	Main valley extends east-west; flows westward into Hanna Channel; small tributary extends north-south, enters Hanna Creek near outlet. Small estuary at outlet. Main valley has a V-shaped valley form with a nonalluvial mainstem entrenched in an inner gorge, broads in upper valley to narrow U-shape with confined to entrenched nonalluvial & semi-alluvial mainstem; small upland lake (11 ha) in headwater tributary; steep slopes on N side of valley with nonalluvial tributary creeks; moderate to steep slopes on S side, mainly nonalluvial tributary creeks, S headwater tributary has semi-alluvial reach. A few old natural landslides in upper valley walls; 1 slide from preCode road; a series of slides in preCode block in gullied sidewalls of inner gorge (CWAP recorded 21 slides). Bare spots on these slides are still visible (2004 satellite image) but becoming revegetated. Bottom 0.8 km of Hanna Creek may be alluvial; channel is stable, regen in adjacent riparian forest inadequate to supply LWD. North tributary: Mostly gentle to moderate terrain; steep areas in upper valley slopes on east side. Most of stream is low-gradient alluvial; adjacent regen inadequate to supply LWD. No landslides. Stream appears stable.	Small alluvial streams in N. tributary & bottom reach of Hanna Creek; estuary. Aquaculture site near outlet.	Terrain stability at gullies & inner gorge in main valley.
Hisnit (Deserted L)	2	Aggraded channels & fans by lakeshore. (Nov 2006 slides)	CWAP 1998, update 2002. Some semi-permanent & permanent road deactivation.	Unit comprises 4 tributary basins draining into Deserted Lake in the south central part of the watershed, which discharges via a short alluvial stream into Hisnit Inlet. WFP manages 66% of the watershed. Alluvial streams are limited to the lower reaches of the tributaries in the vicinity of Deserted Lake & the mainstem below the lake; elsewhere the tributaries have confined to entrenched nonalluvial streams with a few semi-alluvial reaches. There is a large fan on the north shore of the lake & a smaller fan on the southwest shore. The two tributaries on the west side of the watershed have steep-sided V-shaped valleys with several natural landslides in the upper vallet walls & entrenched nonalluvial streams; 4 slides occurred in the southerly tributary during the Nov 2006 storms -- 3 from postCode blocks & 1 from a postCode road, causing aggradation & channel widening on fan by lake. Sediment & wood debris jam also apparent on north shore fan, originating from slides outside of WFP area. Tributary draining southeast part of watershed has moderate terrain with a few steep areas, one natural slide; 4 small headwater lakes.	Alluvial streams & fans in vicinity of Deserted Lake.	Harvesting or road construction on fans. Terrain stability in 2 tributary valleys on west side.
Hoiss	2	Increased sediment in alluvial reaches from 2006 slides.	Some semi-permanent & permanent road deactivation.	Elongate watershed with single dominant mainstem draining southward into Cook Channel. WFP manages 69% of watershed. Lower part of watershed has irregular valley form, moderate slopes, & alluvial & semi-alluvial mainstem-- narrow floodplain at alluvial reaches; small estuary at outlet; alluvial reach is aggraded. A few small upland ponds on west side; no other lakes. Natural sediment supply from upstream but fresh sediment from recent slides. Most of watershed has V-shaped to narrow U-shaped valley form with moderate to steep valley sides & several natural landslides in upper valley slopes; 2 slides in Nov 2006 in recent postCode blocks. Slopes moderately well connected to streams; moderate lower valley slopes provide some runout zones. Confined semi-alluvial mainstem with an alluvial reach in mid watershed (narrow floodplain) & becomes nonalluvial in upper watershed. Regular sediment supply to mainstem from natural slide areas; also fresh sediment & wood from 2006 slides.	Alluvial reaches. FN reserve at outlet.	Terrain stability, landslides in postCode blocks. Harvesting next to alluvial reaches.

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Houston	2	Improving; significant sections of alluvial reaches still overwidened & aggraded.	CWAP 1998. Semi-permanent & permanent road deactivation.	This watershed drains northwestward into Muchalat Inlet. Single dominant mainstem up to branching headwater tributaries. Lower 1.6 km of watershed has irregular moderate to steep terrain with entrenched nonalluvial & semi-alluvial mainstem. Above that, valley form is generally U-shaped with single dominant mainstem in variable valley floor & steep slopes with entrenched nonalluvial tributary creeks; most of mainstem is partially confined to unconfined alluvial channel in broad floodplain; several fans where tributary gullies open onto main valley. Much of alluvial mainstem has widened & aggraded from preCode riparian logging. Channel stability is improving; there are extensive alder flats on floodplain; but channel still appears overwidened & aggraded. A few old natural landslides in upper valley walls; 9 slides from preCode roads, 13 slides in preCode cutblocks. Floodplain & fans provide runout zones along much of the mainstem length. Valley floor constricts in mid-valley & has a short nonalluvial reach. Upper valley branches into dendritic headwater tributaries with several upland headwater lakes; the largest is Lillian Lake (62 ha); most streams in this area are nonalluvial with some semi-alluvial reaches.	Floodplains, alluvial channels, fans.	Harvesting on floodplains & adjacent to alluvial streams. Road maintenance on fans. Terrain stability. Stability of preCode roads.
Kleeptee	1	Generally stable; lower alluvial reach still overwidened & aggraded.	CWAP 1999. Sustainable Forest Management Report 2004. Semi-permanent & permanent road deactivation.	Round watershed with dendritic drainage pattern; drains southward into Williamson Passage; estuary at outlet. WFP manages 90% of this watershed. The east side of the watershed has irregular moderate terrain on the mid & lower slopes; & steep upper slopes. The central & west part of the watershed has irregular moderate terrain with areas of steep upper slopes. There are old natural slides in the steep upper valley walls. Irregular terrain & moderate slopes provide runout zones in much of the watershed. The bottom 1900 m of the mainstem has an alluvial channel on a floodplain that is widest at the outlet & narrows upstream. This reach has experienced widening & aggradation from preCode riparian logging. Just above the alluvial reach there are fans on the east side of the valley; some streams on the fans have also experienced channel instability from preCode logging. PreCode development is limited to the lower part of the watershed; there are 3 slides from preCode roads & 2 slides from preCode blocks in this area. There is a string of headwater lakes at the top of the mainstem & an upland headwater lake at the top of the east tributary. From the bottom alluvial reach to the first lake, the mainstem is mainly semi-alluvial (confined, stable) with a few short alluvial reaches in narrow floodplains. The east tributary has a confined semi-alluvial & nonalluvial stable channel with a short alluvial reach at the bottom.	Lower alluvial reach & floodplain. Fans.	Harvesting on floodplain & next to alluvial streams. Road maintenance on fans. Terrain stability in steep areas.
Leiner (except Perry)	2	Stable	Some permanent road deactivation.	Drains westward into Tahsis Inlet just south of Tahsis; estuary at outlet. Development to date limited to bottom end of watershed, new road over Nimpkish pass. No development-related slides to date. Lower valley, to just above Perry R. confluence, has broad floodplain & unconfined alluvial mainstem. Lower floodplain adjacent to estuary has extensive alder flat (possible old logging); alluvial reach generally in good condition, some natural channel migration. Watershed has dendritic drainage pattern; extensive steep slopes rising to narrow rounded ridgetops; low pass at north end into Nimpkish watershed. Above floodplain, valley form is typically V-shaped to narrow U-shaped & mainstem is confined to entrenched semi-alluvial with a few alluvial & nonalluvial reaches; high energy, stable. Steep nonalluvial tributary creeks, numerous small upland lakes & ponds. Two headwater basins, each with 2 sub-basins.	Floodplain & alluvial channel in lower valley; estuary. Alluvial reaches in headwater basins.	Harvesting on floodplain & adjacent to alluvial streams. Terrain stability.

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Leiner (except Perry) cont'd				North headwater basin: Steep nonalluvial channel up to confluence of 2 headwater sub-basins. North sub-basin has a shallow lake (7 ha) in mid-basin; channel below lake is steep nonalluvial; channel above lake is alluvial in broad valley floor, 2 small headwater lakes; steep valley slopes; several avalanche tracks & old natural slides including a few active rockslides. South sub-basin rises to high-elevation alpine with avalanche tracks & large natural rockslides (large headwater sediment source); mainly steep nonalluvial streams with short alluvial & semi-alluvial reaches mid-valley. South headwater basin: V-shaped to narrow U-shaped; upper slopes & headwater sub-basins extend into high elevation alpine with numerous avalanche & rockslide tracks (large headwater sediment source). Streams mostly nonalluvial; alluvial reach in mid basin. Extensive colluvial cones & aprons on lower hillslopes, especially in headwater sub-basins.		
Perry (Leiner)	1	Improving; several alluvial reaches in sub-basins still overwidened & aggraded.	Semi-permanent & permanent road deactivation.	Drains northwestward into Leiner R. 1.6 km above estuary. Main valley trends northwest-southeast; branches to 2 headwater sub-basins near S. end; low drainage divide to Sucwoa watershed at S. end, on fan. Lower 1.6 km of Perry valley has steep-sided V-shaped valley with entrenched semi-alluvial & nonalluvial mainstem. Above 1.6 km there is a small lake/wetland where valley broadens. Valley floor is irregular in mid-basin, with a confined semi-alluvial mainstem; above this, the valley floor widens to the south; in the upper valley the mainstem includes a narrow shallow lake (Perry Lake, 20 ha); above the lake the mainstem is alluvial in a broad floodplain. There are several small fans along the lakeshore & above the lake. Slopes along the main valley are steep & gullied with numerous natural & development related slides including 6 slides from preCode roads & 12 slides from preCode blocks. West headwater sub-basin: U-shaped valley with irregular valley floor & steep upper slopes, steep nonalluvial tributary creeks; a few small upland ponds. Natural landslides in upper valley walls; 7 slides in preCode blocks, 1 slide from preCode road. Small lake/wetland in mid-valley; mainstem below lake is mainly confined semi-alluvial (stable). Stream above lake is alluvial in broad floodplain; channel has widened & aggraded from preCode riparian logging. Sub-basin extends into alpine, with 2 lakes at the top of the mainstem, the largest is 44 ha. Alluvial fan where sub-basin opens onto Perry valley floor; channel on fan widened & aggraded from harvesting on fan & from slides in preCode blocks; improving but still appears overwidened. South headwater sub-basin: Drainage divide to Sucwoa is on fan; at times this sub-basin may have drained into Sucwoa. U-shaped valley with steep upper slopes; numerous natural landslides, 7 slides in preCode blocks, 1 from preCode road. Mainstem has alluvial & semi-alluvial reaches; lower alluvial reach on fan has widened & aggraded from preCode riparian logging & from landslides (natural & development-related). Channel improving but still appears over-widened. No lakes or ponds. Moderate lower slopes & valley floor provide runout zones in the mid & upper main valley. The upper alluvial reaches (above Perry L.) are in reasonably good condition, except for the east tributary channel on the fan, which still appears to be somewhat widened. Perry Lake & the lower pond in the main valley act as sediment sinks, interrupting sediment transport to downstream reaches. Despite the large number of landslides, most of the mainstem does not appear to be significantly impacted. Most roads across fans have been permanently deactivated.	Alluvial streams at top end of main valley & east sub-basin. Floodplain in upper main valley. Fans.	Harvesting next to alluvial reaches, especially in floodplain. Terrain stability. Road building on slopes with natural slides.

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Mamat	3	Improving; lower alluvial reach still slightly overwidened.	Semi-permanent & permanent road deactivation.	Drains southward into Little Espinosa Inlet; estuary at outlet. Asymmetric drainage with mainstem along west side. Variable irregular valley form; extensive steep terrain on mid & upper slopes; narrow rounded ridgetops along drainage divide. Several old natural landslides in upper valley walls; 3 slides from preCode roads; 2 slides in preCode blocks. Bottom 0.8 km of watershed has partially confined alluvial mainstem in narrow valley floor; channel widened & aggraded from preCode riparian logging; alder bands indicate channel condition improving but still appears slightly overwidened. A second alluvial reach at 1.1 - 1.6 km above estuary; alder riparian zone; channel position appears stable. The rest of the mainstem is confined semi-alluvial & nonalluvial (stable). East tributary has semi-alluvial mainstem; other tributary creeks mainly steep nonalluvial.	Alluvial reaches of mainstem (limited).	Harvesting next to alluvial reaches. Terrain stability upper valley slopes.
McCurdy	2	Mainstem scoured from Nov 2006 landslides.	CWAP 1998, update 2001. Semi-permanent & permanent road deactivation.	Drains southward into Muchalat Inlet. Asymmettric watershed with extensive steep slopes; main valley trends north-south, west tributary basin & 2 headwater basins. The headwater basins have curved alignments around an almost circular knoll in the upper watershed. Main valley has confined to entrenched nonalluvial & semi-alluvial mainstem & steep valley slopes well connected to channel; several natural slides, 6 slides from preCode roads, 2 slides from preCode blocks. Robust channel, stable position; however, full length of mainstem scoured from landslides in Nov 2006 storms. West tributary: drains to mid part of main valley; lower part of basin has steep-sided V-shaped valley with entrenched nonalluvial stream; rest of basin has narrow U-shaped valley withsteep upper slopes; confined to entrenched semi-alluvial & nonalluvial channel; small lake (9 ha) at top of mainstem, short alluvial reach at lake outlet; steep nonalluvial tributary creeks. A few natural landslides including 2 in Nov 2006 storm; 1 slide from preCode road, 3 slides from preCode blocks, 2 from recent postCode blocks (Nov 2006 storm). Hillslopes well connected to channel except in vicinity of lake. West headwater basin: steep-sided V-shaped valley with an entrenched nonalluvial stream at the lower end; hillslopes here are well connected to the channel. Upstream, the valley broadens to a U-shape; the mid & upper valley has alluvial & semi-alluvial reaches; moderate lower slopes provide some runout zones. There are several natural slides in the upper valley walls; 3 slides have occurred from preCode roads, 2 from preCode blocks, 3 from postCode blocks (Nov 2006 storm). East headwater basin: steep-sided V-shaped valley with an entrenched nonalluvial stream at the lower end; hillslopes here are well connected to the channel. Upstream, the valley broadens to a U-shape; the mid part of the basin has a broad valley floor with extensive alluvial reaches. At the bend in the valley alignment there is a fan where a tributary gully opens onto the valley floor. In the mid & upper valley, the valley floor & moderate lower slopes provide some runout zones. There are several natural landslides in the upper valley walls; 11 slides from preCode roads, 9 slides from preCode blocks. Four of the slides (road & cutblock) occurred in the Nov 2006 storm.	Alluvial reaches in headwater basins. Fan in east headwater basin.	Terrain stability; landslides in postCode blocks. Stability of preCode roads. Harvesting next to alluvial reaches in headwater basins. Road maintenance on fan (east headwater basin).
Nesook (except Tlupana)	3	Generally stable; a few short alluvial reaches that are overwidened.	CWAP 1997, updates 2000 & 2006. Semi-permanent & permanent road deactivation.	Nesook River drains westward into Nesook Bay of Tlupana Inlet; estuary at outlet; deep glaciofluvial deposits with large gravel pit just above estuary. At 3 km from the estuary, a small tributary basin drains into the south side of Nesook River channel. From this tributary downstream, terrain is irregular & moderate to steep; the mainstem is entrenched, stable mainly semi-alluvial; the tributary drainage has a confined to entrenched nonalluvial channel & nonalluvial tributary creeks. From this tributary confluence to 7 km above the estuary, the watershed has a steep-sided V-shaped valley form trending east-west; channel is mainly semi-alluvial with short alluvial & nonalluvial reaches; the alluvial reach has experienced widening & aggradation from preCode riparian logging. Below this point hillslopes are generally well connected to the mainstem; there are several natural slides in the upper valley walls, 7 slides from preCode roads, 5 slides in preCode blocks.	Alluvial reaches in vicinity of confluence of upper basins; & in N. tributary. Estuary.	Harvesting adjacent to alluvial streams. Stability of preCode roads on steep terrain. Terrain stability.

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Nesook (except Tlupana) cont'd				From 7 km to 8 km the valley floor widens & the mainstem is alluvial; a few short sections have experienced local widening from preCode riparian logging. At 8 km the upper watershed branches into two tributary basins. North tributary: Irregular drainage shape & valley form with varying valley alignment. Lower part of basin has an entrenched nonalluvial & semi-alluvial channel with steep adjacent valley slopes; channel becomes alluvial just above confluence with S. tributary. Valley broadens in mid-basin; channel is alluvial & semi-alluvial; there are 2 small fans where gullies open onto the valley floor. There are 3 upland lakes in this basin; the largest is Frisco Lake (29 ha). The lower alluvial reach just above the confluence with the south tributary has experienced minor widening from preCode riparian logging. Elsewhere, streams in this basin are in good condition. Few natural slides; 3 from preCode blocks, 1 from postCode block (Nov 2006 storm). South tributary: Has 2 sub-basins. West basin has steep-sided V-shaped valley with confined to entrenched nonalluvial mainstem; steep-gradient nonalluvial tributary creeks. Few old natural landslides in upper valley walls; one slide in recent postCode block. East basin is a string of upland lakes in hanging valleys; the largest is 12 ha. Streams between lakes semi-alluvial & nonalluvial; stream below lowest lake is steep-gradient entrenched nonalluvial. High-energy, robust confined streams; slopes well connected to channel.		
Tlupana (Nesook)	1	Improving; some sections of alluvial mainstem still overwidened. Alluvial reach in upper basin is widened & aggraded.	CWAP 1997, update 2001. Semi-permanent & permanent road deactivation.	Major tributary basin of Nesook watershed but almost a separate watershed; joins Nesook at 1.4 km above estuary. Bottom 4 km above Nesook confluence: broad valley floor with alluvial mainstem, multiple channels & several fans; sections of mainstem overwidened & aggraded from preCode riparian logging; adjacent valley slopes steep with entrenched nonalluvial tribuary creeks; several fans where gullies open onto valley floor; 2 slides from preCode roads on steep slopes south side; natural landslides in steep tributary entering at top end of this section. From 1.4 - 8 km, valley floor narrows; mainstem is mainly confined to entrenched semi-alluvial & nonalluvial with one short alluvial reach at a local widening in the valley floor; alluvial reach is overwidened & aggraded from preCode riparian logging & from development-related slides in a tributary entering just upstream of alluvial reach. At 8 km the upper basin branches into 2 tributary sub-basins. North sub-basin: Valley alignment trends NWS from confluence, curving eastward in upper sub-basin. No lakes. Lower valley is V-shaped with a confined to entrenched nonalluvial mainstem, steep valley slopes generally well connected to mainstem; a few natural landslides; 2 from preCode roads, 1 from edge of postCode block. Debris flows occurred in a few natural slide tracks in Nov 2006 storm; fresh sediment in channel. Upper valley broadens to U-shape; semi-alluvial & alluvial stream, moderate to steep slopes; moderate lower slopes & valley floor provide some runout zones. South sub-basin: Valley alignment trends southeastward from confluence, curving northeast in upper sub-basin. Major mainline (Head Bay Forest Road) & powerline along valley floor & adjacent to alluvial reach in upper sub-basin. Several small headwater lakes at top end of sub-basin; the largest is 6 ha. Lower valley has irregular moderate lower slopes, steep upper slopes; confined to entrenched nonalluvial stream with an alluvial reach at a local widening. Upper valley broadens to U-shape; low pass at drainage divide into Upana; moderate lower slopes, steep upper slopes; natural landslides including some that are chronically active; 1 slide from preCode road, several slides from cutblocks including postCode block. Several new slides (natural & cutblock) in upper valley during Nov 2006 storm. Stream has alluvial reach in powerline ROW that is widened & aggraded, mainly from loss of riparian forest & sediment from natural slide events; fresh sediment in alluvial reach from 2006 events.	Alluvial reaches especially lower mainstem; floodplain; fans. Alluvial reaches.	Harvesting in floodplain & along alluvial reaches. Harvesting or road building on fans. Terrain stability. Inadequate riparian forest along alluvial reach under powerline. Head Bay FSR adjacent to alluvial channel.

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Silverado	3	Consistent with natural; channel aggraded from natural landslides.	Permanent deactivation of one spur.	Drains northwestward into King's Passage of Muchalat Inlet; estuary at outlet. Development virtually all postCode. Elongate watershed trending generally SE-NW; slightly curved. U-shaped valley; single dominant mainstem with short steep nonalluvial tributary creeks; one tributary basin joins mainstem at 1.8 km from estuary. No lakes. Main valley has narrow valley floor with narrow zone of moderate lower slopes (providing limited runout); steep upper slopes. Natural landslides in mid & upper slopes, some recent (Nov 2006); 1 slide in postCode block (Nov 2006). Mainstem mainly confined semi-alluvial with several alluvial reaches; channel appears aggraded mainly from natural landslides; section of alluvial reach in upper basin where leave trees mostly windthrown, channel susceptible to bank erosion (nonfish reach). Tributary basin is almost all steep terrain with deeply incised nonalluvial streams, numerous avalanche paths & active natural slides in upper valley slopes; ongoing sediment supply from these sources. Fan where basin joins main valley; road crossing near apex (favourable). Harvesting to date limited to block at confluence with main valley; buffer along channel on fan.	Alluvial reaches, fans, estuary.	Harvesting adjacent to alluvial reaches. Harvesting or road building on fans (well managed to date) . Terrain stability.
Sucwoa	2	Improving; significant lengths of mainstem & channel on fan at upper drainage divide still overwidened & aggraded.	CWAP 1997. Sucwoa river watershed deactivation assessment 2002. Semi-permanent & permanent road deactivation.	NW-SE trending watershed draining into Head Bay of Tlupana Inlet; estuary at outlet. U-shaped valley with broad floodplain in lower watershed, narrowing in upper watershed; most of mainstem is partially confined to unconfined alluvial; Malaspina Lake (9 ha) at top of mainstem. Several fans along lower valley slopes; low drainage divide to Perry watershed on fan; at times south tributary of Perry may have flowed into Sucwoa. Most roads on fans have been permanently deactivated. East side of valley has steep slopes with steep nonalluvial tributary creeks; natural slides & avalanche paths in the upper valley walls; 3 slides from preCode roads, 7 slides from preCode blocks; confined nonalluvial tributary creeks; several upland lakes & ponds, the largest is 17 ha. West side of valley has irregular moderate to steep slopes with several steep teardrop-shaped tributary basins with mainly nonalluvial streams; areas of natural landslides & avalanche tracks in upper valley walls; 9 slides from preCode roads, 8 slides in preCode blocks & 1 slide in postCode block (Nov 2006). Valley floor & irregular terrain on mid & lower slopes provide runout slopes along much of mainstem. Significant lengths of alluvial mainstem still overwidened & aggraded from preCode riparian logging. Extensive alder in floodplain. Channel on fan at upper drainage divide is widened & aggraded from preCode logging on fan.	Floodplain, alluvial reaches, fans, estuary.	Harvesting on floodplain & adjacent to alluvial reaches. Stability of preCode roads. Terrain stability.
McKelvie (Tahsis)	3 CWS	Consistent with natural; sediment & wood in channel from natural slides.	Community watershed. Power project under construction.	Enters Tahsis River 1.4 km above Tahsis Inlet; small fan at outlet; Tahsis Village partly on fan. No forest development to date in this drainage. Elongate basin with single dominant mainstem, no lakes; extensive steep terrain; upper basin extends into alpine with numerous natural landslides & avalanche tracks. High energy, high transport stream. Lower valley is V shaped with confined to entrenched nonalluvial & semi-alluvial stream; mainly nonalluvial tributary creeks. Mid valley broadens, channel is semi-alluvial & alluvial in narrow valley floor. Upper valley branches into 2 headwater basins; steep terrain extending into alpine, entrenched nonalluvial streams. Hillslopes generally well connected to stream; valley floor & sections of moderate slopes in mid-valley provides some runout slopes. Fresh sediment & wood debris in channel from active natural events (Nov 2006).	Water intake. Fan (most of fan is outside WFP tenure). Alluvial reaches in mid basin (limited).	Harvesting adjacent to alluvial channels. Terrain stability. Water quality at intake.

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Tahsis (except McKelvie)	1	Much of mainstem still unstable.	Semi-permanent & permanent road deactivation of a few spurs.	Drains southward into N. end of Tahsis Inlet; Tahsis Village at outlet of watershed. N-S trending valley with broad valley floor; unconfined to partially confined alluvial channel in wide floodplain that extends 8.7 km upstream from ocean. Lower 1.4 km of floodplain occupied by Village of Tahsis & industrial sites; channel position constrained by development, by McKelvie fan & by slightly higher terrace on west side of channel. Extensive steep terrain above valley floor with numerous natural landslides & a few upland ponds in upper valley walls. Upper watershed has 2 headwater basins extending into alpine with numerous avalanche tracks & natural landslides; several small headwater lakes, the largest is 13 ha. The Tahsis floodplain was logged in the 1930's & early 1940's, & has reforested almost entirely to alder. The channel destabilized & widened following logging, & most of the mainstem is still unstable. The channel is aggraded, with ongoing sediment supply from natural landslides, especially in the east headwater basin. At present there are few active roads in this drainage.	Floodplain & alluvial streams. Fans. Village of Tahsis & industrial sites.	Harvesting on floodplain & adjacent to alluvial channels. Harvesting & road building on fans. Terrain stability.
Tsowwin	1	Aggraded alluvial reaches of mainstem & tributaries, & scoured nonalluvial streams from Nov 1996 landslides.	CWAP 1995, updates 1998 & 2000. Permanent road deactivation.	Flows westward into Tsowwin Narrows of Tahsis Inlet; fan delta & small estuary at outlet. Ovoid watershed shape, dendritic drainage pattern, variable valley alignment; no lakes. The bottom 3.5 km of the watershed has a narrow valley floor with variable floodplain width & partially confined alluvial channel, moderate lower slopes & steep upper slopes. The lower part of the valley floor was harvested in the 1940's; regen on the valley floor has extensive alder & the channel postition appears stable; however the alluvial reaches are aggraded from development-related landslides as well as natural slides. Above 3.5 km the valley floor narrows, channel is mainly semi-alluvial & nonalluvial with one short alluvial reach. Upper slopes throughout watershed are steep, with areas of natural slides in upper valley walls; 15 slides from preCode roads; 20 slides in preCode blocks, 7 slides in postCode blocks; of these, 6 slides were reported in Nov 1996 storm, & several natural slide tracks torrented. Moderate lower slopes & valley floors provide some runout zones. Aggraded channels from both natural & development-related landslides. Tributary basin on the south side of the watershed (T20 Road) drains into Tsowwin Creek at 2.7 km above the estuary. Lower mainstem is alluvial; has widened & aggraded from preCode riparian logging & from landslides (mostly development related); slides from preCode roads & from pre & postCode blocks in this basin.	Alluvial reaches, lower floodplain, fan delta, estuary, fan in mid watershed.	Terrain stability, slides in postCode blocks; stability of preCode roads. Harvesting on floodplain & adjacent to alluvial streams. Harvesting & road building on fan & fan delta.
Wilson	3	Channel scoured from Nov 2006 landslide.	Permanent road deactivation.	Drains NE into Muchalat Inlet; small fan & estuary at outlet; log sort just to east of estuary. Road crosses fan near apex (favourable). WFP has west side of watershed; tenure divides down Wilson Creek channel. Asymmetric drainage; lower watershed has V-shaped steep-sided valley with confined to entrenched nonalluvial & semi-alluvial stream; valley slopes rise to narrow rounded ridgetops; some upland areas of moderate slopes; a few upland ponds in the upper valley slopes. No natural landslides; 6 slides from preCode roads & 4 slides in preCode blocks in WFP's tenure. Several slides in blocks in BCTS tenure including a large slide in Nov 2006; full length of mainstem scoured from this event.	Fan, estuary.	Terrain stability.
Maraude (Zeballos)	2	Improving; channel on fan still slightly overwidened.	Semi-permanent road deactivation of a few spurs.	Tributary to Nomash R.; enters Nomash 0.7 km above confluence with Zeballos R. Fan at outlet of Maraude Creek on Nomash valley floor. Ovoid drainage with Zeballos L. (199 ha) in centre of basin. Development to date limited to area below lake; no development-related landslides. Extensive steep slopes; valley slopes N & S sides of lake rise to alpine with numerous natural landslides & several avalanche tracks; lake traps sediment from transporting downstream. Small fans at lakeshore. Headwater basin above lake has several small upland headwater lakes; main valley & south tributary have narrow U-shaped valley form with several alluvial reaches (nonfish). Stream on fan destabilized by logging fan surface in 1950's; channel stability improving but still slightly overwidened (2004 sat). N-1 mainline crosses at fan apex (favourable).	Fan. Alluvial reaches (mainly nonfish).	Future harvesting or road construction on fan. Terrain stability.

Watershed	Fish Rank	Trend	Assessments & Watershed Initiatives	Watershed Factors	Sensitive Areas	Key Management Concerns
Nomash (Zeballos)	2	Improving, alluvial reaches still slightly widened; large natural sediment supply.	Semi-permanent & permanent road deactivation.	Drains NW into Zeballos R. at 9.5 km above estuary. U-shaped valley form with steep slopes rising to alpine on NE side; small upland lake (3 ha) near drainage divide on SW side; no other lakes. Semi-alluvial & alluvial mainstem on narrow valley floor; limited channel migration zone; becomes unconfined alluvial in main Zeballos valley just above confluence. Several small fans . Numerous natural landslides including a very large rock slide at SE end of basin; several avalanche tracks in upper slopes NE side; 5 slides from preCode roads, 1 slide from postCode road during construction, 8 slides from preCode blocks, 1 slide from postCode block. Large ongoing sediment supply to channel from natural slides especially large rockslide at head of valley. Alluvial reaches of mainstem widened from preCode logging, now improving; aggraded mainly from natural landslides.	Alluvial reaches (limited), fans.	Terrain stability. Harvesting adjacent to alluvial reaches. Road maintenance on fans.
Upper Zeballos	2	Improving, alluvial reaches still slightly widened; ongoing natural sediment supply.	Semi-permanent & permanent road deactivation.	Unit comprises upper Zeballos watershed above Nomash confluence. Long narrow main valley with narrow valley floor & steep adjacent valley slopes, low drainage divide at N. end; extends into alpine on east side. Lower channel is mainly entrenched nonalluvial; rest of mainstem is confined semi-alluvial & partially confined alluvial in narrow valley floor with limited channel migration zones; hillslopes well connected to channel. Several fans along valley, Zeballos Main crosses these. Mainly steep entrenched nonalluvial tributary creeks. Numerous natural landslides, 5 slides from preCode roads, 10 slides in preCode blocks. Headwater basin has upland areas of moderate terrain, several alluvial reaches (nonfish) & small fans; a small upland headwater lake (6 ha) & small ponds.	Alluvial reaches. Fans.	Terrain stability. Harvesting adjacent to alluvial reaches. Road maintenance on fans & rockslides above roads. Stability of Zeballos Main FSR along lower channel.
Zeballos Remainder	1	Improving; sections of alluvial reaches still appear overwidened.	Semi-permanent & permanent road deactivation.	Drains southward into N. end of Zeballos Inlet; estuary at outlet; village of Zeballos at outlet. Unit comprises Zeballos watershed below confluence with Nomash & upper Zeballos basins. Generally broad valley floor with steep adjacent valley slopes; mainly partially confined alluvial channel in floodplain of varying width; a few nonalluvial & semi-alluvial reaches where valley floor narrows. Several fans along valley floor; mainlines cross these fans. Fans & valley floor provide some runout slopes. Tributary creeks mainly steep gradient nonalluvial in gullies & V-shaped valleys; the upper Gold Creek drainage has a U-shaped valley form with an alluvial reach (nonfish). Numerous natural slides in gully sides & upper valley walls; 12 slides from preCode roads, 7 slides from preCode blocks; 2 slides from postCode blocks. Valley floor logged in 1940's & 1950's; alluvial reaches widened & aggraded from preCode riparian logging; improving, some sections still appear overwidened.	Alluvial reaches. Floodplains. Fans. Estuary. Village of Zeballos.	Harvesting on floodplain & adjacent to alluvial reaches. Road maintenance on fans. Terrain stability.

Table A5

TFL 19 -- Total (includes former Canfor TL's in Oktwanch)

Total project area (TFL 19 + TLs in Oktwanch), ha	176,081
km^2	1,761
Harvest history - to 2006	
Total harvested area, ha	46,147
Area harvested before June 1995, ha	32,922
Area harvested June 1995 and later, ha	13,225
Total steep terrain (Class 4&5 + >60%)	89,882
% ot total area	51%
Steep terrain logged before June 1995, ha	8,720
Steep terrain logged June 1995 and later, ha	5,138
Roads - to 2006	
Total road length, km	2,447
Total length M, MH, H stability hazard, km	425
Length M, MH, H hazard not perm. deactivated	302
Roads on steep terrain built before 1995, km	274
Roads on steep terrain built 1995 and later, km	185
Landslides - to Sep 2007	
Slides originating at roads:	
No. of slides at roads built before 1995	287
No. of slides/km of road on steep terrain <1995	1.0
No. of slides at roads built 1995 or later	3
No. of slides/km of road on steep terrain >=1995	0.02
Slides originating in harvested cutblocks:	
No. of slides in pre-1995 cutblocks	339
No. of slides per 100 ha logged in steep terrain, logged before 1995	3.9
No. of slides in 1995 and later cutblocks	54
No. of slides per 100 ha logged in steep terrain, logged 1995 and later	1.1
Slides from cutblocks logged >= 1995, no./km^2:	0.03
Slides originating in unharvested timber:	
Fully forested old naturals	442
No. of slides occurring pre1995, visible in forest cover.	694
No. of slides occurring 1995 and later *-- not all reported*	27
Streams	
Total length of mapped streams, km	4,611
Length alluvial channels, km	396
% of total stream length	9%
Length semi-alluvial channels, km	278
% of total stream length	6%
Length nonalluvial channels, km	3,930
% of total stream length	85%
Length channels in wetland, km	5
% of total stream length	0%
Riparian condition (alluvial & semi-alluvial only)	
Length assessed, km	686
Length CBE, km	10
Length CBE+LWD, km	80
Length LWD, km	252

APPENDIX B

Definitions

Table B1
Definitions -- Road Stability Hazard

Road Stability Hazard		Criteria
High	H	Road on steep slope AND landslides have occurred from or adjacent to road. OR site information is available from other reports or personal knowledge.
Moderately high	MH	Road on steep slope, no slides evident, road built before 1995.
Moderate	M	Road on steep slope, no slides evident, road built after 1995. Also includes roads built before 1995 judged to have a moderate hazard of instability from airphoto review by G. Horel.

1. Road stability hazard is estimated from terrain stability mapping, slope mapping (>60%) and airphoto interpretation.
2. Only road sections with moderate or higher hazard are assigned a hazard level. Roads not assigned a hazard level are considered low or low-moderate stability hazard.
3. The road hazard level does not take into account hazard reduction from deactivation or remedial measures, as this cannot be determined from inventory-level information. The post-deactivation hazard is intended to be recorded in a separate field as resideual hazard, which would be determined from on-site inspections.

Table B2
Definitions -- Sediment Delivery Potential from Landslides

Sediment Delivery Potential		Definitions and Criteria
High	H	*Definition*: Slide from road or cutblock would directly enter fish habitat or impact other resource at time of event.
		Criteria: Slopes below road or cutblock >25% without a significant break (min.50 m) to fish habitat or other resource.
Moderately high	MH	*Definition:* Some slide debris[1] may enter fish habitat or impact other resource at time of event. There is a high potential to transport to fish habitat within first seasonal peak flows.
		Criteria: *Stream transport:* Slide from road or cutblock would enter nonfish stream[2] within 0.5 km of fish habitat or other resource. *Runout slope:* Slopes below road or cutblock <25% for 50-75 m to fish habitat or other resource.
Moderate	M	*Definition:* Most slide debris[1] at time of event would deposit at breaks in gradient or slope breaks; fine sediment may reach fish habitat or other resource. Coarse sediment from slide would transport to fish habitat or other resource over time via normal fluvial processes.
		Criteria: *Stream transport*: Slide from road or cutblock would enter nonfish stream[2] 0.5 to 3 km upstream from fish habitat. *Runout slope*: There is a runout slope <25% for 75-150 m below road or cutblock to fish habitat or other resource.
Low-moderate	LM	*Definition:* Some suspended sediment or small wood debris may reach fish habitat or other resource. Coarse sediment would typically be stored in low gradient reaches, on fans, or on gentle slope areas.
		Criteria: *Stream transport*: Slide from road or cutblock would enter nonfish stream[2] more than 3 km upstream from fish habitat. *Runout slope*: There is a runout slope <25% for 150-250 m below road or cutblock to fish habitat or other resource.
Low	L	*Definition*: Slide material[1] is unlikely to reach fish or nonfish stream[2] or other resource at time of event, or to transport to stream or other resource.
		Criteria: There is a runout slope <25% for >250 m below road or cutblock.

1. "Slide debris" means coarse sediment (gravel sizes and larger) and coarse wood debris.
2. Fish streams are taken to be S2, S2, S3 and S4 streams in WFP's GIS streams coverage. "Nonfish streams" are all other streams.
3. Since the deposition zone would not exceed the total slide length, roads close to the valley floor may be assigned a shorter runout slope than the above criteria.
4. Runout slopes are determined from digital TRIM 20 m contours.

Table B3

Stream Channel Types

Channel Type	Description
Alluvial	Channel has at least one unconfined erodible bank in alluvial deposits, and a definable channel migration zone. Alluvial deposits are material that was deposited by the stream under the contemporary flow regime. Large alluvial streams may have fluvial terraces that are rarely inundated; or may have glaciofluvial terraces that are no longer inundated. Streams confined by glaciofluvial terraces usually have stable positions and are not susceptible to channel migration. When channel types are identified by airphoto interpretation, streams with glaciofluvial terraces are identified as alluvial channels if the deposits cannot be distinguished with certainty. These larger alluvial streams with rarely inundated or dry terraces typically have stable channel positions. LWD may be sparse or absent; or have minimal influence on channel structure.
	Where streamflow is against the rooting zone in alluvial stream banks, riparian vegetation is critical to limit bank erosion. In severe flood events or if the riparian zone is logged, the stream may erode its bank(s) and widen its channel. If there is a significant channel migration zone the stream position may change within this zone, triggered by disturbance or a large flood event. Abandoned channels or flood channels may be present. LWD is critical to structure of small channels; and important in large channels, forming jams, pools and flow diversions. These alluvial channels are often sensitive to disturbance such as logging of riparian forest, increased sediment, removal of LWD from the channel, or loss of LWD supply.
	Alluvial channels are often reaches of highly productive fish habitat. Channel is typically riffle-pool or cascade-pool. Gradient typically <5% (except streams on fans).
Semi-alluvial	Channel has confining banks and stable position. There is no channel migration zone. Semi-alluvial reaches may be deposition zones from sources upstream or may have banks in moderately erodible material such as glaciofluvial deposits. LWD varies from important in small channels to absent or nonfunctional in large channels. Quality of habitat may be affected by aggradation or scour, removal of LWD, or loss of LWD supply. Riffle-pool channel bed. Gradient typically <5%.
Nonalluvial	Channel is typically confined to entrenched with a stable position. Some nonalluvial channels flowing over rock or bolders have limited lateral confinement. Banks are resistant to erosion (i.e. till, colluvium, rock). Nonalluvial channels are less sensitive to disturbance than alluvial or semi-alluvial channels. Small streams, as gradient increases, transition from fluvial to gully processes. Channels in nonrock material may experience bed or bank scour in extreme storm events or debris torrents. Nonalluvial channels are typically transport zones. LWD is typically nonfunctional in high energy streams but in small streams where gully processes occur may help to trap sediment, limit scour, and control sediment transport. Channel bed is typically cascade-pool, step-pool or rock-dominated.
Wetland	Stream flows through or disappears into wetland.

Notes:

1. Stream channel types are identified from airphoto interpretation, TRIM topography and existing information such as watershed assessments.
2. Where channels cannot be clearly seen on airphotos because of small size or canopy closure, channel type is inferred from stream gradient and the surrounding landforms. For these streams, channel type is assigned conservatively. That is, where contours indicate a gradient of less than 5% in terrain that could contain an alluvial stream, the stream is mapped as alluvial. Where stream gradients are 5-10% they are mapped as semi-alluvial.

Table B4

Riparian Condition

The following attributes are captured in an overview-level riparian assessment. Assessment uses airphotos and/or satellite imagery, and forest cover data. Attributes are assigned for right and left banks separately.

Riparian Vegetation *-From forest cover data and airphotos. Visually estimated.*

Type	Description
C	Riparian vegetation is >= 70% conifers.
D	Riparian vegetation is >=70% deciduous.
M	Riparian vegetation is mixed conifer and deciduous.
min	Minimal to no riparian vegetation, eg., between channel and road.

Fringe -- Y	Fringe of mature trees <30 m wide with cutblock or regen behind fringe. If line of trees is less than 50% intact, no fringe is recorded.

Forest Age Class	
0	No riparian forest. (Clearing, right of way, development, road fill).
1	<10 years
2	10-19 years
3	20-39 years
4	40-59 years
5	60-100 years
6	>100 years. Includes old growth and second growth stands of this age range. Includes natural nonforest such as wetland vegetation, alpine, rock, etc.

Riparian Function *- This is assigned only for alluvial and semi-alluvial channels.*

Type	Condition
Natural (n)	Riparian vegetation is in its natural state, typically old growth.
Adequate (a)	Riparian vegetation has been modified but is adequate to supply LWD and provide bank erosion resistance.
LWD	Riparian vegetation inadequate to supply functioning large wood debris. Note: this does not mean the stream is deficient in LWD, only that this section of bank would be inadequate to supply it.
CBE	Riparian vegetation inadequate to provide natural level of erosion resistance on channel banks.

Confidence *- Refers to confidence in identifying channel type.*

H - high	Stream channel and valley form is clearly apparent on airphotos.
M - moderate	Channel partly or fully obscured by canopy; valley form may not be fully apparent.
L - low	Channel not visible because of size or canopy closure; valley form is inferred.

Notes:

1. Riparian assessment based on airphoto interpretation, forest cover and existing information such as watershed assessments.
2. Riparian attributes are assigned for alluvial and semi-alluvial streams that are not S6's.
3. Right and left banks are taken as facing downstream.
4. In determining riparian function, it is assumed that mixed or coniferous forests of Age Class 4 or older have trees of adequate size to supply LWD to small streams (S4, S3, lower range of S5's and S2's).
5. For large streams (S1's, larger S2's and S5's), it is assumed that mixed or coniferous forests of Age Class 5 or older have trees of adequate size to supply LWD.
6. This does not mean that there is adequate LWD within the channel, as this cannot be determined in an overview-level assessment.
7. Stands that are primarily deciduous are not considered adequate to provide functioning LWD.

D. R. Clough Consulting
Fisheries Resource Consultants
6966 Leland Road, Lantzville B.C. V0R 2H0, Phone/Fax 1-250-390- 2901 email: drclough@island.net

RE: TFL 19 Fish Ranking References January 2008-01-29

Below are fish habitat and presence references with respect to the TFL 19 – Fish Habitat Ranking Report. They are presented in alphabetic order as laid out in aforementioned report.

Reference Number: 100
Field Observations by D.R. Clough,-2007
These areas may not have been inspected but observations and adjacent inventories have resulted in these conclusions.

Reference Number: 200
Mapster – Internet Database of DFO and MOE that identifies stream locations, elevations and references.

Reference Number : 1

Title :	PRELIMINARY CATALOGUE OF SALMON STREAMS AND SPAWNING ESCAPEMENTS OF STATISTICAL AREA 25 (THASIS). 1979. FISHERIES AND MARINE SERVICE DATA REPORT 143.
Description :	AF; migration; obstructions; spawning; temperature
Location :	DFO - REGIONAL LIBRARY - VANCOUVER
Reference code :	Government Report
Year :	1979
Author :	BROWN, R.F.

Reference Number: 2
D. R. Clough Consulting
Fisheries Resource Consultants
6966 Leland Road, Lantzville B.C. V0R 2H0,Feb. 19, 1997

Attn: Kevin Somerville
Area Supervisor, Harvesting
Pacific Forest Products, Gold River Operations
Box 220, Gold River B.C. V0P 1G0

RE: Nesook Bay Streams.

Reference Number : 3
July 27, 2005

Attn: Jeff Pawelchak, Assistant Engineer
Nootka Contract Administration
Western Forest Products,
Box 220, Gold River B.C. V0P 1G0

Re: Aston Creek Headwater Fisheries Inventory and Stream Classification

Reference Number: 4
October 4, 2004

Attn: Bruce Creelman
Nootka Contract Administration
Western Forest Products,
Box 220, Gold River B.C. V0P 1G0

RE: Nootka, Indian River, Fisheries Inventory and Stream Classification.

Reference Number: 5
Sep. 21, 1998

Attn: Kevin Somerville
Area Supervisor, Harvesting
Western Forest Products, Gold River Operations
Box 220, Gold River B.C. V0P 1G0

RE: Bolton Lake Block J116

Reference Number: 19
Friday, July 12, 1996

Attn: Mark Graf
Pacific Forest Products Ltd.,
Gold River Operations,
Box 220 Gold River, B.C.
VOP 1GO

Stream Classification within the vicinity of Blocks P35, P74 and P73, Muchalat Lake

Reference Number: 6
October 3, 2004

Attn.: Doug Meske, Resident Engineer
Western Forest Products
Gold River Forest Operation
Box 220, Gold River, BC, V0P 1G0

RE: Cougar Creek and Block H59, Lake and Stream Classification.

Reference Number: 7
October 4, 2004

Attn: Doug Meske, Resident Engineer
Western Forest Products,
Gold River Forest Operation
Box 220, Gold River B.C. V0P 1G0

RE: Block E100 Hanging Creek, Fisheries Inventory and Stream Classification.

Reference Number: 8
July 21, 2000
Attn: Doug Meske
Western Forest Products, Contract Operations
Box 220, Gold River B.C. V0P 1G0
RE: Block S-36 Hisnit Inlet; Fisheries Inventory, July 2000.

Reference Number: 9
July 8, 1996

Attn: Kevin Sommerville
Pacific Forest Products Ltd.,
Gold River Operations,
Box 220 Gold River, B.C. VOP 1GO

Stream Classification of Blocks H39 and H44.Galiano

Reference Number: 10
October 16, 2006

Attn: Jack Reynolds, Logging Engineer
Nootka Contract Administration
Western Forest Products
Gold River B.C. V0P 1G0
RE: Block V50 – Green Creek Fisheries Assessment

Reference Number: 11

August 24, 1998

Attn: Kevin Somerville
Area Supervisor, Harvesting
Western Forest Products, Gold River Operations
Box 220, Gold River B.C. V0P 1G0

RE: Block H47 Streams, Hanna Creek; Fisheries Inventory

Reference Number: 12
July 27, 2007

Attn: Doug Meske, Resident Engineer
Gold River Forest Operations
Western Forest Products,
Box 220, Gold River B.C. V0P 1G0

Re: Saunders Creek, Block M40, Fisheries inventory and stream classification

Reference Number: 13
August 15, 2005

Attn: Jeff Pawelchak, Assistant Engineer
Nootka Contract Administration
Western Forest Products,
Box 220, Gold River B.C. V0P 1G0

Re: Hoiss Creek Block T34, T34A, and T36 Fisheries Assessments.

Reference Number: 14
November 28, 2002

Attn: Bruce Creelman
Western Forest Products,
Nootka Contract Administration
Box 220, Gold River B.C. V0P 1G0
RE: Hisnit Mainline Road Crossings Inspection

Reference Number: 15

Wednesday, November 18, 1996

Attn: Mark Graf
Pacific Forest Products Ltd.,
Gold River Operations,
Box 220 Gold River, B.C.
VOP 1GO

Fisheries Reconnaissance and Stream Classification Within the Kleeptee Watershed

Reference Number: 16

Aug. 28, 2007

Attn: Brian Sommerfeld, Operations Engineer
Gold River Forest Operations
Western Forest Products Limited
Box 220, Gold River B.C. V0P 1G0

RE: Leagh Creek, Block Q 56 Fisheries Assessment

Reference Number: 17
Aug. 28, 2007

Attn: Steve Smith, Forestry Engineer
Nootka Contract Administration
Western Forest Products,
Box 220, Gold River B.C. V0P 1G0

Re: Mamaht Creek, Block Z75 Heli Drop Zone Stream Classification.

Reference Number: 18
November 28, 2002

Attn: Bruce Creelman
Western Forest Products,
Nootka Contract Administration
Box 220, Gold River B.C. V0P 1G0

RE: McCurdy Creek Fisheries Classification Reconnaissance

Reference Number: 19
Attn.: Clayton Smith, RPF
Operations Engineer,
Western Forest Products,
Gold River Forest Operation
Box 220, Gold River BC V0P 1G0

Jan 30, 2002

RE: Muchalat River Block P-114, Fisheries Inventory and Stream Classification.

Reference Number: 20
Aug. 28, 1997
Attn: Kevin Somerville
Pacific Forest Products
Gold River Operations
Box 220, Gold River B. C. V0P 1G0

TFL 19: Tlupana J93 & J84 Fisheries Inventory

Reference Number: 21
May 30, 2001
Attn: Clayton Smith
Western Forest Products
Box 220, Gold River B.C. V0P 1G0

RE: Nesook Lakes; Fisheries Inventory, May 2001.

Reference Number: 22
July 11, 2005

Attn: Jack Reynolds, Field Engineer
Nootka Contract Administration
Western Forest Products,
Box 220, Gold River B.C. V0P 1G0

Re: Tsowwin River, Block U85, Fisheries inventory and stream classification

Reference Number: 23
November 30, 2005

Attn: Mike Wise, Assistant Engineer
Gold River Forest Operations
Western Forest Products Limited
Box 220, Gold River B.C. V0P 1G0

RE: Pamela Creek Ucona River Area, Block E85 Fisheries Assessment.

Reference Number: 24
D. R. Clough Consulting
Fisheries Resource Consultants
6966 Leland Road, Lantzville B.C. V0R 2H0, Phone/Fax 390 2901 email: drclough@island.net

October 27, 2005

Attn: Mike Wise, Assistant Engineer
Gold River Forest Operations
Western Forest Products Limited
Box 220, Gold River B.C. V0P 1G0

RE: Quatchka Creek Area, Block E104 Fisheries Assessment.