COASTAL WATERSHED ASSESSMENT (CWAP)
of
CAMERON WATERSHED
for
MACMILLAN BLOEDEL LIMITED
WEST ISLAND WOODLANDS DIVISION
Franklin Operation

February 25, 1998

by
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CAMERON WATERSHED ASSESSMENT

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1.0 INTRODUCTION

This assessment encompasses the Cameron River basin upstream of Cameron Lake, slopes draining directly into Cameron Lake, and McBey and Lockwood Creek basins which drain into the Little Qualicum River immediately downstream of Cameron Lake. This total area is referred to in this report as the "Cameron Watershed" and comprises the headwater area of the Little Qualicum River watershed, which drains into the Strait of Georgia at Qualicum Beach north of Parksville.

The Little Qualicum River watershed is a designated Community Watershed. The Water Purveyor is the Little Qualicum Waterworks District. There are other water licences within the watershed as well, including Canada Department of Fisheries and Oceans (DFO) on Cameron Lake. The portion of the Community Watershed downstream of this study area is entirely outside TFL 44, and is being assessed separately by the BC Ministry of Environment, Lands and Parks (MOELP).

The Little Qualicum Watershed has a total area of 237 km^2. The Cameron Watershed area is 158 km^2, or 67% of the Little Qualicum drainage area.

Canada Department of Fisheries and Oceans (DFO) operates a hatchery on the Little Qualicum River downstream under a water license which provides for low flow storage. Water quality considerations for the hatchery will be included in the MOELP assessment of the lower Little Qualicum watershed.

Definition of the study area and terms of reference for this assessment of the Cameron Watershed were set out at a roundtable meeting held in Port Alberni on December 12, 1997. The Cameron roundtable session was attended by:

Ken Dobb -- Ministry of Forests (MOF)
Warren Cooper -- MOELP
Jim Davies -- MOELP
Bill Norman -- Little Qualicum Waterworks District (LQWD)
Wayne French -- MacMillan Bloedel Limited (MB)
Glynnis Horel -- consultant to MB.

It was agreed that the Forest Practices Code Guidebook, *"Coastal Watershed Assessment Procedure (CWAP)"* was appropriate to assess the Cameron Watershed study area. While the CWAP is to cover the entire study area, recommendations from the CWAP can apply only to crown and private lands within the Tree Farm License. The Forest Practices Code does not apply to other private lands.

2.0 BACKGROUND -- LITTLE QUALICUM WATERWORKS

The Little Qualicum Waterworks District operates under License CO39960 which authorizes water extraction to a maximum 275,000 gpd. The intake point (near Qualicum Beach) is an infiltration gallery in the river bed. The infiltration gallery has been in place since 1973. Mr. Norman advised that water quality with respect to sediment has generally been good; the rock filters were changed for the first time three years ago. The LQWD's main concern is for chemical and biological contamination. However, water quality with respect to sediment is of interest to LQWD, particularly fine suspended sediment that could penetrate the gallery.

The main concern with this assessment is therefore sediment production in the watershed which could affect water quality downstream of Cameron Lake.

3.0 AVAILABLE INFORMATION

The following information was provided by MacMillan Bloedel Limited (MB) from the most recent 1:20,000 inventories available at this time.

- 1994 colour airphotos at an approximate scale of 1:20,000.
- 1956 airphotos providing partial coverage of the Cameron River channel at an estimated scale of 1:15,000.
- 1:22,000 maps (NAD 27 base) with MB's Inventory Revisions completed to December 31, 1996 and SPARKS updates for 1997 showing data for MB's forest lands including:
    - watershed boundary, basins and sub-basins
    - forest cover including roads and streams
    - fisheries classes (A, B, C)
    - terrain stability (Es) mapping
    - existing and proposed cutblocks from 1998 to 2001 to provide current harvesting information.
- 1:20,000 TRIM maps with contours.
- 1:20,000 maps derived from TRIM topography showing watershed, basin and sub-basin boundaries, with stream gradients and slope areas steeper than 60%.
- MB's CWAP data reports (based on the December 31, 1996 IR plus SPARKS) providing summaries of GIS data for stream and road lengths, fish habitat lengths, rate of cut and tree height data, inoperable and nonforest areas, areas of Class IV and V terrain.

MB also provided historical information on events in the Cameron River basin.

Environment Canada provided flow data for the Little Qualicum River at Station No. 08HB004 at the outlet of Cameron Lake, and for Station No. 08HB029 at Qualicum Beach. The Cameron Lake station provided data for 1914 - 1921 and 1962 - 1992. The Qualicum Beach station provided data from 1962 to 1986.

The engineering office of the City of Port Alberni provided precipitation records including rain and snow for Port Alberni.

MOELP in Port Alberni provided a report entitled "MacMillan Provincial Park Hydrological Assessment" by Hay & Company Consultants Inc. dated June 1997

4.0 METHODOLOGY

The compilation of watershed data was done generally in accordance with the Forest Practices Code of B.C. Guidebook, *Coastal Watershed Assessment Procedure (CWAP)* dated September 1995. A summary of the CWAP data is given in Appendix I, Table I - A. Table I - B gives other watershed characteristics of interest to a hydrological assessment of the study area; and Table I - C shows rates of cut, ECA and road densities projected to the end of the Forest Development Plan in 2001.

Some adjustments were made to the CWAP procedure. For example, the mainstem length used in this report is defined as the full length of a stream that can reasonably be identified as the main stream within the watershed or basin, with gradients up to 20%, as determined from TRIM maps. Appendix III contains channel profiles for each basin and sub-basin. The channel profiles were constructed from the contours on 1:20,000 TRIM maps. The stream in Sub-basin 1 is the upper part of the Cameron mainstem; the channel profile for the mainstem Cameron includes the stream through Sub-basin 1.

Headwater streams were taken as all stream reaches with gradients greater than 60% identifiable on the TRIM maps.

Road lengths within 100 m of streams were measured from MB's 1:20,000 (NAD 27) maps in MB's area, and from TRIM maps in nonMB areas.

MB's GIS CWAP data reports provided the following information for the total watershed, by basin and sub-basin areas:

- total areas of each basin, sub-basin and the total watershed, and MB's portion of each;
- areas by elevation band;
- stream lengths;
- road lengths.

MB's CWAP data reports provided the following information for MB's area only:

- tree height data and age of logging for second growth stands, with data runs from 1996 to 2001, which allows estimation of Equivalent Cut Area (ECA) and recovery in second growth stands;
- area of Es1 and Es2 terrain by basin, sub-basin and watershed
- road lengths on Es1 and Es2 terrain;
- areas logged on Es1 and Es2 terrain;
- areas of inoperable forest and nonforest terrain;
- total stream lengths, and stream lengths logged;
- fisheries stream lengths and fisheries stream logged.

Note that MB's stream inventory data is considerably enhanced over both the TRIM (NAD83) maps and the NAD27 maps. Any data dependent on stream densities, therefore, will give higher CWAP scores for stream-related factors than there would be with the NAD27 or NAD83 map data.

Old burns and other natural disturbances that show as immature stands in the forest cover mapping are taken into account in the ECA computations. The ski runs at the top of McBey Creek basin were disregarded.

For McBey and Lockwood Creeks, the length of fish stream was assumed to be the same as the length of the mainstem.

For nonMB areas, stand heights and ages were estimated based on similar-appearing stands of known age on MB's area. Rates of ECA recovery for the nonMB areas were estimated using the overall average rate of recovery on MB's areas.

Because of the methods of measurement, data in the non-MB parts of the watershed are numerically less accurate than data generated by GIS for MB's tenure.

Numbers of landslides were taken from the 1994 airphotos. I counted landslides which are bare of vegetation; and landslides which are vegetated but have younger vegetation than the surrounding forest. I did not count old natural landslides where the vegetation appears to be the same age as the surrounding forest. My reasoning is that the stream channels will have completely re-adjusted to impacts from the very old landslides. Landslide locations are shown on the maps in Appendix VI.

A field reconnaissance was carried out on February 9 and 23, 1998. Site notes and photographs are in Appendix V. The purpose of the field reconnaissance was to observe the physical channel characteristics and determine whether or not channel impacts were likely to have occurred from logging activities. Of particular concern are erodible alluvial stream reaches; that is, sections of stream flowing over and depositing alluvial sediments. These reaches are characterized by gravel/cobble channel beds, bars and islands; often have low terraces with erosion or deposition at stream bends; and are sensitive to changes in stream flow or sediment loads.

Stream gradients were measured by hand-held inclinometer at the field stops. Gradients at other locations referred to in this report were determined from the TRIM contours.

5.0 FISHERIES VALUES

I understand that Little Qualicum Falls, approximately 5 km downstream from Cameron Lake, is a barrier to anadromous fish. There are no anadromous fish within the study area. Cameron Lake and Cameron River for about 5 km above the lake are stocked for sport fishing. There are brown trout to about 4 kg in Cameron Lake, as well as rainbow, cutthroat and kokanee. Trout spawn at the lake outlet. The upper Cameron River has rainbow, cutthroat and dolly varden. Resident trout extend up to and including Labour Day Lake. The lower reaches of Stream 2 also have resident trout.

6.0 WATERSHED DESCRIPTION

The Cameron watershed is located in Hydrologic Zone 39, known as the Leeward Island Mountains. The average annual total precipitation in Port Alberni is 1873 mm. Mean annual snowfall is 118 cm. The 10 year averages for both rain and snow are less than the long term averages. The 10 year rainfall average is about 10 mm less than the 27 year average. The

10 year snowfall average is 39 cm below the 27 year average and 45 cm below the 97 year average. Plots of precipitation trends are in Appendix IV.

The total study area is 15,818 ha; of this, 71% is the Cameron River basin. The watershed ranges in elevation from approximately 180 m at the confluence of Lockwood Creek and the Little Qualicum River, to 1819 m at the Mount Arrowsmith peak. Of the total study area, 9% is below 300 m elevation, 39% is between 300 m and 800 m, and 52% is above 800 m.

Of the total study area, 64% (10,109 ha) is crown and private forest lands managed by MB under TFL 44. MB manages an additional 2073 ha (13%) of private forest land outside the TFL. The study area also includes 1056 ha of parks (7%). The rest of the study area (16%) is other crown forest land and private land.

There are no glaciers or icefields in the study area. The higher elevations sustain a snowpack throughout the winter. There is a developed ski area (the Mount Arrowsmith skihill) at the top of the McBey Creek basin.

Bedrock Geology[1]

Bedrock within the study area is mainly volcanic. The two dominant units (both volcanic) are the Karmutsen Formation of Upper Triassic age, and the Sicker Group of Pennsylvanian age and older. Slopes on the north side of Cameron Lake are mainly in the Karmutsen Formation.

The drainage pattern in the Cameron River basin is strongly dominated by major bedrock faults. From the confluence with the Sub-basin 4 stream to the confluence with the Sub-basin 2 stream, the Cameron River channel follows first a south trending fault, then a southeast trending fault that separates Karmutsen volcanics to the east from Sicker volcanics to the west. Upstream of the Sub-basin 2 confluence, the Cameron channel continues along a fault line within the Karmutsen volcanics. The Sub-basin 2 stream also coincides with a fault line that separates Karmutsen volcanics (east side) and Sicker volcanics (west side). Yellow Creek (in Sicker volcanics) coincides with a north-south trending fault slightly offset from the lower Cameron alignment.

There is a ridge of Sicker limestone along the upper parts of Sub-basin 4 and the St. Mary Lake drainage. McBey basin and the west side of Lockwood basin are in Karmutsen volcanics; the east side of Lockwood is in granitic rock of the Island Intrusions.

6.1 Cameron Lake Slopes -- Remainder

This unit comprises Cameron Lake and the slopes and small tributaries draining directly into it. The area is 2081 ha, or 13% of the Cameron watershed. Cameron Lake has an area of 453 ha and a mean depth of 28 m. On the slopes above the south side of the lake, 260 ha is managed by MB under TFL 44 and 549 ha is private forest land. Cameron Lake Provincial Park (255 ha in this unit) extends along the south shore of the lake and crosses the Little Qualicum River at the east end of the lake.

[1] GSC Map 17-1968

The north side of Cameron Lake has steep bedrock slopes with some colluvial veneers and talus deposits. The CN railway follows the shoreline along the lower part of the slope. I noted nine natural rockslides in the steep upper slopes; none reached the lake. There has been one rockslide above the railway that extends to the lake; I counted this as a "post-harvesting" slide. These slopes are scrub forest and bare rock, and have not been logged. There are no stream channels on these slopes.

The south side of Cameron Lake has moderate to steep slopes rising to rounded hummocky terrain at the ridgetop with several small lakes. Most of the lower slopes are blanketed with deep silt till; some rock ridges are apparent. The till is thin and patchy on the upper slopes and ridgetop where bedrock is predominant. There are several small tributaries on this slope; these have incised channels with steep gradients. There has been extensive logging on the private lands on this side of the lake above the park. Second growth is now well advanced; tree heights were estimated at more than 7 m. An old access road system switchbacked up this slope; the roads are now heavily overgrown. No natural or logging-related slides were found on this slope. No erosion was apparent on the 1994 airphotos, and no significant sediment movement was observed at the highway that follows along the shoreline on this side of the lake.

To the end of 1997, the total area logged in this unit is 479 ha (23%). With the advanced size of the second growth, the weighted ECA was estimated at 9%. Excluding the highway and railway, the road density is 0.8 km/km^2. There are no significant instability or erosion problems in this unit.

6.2 McBey Creek -- Basin 5

McBey Creek enters the Little Qualicum River 0.6 km downstream from Cameron Lake. This is a teardrop-shaped basin with an area of 1091 ha, of which 411 ha (38%) is within TFL 44. The TFL lands cover the midportion and upper west side of the basin. The lower portion is mostly private land, with a small area in Cameron Lake Provincial Park. Most of the upper portion is the Mt. Arrowsmith Park, which includes the ski hill. The total area of parks in this basin is 458 ha (42%).

The main channel has its headwaters in ponds and small creeks in the upper basin. There is one tributary that joins the main channel about 250 m above the Little Qualicum River. Other than winter snowpack at the higher elevations, there is no significant water storage in the basin.

The lower portion of this basin, to about 300 m elevation, has moderate slopes and is blanketed with deep silt tills. From 300 m to about 950 m elevation, the terrain consists of steep bedrock slopes with colluvial veneers. There are five natural landslides in this area, in rock and colluvium. Four are in the McBey Creek canyon; one is in the tributary drainage. The slide in the tributary drainage is the most recent and has an unvegetated scarp.

The upper two-thirds of the basin area is mainly in irregular hummocky bedrock terrain with rounded ridges and a few small ponds. In this part of the basin there are steep slopes along the valley sides, and at the upper drainage divide where the elevation reaches 1600 m at Mount Cokely. The Arrowsmith ski area is between 940 m and 1100 m.

The tributary creek also occupies a confined steep-gradient channel. Sediment from the natural landslide in this drainage transported to McBey Creek. A small bar with mossy stones and alders to about 100 mm diameter is present just above the Little Qualicum confluence; this bar appears to be the remains of deposition from the natural slide.

The lower 1 km of McBey Creek has a confined, boulder step-pool to cobble cascade-pool channel with gradients of 4 - 11%. From 1 km to 3.0 km (260 - 860 m elevation), the stream is incised in a steep canyon with gradients of up to 53%. At 1.2 km the channel gradient exceeds 20%; this is considered the top of the mainstem. Above 3 km, the channel is in an upper canyon with more moderate sideslopes and gradients flattening to less than 10%.

The lower channel reaches have been logged. The channel banks have low erosion potential and are not sensitive to peak flow effects. Impacts from past logging (on private land) would be loss of riparian forest and large wood debris in this bottom reach, and possible minor sediment aggradation although it would likely not have been significant relative to the natural slide. Large wood debris is unlikely to have been functional in the channel above 1 km.

Fish presence would be limited to the bottom 1 km; gradients above this reach are likely too steep to support fish habitat.

There have been no logging related landslides in this basin. To the end of 1997, 12% of the total basin area has been logged; nearly half of this was more than 20 years ago. The weighted ECA[2] is estimated at 8%. The road density is 0.9 km/km^2. Logging roads in the older logged areas are overgrown. No significant erosion or sediment transport is occurring at present. Impacts are minor. .

6.3 Lockwood Creek -- Basin 6

Lockwood Creek enters the Little Qualicum River 0.8 km downstream from Cameron Lake. The basin area is 1429 ha. Of this, 54 ha (4%) is within TFL44 and 21 ha is park; the rest is private land.

This basin is roughly teardrop-shaped, with a main channel that forks into two upper drainages at 4.2 km above the confluence with the Little Qualicum. There are a few small ponds along the rounded ridgetop on the west side of the basin but, aside from winter snowpack, no significant water storage.

This basin has a steep sided valley with an incised stream. The lower part of the valley has moderate slopes blanketed with deep silt tills. The steep mid slopes are rock with colluvial and thin till veneers. The valley walls rise to rounded bedrock ridges except for the steep ridge to the east of Mt. Cokely on the southern drainage divide. The TFL portion of this basin is in moderately sloping, bedrock terrain with rounded ridges on the west side of the basin.

One natural landslide was noted, which is now vegetated. Four logging-related slides were noted, all from roads. Two of these entered the channel. There are no clearcut failures.

[2] The ECA does not include areas cleared for ski runs.

The mainstem is 5 km long, above which stream gradients are steeper than 20%. The bottom 1.6 km has gradients of less than 10%. At the highway, the channel has partially aggraded cascade-pool morphology and a gradient of 4%. Impacts to the channel have primarily been loss of large wood debris in the lower reaches, and some sediment aggradation. Wood debris would not have been functional in the steep upper reaches.

To the end of 1997, 60% of the basin area has been logged. The weighted ECA is estimated at 22%.

Management concerns in the TFL portion of this basin would mainly be stability considerations for road sections on slopes steeper than 60%, and for the condition of the large number of existing stream crossings. Open slope "clearcut" failures are unlikely in this terrain.

6.4 Cameron River Basin

Distances along the Cameron River channel are measured upstream from the Cameron River outlet at Cameron Lake. See topographic map sheets, Appendix VI.

The Cameron River basin has a total area of 11,217 ha. Of this, MB manages 9122 ha (81%) under TFL 44, and another 1333 ha (12%) of private forest land outside the TFL. There is 322 ha of parks in the basin. The rest of the basin (440 ha) is other crown forest land.

The Cameron basin has a long narrow shape and a simple drainage pattern with a long dominant mainstem and three tributary sub-basins. (Basin 1 is the headwater area of the mainstem). There are no icefields or perennial snowpacks, although the higher elevations in the upper basin sustain a snowpack throughout the winter. Labour Day Lake (74 ha), at the top of the mainstem, is the largest lake. There are other smaller lakes including Peak Lake (5.2 ha), Kammet Lake (7.6 ha), Henry Lake (4.6 ha), and St. Mary Lake (2.5 ha); as well as smaller ponds. The total area of lakes in the basin comprises about 1% of the basin area; it provides no significant water storage within the basin.

The basin has a maximum elevation of 1819 m at the Mount Arrowsmith peak on the east side, and a minimum elevation of 186 m at the outlet at Cameron Lake.

The lower valley (0 - 3.2 km) has a broad flat valley floor with extensive alluvial deposits and low alluvial terraces adjacent to the channel. There is a similar valley floor section in the mid portion of the basin at 15.5 - 21.1 km. Elsewhere in this basin the main valley floor is narrow with a confined channel. At 7 - 12 km the valley bottom is a deep canyon.

Channel descriptions by reach for the Cameron River are in Table 1. Reach breaks are shown on the maps in Appendix VI. Channel profiles are in Appendix III.

The lower valley slopes are blanketed with deep silt tills with minor glaciofluvial deposits. The steeper mid and upper slopes are mostly bedrock with thin colluvial and till veneers and pockets. In the upper part of the basin (Sub-basin 1), coarse colluvial deposits are more prevalent on the lower slopes; tills diminish at these elevations. Frequent large boulders and

Table 1
CAMERON RIVER CHANNEL DESCRIPTION

Reach Number	Distance, km From	To	At	Description
			0	Outlet of Cameron River into west end of Cameron Lake.
1	0	3.39		Unconfined alluvial channel on floodplain 300 - 700 m wide. Channel gradient averages 0.6 - 0.7%. Low terraces adjacent to channel; erodible channel banks. Bars, islands and multiple channels. Channel substrate is mainly gravel and sand; some cobbles. This reach has riffle-pool morphology and is partially aggraded. Aggradation is more apparent in lowest reaches, vicinity of highway bridges. Wood debris is present along banks and as jams on bars; large wood debris is functioning in channel. Logging debris from upstream reaches has accumulated in sidechannels and on bars in this reach; there is excess wood debris on some sections. Wood debris at some locations was substantially increased from windthrow during the winter storm of 1997. About 640 m of this reach has been logged on one side; the logged banks show evidence of increased bank erosion and channel widening. Varying vegetation ages indicate there has been some movement of the channel historically. The Hay report tracks changes in the channel over time (1951 - 1997) in this reach. The channel positions at the highway bridges have been stable.
			0.23	Highway bridges (2 channels). Field Stops #5 and #6.
			1.77	Bridge (private land).
2	3.39	3.79		Uniform straight channel, east bank confined by valley wall. Average gradient 0.7% (from TRIM). Riparian zone has not been logged. Channel position stable; no bank erosion apparent.
3	3.79	4.92		Unconfined meandering alluvial channel on floodplain 400 m wide. Channel gradient approximately 1%. Substrate is cobbles and gravel. Riffle-pool morphology, partially aggraded. Large wood debris along banks. Left bank is unlogged; riparian zone on right bank was logged, leaving a fringe. Date of logging approx. 1987. Fringe is mostly intact except for one or two spots where bank erosion has gone through the fringe. Large wood debris along channel banks.
			4.67	Bridge (private land). Field Stop #7.
4	4.92	7.09		Uniform straight channel with one bend. Confined by valley wall and highway on west side. Low terraces on east bank. West bank has not been logged except where highway encroaches; east bank has been logged with a fringe left along channel. Fringe is intact indicating minimal bank erosion. Channel gradient 1 - 3%. Riffle-pool morphology. Partially aggraded?
			5.94	St. Mary Creek
			7.09	Unnamed creek -- Sub-basin 4.
5	7.09	13.71		This reach is incised in a canyon that formed along intersecting bedrock faults. The channel is bedrock controlled, typically with bedrock/boulder step-pool morphology, and has falls and rapids. Channel gradients range from 2% to 12% (from TRIM). From 7.09 - 11.02 km, the riparian zones have not been logged. From 11.02 - 13.71 km, the channel is logged on one side. Most of this reach has channel banks that are not erodible; however, one slough has occurred on the north side of the bank, and several slides from Cameron Main road entered the channel in the vicinity of Yellow Creek. This is a high energy reach that is not sensitive to impacts, but will deliver sediment rapidly to the lower reaches.
			10.55	Yellow Creek confluence
			12.40	Cop Creek confluence

Table 1 (cont'd)

Reach Number	Distance, km From	To	At	Description
6	13.71	15.51		Most of this reach has a uniform partially confined channel with gradients averaging 0.8% and riffle-pool morphology, partially to moderately aggraded. The riparian zone on both sides of the channel has been logged for the full length of this reach. It is now 25 - 35 year old second growth conifers with an alder fringe along the banks. Except as noted below, there is little bank erosion evident on this reach and the channel position is stable.
	13.7	14.0		Increased channel sediment and bank erosion apparent.
			14.4	Bridge at Cameron Mainline. Field Stop #11.
	14.9	15.0		Bank erosion, channel widening, increased channel sediment.
7	15.51	21.08		Unconfined alluvial channel in floodplain 400 - 700 m wide. Low alluvial terraces adjacent to channel; erodible banks. Channel gradient 0.5% - 1%. Riffle-pool morphology; moderately to severely aggraded. All except 1.44 km of this reach has been logged on both sides of the channel. Of the 1.44 km, 0.64 has been logged on one side. This reach exhibits significant bank erosion, channel widening and sediment aggradation since the 1956 (prelogging) airphotos. The logged riparian zones now have 20 - 30 year old second growth, typically conifers with a fringe of alders along the channel banks.
			17.12	Kammat Creek
	18.04	18.84		Old growth riparian zone, both sides.
	18.84	19.48		Old growth riparian zone right bank, left bank logged.
			19.48	Old road crossing, bridge pulled out.
8	21.08	28.16		This reach is partially confined in a narrow valley floor in mainly coarse colluvial deposits. Bank erosion is minor. The riparian zones throughout this reach have been logged; the second growth is 25 - 30 years old. Channel gradients range from 2% to 8%; channel morphology is boulder step-pool and cascade-pool. Wood debris throughout most of this reach would have a minor functional role in channel form. Impacts limited to minor sediment aggradation.
			21.34	Unnamed creek -- Sub-basin 2.
			21.61	Bridge.
			23.36	Old road crossing.
			25.88	Old road crossing.
9	28.16	29.22		This is a steeper gradient section (7% - 20%) that includes the falls at 28.2 km. The valley floor here is narrow and gently sloping. The channel has mainly boulder/bedrock step-pool morphology. A fringe of old growth was left along the channel banks; it appears to be intact, suggesting minimal bank erosion has taken place. Impacts are minor.
			28.20	Falls
			28.30	Road crossing
10	29.22	33.38		This reach comprises the headwater end of the Cameron mainstem and includes Labour Day Lake and a pond in the upper headwater bowl. The area has not been logged.

Notes:

1. Channel descriptions from airphotos and TRIM maps, supplemented with field spot checks. See also site specific channel descriptions in Appendix V.

blocks are present on the lower slopes and valley bottom through this sub-basin, from rockfalls in the upper valley walls.

Along most of the basin boundaries, the valley slopes rise to rounded ridges at the drainage divide. The highway and several logging road systems cross over the upper watershed boundary. Rugged topography and steep gullied bedrock ridges are present along the east side of Sub-basin 4 in the vicinity of Mount Arrowsmith, on the north side of Labour Day Lake around Mount Moriarty, and along the southeast boundary of Sub-basin 2.

A total of 39 natural landslides was identified in this basin. These are mainly rockslides in the steep upper valley walls of Sub-basin 1 and Sub-basin 2, and the main valley walls southeast of Mount Arrowsmith. Some rockfall rubble reached the main channel in Sub-basin 1; however, in general, the rate of sediment entering the channel from natural landslide events is low.

A total of 37 logging-related landslides was identified in this basin; 33 of these were from roads and four were on slopes or gully sides. Of these four, three initiated below roads and may have been related to road drainage. All of the slides were quite small, although some travelled down gullies and gained volume through logging debris and erosion of the gullies. Most are now at least partially revegetated. Two slides from the Cameron Main road in the vicinity of Yellow Creek entered the channel; I counted these as "Landslides terminating in mainstem" even though the slides were not large.

The total road length in the basin is 268 km; the road density is 2.4 km/km^2, which is high. The density of stream crossings is $3.5/km^2$ over the total basin, which is also high. In addition there are numerous backspar and access trails visible on the airphotos that are not mapped as roads. The road length does not include the highway. The length of highway through the Cameron River basin is 7.5 km.

This basin was heavily harvested in the 1960's and '70's. During that period and into the 1980's, MB's files report a number of large debris torrents that transported to the Cameron River channel. The majority initiated as slides from roads that became channelized in gullies. Some initiated in logged gullies as erosion of the gully bottom that mobilized into a torrent. The volume of torrents was substantially increased by logging debris left in the gullies. This material entered the Cameron River, deposited sediment, and developed large log jams in the channel. At one location on MB's private land, the stream began eroding a new channel around a log jam; in consultation with DFO and MOELP fisheries biologists, MB removed the jam to restore the channel to its original location.

In addition to torrents and slides, logging practices of the day used access and backspar trails, often with steep gradients, that were cut well into mineral soil and subsequently eroded, contributing additional sediment to stream channels. Yarding procedures disturbed channel banks and steep slopes, leaving yarding tracks that subsequently eroded.

Site reports from that time describe torrented gullies, severely aggraded reaches of the Cameron River, and large log jams in the Cameron River and its tributaries.

With a decline in activity in this watershed in the last 15 years, many of the roads and trails are growing in and sediment production has decreased sharply. The debris torrent tracks are becoming revegetated. Second growth is becoming reestablished in the riparian zone, although erodible channel banks on logged alluvial reaches do not yet appear to have stabilized. The extent of channel aggradation appears to be diminished from that described in the MB reports; considerable sediment appears to have moved through the system. Wood debris is also moving. Much of the wood debris described in earlier reports appears to have accumulated in the lower reaches of the Cameron River in MacMillan Park. A storm in the winter of 1997 caused major windthrow in the park which substantially increased large wood debris in channels through the park. The Hay report predicts that the increased wood may promote flow diversion and channel shifting.

In summary, this basin was severely impacted by the logging methods of the 1960's and 70's, but since that time, recovery is taking place. Erosion and sediment movement stemming from the high road density, high density of stream crossings, and old road construction standards remain a management concern, as do the alluvial reaches of the Cameron River where channel bank erosion has not yet stabilized.

6.5 Upper Cameron -- Sub-basin 1

This sub-basin is the headwater area of the Cameron mainstem, above 21.3 km. It has a V-shaped valley form with moderate to steep slopes. The southwest side of the valley is dissected with deep bedrock gullies. Fifteen natural landslides were noted in this sub-basin, typically rockslides from the upper valley walls. There have been two logging-related slides, one from a road and one in a gully. Both were small events.

The total basin area is 2303 ha; of this, 2160 ha (94%) is within TFL 44. The area around Labour Day Lake is park (118 ha). The highest elevation is 1605 m at Mount Moriarty. To the end of 1997, 613 ha (27%) had been logged. Most of this (18% of the basin area) was more than 20 years ago. The weighted ECA is 9%. The total road length is 27.5 km; the road density is 1.2 km/km^2.

Most of the mainstem (61%) has been logged on both sides. Most of the stream channel is confined by banks in coarse colluvium; bank erosion has been minor. The stream reaches through this basin are fairly high energy; channel morphology is predominantly boulder step-pool and cascade-pool with minimal function from large wood debris. The main impact is minor sediment aggradation. The management concern for this basin would be large sediment inputs which could degrade resident fish habitat on these reaches, and sediment delivery to sensitive alluvial reaches downstream.

6.6 Unnamed Creek -- Sub-basin 2

This stream joins the Cameran River at 21.3 km. The sub-basin has a total area of 1114 ha; of this, 1108 ha (99%) is within TFL 44. The maximum elevation is 1418 m, at the eastern drainage divide. This basin has a few small ponds and marshy areas but no lakes and no significant water storage.

This sub-basin has a U-shaped valley form with a broad valley floor. The gentle lower valley slopes are blanketed with deep silt till and include some glaciofluvial deposits. Mid and upper slopes become steep and gullied; till diminishes and terrain consists of bedrock with colluvial and till veneers. There are rockslide and avalanche tracks in the upper valley slopes. Eighteen natural landslides were noted in this sub-basin and nine logging-related slides, eight from roads and one on a slope. The open-slope failure is below a road, and I suspect was caused by road drainage. None of the landslides entered the channel directly.

The channel has gentle gradients (less than 10% and mostly less than 5%) up to the top of the mainstem. Channel morphology is typically riffle pool and cascade pool, partially to moderately aggraded. Virtually all of the mainstem has been logged in this sub-basin. From 2 km to 4 km, increased bank erosion, channel widening and sediment aggradation are apparent. Elsewhere along the stream the channel is more confined and the banks appear less susceptible to erosion, but some sediment aggradation is apparent in the channel bed. Throughout the channel, there has been loss of large wood debris which would have been present and functioning in the natural channel.

To the end of 1997, 62% of the sub-basin area had been logged. Most of this (58% of the sub-basin) was logged more than 20 years ago. The weighted ECA is 12%.

The road density (2.8 km/km^2) and density of stream crossings (7.8/km^2) are high, and in addition to the road-related slides, there has been considerable sediment movement in this sub-basin from erosion. Many of the roads are now overgrown, and the rate of sediment production has decreased. However, while this sub-basin is tending towards recovery, the past effects of logging are still a management concern.

6.7 Cop & Henry Creeks -- Sub-basin 3

Cop Creek joins the Cameron River near the top of the canyon at 12.4 km. The basin is roughly oval-shaped with two creek valleys that join at 0.7 km above the Cameron confluence. The larger of the two creeks is Henry Creek on the east side of the basin. Cop Creek drains the west side of the basin. For this assessment I have taken Henry Creek as the main channel because it is a longer stream and the channel gradients are flatter than Cop Creek.

The upper Henry Creek valley is U-shaped with a gently sloping valley floor and a headwater cirque-like bowl containing Henry Lake. The creek through this upper valley has a confined channel with gradients of 5 - 6%. About 1 km below the lake, the valley becomes a steep-sided V shape with an incised steep gradient channel; gradients range from 15% to 46%. From the confluence with Cop Creek to the Cameron Main road, the gradient flattens to 6%; it then increases below the road where it enters a rock canyon that extends to the Cameron confluence. The full length of Henry Creek below the lake has been logged, but little bank erosion is apparent.

Above the Cop/Henry confluence up to the 130 Road, Cop Creek also has an incised channel with even steeper gradients than Henry Creek. Most of the Cop Creek channel below the 130 Road to the Henry confluence has not been logged. Above the 130 Road, the terrain becomes irregular hummocky bedrock with thin till or colluvial veneers. The upper reach of Cop Creek is on a slightly hummocky bench; the gradient flattens on this reach. There were three slides from the 132A Road above this bench. The slides did not enter the channel directly, but sediment aggradation in the Cop channel immediately downslope of the slides is apparent. This portion of the Cop channel has been logged.

Both Cop and Henry Creeks have high energy channels with predominantly boulder step-pool morphology. Except for the channel reach through the upper valley, large wood debris is likely to have had little function. There has been minor sediment aggradation in the channel, but the main consideration would be delivery of sediment to the Cameron River.

Terrain between Cop and Henry Creeks is irregular hummocky bedrock. The drainage divide at the top of the sub-basin follows rounded bedrock ridges. There are no natural landslides in this basin. Five logging-related slides have occurred, all from roads. One entered the Cop Creek channel above the Cop/Henry confluence.

To the end of 1997, 49% of the sub-basin area had been logged. The weighted ECA is 24%. The road density is 2.6 km/km^2, and the density of stream crossings is 1.5/km^2. There are also access and backspar trails visible on the airphotos that are not mapped as roads.

6.8 Unnamed Creek -- Sub-basin 4

This unnamed creek enters the Cameron River at 7.09 km, just below the canyon. The sub-basin has a total area of 1139 ha; of this, 499 ha (44%) is within TFL 44. There is 39 ha of park in the upper part of the basin. The park and TFL 44 lands are in the upper part of the basin; the lower part of the basin is private forest land.

The lower part of the basin has gentle to moderate slopes in deep tills with minor glaciofluvial deposits. The midslopes become steeper and are blanketed with gullied till and colluvium; till thickness diminishes upslope. The upper part of the basin is in steep gullied bedrock slopes that rise to steep peaks at the drainage divide in the vicinity of Mount Arrowsmith.

There are no natural slides in the basin. Four logging-related slides have occurred, all from roads. One entered the channel upstream of the defined mainstem.

The drainage pattern is roughly rectangular, with the main channel sub-parallel to the Cameron River. The stream has an incised channel which rises from the Cameron River at gradients of 16 - 17%, then flattens to 7 - 9% for 1.8 km. Channel gradients then increase to 11 - 18%. The mainstem length, to where the channel gradient increases above 20%, is 4.7 km. All of this length has been logged. There are small sloughs apparent in the logged gully sides, and fresh sediment is evident in the channel. The channel morphology is expected to mainly be partially to moderately aggraded boulder step-pool. (Access to the private land is gated.)

To the end of 1997, 59% of the sub-basin had been logged; 31% of the basin area was logged more than 20 years ago. The weighted ECA is 30%. The road density is 2.7 km/km^2, and the density of stream crossings is 3.2/km^2. As well; there are numerous access and backspar trails not mapped as roads. The access road to the Mount Arrowsmith ski area switchbacks up the south side of this sub-basin; it is included in the road density.

The cumulative effects of erosion of roads, trails, and stream crossings; from logged gully banks adjacent to the stream; and from the few road related slides have been significant with respect to introduction of sediment to the channel. Although the rate of sediment production has decreased as roads have grown in and revegetation has occurred, it would still be a management concern in this sub-basin.

MB's inventory indicates no fish habitat in this basin; the main concern would be for delivery of sediment to the Cameron mainstem.

7.0 HYDROLOGY & WATER QUALITY RECORDS

The comparable years of record of the WSC stations at the Cameron Lake outlet and at Qualicum Beach are 1962 to 1986, when both stations were operating. Appendix IV contains plots of some of the data sets including mean annual, maximum daily and minimum daily flows for the two stations, as well as precipitation trends in Port Alberni.

For the comparable period of record, average flow values are as follows:

	Qualicum Beach	Cameron Lake
Maximum daily flow	93 m^3/sec	74 m^3/sec
Minimum daily flow	1.2 m^3/sec	0.9 m^3/sec
Mean annual flow	11.8 m^3/sec	8.9 m^3/sec
Maximum daily flow of record	166 m^3/sec (1980)	189 m^3/sec (1961)

As previously noted, the Cameron watershed comprises 67% of the total Little Qualicum watershed area. For the comparable years of record, mean annual flows in the Cameron watershed average 75% of the flows in the Little Qualicum at Qualicum Beach. The maximum daily flow in the Cameron averages 78% of the Little Qualicum, and the minimum daily flow in the Cameron averages 73% of the Little Qualicum. See plots, Appendix IV.

There are probably intermediate flow losses and gains in the watershed between the Cameron Lake station and the Qualicum Beach station but it is clear that the Cameron Lake watershed contributes the majority of flow to the Little Qualicum river system. There is a strong correlation between the two stations for mean annual flows and maximum daily flows. The correlation in minimum daily flows is more variable and other conditions in the watershed downstream of Cameron Lake may have a greater influence on minimum flow conditions. As well, DFO has a low flow control structure at the outlet of Cameron Lake that may have some effect.

At the Cameron Lake station, maximum instantaneous flows were only recorded for the period 1988 - 1992. For this period, the maximum daily flow averaged 91% of the maximum instantaneous flow. The range for the 7 years of record was 90% to 93%.

At the Qualicum Beach station, maximum instantaneous flows were recorded for the period 1962 - 1986. For this period the maximum daily flow averaged 84% of the maximum instantanous flow. The range was 72% to 96%.

Although the instantaneous flow records for Cameron Lake are limited, the narrow range of variation between maximum instantaneous and daily flows coming out of the lake suggests that the lake storage has a damping effect on spikes in peak flows.

Cameron Lake itself comprises 2% of the Little Qualicum watershed area. The storage capacity over the total Little Qualicum watershed area is relatively minor, although it is significant to maintain low flow levels to the hatchery downstream.

DFO has found that during sediment events in the Cameron valley, the lake and lower river become turbid, sometimes for long periods. Water quality sampling by DFO at the outlet of Cameron Lake determined that during periods of high turbidity in the lake, fine suspended sediment (clay sizes) passes through the lake outlet. Silt sizes and larger are retained in the lake.

With respect to water quality at the Little Qualicum intake, therefore, impacts from the Cameron basin would be periods of turbidity from suspended clay size particles.

8.0 WATERSHED ASSESSMENT RESULTS (CWAP)

The Coastal Watershed Assessment Procedure uses the criteria given in Appendix I to predict the potential for impacts to stream channels to have occurred as a consequence of forest development. The type of impacts contemplated by the CWAP methodology are increased peak stream flows, increased sediment to the channels, and riparian disturbance from logging channel banks. The CWAP methodology develops five major factors to identify what the sources of impacts are likely to be. The results of the CWAP scoring procedure for the five major factors are shown in Table 2.

The CWAP procedure is intended to give a preliminary view of the potential hydrologic health of the watershed. Beyond the CWAP scores, the conclusions and recommendations in this report are based on my observations of the physical characteristics and condition of this watershed.

8.1 Total Watershed

Peak Flow Effects

The CWAP methodology estimates the potential for peak flow effects from a combination of the weighted Equivalent Cut Area (ECA) and the road density.

As noted above, the instantaneous flow data suggests that storage in Cameron Lake provides a buffer to downstream reaches from spikes in peak flow from the portion of this study area that drains into the lake. The main concern for peak flow effects would be within the channels of the basins and sub-basins, as discussed below. The portions of the study area not buffered by the lake would be McBey and Lockwood Creeks which enter the Little Qualicum River below Cameron Lake.

Table 2
CAMERON WATERSHED
COASTAL WATERSHED ASSESSMENT PROCEDURE (CWAP)
HAZARD INDEX SCORES

17-Feb-96	Peak Flow Effects		Surface Erosion Effects		Riparian Effects		Landslide Effects		Headwater Effects	
	Score	Impact	Score	Impact	Score	Impact	Score	Impact	Score	Impact
Total Watershed	0.5	Moderate	0.9	High	1.0	High	0.9	High	0.4	Low
Basin 5 McBey Creek	0.3	Low	0.3	Low	1.0	High	0.3	Low	0.2	Low
Basin 6 Lockwood Creek	0.6	Moderate	0.9	High	1.0	High	0.5	Moderate	0.4	Low
Cameron River Total Basin	0.6	Moderate	0.9	High	1.0	High	1.0	High	0.5	Moderate
Sub-basin 1 Labour Day Lake	0.3	Low	0.7	Moderate	1.0	High	0.9	High	0.2	Low
Sub-basin 2 Unnamed	0.6	Moderate	1.0	High	1.0	High	1.0	High	0.7	Moderate
Sub-basin 3 Cop/Henry Creeks	0.7	Moderate	0.9	High	1.0	High	1.0	High	0.1	Low
Sub-basin 4 Unnamed	0.7	Moderate	1.0	High	1.0	High	0.8	High	0.3	Low

<u>Impact Categories:</u>

Low	<0.5
Moderate	0.5 - 0.7
High	>0.7

Harvesting

The forest cover mapping shows logging in the study area dating back to the last century, when some harvesting was done in the lower McBey and Lockwood Creeks and the lower Cameron River. (Note that natural disturbances showing as immature forest in MB's forest cover are included as cut areas.) The Cameron River basin was logged extensively in the 1960's and '70's.

To the end of 1997, 46% of the total study area had been logged. Over this area, the rate of logging has been 3% in the past 5 years, 6% in the past 10 years and 20% in the past 20 years. Twenty-six percent was logged more than 20 years ago. (The date of logging in nonMB lands was estimated from the age of similar-appearing stands in MB's forest cover.)

The Equivalent Cut Area for the total study area, taking into account recovery in the second growth and weighted for the "rain on snow zone" (300 m to 800 m elevation), is 18%. The average rate of recovery is 183 ha/year. This means that, if no further harvesting were to take place, the weighted Equivalent Cut Area would be reduced by 183 ha per year because of the rate of growth in the second growth forest. (Rate of recovery for MB's area was computed using GIS data based on stand formulae. Rate of recovery on nonMB lands was estimated based on the average rate of recovery in MB's area).

Over the total study area, the peak flow effects from clearcut logging are low.

Roads

Road density is high over the total study area. As noted above, because of the buffering effect of Cameron Lake, peak flow effects of roads would mainly be of interest in individual basins and sub-basins with respect to effects on the channels.

<u>Surface Erosion Effects</u>

The CWAP methodology estimates the potential for surface erosion effects from a combination of road density, length of road on erodible soil, mainline road length within 100 m of a stream, and density of stream crossings. For this study, surface erosion mapping was not yet entered into MB's GIS inventory; however, given the values for the other factors, length of road on erodible soil would not have influenced the scores.

Surface erosion effects rank as high over the total study area. Using MB's stream inventory (which has a greater stream density than TRIM maps) will yield higher scores than using TRIM streams; however, with the history of this study area, it is clear that significant erosion effects have occurred and the estimate of high impacts is realistic. As previously noted, in addition to the high road densities there are also numerous access and backspar trails in the study area that are not mapped as roads and are still quite visible on the 1994 airphotos.

Studies reported in the literature have shown that sediment generated from active haul roads is up to 1000 times greater than that from inactive road. With the low level of activity in this study area in the past 10 years, sediment production has dropped sharply. However, with the extent of past impacts, surface erosion remains a management concern.

Riparian Effects

The CWAP scores are based on a combination of total stream length logged, length of fish stream logged and length of mainstem logged.

Riparian effects rank high for all parts of the study area, reflecting old logging practices that did not leave buffer zones along streams. While there are many stream reaches that do not have sensitive channel banks, there are also stream reaches, particular the Cameron mainstem in the central Cameron valley, where significant impacts have occurred from logging the channel banks.

Landslide Effects

The potential for landslide effects estimated by the CWAP is based on the total number of landslides, large landslides that have entered a main channel, areas of Es1 and Es2 terrain logged (as determined from the 1:20,000 terrain stability mapping, not 1:5000 scale on-site assessments), and road lengths on Es1 and Es2 terrain.

Landslide effects rank high for the whole watershed and for all basins except McBey and Lockwood Creeks. The high scores come from values for road length and area logged on Es1 and Es2 terrain. There are natural landslides in some parts of the study area, as discussed below, but over the total study area the occurrence of natural slides is low. The actual occurrence of logging-related landslides has also been low. All of the post-logging landslides except four initiated at roads. Of the four that did not, three may have been caused by road drainage.

Slides from the roads reflect old road building practices. Although the density of these slides is low, given the past total impacts especially in the Cameron basin, the road system needs attention.

Open slope failures in this study area are very rare, despite old logging practices that did not include terrain stability evaluations. In this respect the terrain stability mapping is conservative at predicting clearcut failures. I note that 1253 ha of Es1 and Es2 terrain has been logged, of which 263 ha was Es1 terrain. If all 4 open slope/gully failures were in Es1 terrain, the landslide frequency is 0.015 slides per hectare, which is rated as a very low hazard of landslide initiation according to the Forest Practices Code guidebook, *"Mapping and Assessing Terrain Stability"* (April 1995).

The CWAP scores for landslide effects substantially overestimate the occurrence of landslides in this study area. However, as previously noted, there has been a significant impact from slides off roads.

Headwater Effects

The CWAP procedure predicts the potential for headwater effects based on the number of stream crossings and the length of streams logged on slopes steeper than 60%.

Over the total study area, headwater effects rank as low.

8.2 McBey Creek -- Basin 5

The potential for peak flow effects ranks as low for this basin, reflecting both a low ECA and a low road density. Landslide effects, headwater effects and surface erosion effects also rank as low in this basin. Riparian effects rank high, reflecting past logging of the mainstem creek. The channel banks along this creek are not highly erodible and minimal bank erosion has occurred. As well, the banks are revegetated and second growth along the creek is now about 40 years old. Recovery is progressing, although there is still a lack of large wood debris to recruit.

8.3 Lockwood Creek -- Basin 6

The weighted ECA in this basin is low and the road density is moderate, giving a moderate ranking for peak flow effects. Surface erosion effects rank high, reflecting a high density of stream crossings. Landslide effects rank as moderate. Two slides from a road entered the channel; they are now mostly revegetated. Headwater effects rank as low.

It is apparent that sediment has entered the creek channel from the road slides and from erosion at numerous creek crossings. This would have occurred during original logging; most of these roads are now overgrown and the second growth is well advanced. The rate of sediment production has slowed significantly; there was no evidence of recent deposition at the highway bridge crossing. However, the condition of the creek crossings should be checked.

Riparian effects also rank high because of extensive past logging of stream channels. The second growth is now well advanced and the channel banks are revegetated. The second growth has not yet reached sufficient size for adequate recruitment of large wood debris.

8.4 Cameron River Basin

Over the total basin, peak flow effects rank as moderate. This is due to a high road density; the weighted ECA is low (21%).

Surface erosion effects rank as high because of the high road density and high density of stream crossings. While sediment production has dropped and recovery is taking place, erosion effects remain a management concern.

Riparian effects rank high because of the extent of streams and mainstem logged. Revegetation of the riparian zones for the tributaries and small creeks is occurring, but sections of the main Cameron River channel (especially Reach 7) continue to be unstable.

Landslide effects rank as high because of the values for area logged and road constructed on Es1 and Es2 terrain. The actual occurrence of natural and logging-related landslides is low throughout the basin, except in Sub-basin 2 where there is a high density of natural landslides. The density of post-logging landslides is low in Basin 2.

Headwater effects rank as moderate over the total basin, because of logging upper gullied valley slopes in the main Cameron valley (the Remainder) and in Sub-basin 2.

8.5 Upper Cameron -- Sub-basin 1

The potential for peak flow effects in Sub-basin 1 is low. Both the ECA and the road density are low in this sub-basin.

Surface erosion effects rank as moderate because of the high density of stream crossings. There are sections of steep road grades and eroding ditches on the Cameron Main road in this sub-basin; a moderate ranking for erosion effects is appropriate.

Riparian effects rank as high because of extensive past logging of streams, including the Cameron River channel. The Cameron channel banks through this sub-basin are not susceptible to erosion, and large wood debris would have minimal function for most of the channel length (boulder step-pool and boulder cascade-pool morphology). Riparian effects here are less significant than for more sensitive channel reaches.

Landslide effects rank as high; this is due to values for road length and areas logged on Es1 and Es2 terrain. The occurrence of natural and logging-related slides is low.

Headwater effects rank as low, reflecting the lack of logging in steep upper stream reaches.

8.6 Unnamed Creek -- Sub-basin 2

Peak flow effects rank as moderate. The ECA in this basin is low, road densities are high. Surface erosion effects rank as high because of a high road density and a very high density of stream crossings. As well, there are eroded gullies and trails. Although the rate of sediment production has slowed in this sub-basin, erosion continues to be a management concern.

Headwater effects rank as moderate because of a high density of stream crossings on steep slopes. (This sub-basin has a high drainage density.)

Riparian effects rank as high because of extensive logging of stream channels. The main channel has experienced bank erosion, sediment aggradation and channel widening; the erodible channel reaches have not yet stabilized.

Landslide effects rank as high because of a high occurrence of natural landslides and because of values for road length and area logged on Es1 and Es2 terrain. The density of post-logging landslides is low, but failures are concentrated on the C200 and CE10 roads. There have also been erosion events in gullies and avalanching large rock fills. Stability on the C200 and CE10 roads is worthy of review.

8.7 Cop & Henry Creeks -- Sub-basin 3

Peak flow effects rank as moderate because of a high road density. The ECA is low.

Surface erosion effects rank as high because of the high road density and a high density of stream crossings. There are some sections of steep road grades in this basin and high cuts in deep tills and colluvial deposits. Because of the old road construction standards, considerable fill material was spilled into the channels at some stream crossings (such as the Henry Creek crossing on the C100 road – Field Stop #10). As well, there are some eroded gullies and trails.

Riparian effects rank high because of logging of stream channels. The main channel is incised and does not have erodible channel banks. A few small sloughs have occurred in the logged gully sides above the channel. Wood debris likely did not have a functional role in most of the channel (steep, high energy, boulder step-pool morphology). Riparian effects in this sub-basin are not as significant as for other more sensitive stream channels.

Landslide effects rank high because of values for road length and area logged on Es1 and Es2 terrain. There are no natural landslides in this basin and the occurrence of logging-related slides is low. However, some individual events had a substantial impact on the channel. Sediment entering the Cop or Henry Creek channnels is delivered rapidly to the Cameron mainstem, as occurred in one documented debris torrent (1986) that initiated from a spur off the C100 road and was estimated by DFO to have a final volume exceeding 200,000 m^3.

Headwater effects rank low.

8.8 Unnamed Creek – Sub-basin 4

Peak flow effects rank as moderate; the ECA is in the moderate range and the road density is high.

Surface erosion effects rank high because of the high road density and a high density of stream crossings. There are many sections of steep road grades in deep soils; there are also numerous steep access and backspar trails not mapped as roads. The main channel is aggraded for much of its length. The main source of sediment appears to be from erosion of roads, trails and crossings; and from some sloughs in the adjacent logged gully sides. While the rate of sediment production has declined in recent years, thick sediment is still apparent in the channel and erosion continues to be a management concern in this sub-basin.

Riparian effects rank high because of extensive logging of creek channels including the full length of the mainstem. The channel is an incised, fairly steep gradient stream with no fish values. The main concern with this stream is delivery of sediment to the Cameron River channel.

Landslide effects rank high in this basin because of values for road length and areas logged in Es1 and Es2 terrain. There are no natural slides and the frequency of logging-related slides is low. Landslide effects are overestimated.

Headwater effects rank low.

9.0 SUMMARY OF KEY FINDINGS

Cameron Lake functions as a settling basin for most sediment entering the lake. During periods of high lake turbidity, fine suspended (clay-sized) sediment passes through the lake into the Little Qualicum River.

9.1 Cameron Lake Slopes

This area is in generally good condition. North side slopes have not been logged and there is minimal development along the north side. There has been a rockslide from above the railway that entered the north side of the lake.

The south shore of the lake is buffered by the park that extends along the shore. Impacts along the shoreline would be at sections where the highway encroaches. Slopes above the park have been logged; there are no logging related slides and there is minimal sediment production from the logged areas.

9.2 McBey Creek -- Basin 5

This basin is in generally good condition. There are no post-logging slides, and sediment production from past logging is minimal. There are natural slides; the occurrence is infrequent but sediment from these has reached the Little Qualicum River. Current sediment production from existing natural slide tracks is minimal.

There has been a loss of large wood debris in the low-gradient reaches above the Little Qualicum confluence. Channel banks have revegetated since logging of the riparian zones but the second growth is not yet large enough for large wood recruitment by the stream.

9.3 Lockwood Creek -- Basin 6

There is a high density of stream crossings in this basin, one natural landslide and four logging-related landslides.

Impacts have been:

- sediment aggradation in the Lockwood channel from landslides off roads and from erosion and fill sloughing at stream crossings;
- loss of large wood debris in the low-gradient reaches of Lockwood Creek.
- introduction of sediment to the Little Qualicum River channel, mostly following the slide events from roads.

The area was mostly logged more than 15 years ago and second growth is well advanced. Sediment production is significantly reduced, channel banks have revegetated, and the extent of sediment aggradation in the creek channel has diminished. At present, the residual impacts are minor aggradation in the creek channel and lack of large wood debris in the low gradient reaches.

9.4 Cameron River Basin

This basin was logged extensively in the 1960's and '70's. As a result of logging and road building practices of that time the Cameron River channel was severely impacted by:

- sediment aggradation from torrents in logged gullies, slides off roads, and erosion of roads, trails and yarding tracks;
- large debris jams that promoted channel scour, flow diversion and channel instability;
- logging of riparian zones in sensitive alluvial reaches that caused channel bank erosion, channel widening, sediment aggradation, channel instability, and loss of functioning large wood debris in the channel structure.

With a decline in logging activities since that period, sediment production has dropped sharply, much of the second growth is now 20 - 30 years old, and recovery is taking place. Sediment loads and debris jams in the channel have diminished. Residual impacts that are currently apparent in the Cameron River channel are as follows:

- Partial to moderate aggradation in the lower channel (Reach 1 -- up to 3.39 km); accumulations of wood debris within the park, especially along side channels; channel instability at the vicinity of the boundary between the park and private land; channel bank erosion at logged sections.
- Bank erosion, channel widening and sediment aggradation at two short sections of Reach 6 (13.7 - 14.0 km and 14.9 - 15.0 km).
- Moderate to severe aggradation in Reach 7 (15.51 - 21.08 km), bank erosion, channel widening, loss of functioning large wood debris. Channel banks have not yet stabilized.

Channel erosion and aggradation are apparent along low gradient reaches of Stream 2. There is a concentration of slides from the C200 and CE 10 roads in Sub-basin 2.

Thick channel sediments are apparent in the Stream 4 channel.

10.0 RECOMMENDATIONS FOR WATERSHED MANAGEMENT

To provide an overall management strategy I have made recommendations for the total study area including private lands, even though these recommendations will only be applied in TFL 44 and other crown forest lands.

10.1 Terrain Stability

Despite past logging methods in the older logged areas that did not take into account terrain stability, there is a low frequency of logging-related landslides throughout the study area. Of the slides that have occurred, the large majority are from roads and some of these had a severe impact on the Cameron River channel. There is a very low potential for clearcut failures in either Class IV or Class V terrain. Given the history of terrain performance in this area, I recommend the following approach to management of terrain stability:

- Carry out terrain stability field assessments of all proposed road locations on Class IV or Class V terrain.

- Carry out terrain stability field assessments of all cutblocks proposed on Class V terrain, and in Class IV terrain where gullies are present within the proposed cutblock.

10.2 Cameron Lake Slopes

The main management concern in this area is the slope above the park on the south side of the lake, where logging roads switchback up some steep slope sections. This area is mostly private land. The roads are currently inactive and becoming overgrown.

When these roads are reactivated for use in future, road drainage systems should be assessed and upgraded to control sediment production from erosion of steep ditches and road surfaces.

10.3 McBey Creek -- Basin 5

The lower part of this basin is also in private land. Riparian buffers should be preserved along the channel during future logging of the second growth. Normal good practices for erosion control and properly armoured stream crossings should apply throughout the basin.

10.4 Lockwood Creek -- Basin 6

Many of the road systems in this basin are also overgrown and inactive. The main management concern would for steep road sections that have experienced slides, and the high density of stream crossings. Many of these are on private land.

I recommend assessing the stability of road sections that have experienced slides and the condition of the stream crossings to determine what remedial work may be required.

Future logging of the second growth should preserve riparian buffers along the main channel.

10.5 Cameron River Basin

The primary objective in this basin should be to ensure the continuing recovery of the Cameron River channel and its tributaries. Of specific concern are erosion of logged channel banks and sediment delivery to the channels. Channel bank erosion could be aggravated by increases in peak flows. Roads are the main source of sediment to the channels.

The channel in Sub-basin 1 (the headwater area of the Cameron mainstem) has a low potential for bank erosion and is not sensitive to peak flow effects. The stream here is fish bearing and there is a concern for sediment delivery to the channel. This upper part of the river is fairly high energy; there is also a concern for delivery of sediment and possible peak flow increases to the unstable channel sections in Reach 7 downstream of this sub-basin.

Sub-basin 2 has resident fish habitat in the lower reaches of this stream, and has alluvial reaches that have experienced aggradation and channel widening. The concerns in this basin are for impacts to these stream reaches, as well as delivery of sediment and increased flows to Reach 7 in the Cameron River downstream.

Sub-basin 3 (Cop and Henry Creeks) and Sub-basin 4 have no fish habitat. The concern is for sediment delivery, and possible peak flow increases at eroding channel sections in Reach 1 of the Cameron River downstream.

Roads

The Cameron River basin has a large road network with a legacy of old road construction standards, including old bridges and culverts, as well as numerous tracks and trails. Sediment production has declined as the trails and inactive roads become revegetated, but many of the old roads and trails are still clearly apparent on the 1994 airphotos. While the overall frequency of landslides from roads is not high, some road sections continue to be of concern. The active roads, especially mainlines, are of particular concern because these roads have the greatest potential to generate sediment.

There needs to be a specific strategy to manage roads, limit road densities and control erosion in this basin so as to minimize sediment input to the Cameron River channel.

In view of these considerations I propose the following approach:

1. The active mainline roads should be the highest priority for upgrading of crossing structures, unstable sections, and erosion control measures. Specific sites that should be assessed are the Yellow Creek crossing on the Cameron Main road, and the section of Cameron Main along the canyon from the watershed boundary near Yellow Creek to the Cop Creek crossing. Drainage measures and erosion control should also be reviewed on the Mount Arrowsmith ski road.

2. Stream crossings on other long-term roads should be the next priority for assessment and upgrading where needed. The Henry Creek crossing on the C100 Road in Sub-basin 3 should be included in these sites.

3. Old roads with landslides should be assessed to determine if remedial work is needed and feasible. The highest priority would be the CE10 and C200 roads in Sub-basin 2.

4. New road construction should be offset by debuilding and revegetating an equivalent length of existing road, so as not to increase the road densities. Roads for debuilding should be selected to give the most beneficial results, i.e., those that are still actively generating sediment or conducting water.

5. Erosion control should be a specific objective in this basin, for example:
    - seeding of exposed mineral soil on all cuts and fills. There has been considerable hydroseeding done in this basin but not all cuts and fills have been grassed. As well, high sloughing cuts do not seed successfully unless other measures to stabilize the cuts are taken first.
    - armouring of the inlet and outlet areas of culverts so that road fills do not erode or slough into the creeks.

- suitable measures (armouring, checkdams, etc) to control erosion of ditchlines on steep grades.
- prompt deactivation of roads with steep grades when they are not in active use.

With respect to actions to be taken during the term of the Forest Development Plan (1998 - 2001), stability and erosion concerns on the active haul roads should be addressed during the period covered by the FDP. As well, the equivalent length of new road construction should be debuilt and replanted during this time period. A plan to address problems on the other long term roads in the basin should be put in place.

<u>Rate of Cut</u>

Increased peak flow effects are of concern to the logged reaches of erodible channel banks that have not yet stabilized. The most extensive section is on Reach 7 of the Cameron River channel. There is also a significant section in the Sub-basin 2 stream, and short sections of logged channel banks in Reach 1 of the Cameron.

Until these channel sections have stabilized, the potential for peak flow effects from ECA's should be maintained in the low range. That is, the weighted ECA for the total Cameron basin and in each of the four sub-basins should not exceed 30%.

11.0 PROPOSED FOREST DEVELOPMENT PLAN

A summary of proposed cutblocks by year is in Appendix II. Harvesting and road construction in TFL 44 are planned only for the Cameron basin. Table I - C in Appendix I shows the rate of cut, ECA, and road density for each basin, sub-basin and the total study area in 2001 that would result from this Forest Development Plan. Harvesting plans for private land outside TFL 44 are unknown.

<u>Roads</u>

Some deactivation has been done in the Cameron watershed but, in view of the large number of unmapped access and backspar trails, I have not made any allowance for road deactivation in projecting future road densities.

The proposed road construction of 3.3 km over the life of the Forest Development Plan increases the road density in Sub-basin 1 from 1.2 to 1.3 km/km^2, but does not noticeably increase the road density in the total Cameron basin.

This level of road construction is minimal, however, given the high road density over the total basin, it would be desirable to debuild and revegetate an equivalent length of existing road.

<u>ECA</u>

The projected ECA's take into account recovery in the second growth forest as the trees grow. Because of the age of the second growth forest, recovery rates are quite rapid over most of the study area at the present time. Estimated rates of recovery for each basin are shown in Tables I - B and I - C in Appendix I.

The total cut proposed in the TFL 44 portion of the Cameron basin of 2.2% over five years is low. This level of cut allows the weighted ECA to decline over the total basin and in Sub-basins 3 and 4. The weighted ECA would increase in Sub-basin 1 from 9% to 10%, and in Sub-basin 2 from 12% to 14%. These ECA's are in the low range and well within the limits recommended for this basin.

Provided that a good strategy for controlling sediment from roads is implemented, the proposed Forest Development Plan would allow a continuing recovery of this basin.

Glynnis Horel

Glynnis Horel, P. Eng.
Geological Engineer

FEB. 25/98

Table I - A

CWAP DATA -- CAMERON WATERSHED

17-Feb-98

Data to end 1997		Total Watershed	Score	McBey Ck Basin 5	Score	Lockwood Ck Basin 6	Score	Cameron Lk Remainder	Score	Cameron River Basin	Score
Area	ha	15818		1091		1429		2081		11217	
	km^2	158.18		10.91		14.29		20.81		112.17	
Peak Flow Effects											
2. Weighted ECA	ha	2921		82		320		195		2324	
	%	18%	0.3	8%	0.2	22%	0.4	9%		21%	0.4
3. Road length	km	321		10		28		16		268	
Road density	km/km^2	2.0	0.7	0.9	0.3	2.0	0.7	0.8		2.4	0.8
Surface Erosion Effects											
4. Road density	km/km^2	2.0	0.7	0.9	0.3	2.0	0.7	0.8		2.4	0.8
5. Mainline road within 100 m	km	14		0		1.7		0.3		12	
of stream	km/km^2	0.09	0.3	0	0	0.12	0.3	0		0.11	0.3
6. Stream crossings	no.	445		4		33		10		398	
	no./km^2	2.8	1.0	0.4	0.2	2.3	1.0	0.5		3.5	1.0
Landslide Effects											
7. Natural landslides	no.	54		5		1		9		39	
	no./km^2	0.34	0.2	0.46	0.3	0.1	0.1	0.43		0.35	0.2
8. Post-logging landslides	no.	42		0		4		1		37	
	no./km^2	0.27	0.1	0	0	0.28	0.2	0.05		0.33	0.2
Landslides from roads	no.	38		0		4		1		33	
Slides -- open slopes & gullies	no.	4		0		0		0		4	
9. Large landslides terminating	no.	1	0.3	0	0	2	0.5	0		2	0.5
in mainstem stream	no./km^2	0.01		0		0.14		0		0	
10. Road length on Es1 and Es2	km	52		0		1.6		3.5		47	
or 60% slopes.	km/km^2	0.33	0.9	0	0	0.11	0.4	0.17		0.42	1.0
11. Area Es1 and Es2 logged	ha	1440		6		63		118		1253	
or 60% slopes	%	9%	0.9	0.6%	0.1	4%	0.4	6%		11%	1.0
Riparian Effects											
Stream length	km	336		26		32		12.2		266	
Drainage density	km/km^2	2.1		2.3		2.2		0.6		2.4	
12. Stream logged	km	173		1.7		17.4		6.7		148	
	%	52%	1.0	7%	0.3	54%	1.0	55%		55%	1.0
Mainstem stream length	km	34.0		1.2		5.0		0.6		33.4	
13. Mainstem stream logged	km	23.9		1.0		3.2		0.6		17.8	
	%	70%	1.0	83%	1.0	64%	1.0	100%		53%	1.0
Fisheries stream length	km	44		1.2		5.0		0.6		38	
14. Fisheries stream logged	km	32		1.0		3.2		0.6		27	
	%	72%	1.0	83%	1.0	64%	1.0	100%		72%	1.0
Headwater Effects											
15. Stream crossings on slopes	no.	34		2		3		2		27	
>60%	no./km^2	0.21	0.2	0.18	0.2	0.21	0.2	0.10		0.24	0.3
16. Streams logged on slopes	km	18		0.06		1.5		1.38		14.5	
>60%	km/km^2	0.11	0.4	0.01	0.1	0.11	0.4	0.07		0.13	0.5

Notes: In McBey and Lockwood creeks, fisheries stream length is assumed to be the same as mainstem length.
The post-logging slide in Cameron Lake remainder is actually a rockslide at the railway.
The highway and railway are excluded from road lengths. Data outside MB's area are taken from TRIM maps and airphotos.
ECA's outside MB's area are estimated based on similar-appearing MB stands of known age.

Table I - A

CWAP DATA – CAMERON RIVER BASIN

17-Feb-98

Data to end 1997		Labour Day Lk Sub-basin 1	Score	Unnamed Sub-basin 2	Score	Cop Creek Sub-basin 3	Score	Unnamed Sub-basin 4	Score	Remainder	Score
Area	ha	2303		1114		904		1139		5757	
	km^2	23.03		11.14		9.04		11.39		57.57	
Peak Flow Effects											
2. Weighted ECA	ha	208		139		213		340		1424	
	%	9%	0.2	12%	0.2	24%	0.4	30%	0.5	25%	
3. Road length	km	27.5		31.0		23.3		30.5		155.2	
Road density	km/km^2	1.2	0.4	2.8	1.0	2.6	0.9	2.7	0.9	2.7	
Surface Erosion Effects											
4. Road density	km/km^2	1.2	0.4	2.8	1.0	2.6	0.9	2.7	0.9	2.7	
5. Mainline length within 100 m of	km	3.0		0.2		0.24		0		8.36	
stream	km/km^2	0.13	0.4	0.02	0.1	0.03	0.1	0	0	0.15	
6. Stream crossings	no.	57		87		14		36		204	
	no./km^2	2.5	1.0	7.8	1.0	1.5	0.8	3.2	1.0	3.5	
Landslide Effects											
7. Natural landslides	no.	15		18		0		0		6	
	no./km^2	0.65	0.4	1.62	0.8	0	0	0	0	0.10	
8. Post-logging landslides	no.	2		9		5		4		17	
	no./km^2	0.09	0.1	0.81	0.4	0.55	0.3	0.35	0.2	0.30	
Landslides from roads	no.	1		8		5		4		15	
Slides – open slopes & gullies	no.	1		1		0		0		2	
9. Large landslides terminating	no.	0	0	0	0	0	0	0	0	2	
in mainstem stream	no./km^2	0		0		0		0		0.0	
10. Road length on Es1 and Es2	km	6.3		7.4		7.0		4.1		22.5	
	km/km^2	0.28	0.8	0.66	1.0	0.77	1.0	0.36	1.0	0.39	
11. Area Es1 and Es2 logged	ha	203		167		183		69		631	
	%	9%	0.9	15%	1.0	20%	1.0	6%	0.6	11%	
Riparian Effects											
Stream length	km	57.1		43.5		13.0		26.5		126.3	
Drainage density	km/km^2	2.5		3.9		1.4		2.3		2.2	
12. Stream logged	km	23.4		29.6		7.6		15.2		71.9	
	%	41%	1.0	68%	1.0	58%	1.0	57%	1.0	57%	
Mainstem stream length	km	12		5.6		2.1		4.7		21.3	
13. Mainstem stream logged	km	7.3		5.6		2.1		4.7		10.5	
	%	61%	1.0	100%	1.0	100%	1.0	100%	1.0	49%	
Fisheries stream length	km	9.4		0.8		0.1		0.0		27.2	
14. Fisheries stream logged	km	8.3		0.8		0.1		0		18.0	
	%	89%	1.0	100%	1.0	100%	1.0	0%	0.0	66%	
Headwater Effects											
15. Stream crossings on slopes	no.	3		9		0		1		14	
>60%	no./km^2	0.13	0.1	0.81	0.8	0	0.0	0.09	0.1	0.24	
16. Streams logged on slopes	km	1.3		1.9		0.3		0.9		10.2	
>60%	km/km^2	0.06	0.2	0.17	0.6	0.03	0.1	0.08	0.3	0.18	

Table I - B

CAMERON WATERSHED CHARACTERISTICS

15-Feb-98

Data to December 31, 1997		Total Watershed	McBay Basin 5	Lockwood Basin 6	Cameron L. Remainder	Cameron River Basin upstream of Cameron Lake: Total Basin	Labour Day L. Sub-basin 1	Unnamed Sub-basin 2	Cop/Henry Ck Sub-basin 3	Unnamed Sub-basin 4	Remainder
Area	ha	15818	1091	1429	2081	11217	2303	1114	904	1139	5757
	km^2	158.18	10.91	14.29	20.81	112.17	23.03	11.14	9.04	11.39	57.57
MB Area (TFL + private)	ha	12182	418	797	513	10455	2160	1108	904	920	5363
Forest Area (MB area only)	ha	9957	238	597	498	8623	1118	886	858	825	4937
(% of MB area)	%	82%	57%	75%	97%	82%	52%	80%	95%	90%	92%
Nonforest Area (MB)	ha	2226	179	199	15	1832	1043	222	46	95	426
TFL 44 area	ha	10109	411	54	264	9122	2160	1108	904	499	4452
MB private land outside TFL 44	ha	2073	7	465	249	1333	0	0	0	421	911
Parks	ha	1056	458	21	255	322	118	0	0	39	165
Elevation											
Maximum	m	1819	1679	1679	1260	1819	1605	1418	1361	1819	1819
Minimum	m	180	180	180	180	186	535	535	455	245	186
0 - 300 m zone	ha	1427	39	53	772	564	0	0	0	4	560
	%	9%	4%	4%	37%	5%	0%	0%	0%	0.3%	10%
300 - 800 m zone	ha	6098	115	469	795	4719	363	644	173	604	2936
	%	39%	11%	33%	38%	42%	16%	58%	19%	53%	51%
>800 m zone	ha	8293	937	907	515	5935	1940	471	731	532	2261
	%	52%	86%	63%	25%	53%	84%	42%	81%	47%	39%
Logging History											
Earliest Date of Logging		1890	1900	1900	1890	1891	1967	1965	1952	1923	1891
Area logged -- total	ha	7201	127	856	479	5740	613	693	447	677	3310
(% of total area)	%	46%	12%	60%	23%	51%	27%	62%	49%	59%	58%
last 5 years	ha	528	0.9	1.9	66	460	27	6	68	9	350
	%	3.3%	0.1%	0.1%	3%	4%	1%	0.5%	7%	1%	6%
last 10 years	ha	878	75	21.9	68	713	59	6	68	53	527
	%	6%	7%	1.5%	3%	6%	3%	0.5%	7%	5%	9%
last 20 years	ha	3136	76	527	379	2154	188	48	211	323	1384
	%	20%	7%	37%	18%	19%	8%	4%	23%	28%	24%
>20 years	ha	4065	51	329	100	3586	424	645	236	364	1926
	%	26%	5%	23%	5%	32%	18%	58%	26%	31%	33%
Unweighted ECA	ha	2423	81	264	175	1902	182	104	196	253	1167
	%	15%	7%	18%	8%	17%	8%	9%	22%	22%	20%
Weighted ECA	ha	2921	82	320	195	2324	208	139	213	340	1424
	%	18%	8%	22%	9%	21%	9%	12%	24%	30%	25%
ECA recovery - 5 yr. avg.	ha/year	183	5	26	10	143	16	7	15	32	74
Road length	km	321	9.8	28.1	15.7	268	27.5	31.0	23.3	30.5	155.2
Road density	km/km^2	2.0	0.9	2.0	0.8	2.4	1.2	2.8	2.6	2.7	2.7
Post-logging Landslides											
- From roads	no.	38	0	4	1	33	1	8	5	4	15
- From slopes or gullies	no.	4	0	0	0	4	1	1	0	0	2
TOTAL:	no.	42	0	4	1	37	2	9	5	4	17
	$no./km^2$	0.3	0	0.3	0.0	0.33	0.09	0.8	0.6	0.4	0.30

Notes: Date of oldest logging in nonMB areas estimated from oldest logging shown on nearby MB land.
Nonforest includes rock, slides, water, alpine, grassland, scrub, and industrial sites.
Roads exclude highway and railway. In Cameron R. basin, highway is 7.52 km. In Cameron L. area, highway is 6.05 km
Post-logging slide in Cameron L. is actually rockslide on railway, north side of lake.
ECA recovery in non-MB areas estimated from average ECA recovery in MB area for co mparable ages of logging.

Table I - C

CAMERON WATERSHED DATA PROJECTED TO END OF 2001

15-Feb-98

			McBey	Lockwood	Cameron L.	Cameron River Basin upstream of Cameron Lake					
Based on 1996 IR		Total Watershed	Basin 5	Basin 6	Remainder	Total Basin	Labour Day L. Sub-basin 1	Unnamed Sub-basin 2	Cop/Henry Ck Sub-basin 3	Unnamed Sub-basin 4	Remainder
Area	ha	15818	1091	1429	2081	11217	2303	1114	904	1139	5757
	km^2	158.18	10.91	14.29	20.81	112.17	23.03	11.14	9.04	11.39	57.57
MB Area (TFL44 & private)	ha	12182	418	797	513	10455	2160	1108	904	920	5363
Area logged -- total	ha	7406	127	856	479	5944	698	736	447	677	3387
(% of total area)	%	47%	12%	60%	23%	53%	30%	66%	49%	59%	59%
last 5 years	ha	522	0.7	0.0	60	462	110	43	66	0	243
	%	3.3%	0.1%	0.0%	3%	4%	5%	4%	7%	0%	4%
last 10 years	ha	761	0.9	21.9	66	673	112	48	68	9	436
	%	5%	0.1%	1.5%	3%	6%	5%	4.3%	7%	1%	8%
last 20 years	ha	2436	77	377	371	1612	192	58	144	285	932
	%	15%	7%	26%	18%	14%	8%	5%	16%	25%	16%
>20 years	ha	4970	51	479	108	4333	506	677	303	391	2455
	%	31%	5%	34%	5%	39%	22%	61%	34%	34%	43%
Unweighted ECA	ha	2019	60	178	139	1642	210	123	144	154	1012
	%	13%	6%	12%	7%	15%	9%	11%	16%	14%	18%
Weighted ECA	ha	2433	62	216	155	2000	234	160	153	204	1250
	%	15%	6%	15%	7%	18%	10%	14%	17%	18%	22%
ECA recovery - 5 yr. avg.	ha/year	183	5	26	10	143	16	7	15	32	74
Road length 1997	km	321	9.8	28.1	15.7	268	27.5	31.0	23.3	30.5	155.2
New construction 1998-2001	km	3.3	0.0	0.0	0.0	3.3	2.5	0.3	0.0	0.0	0.4
Road length at 2001	km	324	10	28	16	271	30	31	23	31	156
Road density at 2001	km/km^2	2.1	0.9	2.0	0.8	2.4	1.3	2.8	2.6	2.7	2.7

Notes:

No logging plan information is available for private land (McBey & Lockwood basins, the Cameron Lake slopes, private land within Cameron River basin).

Age of logging on nonMB land was assumed not to change age category up to 2001.

Table II - A

DEVELOPMENT PLAN SUMMARY 1998 - 2001

Cameron River Basin

Harvest Year	Cutblock Number	Basin	Cutblock Area By Elevation Band			Cutblock Area, ha	Weighted ECA	
			0 - 300m	300 - 800m	>800m		ha	%
1998	1830	1			7.6	7.6	7.6	
	2704	0		14.4		14.4	21.6	
					1998 Total:	**22.0**	**29.2**	**0.26%**
2000	1801	2		15.4	27.1	42.5	50.2	
	1805	1		9.5	8.2	17.6	22.4	
	1805A	1			10.1	10.1	10.1	
	1826	1			7.0	7.0	7.0	
	1826A	1			20.7	20.7	20.7	
	1875	1			22.2	22.2	22.2	
					2000 Total:	**120.1**	**132.5**	**1.18%**
2001	1705	0		9.2	21.6	30.8	35.4	
	2703	0		31.8		31.8	47.7	
					2001 Total:	**62.5**	**83.0**	**0.74%**
GRAND TOTAL 1998 - 2001:						**205**	**245**	**2.2%**

12-Dec-97

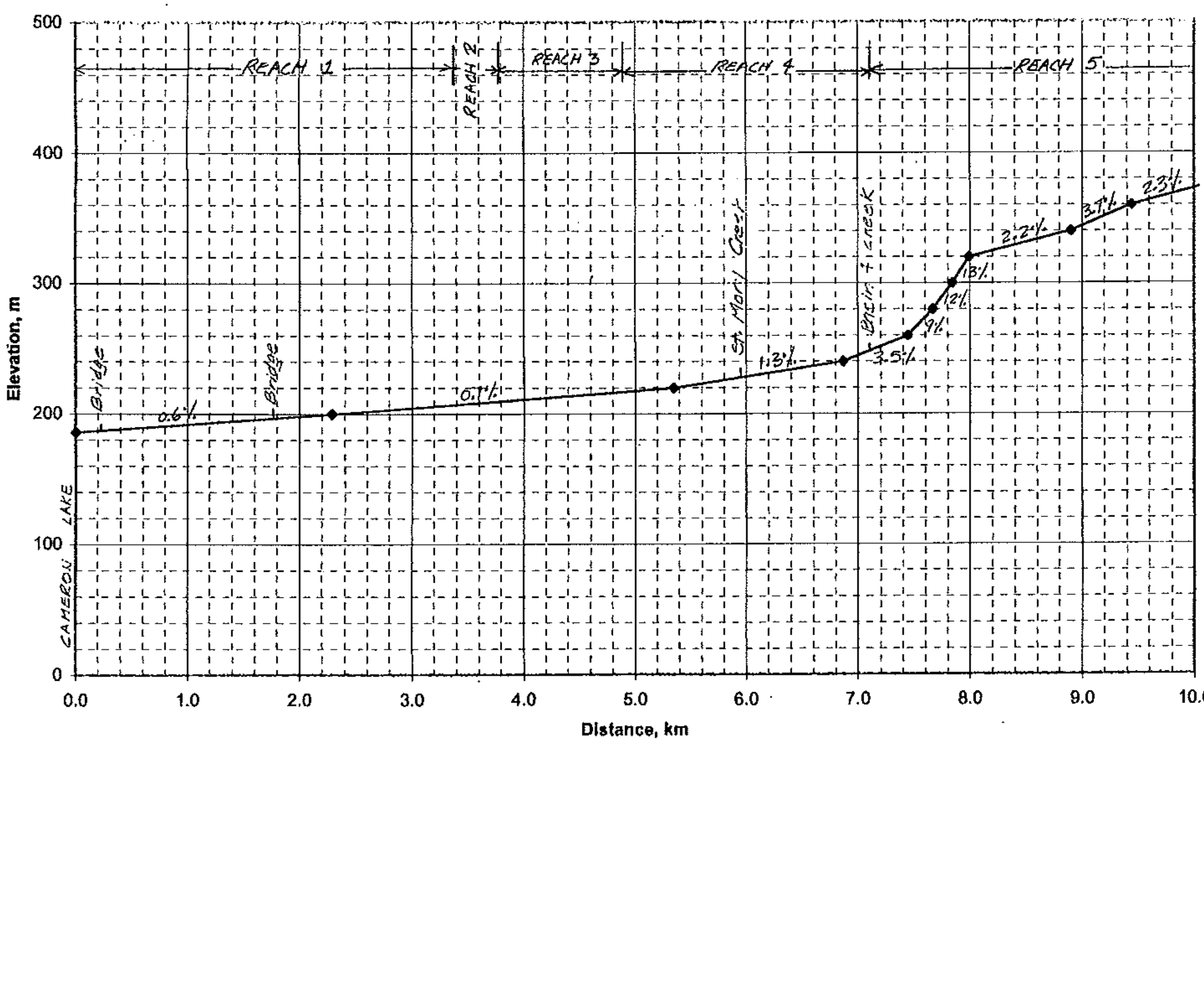
Table II - B
SUMMARY -- TOTAL PROPOSED HARVEST BY BASIN

Basin	Total Cut ha	Weighted ECA, ha	ECA , % of basin area
1	85.2	90.0	3.9%
2	42.5	50.2	4.5%
3	0.0	0.0	0.0%
4	0.0	0.0	0.0%
Remainder	76.9	104.6	1.8%
TOTAL:	204.6	244.8	2.2%

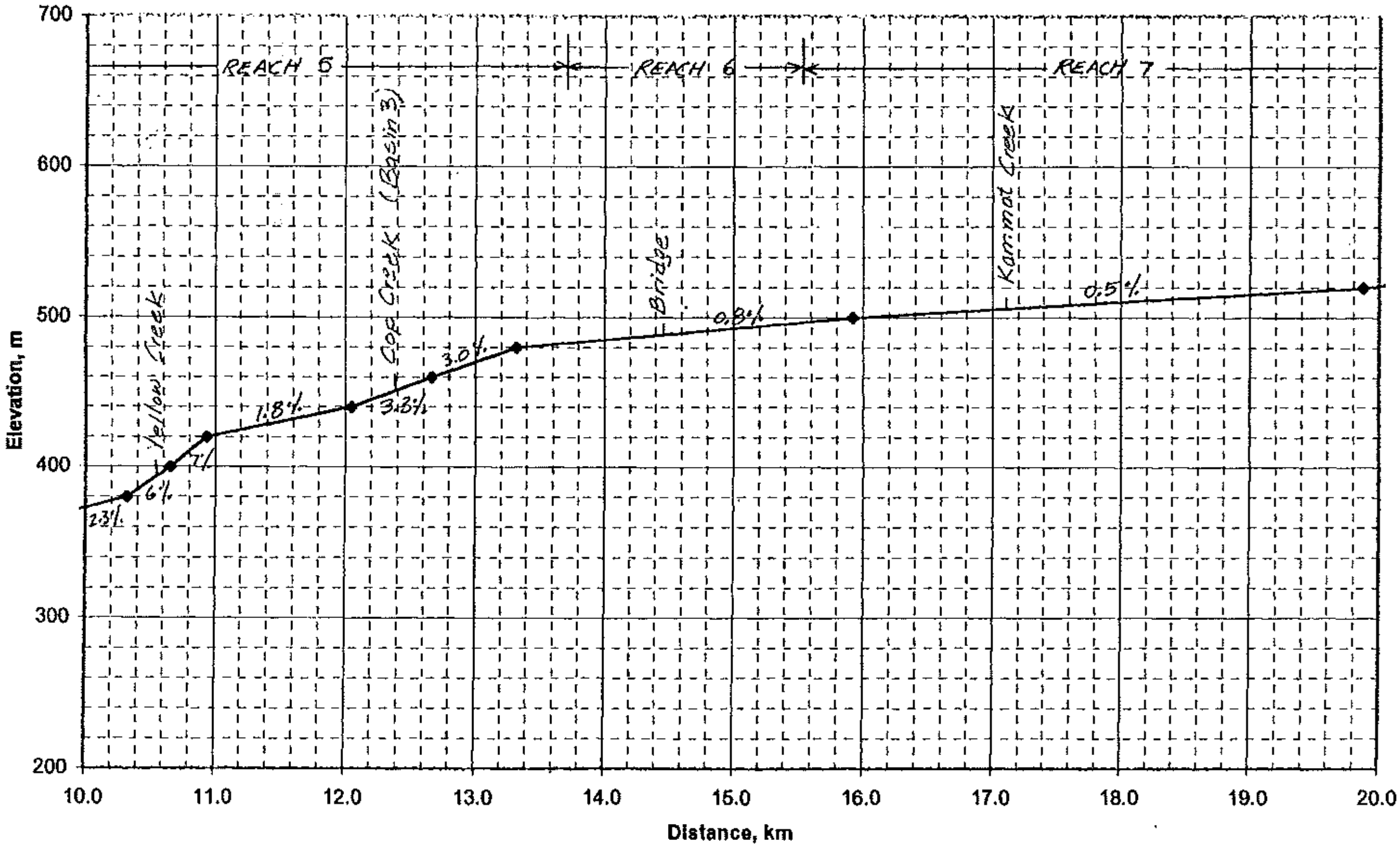
Basin 1 Upper Cameron valley
Basin 2 unnamed creek beside Cameron East road
Basin 3 Cop Creek/Henry Creek
Basin 4 unnamed - joins east side of Cameron River at the bottom of the canyon
Remainde main Cameron valley

Road Construction 1998 - 2001	
Basin 1	2.54
Basin 2	0.31
Basin 3	0
Basin 4	0
Remainder	0.41
Total:	3.25

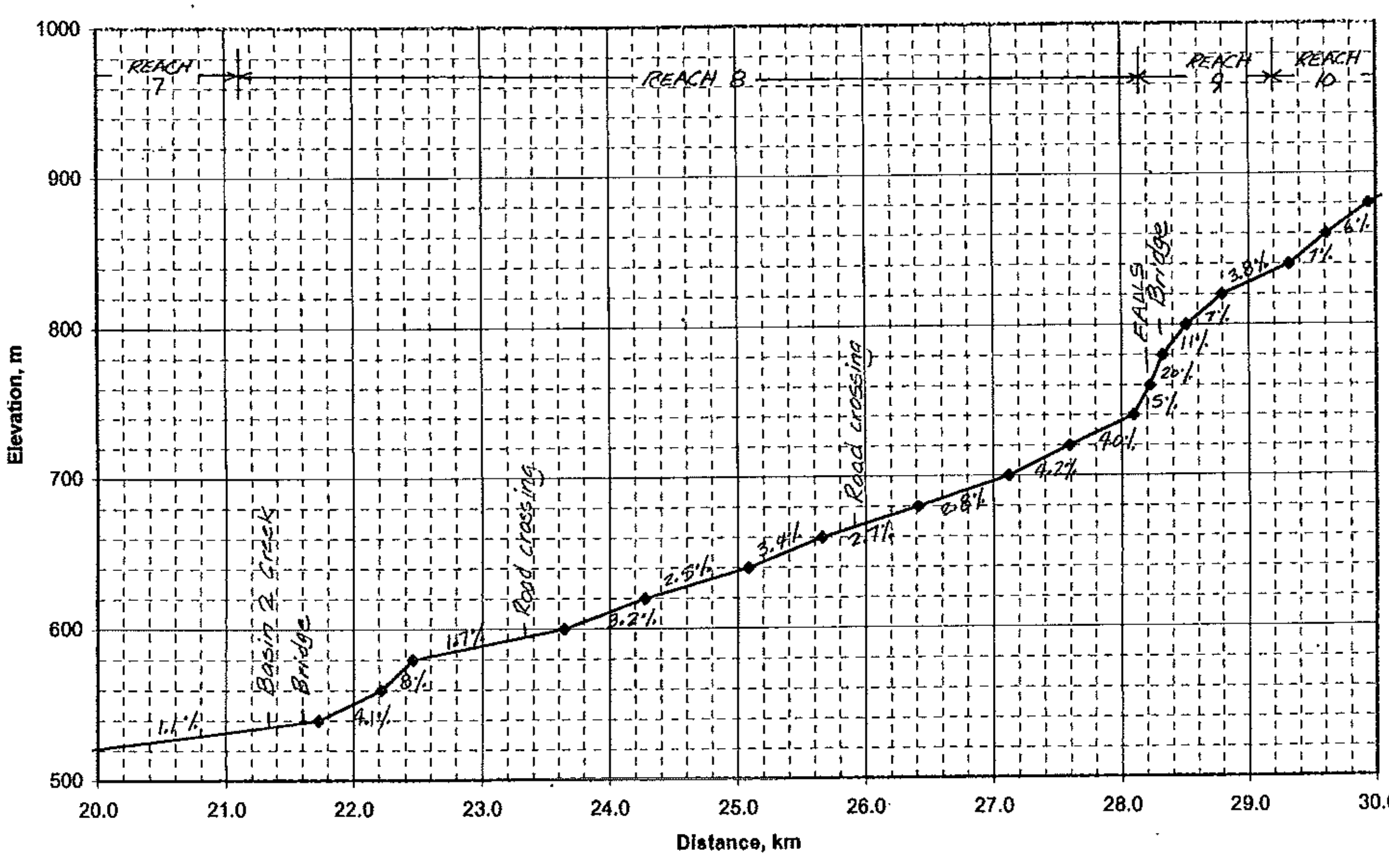
Cameron River Profile



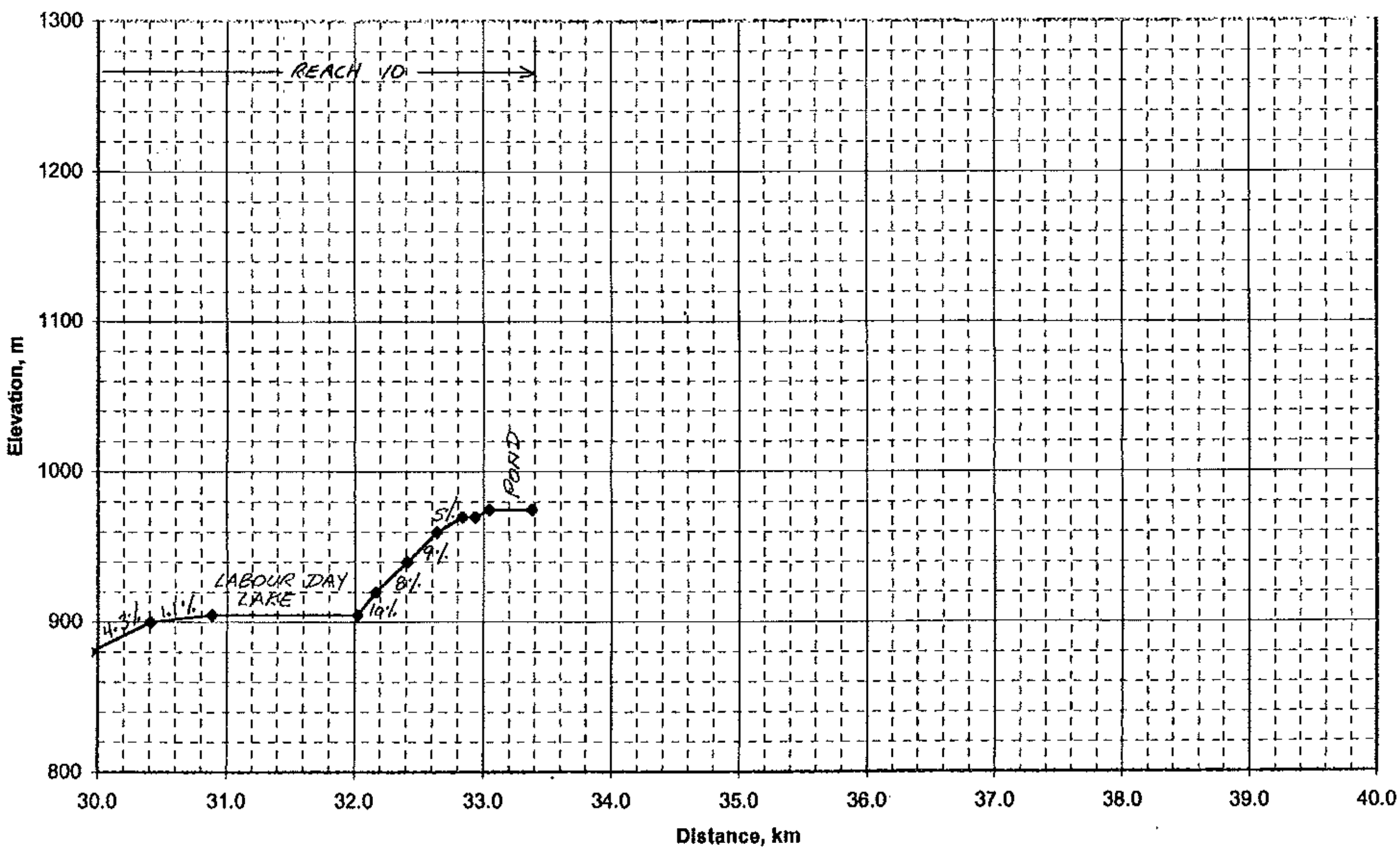
Cameron River Profile



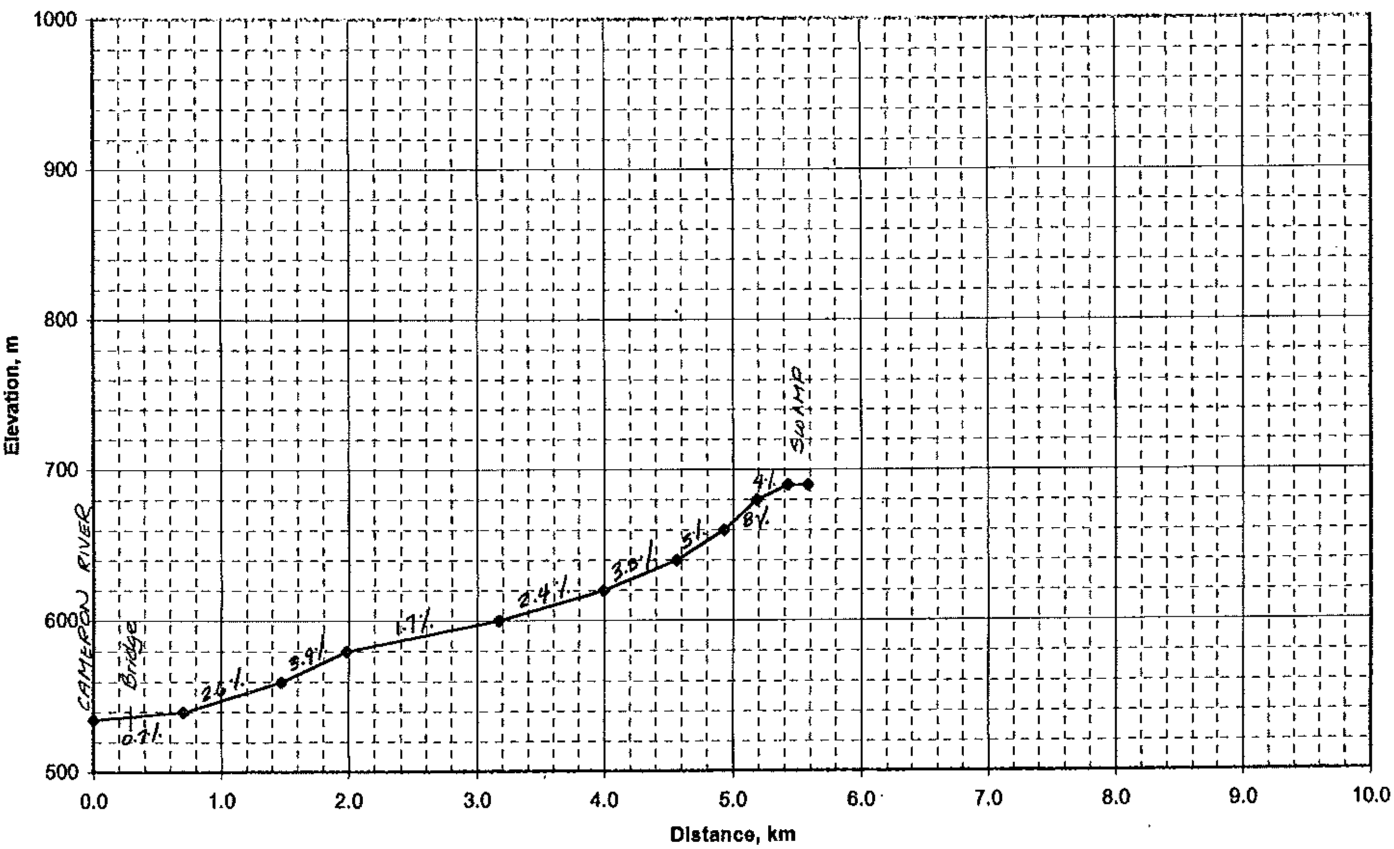
Cameron River Profile



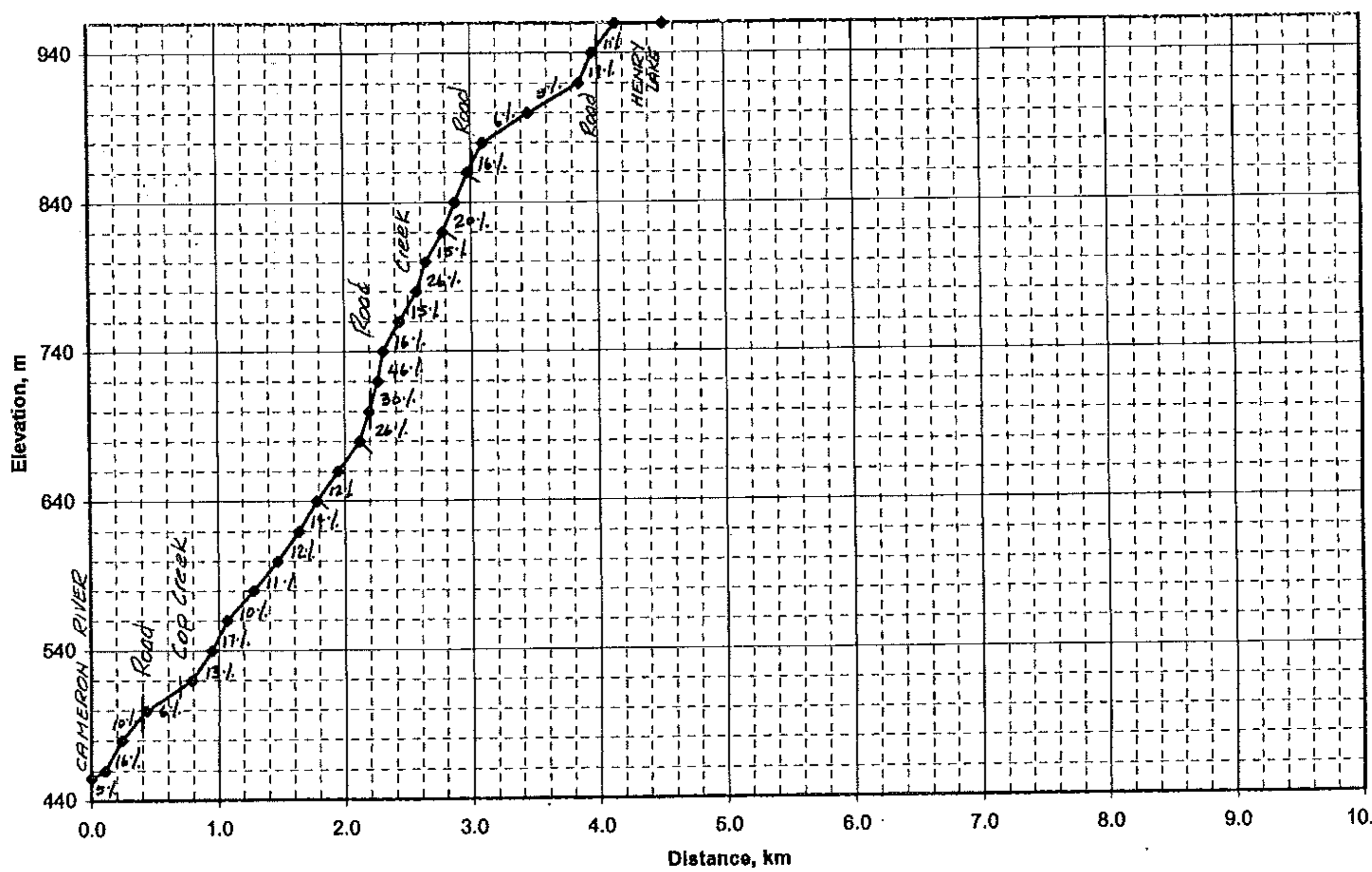
Cameron River Profile



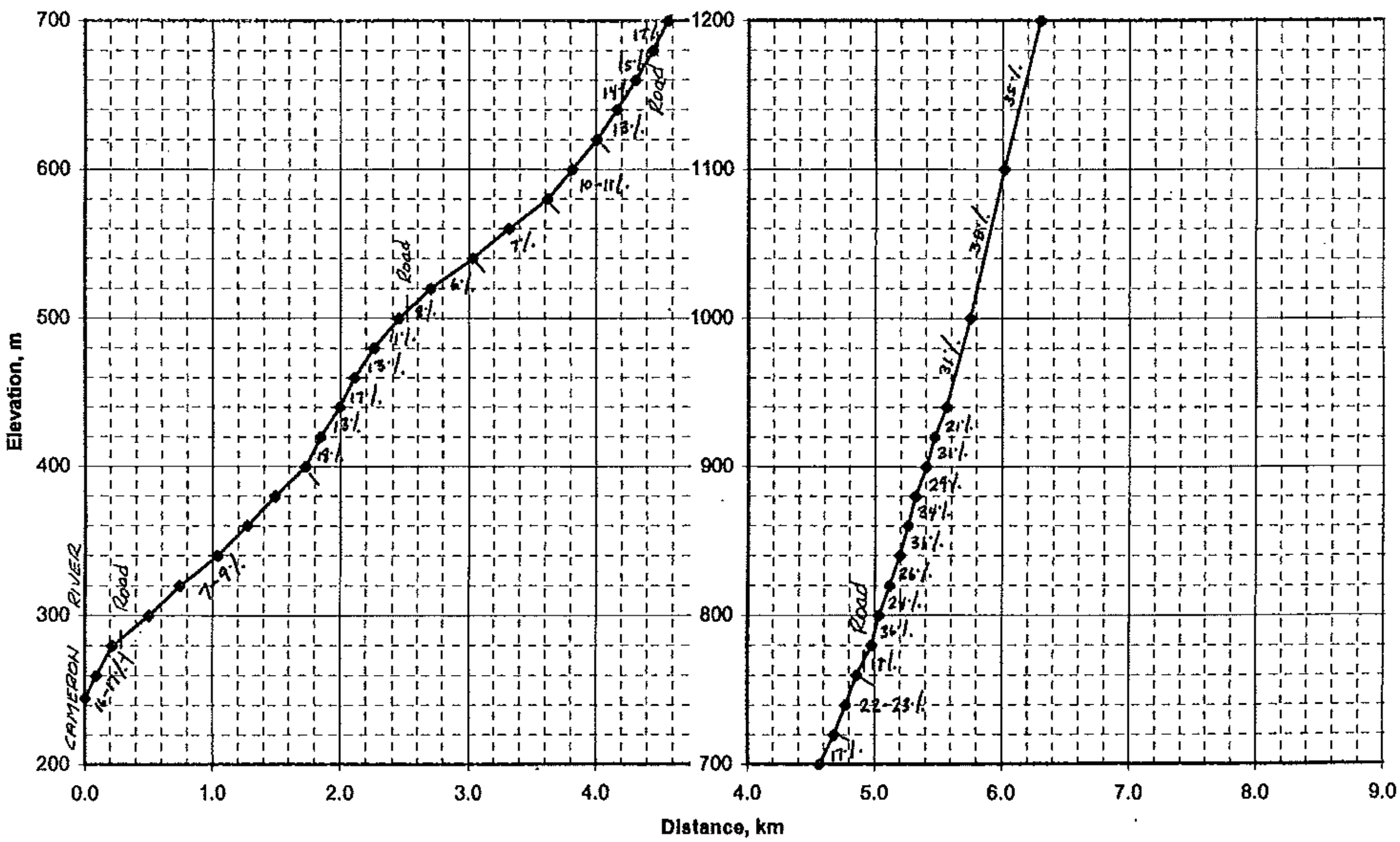
Profile -- Stream 2



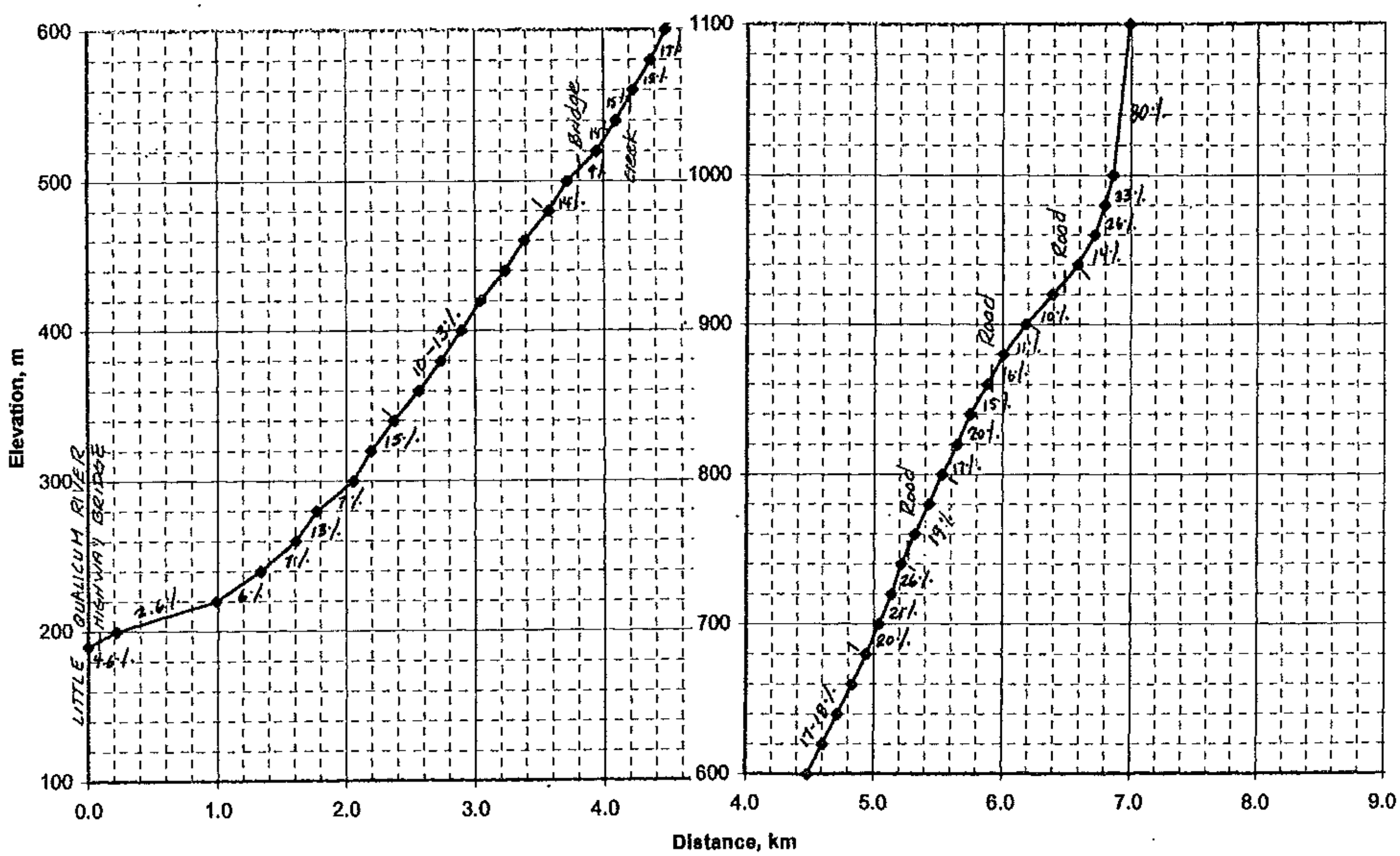
Henry Creek Profile



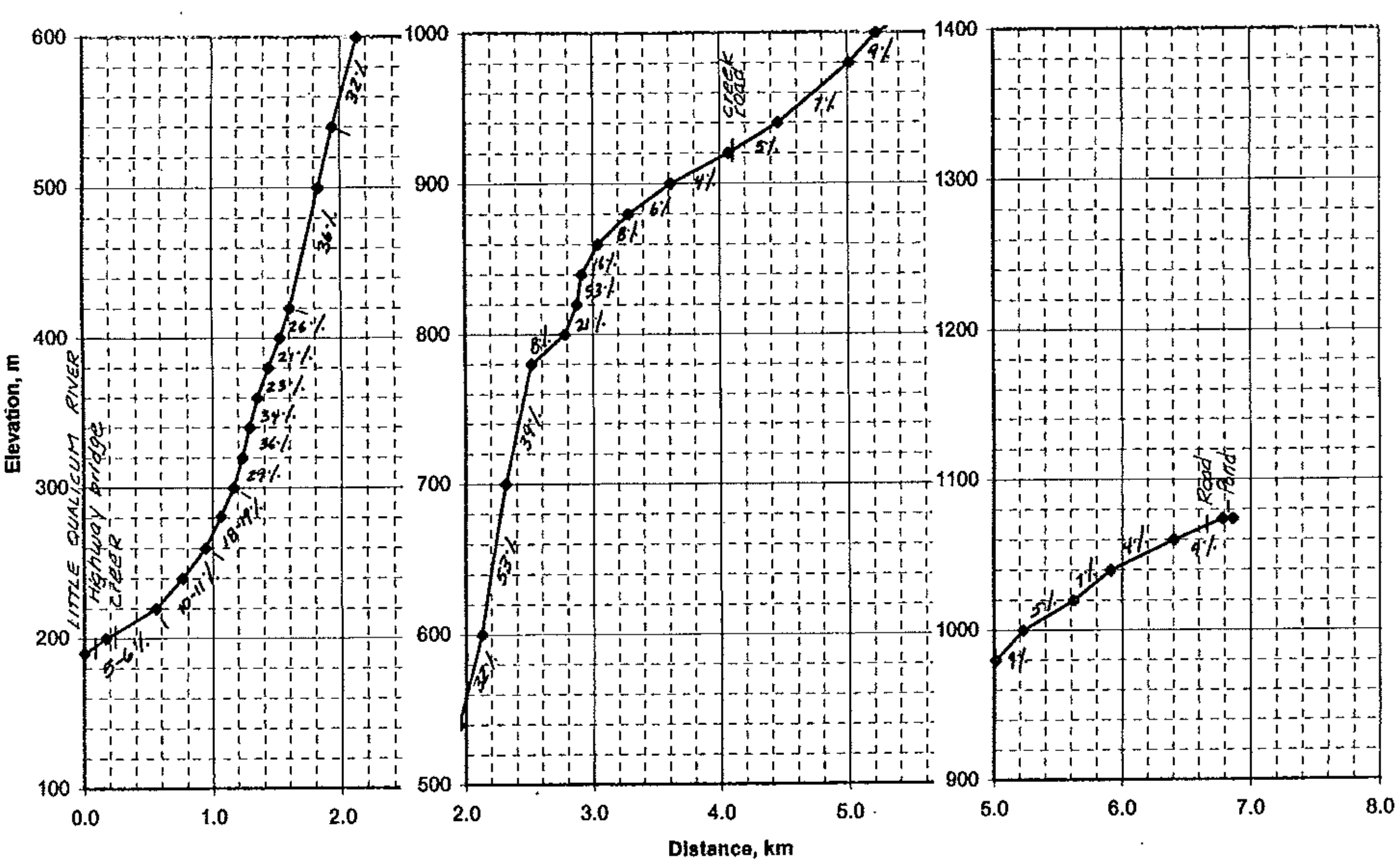
Profile -- Stream 4

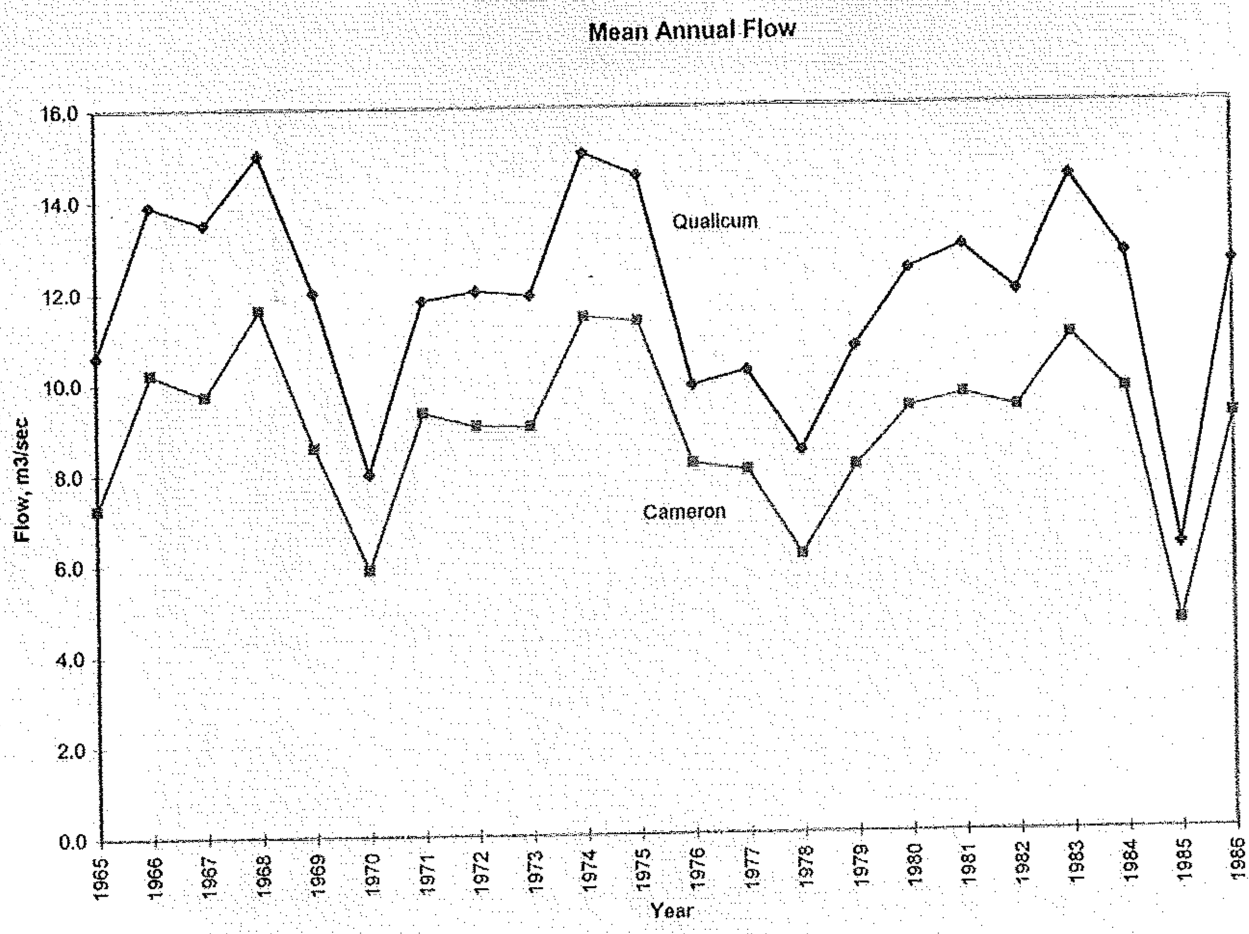


Lockwood Creek Profile



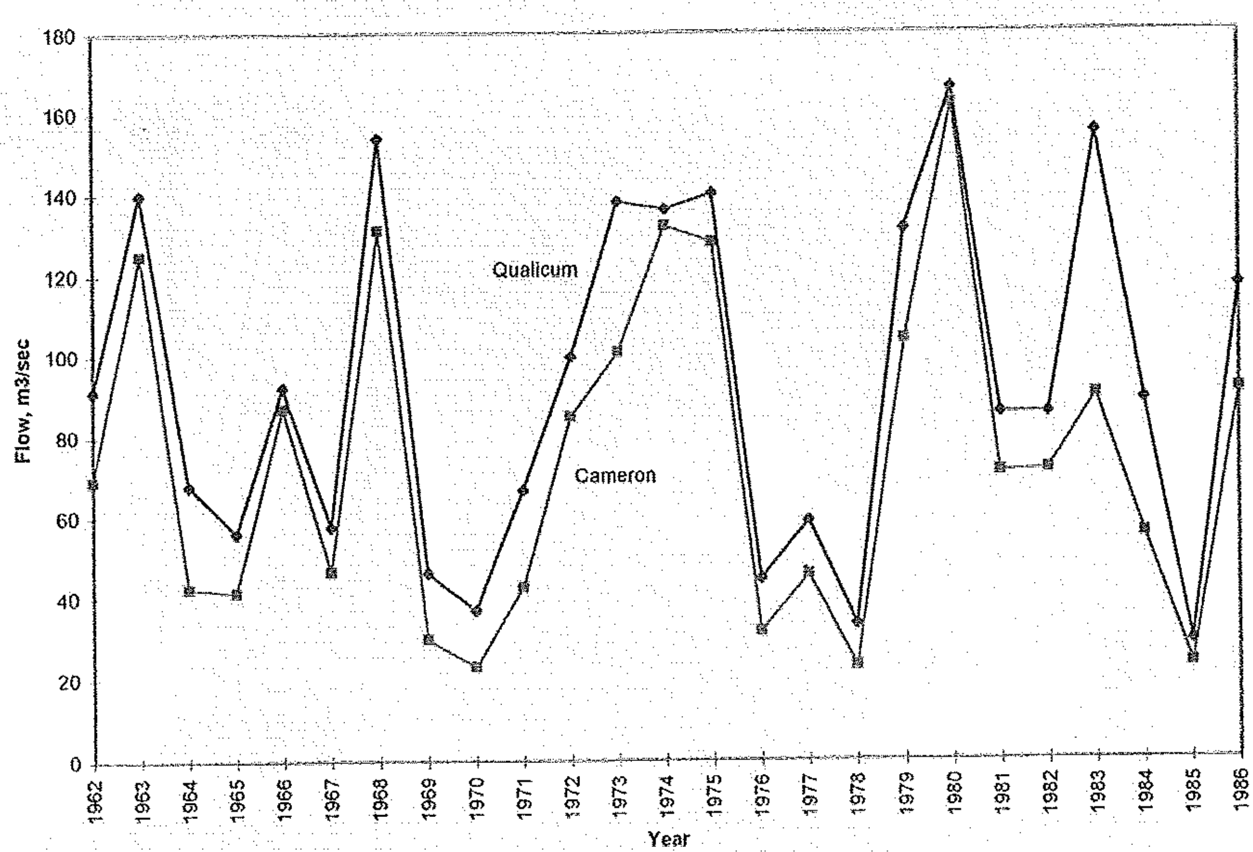
McBey Creek Profile



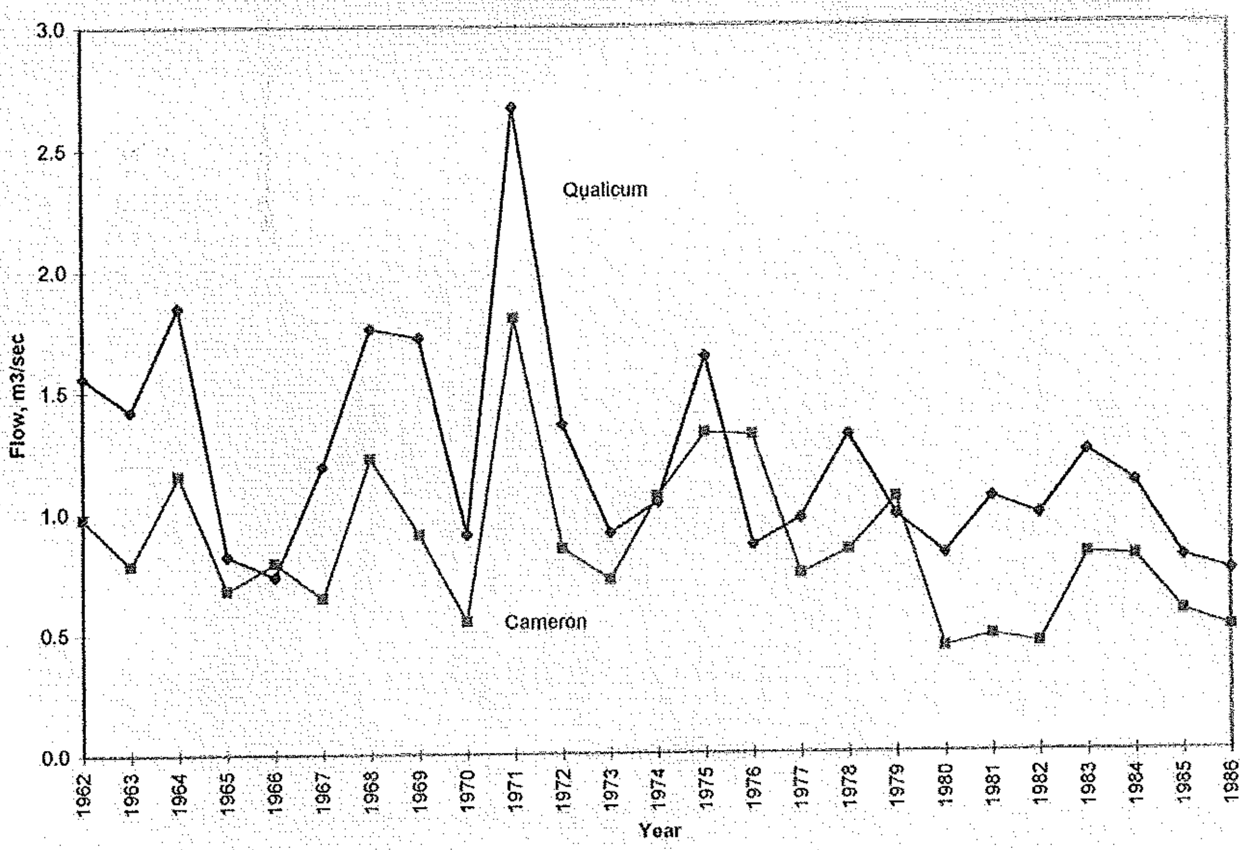


Mean Annual Flow
Qualicum
Cameron
Flow, m3/sec
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
Year

MAXIMUM DAILY FLOW

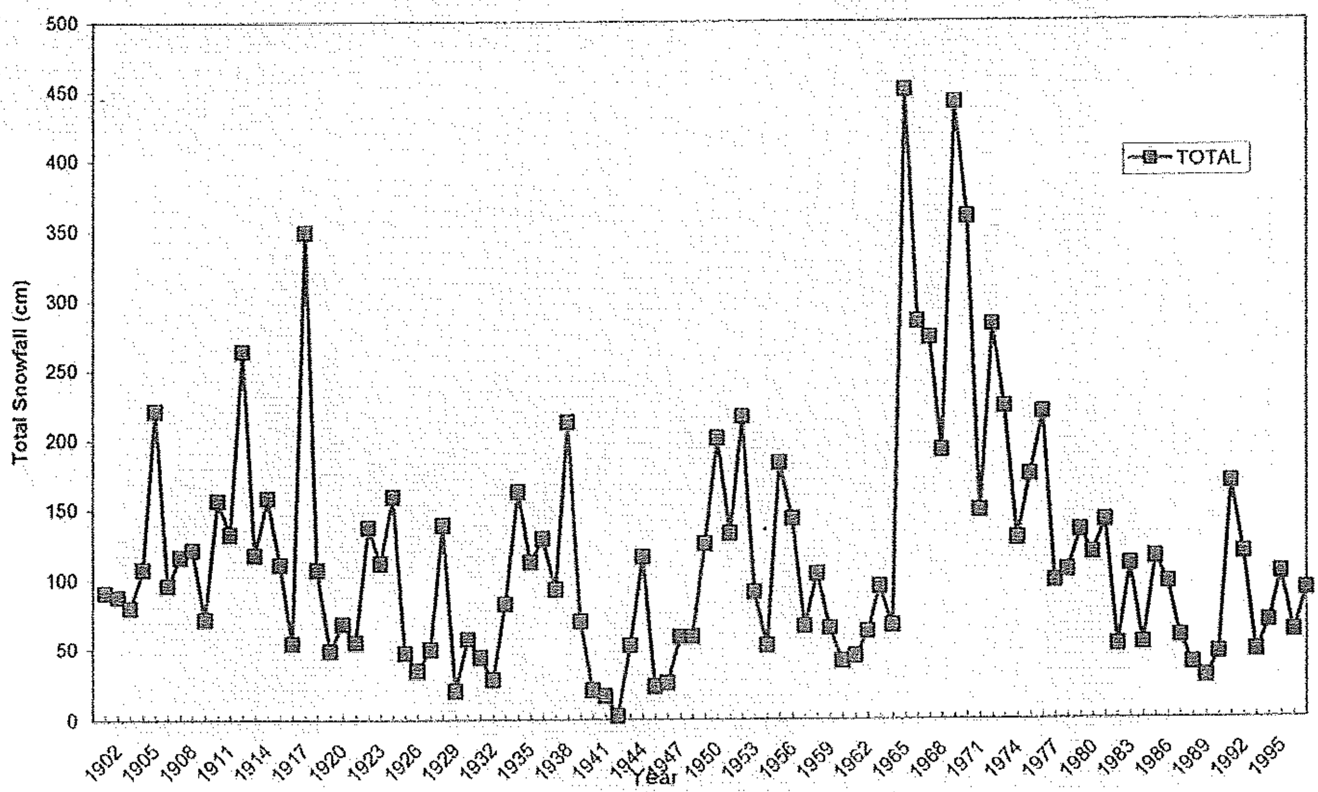


Minimum Daily Flows

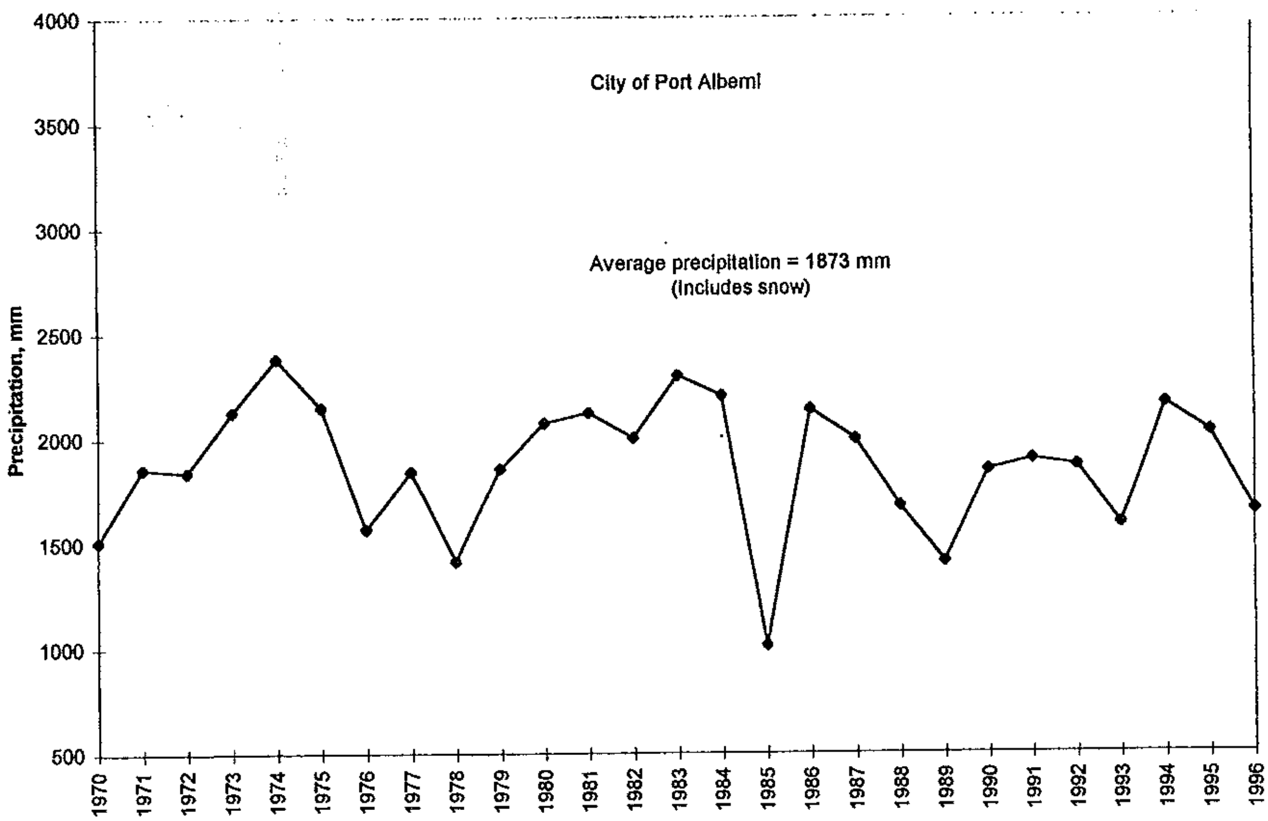


snow graph-yr

PORT ALBERNI - HISTORICAL SNOWFALL BY YEAR



Total Precipitation, 1970 - 1996



CAMERON WATERSHED ASSESSMENT
FIELD RECONNAISSANCE
SITE NOTES AND PHOTOGRAPHS
February 9 & 23, 1998

Left and right bank references are facing downstream. Distances indicated in the Cameron River basin are measured along the channel upstream from Cameron Lake. The weather during the field reconnaissance was cool and partly overcast.

STOP #1

Photographs: Plates 1, 2

Basin: Basin 6

Stream: Lockwood Creek

Location: Bridge at highway, just upstream of confluence with Little Qualicum River.

Stream width: 9 m (measured by hipchain across bridge); mean channel depth approx. 0.4 m.

Stream gradient: 4%

Channel type and condition: Cobble to boulder cascade pool, partially aggraded. Boulder lines apparent. Very sparse large wood debris, not functioning.

Description: Bed material is cobbles and boulders to max. 350 mm; mean 250 mm; minor gravel infilling. Riparian zone is second growth about 40 years old, mixed conifers and alder. There is a stepped concrete apron in the channel bottom below the railway bridge just downstream from the highway bridge. Channel position is stable; no significant bank erosion apparent.

Possible effects: With a low occurrence of natural landslides in this basin and few natural point sources of sediment, a stable channel morphology would be expected under natural conditions here, with stone lines and some functioning large wood debris. Probable impacts to the channel have been some sediment aggradation and loss of large wood debris.

STOP #2

Photographs: Plates 3, 4

Stream: Little Qualicum River

Location: Railway bridge beside highway just below confluence with McBey Creek.

Stream width: 18 m (measured by hipchain across bridge)

Stream gradient: 4%

Channel type and condition: Boulder cascade pool, partially degraded. Sparse large wood debris.

Description: Riparian zone is second growth approx. 40 years old, mixed conifers, some alder. No significant bank erosion apparent, channel position stable.

Possible effects: Partially degraded channel condition is natural condition here, from location downstream of lake. Some large wood debris would be expected along channel banks under natural conditions. Impacts here would be mainly loss of large wood debris.

STOP #3

Photographs: Plates 5, 6, 7

Basin: 5

Stream: McBey Creek

Location: Bridge at highway, just upstream of confluence with Little Qualicum River.

Stream width: 11 m at bridge, becoming narrower upstream (measured by hipchain across bridge).

Stream gradient: 6% U/S, 4% D/S

Channel type and condition: Boulder step-pool upstream, becoming boulder cascade-pool downstream. Partially aggraded. Stone lines apparent. Sparse large wood debris, not functioning.

Description: Bed material is boulders to max. size 400 mm dia., mean size approx. 350 mm. Minor gravel infilling. Riparian zone is second growth conifers and alder about 40 years old. There is a cobble bar just above the confluence with Little Qualicum River; the bar is mossy and stable with alders to about 100 mm dia. growing on it.

Possible effects: There are no logging related landslides in this basin; the mossy bar is probably the result of a natural landslide that entered the creek channel about 20 - 30 years ago. The partially aggraded channel condition here would be consistent with this natural event. This channel would be expected to have some functioning large wood debris under natural conditions. The main impacts here would be loss of large wood debris.

STOP #4

Photographs: Plate 8, 9

Stream: Little Qualicum River

Location: Bridge at campground, east end of lake.

Stream width: 19 m (measured by hipchain across bridge)

Stream gradient: <1%

Channel type and condition: Riffle pool, partially degraded (at lake outlet). Wood debris present (from large second growth) along banks; functioning.

Description: Near mature second growth riparian zone. Channel position stable.

Possible effects: At this location at the lake outlet there would be no sediment effects. With the advanced age of the second growth, recruitment of large wood debris is taking place although the amount and sizes have not yet reached natural levels. This is on private land with a campground adjacent to the channel; recovery of the riparian zone depends on activities and development along the channel.

STOP #5

Photographs: Plates 10, 11

Basin: Cameron remainder - 0

Stream: Cameron River side channel

Location: First highway bridge in park at west end of Cameron Lake.

Stream width: 22 m (measured by hipchain across bridge).

Stream gradient: <1%

Channel type and description: Gravel riffle-pool, moderately aggraded. Large wood debris present and functioning.

Description: Alluvial channel with erodible banks in gravel and silty sand. Channel bed and bars are gravel and sand. The riparian zone is old growth. Midchannel bars upstream of bridge are at bank height. Wood debris is present along the channel banks and on bars. Channel position is stable.

Possible effects: Channel banks are undisturbed and riparian zone is intact old growth (in park). The effect here of development in the basin upstream is sediment aggradation.

STOP #6

Photographs: Plates 12, 13

Basin: Cameron remainder - 0

Stream: Cameron River, main channel.

Location: Second highway bridge in park, west end of Cameron Lake.

Stream width: 27 m

Stream gradient: <1%

Channel type and condition: Gravel riffle pool, moderately aggraded. Large wood debris present and functioning.

Description: Alluvial channel with erodible channel banks, mainly gravel. Bed and bar material is predominantly gravel. Bars up to bank height are present. Stream has sinuous flow path within channel. Minor bank erosion is apparent. Channel position stable. Old growth riparian zone. Large wood debris along banks and on bars.

Possible effects: Banks are undisturbed and old growth riparian vegetation is intact. The impact at this location is sediment aggradation.

STOP #7

Photographs: Plates 14, 15

Basin: Cameron remainder - 0

Stream: Cameron River

Location: Bridge at 4.67 km (private land)

Stream width: 21 m (measured by hipchain across bridge)

Stream gradient: 1% approx.

Channel type and condition: Gravel to cobble riffle-pool, slightly aggraded. Sparse large wood debris along channel banks, partial function.

Description: Alluvial channel. Left bank is alluvial terraces. Right bank becomes partially confined downstream. Old growth riparian zone left bank. Riparian zone on right bank has been logged, leaving a fringe of old growth along channel bank. Channel bars below bank height.

Possible effects: Some sediment aggradation. There is large wood debris available from adjacent old growth; the relative scarcity of large wood debris at this location might be natural. The reach upstream is partially confined and stream velocities are quite high.

STOP #8

Photographs: Plates 16, 17

Basin: Cameron remainder - 0

Stream: Yellow Creek

Location: Yellow Creek crossing on Cameron Mainline.

Stream width: 5 - 6 m

Stream gradient: Average 20%.

Channel type and condition: Upstream: Bedrock boulder step-pool becoming cobble riffle-pool for about 20 m above the culvert. Downstream: Boulder step-pool, partially aggraded. Stone lines disturbed. Wood debris spans channel, does not function. The riparian zone is mostly mature second growth (dated 1901).

Description: This is a confined fairly steep-gradient channel. Bed and bank materials have low erosion potential. The road crossing here is a deep fill with two large pipe culverts at staggered elevation. The road fill has sloughed into the creek and eroded in the past. Fillslopes are now grassed and have young alders and conifers. Minor fill erosion is occurring at the road shoulder.

Possible effects: Sediment aggradation on upstream end of culverts from channel upstream. Sediment introduction into Yellow Creek channel from old road fill sloughs and erosion of road fill; would have mostly transported to Cameron River. Increased stream velocities through culvert likely to have caused channel degradation downstream of fill; but sediment introduced from fill.

STOP #9

Photographs: Plates 18, 19

Sub-basin: 3

Stream: Cop Creek (below confluence with Henry Creek)

Location: Bridge on Cameron Mainline.

Stream width: 8 m (measured by hipchain across bridge)

Stream gradient: 6% U/S, approx. 8% D/S

Channel type and condition: Upstream: Bedrock/boulder step-pool, partially degraded. Downstream: Bedrock step-pool, degraded. Sparse large wood debris, nonfunctional.

Description: Bed material upstream is boulders and cobbles; sizes larger than 500 mm are mossy. Riparian zone is second growth alders and conifers, approx. 30 years old. High energy channel; in natural channel condition wood debris would have at most minor function. Bedrock channel downstream.

Possible effects: This channel is not sensitive to erosion, and there has been no significant sediment accumulation. Wood debris is unlikely to have had a significant function. Impacts here are minimal.

STOP #10

Photographs: No photo

Sub-basin: 3

Stream: Henry Creek

Location: Bridge on Cop Main road.

Stream width: 8 m

Stream gradient: Falls upstream, >30%. 26% D/S.

Channel type and condition: Upstream: Steep bedrock channel with falls, no sediment. Downstream: Bedrock step-pool, partially degraded. No functioning wood debris.

Description: Steep-gradient, high energy, bedrock dominated channel upstream, bedrock & boulder channel downstream. Channel upstream is not sensitive to sediment input or erosion, wood debris would be nonfunctional in natural channel. Downstream, natural channel is likely to have been partially degraded boulder step-pool. Large wood debris was probably nonfunctional. Road fill was spilled into the creek; sediment would likely have transported to the Cameron River. High cuts in silt till on this road; sections of steep grades.

Possible effects: Sediment introduction from road fills and erosion, mostly transported downstream.

STOP #11

Photographs: Plates 20, 21

Sub-basin: 0

Stream: Cameron River

Location: Bridge on Cameron Main at 14.4 km.

Stream width: 17 m (measured by hipchain across bridge); estimated depth 1.5 m.

Stream gradient: 1%.

Channel type and condition: Gravel riffle-pool, partially to moderately aggraded. Large wood debris very sparse.

Description: Uniform alluvial channel, straight reach. Bed material is gravel and cobbles with a few boulders and sand pockets. Gravel bars are below bank height. Channel position is stable. No significant bank erosion here. Riparian zone is 30-year old second growth conifers with an alder fringe along channel banks. Natural condition likely to have been stable gravel riffle-pool morphology, with large wood debris mostly along channel banks.

Possible effects: Some sediment aggradation, loss of large wood debris from channel banks.

STOP #12

Photographs: Plates 22, 23, 24

Sub-basin: Cameron remainder -- 0

Stream: Cameron River

Location: Old Alley Road crossing at 19.48 km. Bridge removed.

Stream width: 19 m (measured by Rangefinder).

Stream gradient: <1%

Channel type and condition: Gravel riffle-pool, moderately aggraded. Minor large wood debris.

Description: Alluvial channel with low alluvial terraces; erodible channel banks. Channel bars up to bank height. Bed and bars are gravel, small cobbles and sand. Old growth riparian zone downstream; 30-year old second growth riparian zone upstream . Minor bank erosion is occurring.

Possible effects: Sediment aggradation, loss of functioning large wood debris.

STOP #13

Photographs: Plates 25, 26

Sub-basin: 2

Stream: Unnamed

Location: Bridge on River Road

Stream width: 10 m (hipchained over bridge); estimated channel depth 1 m.

Stream gradient: 1%

Channel type and condition: Cobble riffle-pool, moderately aggraded. Sparse large wood debris, functions where present.

Description: Alluvial channel, right bank in till, left bank in low terraces. Bed is cobbles and small boulders, some gravel. Bars less than bank height. Riparian zone is 25 - 30 year old second growth with alder fringe along banks. In a natural condition this reach would be expected to have functioning large wood debris. Channel position stable, no significant bank erosion.

Possible effects: Some sediment aggradation, loss of large wood debris.

STOP #14

Photographs: Plates 27, 28

Sub-basin: 1

Stream: Cameron River

Location: Bridge at 21.6 km, just upstream of confluence with Stream 2.

Stream width: 14 m (hipchained across bridge).

Stream gradient: 2% D/S; benchy upstream, approx. 5%.

Channel type and condition: Upstream: Bedrock/boulder step-pool, degraded. Downstream: Cobble cascade-pool, partially degraded. Minor wood debris along banks; minimal function downstream, nonfunctional upstream.

Description: Bed material is cobbles and boulders. Upstream banks are nonerodible; downstream, no significant erosion is apparent. Channel position stable. Riparian zone is 28 year old second growth with an alder fringe along the channel banks.

Possible effects: Wood debris would have limited to no function naturally in this reach. Banks are not susceptible to increased erosion following logging. No sediment aggradation has taken place. Impacts are minimal.

Plate 1. Stop #1. Looking upstream at Lockwood Creek from highway bridge.

Plate 2. Stop #1. Looking downstream at Lockwood Creek from highway bridge toward railway bridge.

Plate 3. Stop #2. Looking upstream at Little Qualicum River from railway bridge.

Plate 4. Stop #2. Looking downstream at Little Qualicum River from railway bridge.

Plate 5. Stop #3. Looking upstream at McBey Creek from highway bridge.

Plate 6. Stop #3. Looking upstream at McBey Creek channel from under railway bridge. Highway bridge in upper photos.

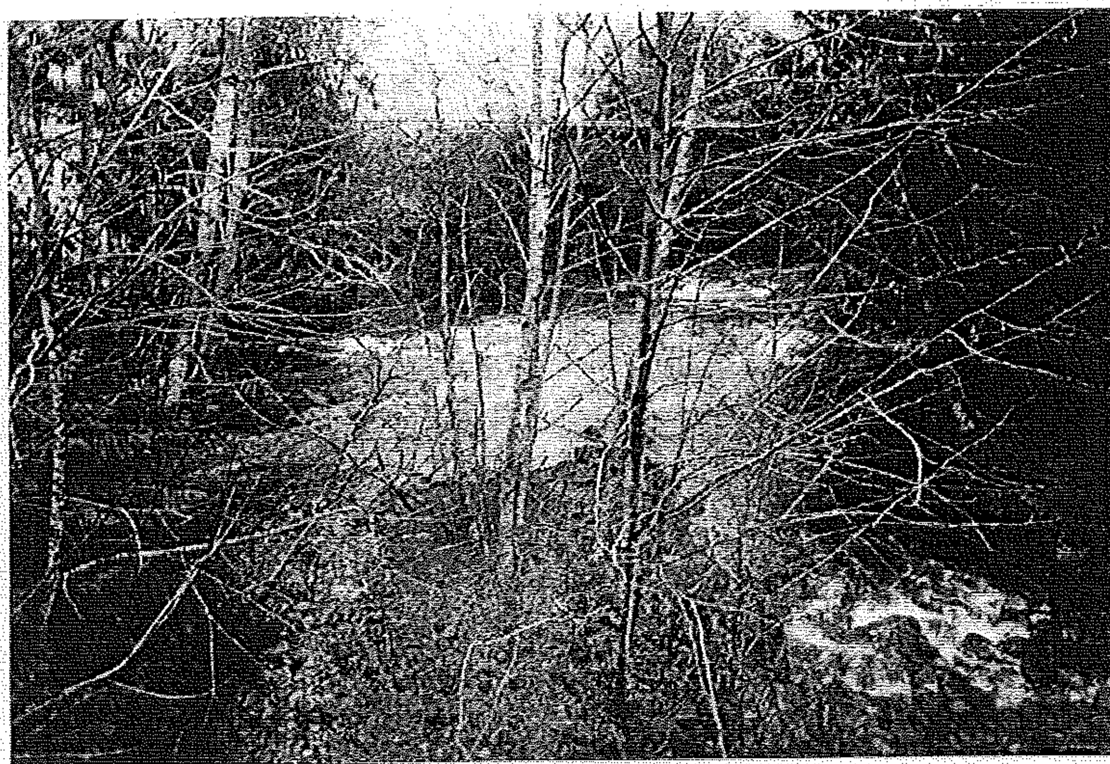


Plate 7. Stop #3. Looking downstream at confluence of McBey and Little Qualicum River. Aldered cobble bar visible in center of McBey channel. Railway bridge at top of photo.

Plate 8. Stop #4. Looking downstream at Little Qualicum River from bridge at campground, east end of lake.

Plate 9. Stop #4. Looking west at Cameron Lake from bridge at lake outlet.

Plate 10. Stop #5. Looking downstream from highway bridge at side channel of Cameron River.

Plate 11. Stop #5. Looking upstream from highway bridge at side channel of Cameron River.

Plate 12. Stop #6. Looking upstream from highway bridge at main channel of Cameron River.

Plate 13. Stop #6. Looking downstream from highway bridge at main channel of Cameron River.

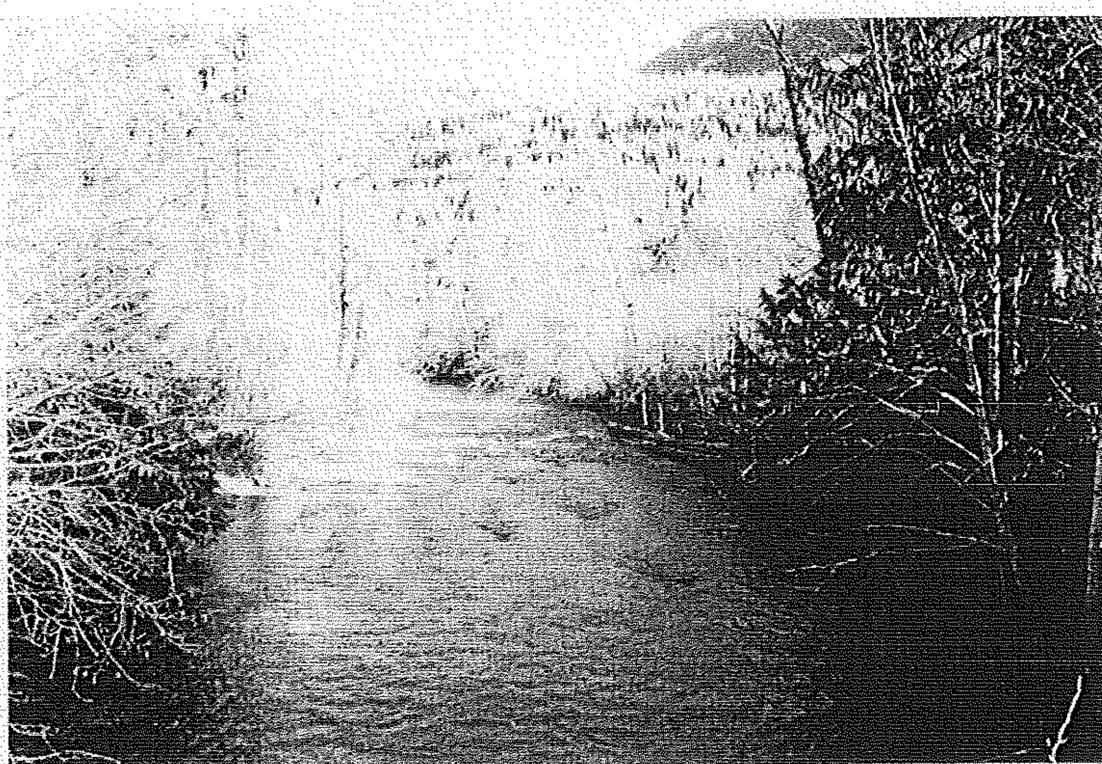


Plate 14. Stop #7. Looking downstream at Cameron River channel from bridge at 4.67 km.

Plate 15. Stop #7. Looking upstream at Cameron channel from bridge at 4.67 km.

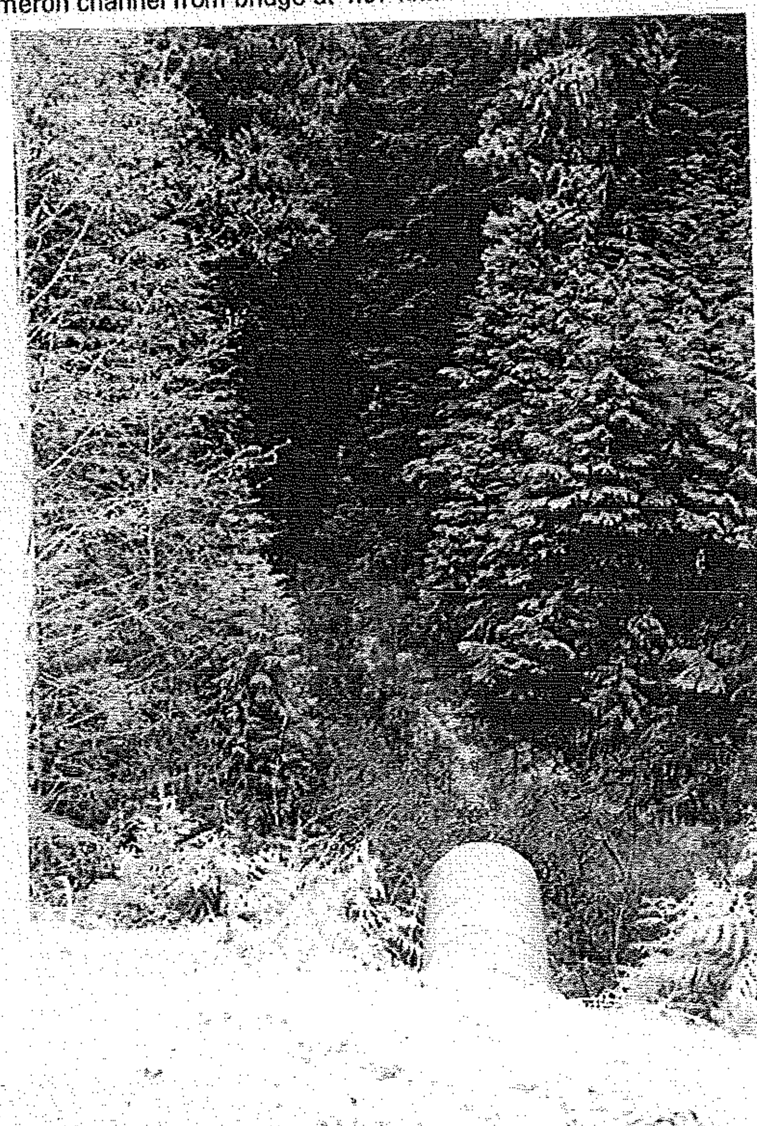


Plate 16. Stop #8. Looking upstream at Yellow Creek from Cameron Main. Upper of two culvert pipes visible.

Plate 17. Stop #8. Looking downstream at Yellow Creek from Cameron Main. Two culvert pipes visible.

Plate 18. Stop #9. Looking upstream at Cop Creek channel from bridge on Cameron Main.

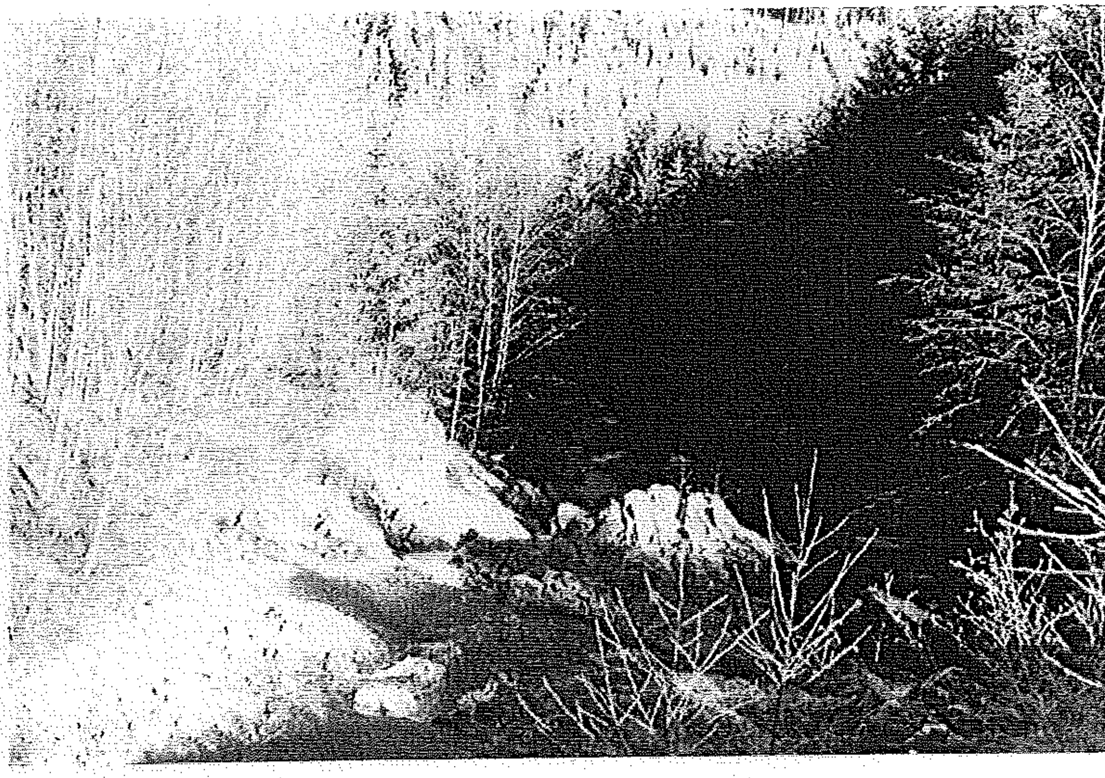


Plate 19. Stop #9. Looking downstream at Cop Creek channel from bridge on Cameron Main.

Plate 20. Stop #11. Looking upstream at Cameron River channel from bridge at 14.4 km.

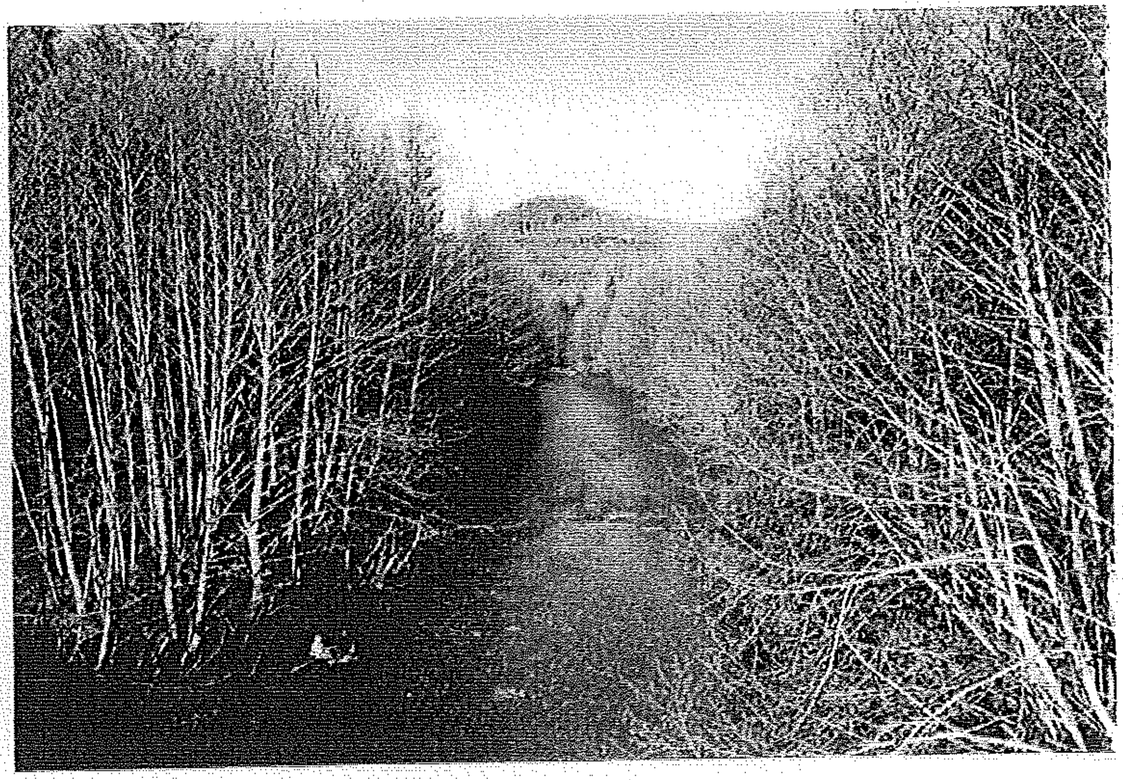


Plate 21. Stop #11. Looking downstream at Cameron River from bridge on at 14.4 km.

Plate 22. Stop #12. Old Alley Road crossing. Looking upstream at Cameron channel.

Plate 23. Stop #12. Old Alley Road crossing. Looking upstream at Cameron River from bar on south (left) bank.

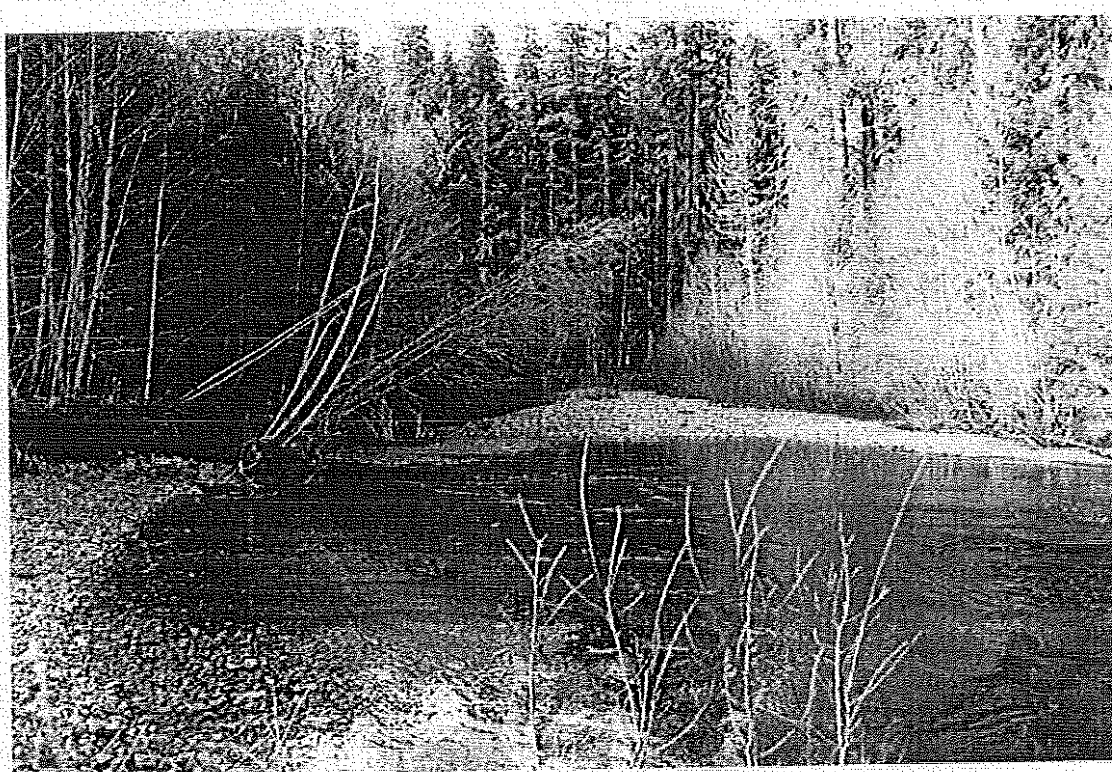


Plate 24. Stop #12. Old Alley Road crossing. Looking downstream at Cameron channel.

Plate 25. Stop #13. Looking downstream from bridge on River Road at Stream 2.

Plate 26. Stop #13. Looking upstream from bridge on River Road at Stream 2.

Plate 27. Stop #14. Looking downstream from bridge on River Road at Cameron channel.

Plate 28. Stop #14. Looking upstream from bridge on River Road at Cameron River.

Plate 29. Looking upstream at Cameron River channel in Sub-basin 1. Large boulders from rockfalls.

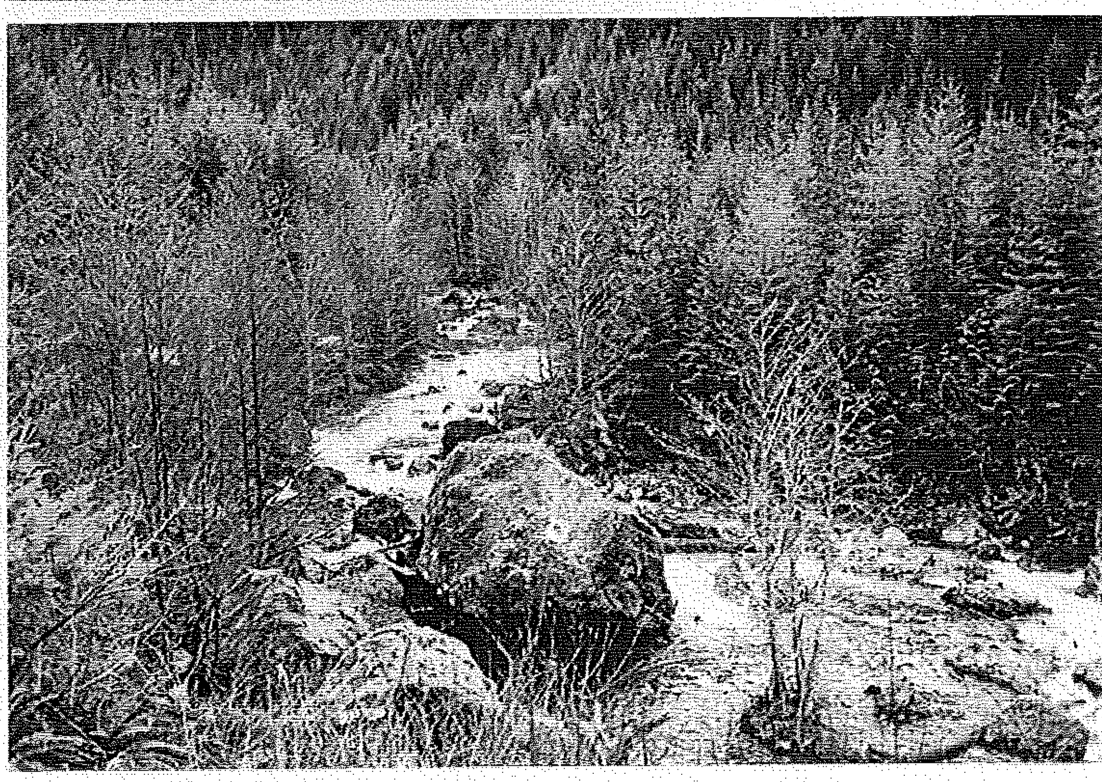


Plate 30. Looking upstream at Cameron River channel in Sub-basin 1.

Plate 31. Looking downstream Cameron channel, Sub-basin 1.

Plate 32. Deep silt till in road cuts near Yellow Creek crossing.

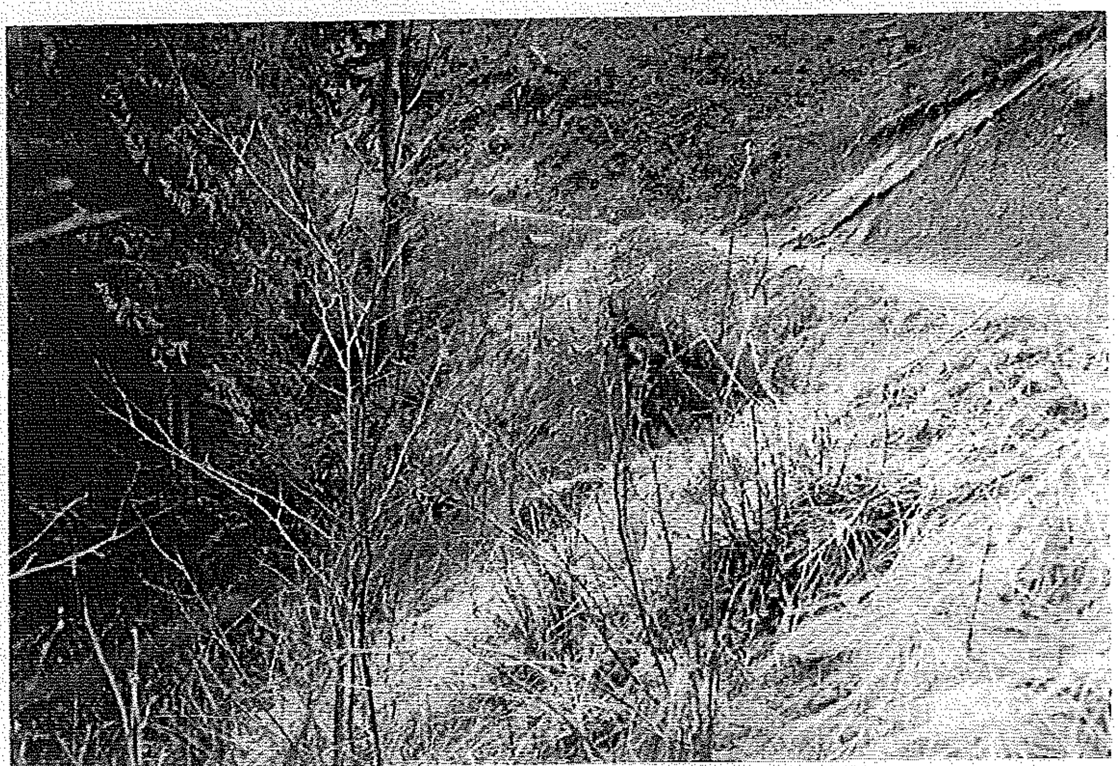
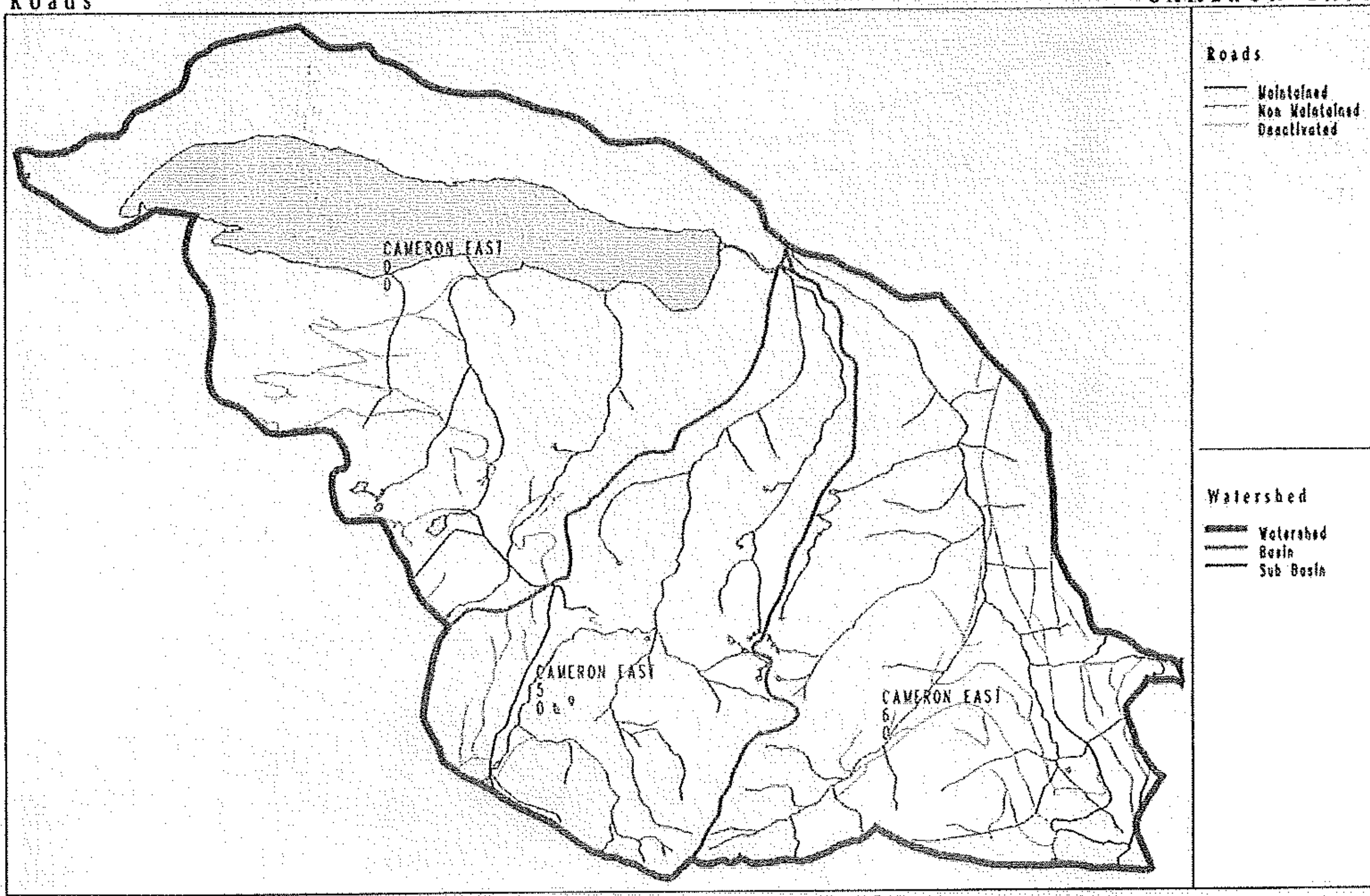


Plate 33. Log crib at old slide area above Cameron canyon.

Roads CAMERON EAST



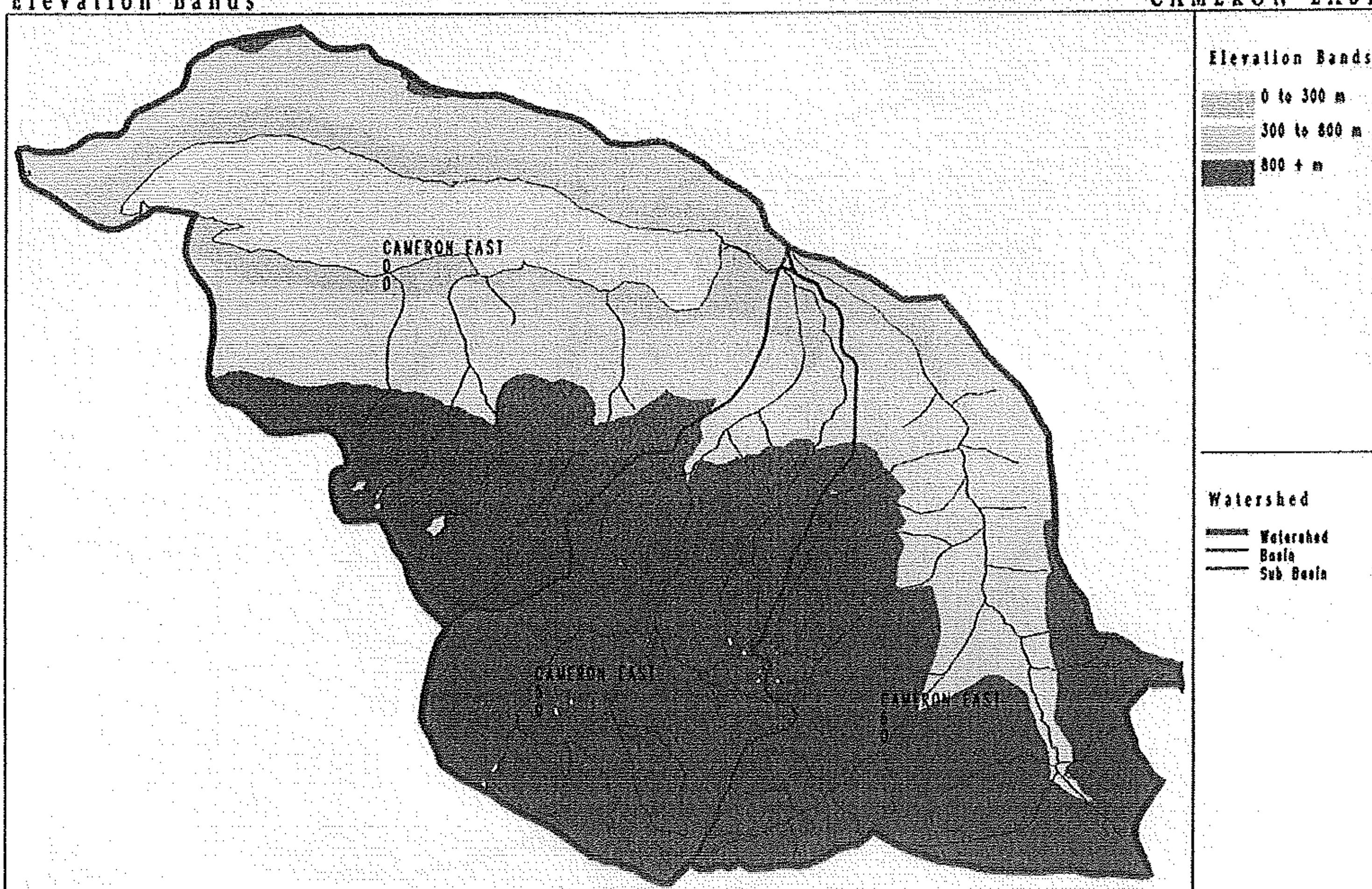
Map 2 - Roads
Inventory Revision 1996
CWAP Version: cameast1
Date: 1998-MAR-03 - 10:15 AM

Scale 1:49000

MacMillan Bloedel Limited
Woodland Services

Elevation Bands

CAMERON EAST



Map 1 - Elevation Bands
Inventory Revision 1996
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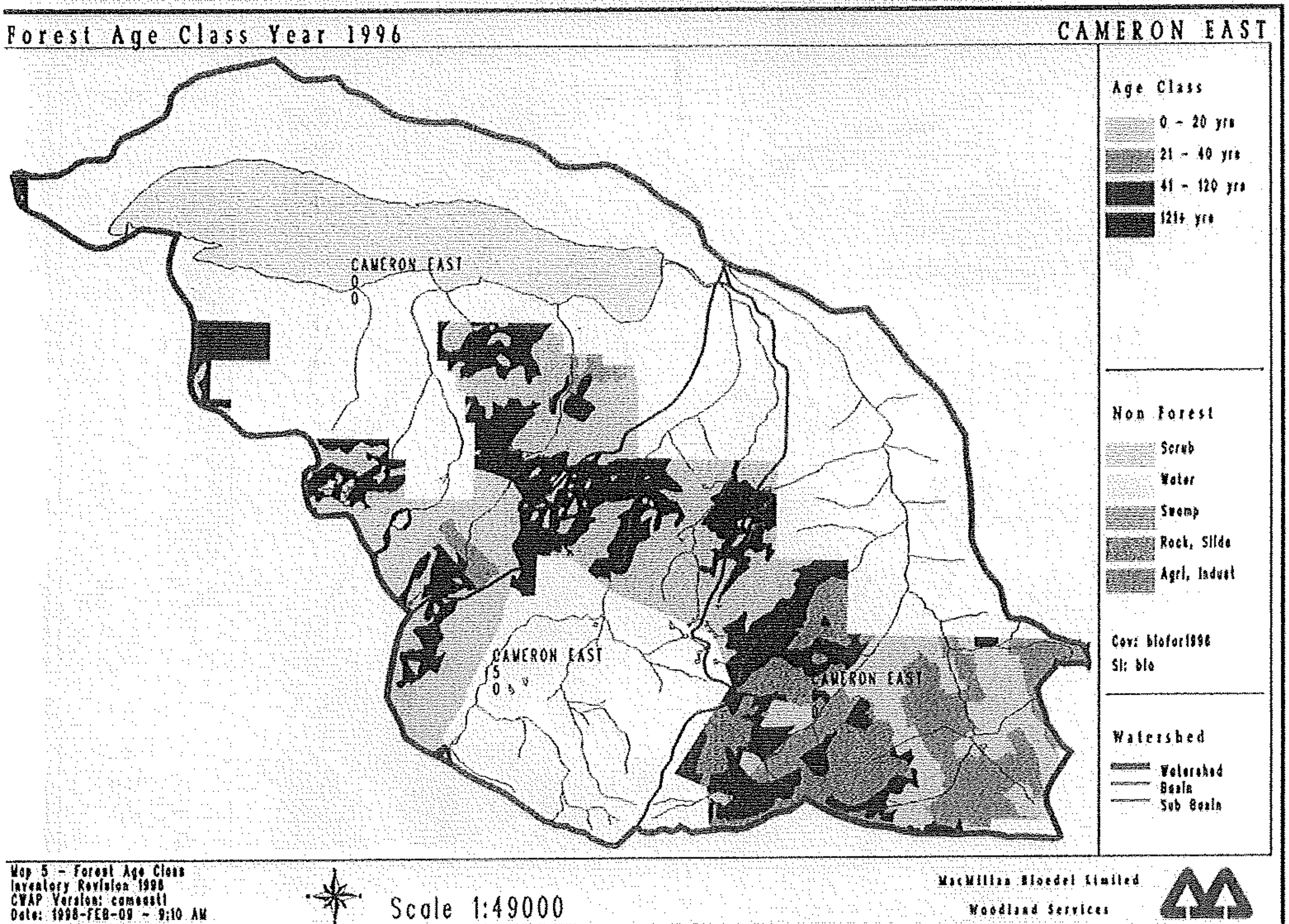
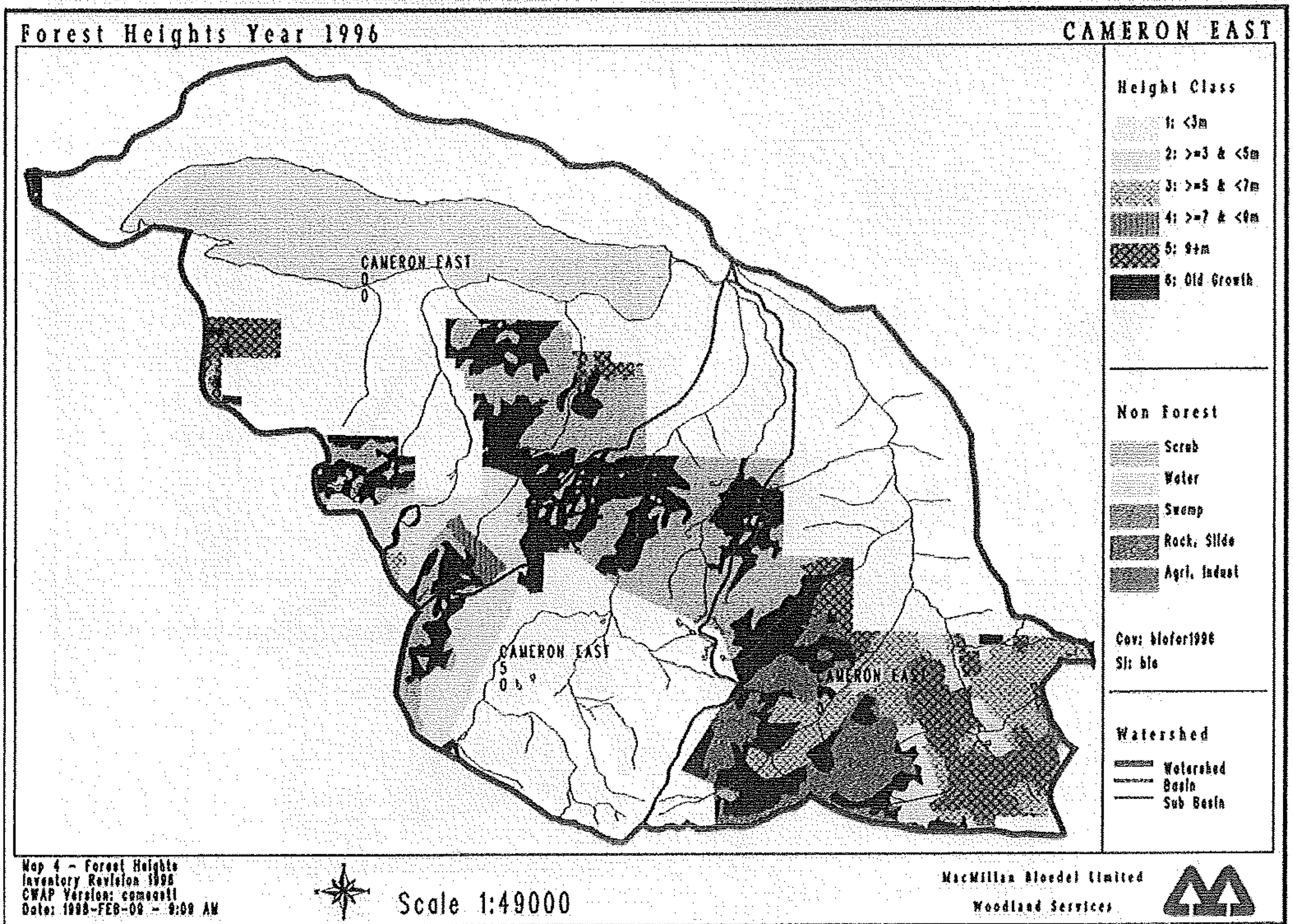
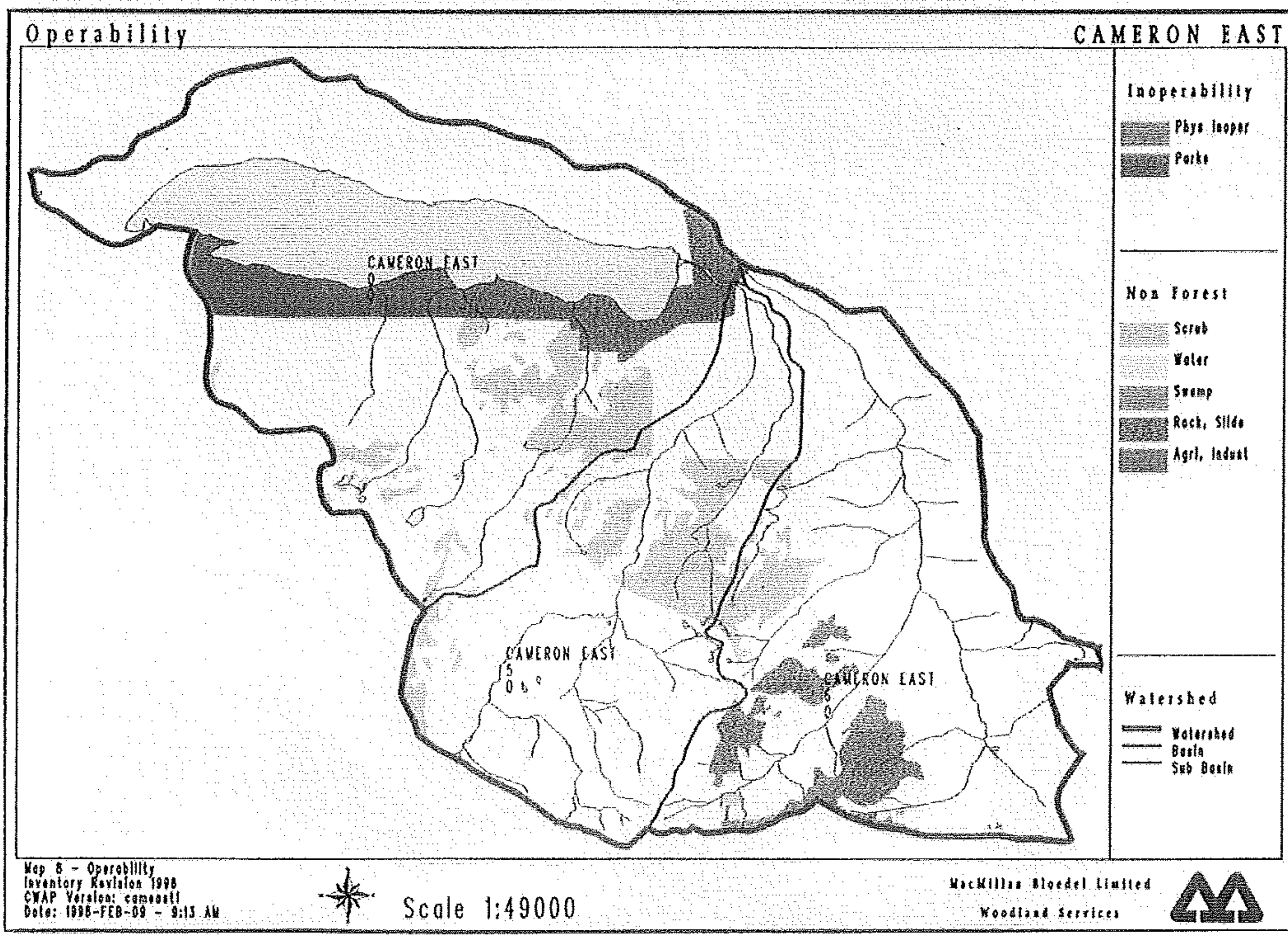
MacMillan Bloedel Limited
Woodland Services


Forest Age Class Year 1996
CAMERON EAST
CAMERON EAST
CAMERON EAST
CAMERON EAST
Age Class
0 - 20 yrs
21 - 40 yrs
41 - 120 yrs
121+ yrs
Non Forest
Scrub
Water
Swamp
Rock, Slide
Agri, Indust
Cov: bfofor1996
Sl: bfo
Watershed
Watershed
Basin
Sub Basin
Map 5 - Forest Age Class
Inventory Revision 1996
CWAP Version: cameast1
Date: 1998-FEB-09 - 9:10 AM
Scale 1:49000
MacMillan Bloedel Limited
Woodland Services



Forest Heights Year 1996
CAMERON EAST
CAMERON EAST
CAMERON EAST
CAMERON EAST
Height Class
1: <3m
2: >=3 & <5m
3: >=5 & <7m
4: >=7 & <9m
5: 9+m
6: Old Growth
Non Forest
Scrub
Water
Swamp
Rock, Slide
Agri, Indust
Cov: blofor1996
Sl: blo
Watershed
Watershed
Basin
Sub Basin
Map 4 - Forest Heights
Inventory Revision 1996
CWAP Version: cameast1
Date: 1998-FEB-09 - 9:09 AM
Scale 1:49000
MacMillan Bloedel Limited
Woodland Services



Operability
CAMERON EAST
Inoperability
Phys Inoper
Parks
Non Forest
Scrub
Water
Swamp
Rock, Slide
Agri, Indust
Watershed
Watershed
Basin
Sub Basin
CAMERON EAST
CAMERON EAST
CAMERON EAST
Map 8 - Operability
Inventory Revision 1998
CWAP Version: cameast1
Date: 1998-FEB-09 - 9:13 AM
Scale 1:49000
MacMillan Bloedel Limited
Woodland Services