Appendix 1: Full Cycle Trees

Full Cycle Trees

Full Cycle Trees are stems that are left on managed forest sites to mature, grow old, die, fall to the ground, and decay – in other words to complete the full life cycle of a forest tree. The purpose of this is to provide the full range of ecological structures that are found in natural forests on managed forest sites. These full cycle trees are required to maintain habitat, maintain biodiversity, store and filter water, and maintain soils.

The Management Plan for W1832 sets a goal of diverting 15% of net timber management site productivity to create and maintain full cycle trees. This target will be met through individual tree retention and small patch retention. The final number of stems per hectare required to achieve this goal is not known at this time. The full cycle stems will become very large as they mature, and will take up much more growing space per tree at age 500 than they currently do at age 100. If 15% of the current young stems in the stand were left on site to become full cycle trees, they would likely fully stock the site with 100% crown closure at age 250. This is not what we wish to achieve: protected old growth forests will be found within protected areas in W0090 and the surrounding landscape. Within the timber management zones, we wish to maintain old growth structures, but to grow repeated timber crops in the space beneath and around the full cycle trees.

The exact number of full cycle stems per hectare will be determined over time, with experience, modeling and monitoring. At this early stage in the process, sufficient trees will be left to allow future managers to make informed, responsible decisions.

Trees that will become full cycle trees will be chosen from the largest, healthiest trees currently on a site. More than enough of these large trees will be left after initial intermediate cutting in W1832 to supply initially required full cycle trees. These stems are highly desirable crop trees from a timber manager’s viewpoint, but they are also the most desirable stems from an ecological perspective. They have robust trunks and full healthy crowns, and large healthy root systems. They can thus resist windthrow, withstand heavy snow loads, and grow rapidly to full mature size. These trees will also produce abundant seed crops for regeneration, and may be genetically better suited to the site than the smaller, weaker trees in the current stands.

The location and species of designated full cycle trees should be mapped and recorded in a record keeping system. The trees themselves should be marked. The purpose is to communicate the intent in leaving the trees, and the location of the trees, to future forest users long after current forest managers have passed on. As is common in ecoforestry, what we are describing is the need for “people management”, in addition to forest management.

Appendix 2: Correlation between mapped Point of Diversion Codes and Water Licencee Names

82.F.063.1.1 E	Winlaw Creek	ERVEN PAUL A &LISA GENERAL DELIVERY WINLAW BC V0G2J0
82.F.063.1.1 E	Winlaw Creek	WITTON THOMAS P 27 2336 ORIENT PARK DR OTTAWA ON K1B4N5
82.F.063.1.1 F	Dumont Creek	CUTHBERT KENNETH C & FRANCES L RR 1 GROUP 1 COMP 5 WINLAW BC V0G2J0
82.F.063.1.1 K	Winlaw Creek	AVIS LARRY M BOX 76 WINLAW BC V0G2J0
82.F.063.1.1 P	Winlaw Creek	BARISOFF BILL & MARION M PO BOX 143 WINLAW BC V0G2J0
82.F.063.1.1 P	Winlaw Creek	BARISOFF BILL PO BOX 143 WINLAW BC V0G2J0
82.F.063.1.1 P	Winlaw Creek	HUNGRY WOLF CAFE INC. PO BOX 131 WINLAW BC V0G2J0
82.F.063.1.1 P	Winlaw Creek	KALMAKOFF FRANK & FAYE PO BOX 145 WINLAW BC V0G2J0
82.F.063.1.1 P	Winlaw Creek	SHELOFF HELEN L PO BOX 108 WINLAW BC V0G2J0
82.F.063.1.1 P	Winlaw Creek	SHERBININ FRED F & JOHN F RR 2 SITE 13 COMP 2 CASTLEGAR BC V1N3L4
82.F.063.1.1 P	Winlaw Creek	STOOCHNOFF LARRY PO BOX 162 WINLAW BC V0G2J0
82.F.063.1.1 P	Winlaw Creek	TARR W GUY PO BOX 115 WINLAW BC V0G2J0
82.F.063.1.1 P	Winlaw Creek	TEES PATRICIA R BOX 62 WINLAW V0G2J0
82.F.063.1.1 P	Winlaw Creek	THOMPSON DANNY R & GWENN L PO BOX 78 WINLAW BC V0G2J0
82.F.063.1.1 Q	Winlaw Creek	GAUTHIER JEAN BOX 246 NELSON BC V1L5P9
82.F.063.1.1 Q	Winlaw Creek	GEORGE'S EXCAVATING LTD. BOX 188 SLOCAN BC V0G2C0
82.F.063.1.1 Q	Winlaw Creek	HOLLADAY DAVID A PO BOX 39 WINLAW BC V0G2J0
82.F.063.1.1 Q	Winlaw Creek	KIRK ALAN D GD WINLAW BC V0G2J0
82.F.063.1.1 Q	Winlaw Creek	RUSSELL ANNE L BOX 68 WINLAW BC V0G2J0
82.F.063.1.1 Q	Winlaw Creek	SKEETE BARTEL PO BOX 92 WINLAW BC V0G2J0
82.F.063.1.1 Q	Winlaw Creek	SLOGGETT KEVIN D BOX 75 WINLAW BC V0G2J0
82.F.063.1.1 Q	Winlaw Creek	TEINER WOLFGANG W F BOX 137 WINLAW BC V0G2J0
82.F.063.1.1 Q	Winlaw Creek	THERRIEN ALLEN H PO BOX 77 WINLAW BC V0G2J0
82.F.063.1.1 Q	Winlaw Creek	TRANSPORTATION & HIGHWAYS MINISTRY OF 310 WARD ST NELSON BC V1L5S4
82.F.063.1.1 R	Winlaw Creek	HEIMANN MARY M RR 3 SITE 12 COMP 4 NELSON BC V1L5P6

82.F.063.1.1 R	Winlaw Creek	LIL' HOLDINGS (1995) LTD BOX 30 WINLAW BC V0G2J0
82.F.063.1.1 R	Winlaw Creek	PURVIS STANLEY W 5180 SIDLEY ST BURNABY BC V5E1T5
82.F.063.1.1 S	Winlaw Creek	GEORGE'S EXCAVATING LTD. BOX 188 SLOCAN BC V0G2C0
82.F.063.1.1 S	Winlaw Creek	MERRY KENNETH A & DORIT H PO BOX 133 WINLAW BC V0G2J0
82.F.063.1.1 S	Winlaw Creek	STEWART JOHN R PO BOX 797 NELSON BC V1L5S9
82.F.063.1.1 T	Winlaw Creek	AVIS LARRY M BOX 76 WINLAW BC V0G2J0
82.F.063.1.1 T	Winlaw Creek	MERRY KENNETH A & DORIT H PO BOX 133 WINLAW BC V0G2J0
82.F.063.1.1 T	Winlaw Creek	PIPPEN DANIEL C & KATHLEEN PO BOX 1565 MERRITT BC V1K1B8
82.F.063.1.1 T	Winlaw Creek	ROMAO GEORGE M PO BOX 1956 BROOKS AB T1R1C7
82.F.063.1.1 T	Winlaw Creek	WILLOWS WENDY-ANN BOX 121 WINLAW BC V0G2J0
82.F.063.1.1 U	Winlaw Creek	PATTERSON LOGGING LTD ET AL BOX 6 SLOCAN BC V0G2C0
82.F.063.1.1 V	Winlaw Creek	ALEXANDER DEVELOPMENTS LTD PO BOX 1070 SQUAMISH BC V0N3G0
82.F.063.1.1 V	Winlaw Creek	AVIS LARRY M BOX 76 WINLAW BC V0G2J0
82.F.063.1.1 V	Winlaw Creek	AVIS VELMA N GENERAL DELIVERY WINLAW BC V0G2J0
82.F.063.1.1 V	Winlaw Creek	CROSFIELD EDWARD B RR 1 COMP 26 SITE 3 CASTLEGAR BC V1N3H7
82.F.063.1.1 V	Winlaw Creek	NOAD JAMES B & SUZANNE 502 COLUMBIA AVE CASTLEGAR BC V1N1G7
82.F.063.1.1 V	Winlaw Creek	PARKER IRIS A & EARL G BOX 153 WINLAW BC V0G2J0
82.F.063.1.1 V	Winlaw Creek	PATTERSON LOGGING LTD ET AL BOX 6 SLOCAN BC V0G2C0
82.F.063.1.1 V	Winlaw Creek	SMOCH ANTHONY G SITE 12 COMP 107 RR 1 SOUTH SLOCAN BC V0G2G0
82.F.063.1.1 W	Winlaw Creek	PATTERSON LOGGING LTD ET AL BOX 6 SLOCAN BC V0G2C0
82.F.063.1.2 A	Holt Creek	NEW FAMILY SOCIETY C/O NANCY HARRIS BOX 89 WINLAW BC V0G2J0
82.F.063.1.2 B	Holt Creek	NEW FAMILY SOCIETY C/O NANCY HARRIS BOX 89 WINLAW BC V0G2J0
82.F.063.1.2 D	Winlaw Creek	HARASEMOW JOHN P & MARY RR 1 WINLAW BC V0G2J0
82.F.063.1.2 D	Winlaw Creek	POPOFF ELI & ALICE RR 1 GROUP 2 COMP 2 WINLAW BC V0G2J0
82.F.063.1.2 E	Dumont Creek	CUTHBERT KENNETH C & FRANCES L RR 1 GROUP 1 COMP 5 WINLAW BC V0G2J0
82.F.063.1.2 E	Dumont Creek	HADIKIN HANNAH G 406 VICTORIA ST NELSON BC V1L4K5
82.F.063.1.2 F	Dumont Creek	CUTHBERT KENNETH C & FRANCES L RR 1 GROUP 1 COMP 5 WINLAW BC V0G2J0

82.F.063.1.2 F	Dumont Creek	KATASONOFF HELEN RR 1 SITE 5 COMP 63 CRESCENT VALLEY BC V0G1H0
82.F.063.1.2 J	Dumont Creek	ASH JENNIE D RR 1 WINLAW BC V0G2J0
82.F.063.1.2 J	Dumont Creek	BRUNN HAROLD E & JOANNE BOX 366 SLOCAN BC V0G2J0
82.F.063.1.2 J	Dumont Creek	COTTON BERNARD W RR 1 SITE 1 COMP 2 WINLAW BC V0G2J0
82.F.063.1.2 J	Dumont Creek	FRASER JAN C BOX 120 WINLAW BC V0G2J0
82.F.063.1.2 J	Dumont Creek	HALL JORDAN A BOX 97 WINLAW BC V0G2J0
82.F.063.1.2 J	Dumont Creek	JUFFS ROBERT J BOX 88 WINLAW BC V0G2J0
82.F.063.1.2 J	Dumont Creek	KATASONOFF HELEN RR 1 SITE 5 COMP 63 CRESCENT VALLEY BC V0G1H0
82.F.063.1.2 J	Dumont Creek	MATTINSON JAMESON M & BEATRICE B BOX 15 WINLAW BC V0G2J0
82.F.063.1.2 J	Dumont Creek	PERRIERE JOSEPH & DENISE BOX 96 WINLAW BC V0G2J0
82.F.063.1.2 J	Dumont Creek	PICARD MARIE HELENE RR 1 GROUP 14 COMP 9 WINLAW BC V0G2J0
82.F.063.1.2 J	Dumont Creek	REAVELEY LORRAINE J BOX 14 6061 CEDAR CREEK RD WINLAW BC V0G2J0
82.F.063.1.2 K	Winlaw Creek	MATTHEWS JOHN A & RUTH E PO BOX 3 WINLAW BC V0G2J0
82.F.063.1.2 K	Winlaw Creek	MEYER DIANE BOX 69 WINLAW B C V0G2J0
82.F.063.1.2 K	Winlaw Creek	WALKER ROBERT E BOX 25 WINLAW BC V0G2J0
82.F.063.1.2 M	Winlaw Creek	CONNAUTON JOHN M & RUTH M BOX 124 WINLAW BC V0G2J0
82.F.063.1.2 M	Winlaw Creek	NAYLOR SHANNON PO BOX 117 WINLAW BC V0G2J0
82.F.063.1.2 N	Woodward Bro	BOMBIER JAN T PO BOX 7 WINLAW BC V0G2J0
82.F.063.1.2 N	Woodward Bro	LARSTONE TERRANCE E BOX 147 WINLAW BC V0G2J0
82.F.063.1.2 N	Woodward Bro	MCRAE MERRILL DEAN BOX 129 WINLAW BC V0G2J0
82.F.063.1.2 N	Woodward Bro	WOODWARD RONALD F & MEREDITH L 662 7TH AVE E VANCOUVER BC V5T1P1
82.F.063.1.2 P	Gravel Sprin	BRENNAN JIM 1093 MOSS ST VICTORIA BC V8V4P4
82.F.063.1.2 Q	Winlaw Creek	STUBBE CLINTON V BOX 106 WINLAW BC V0G2J0
82.F.063.1.2 R	Winlaw Creek	DONAHUE ROBERT J BOX 106 WINLAW BC V0G2J0
82.F.063.1.2 R	Winlaw Creek	LARSTONE PHILIP C & KATHY D PO BOX 99 WINLAW BC V0G2J0
82.F.063.1.2 R	Winlaw Creek	MILES ROSEMARY J PO BOX 168 WINLAW BC V0G2J0
82.F.063.1.2 S	Winlaw Creek	HORSWILL WILLIAM J BOX 176 WINLAW BC V0G2J0

82.F.063.1.2 T	Winlaw Creek	FARRER JAMES H BOX 102 WINLAW BC V0G2J0
82.F.063.1.2 U	Bockner Spri	FARRER JAMES H BOX 102 WINLAW BC V0G2J0
82.F.063.1.2 V	Winlaw Creek	BEVAN GEORGE F & JOAN D BOX 61 5782 HWY 6 WINLAW BC V0G2J0
82.F.063.1.2 V	Winlaw Creek	PEASE ROSS W & BRENDA J BOX 175 WINLAW BC V0G2J0
82.F.063.1.2 V	Winlaw Creek	POPOFF ANDY A JR & ELAINE RR 1 WINLAW BC V0G2J0
82.F.063.1.2 V	Winlaw Creek	SHKURATOFF HARVEY & DAWN M RR 1 COMP 9 GRP 1 WINLAW BC V0G2J0
82.F.063.1.2 V	Winlaw Creek	TEDESCO ROY E & NANCY Y BOX 107 WINLAW BC V0G2J0
82.F.063.1.2 V	Winlaw Creek	TEINER WOLFGANG W F BOX 137 WINLAW BC V0G2J0
82.F.063.1.2 V	Winlaw Creek	ZARCHIKOFF HARRY & NETTIE RR 1 WINLAW BC V0G2J0
82.F.063.1.2 X	Dumont Creek	BRAUNDY MARCIA ANN C/O W J WATT PO BOX 116 WINLAW BC V0G2J0
82.F.063.1.2 X	Dumont Creek	FLAVELLE ALIX J PO BOX 51 WINLAW BC V0G2J0

Appendix 3: Interior Watershed Assessment Procedure: Results for Sub-Basins in W1832 for which Development is Proposed

Appendix 3
Interior Watershed Assessment Procedure
Results for Sub-Basins in W1832 for which Development is Proposed

Prepared by Woodlot Licence W1832 Staff

Interior Watershed Assessment Procedure

Results for Sub-Basins in W1832 for which Development is Proposed

Table of Contents

List of Figures and Tables

1 Introduction

This Appendix presents the results of Interior Watershed Assessment Procedure (IWAP) assessments of the four watersheds impacted by development activities proposed in the first Forest Development Plan for W1832. These watersheds are

- Dumont Creek
- Winlaw Creek – North Fork Sub-Unit
- Slocan River Watershed – Woodward Face Sub-Unit
- Winlaw Creek – Lower Main Watershed Sub-Unit

Portions of the Trozzo Creek – Lower Main Sub-Unit and Dunn Creek watersheds are also contained in W1832, but these areas are not affected by proposed development activities and were not assessed at this time.

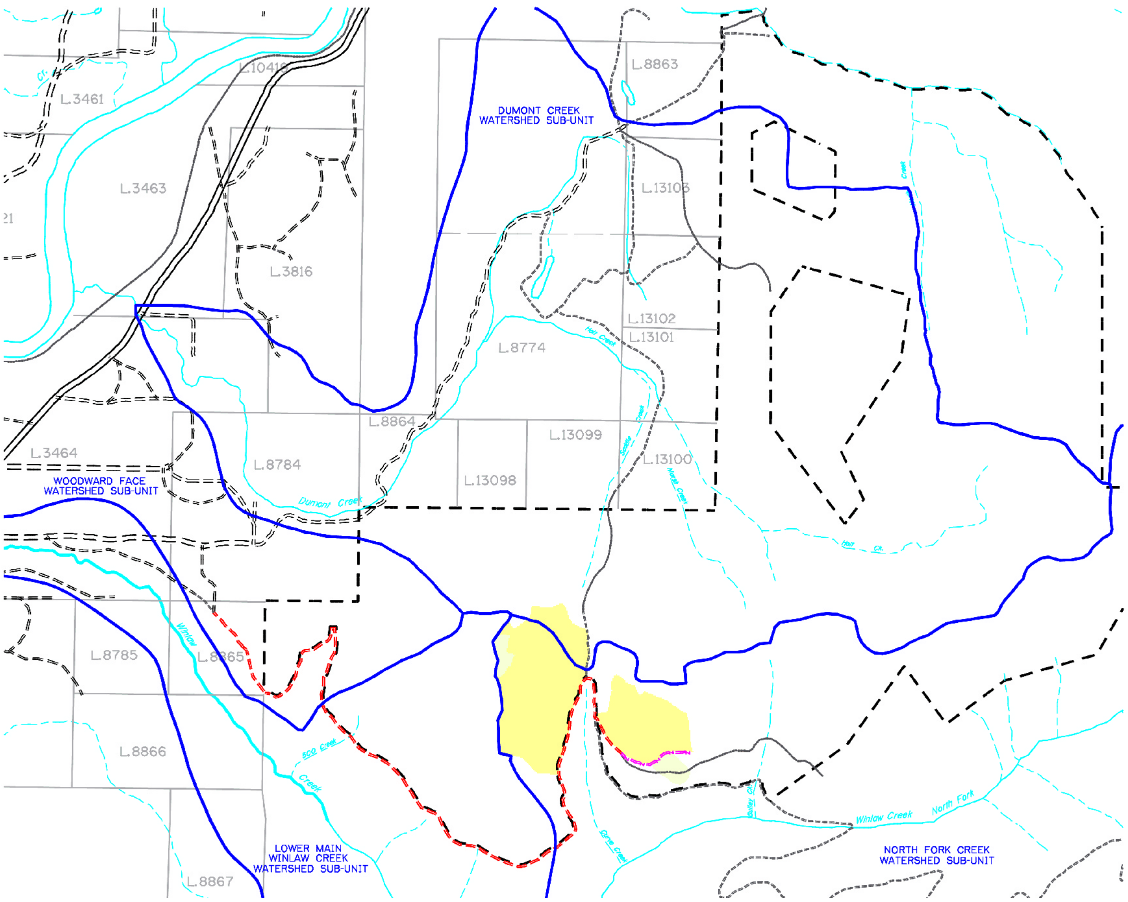

Figure 1: Map of Watershed Boundaries and Proposed Development in W1832 Crown Portion. Watershed boundaries shown in dark blue. Proposed road modification shown in red, proposed new road construction shown in magenta. Proposed partial cutting shown in yellow. W1832 boundary is black dashed line.

Sections 2 through 10 following present:

- standard assessment tables prepared per the Forest Practices Code Interior Watershed Assessment Procedure Guidebook (Level 1 Analysis), published September 1995 by the B.C. Ministry of Forests, and

- relevant sections of the Code Interior Watershed Assessment Procedure Guidebook which explain the derivation of the tables and which suggest interpretations of the tables.

Section 11 contains comments and assessments from the Licencee.

2 Determination of the H60 elevation

In much of the British Columbia interior, snow typically covers the upper 60% of a watershed when streamflow levels begin to rise in the spring. The H60 is the elevation for which 60% of the watershed area is above.

To estimate the elevation of this snowline (H60), draw a hypsometric (area-elevation) curve for the watershed. A hypsometric curve is constructed by calculating the area between contours (use 100 m) on a topographic map and plotting the cumulative area above a given elevation versus that elevation. If the difference between the highest and lowest elevation in the watershed is less than 300 m, use the entire watershed to estimate the equivalent clearcut area.

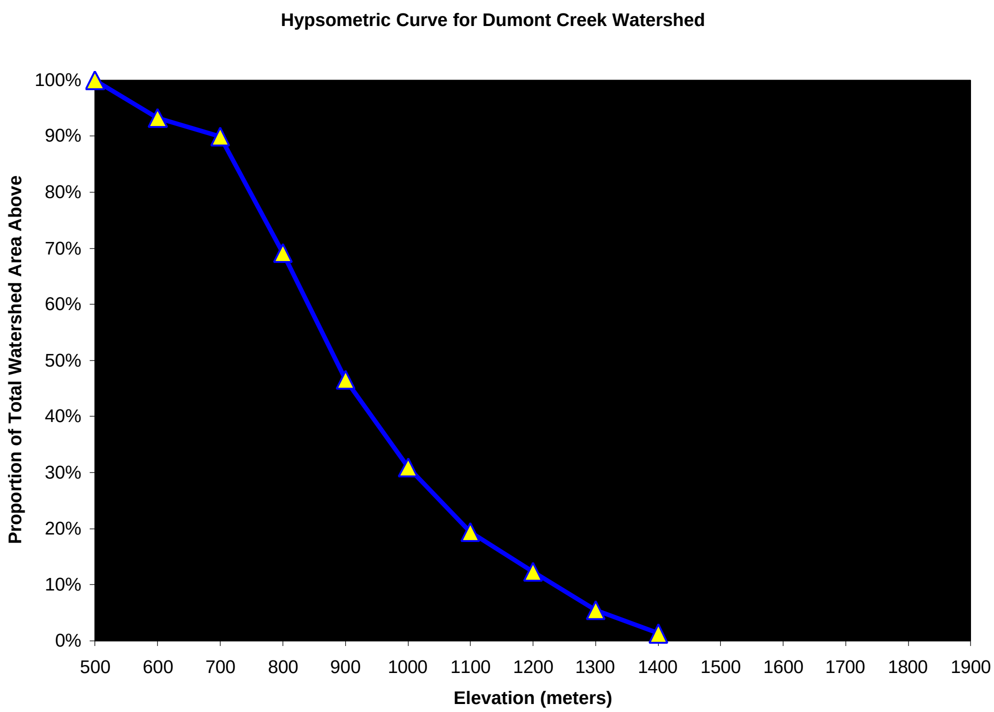

Figure 2: Hypsometric Curve for Dumont Creek Watershed.

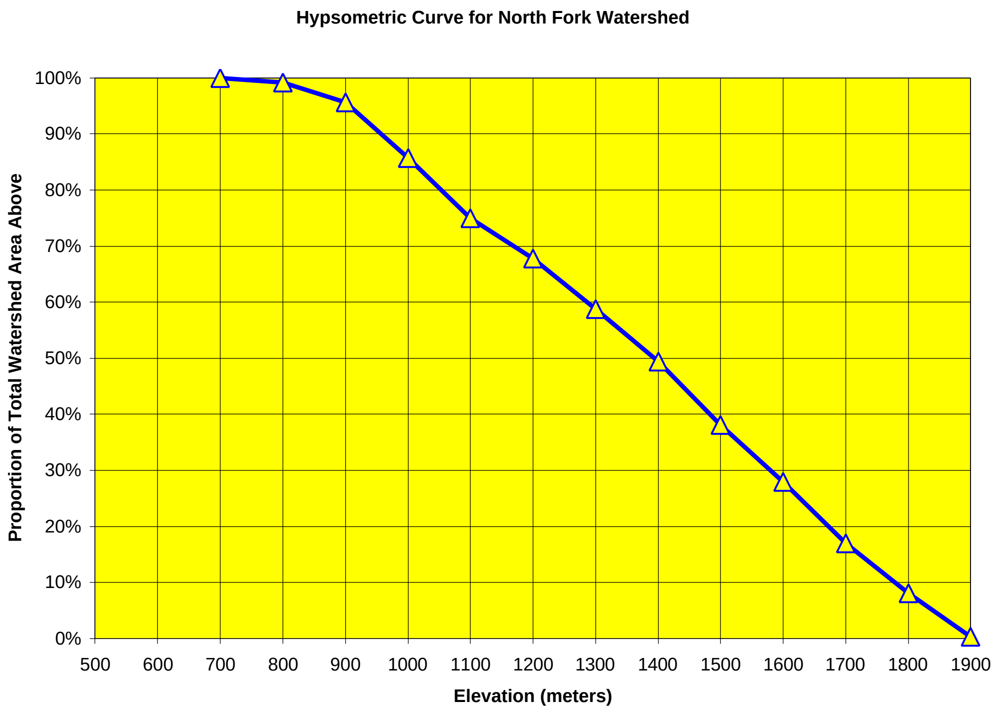

Figure 3: Hypsometric Curve for North Fork Watershed.

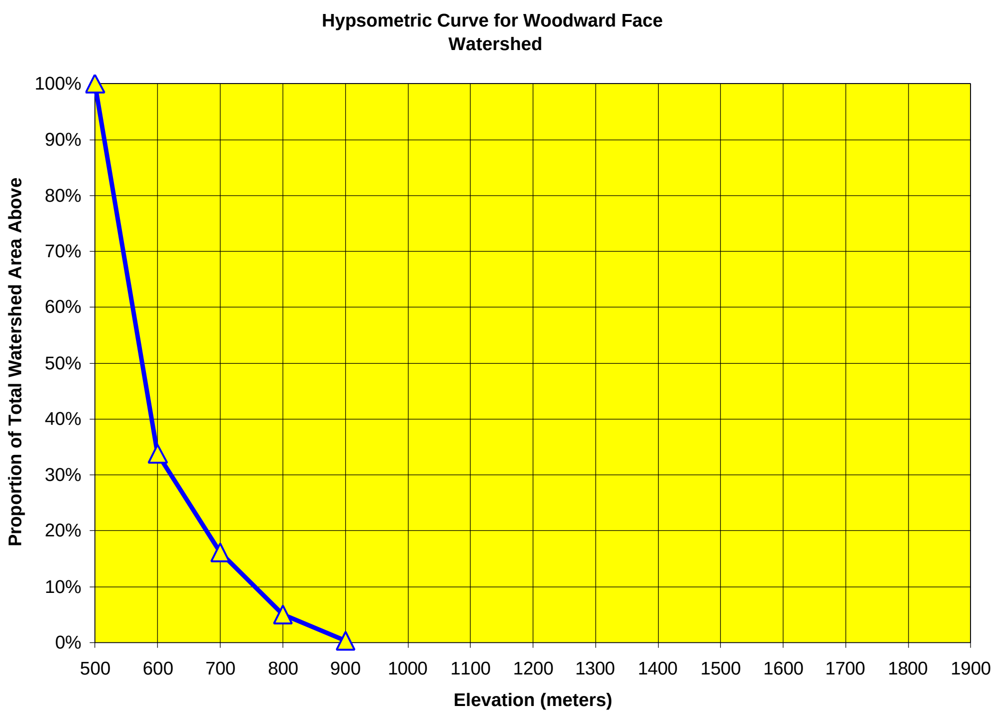

Figure 4: Hypsometric curve for Woodward Face Watershed.

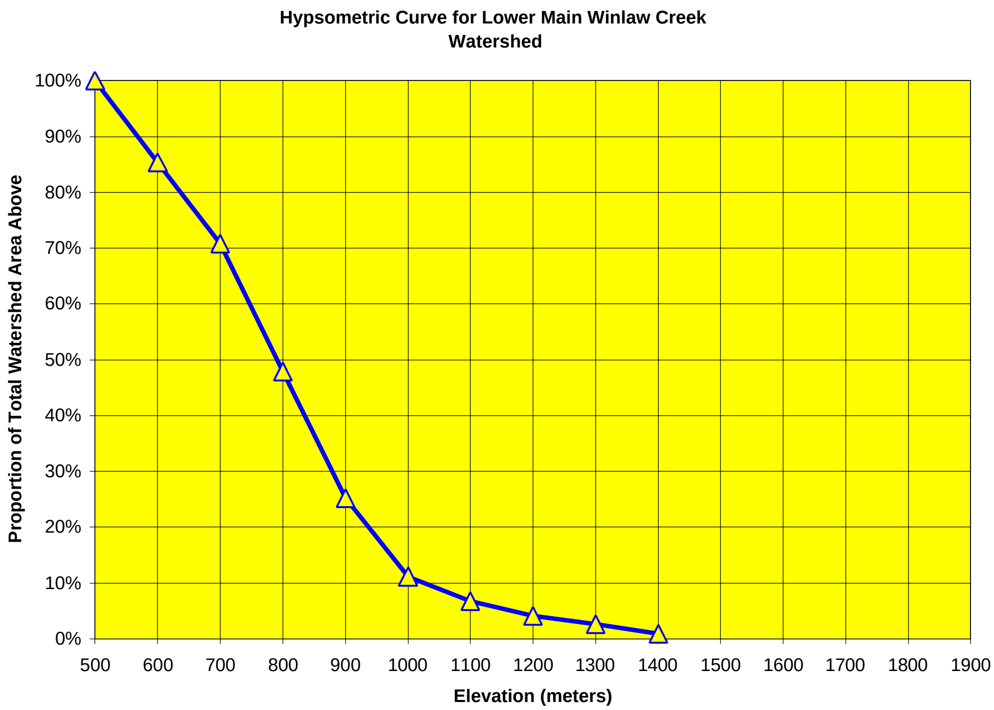

Figure 5: Hypsometric Curve for Lower Main Winlaw Creek Watershed.

Sub-Basin Name	H60 Elevation (meters)	Area Below H60 Line		Area Above H60 Line		Total Area of Sub-basin
		Hectares	Percent	Hectares	Percent	Hectares
Dumont Creek	840	249	42%	340	58%	589
North Fork Creek	1,300	329	41%	468	59%	798
Woodward Face	560	90	50%	90	50%	180
Lower Main Winlaw Creek	750	117	43%	154	57%	271

Form 1: Area Measurements by Elevation Band and Sub-Basin.

(Note: The H60 area in the smaller watersheds deviates from a 40/60 split because of the large area between each two 20 meter contours in relation to the small total area of the watersheds.)

3 Effects of Harvesting on Stream Flow

3.1 Peak Flows

Most hydrologic impacts occur during periods of the peak stream flow in a watershed. Stream flow is defined as the channelized flow of water at the earth's surface. Peak flow is the maximum flow rate that occurs within a specified period of time, usually on an annual or event basis. In the interior of British Columbia, peak flows occur as the snowpack melts in the spring. Occasionally, periods of high stream flow can be caused by rainstorms and rain-on-snow events, particularly in the coast transition zone.

Snow melts from a watershed in a predictable pattern. Melt begins earlier in the season at lower elevations and proceeds upslope. Snow has generally disappeared from the lower elevations some time before the spring stream flows peak. During peak flow, snow is beginning to disappear from the mid-elevations and is actively melting at the higher elevations of a watershed.

After an area has been harvested, both winter snow accumulation and spring melt rates increase. This effect is less important at lower elevations, since the snow disappears before peak flow. At mid-elevations, the additional melt may or may not be important, depending on seasonal variations. Harvesting at high elevations will have the greatest impact and is, therefore, of most concern.

The changes in snow accumulation and melt brought about by forest harvesting are reduced as new forests grow. This is commonly referred to as hydrologic recovery.

3.2 Hydrologic Recovery

Second-growth forests are said to be hydrologically recovered when snowpack conditions approximate those prior to logging and, as a result, any impact on stream flow is minimized. The most important influence of vegetation on snow accumulation is the interception of snow by the forest canopy and the subsequent loss of this snow to the atmosphere. This interception effect is a result of the combined effects of tree height and canopy closure. The rate at which the snowpack melts is affected by the extent to which the snowpack is exposed to solar radiation which, like interception, is also controlled by the canopy. Consequently, canopy closure is one of the main stand characteristics affecting snow accumulation and melt.

The degree of canopy closure is determined by tree species, height, and stocking density. Since tree height data is readily available and is closely correlated with canopy closure, it is the variable used to evaluate hydrologic recovery.

The first approximation of hydrologic recovery (Table 8-1) for the southern interior is based on theoretical estimates of the effects of canopy closure on radiation penetration and snow interception, stand growth curves relating tree height and canopy closure, and snow data from studies in the Okanagan and Kootenays. The recovery estimates apply to fully stocked stands that reach a maximum crown closure of 50-70% and height of 20-30 m when mature. The growth curves used to convert crown closure to tree height assume a stand density of 1500 stems per hectare when the main canopy is 3 m in height. Tree heights refer to the average height of the main canopy (that is, co-dominant and intermediate trees, not dominant and suppressed stems).

Average Height of the Main Canopy (meters)	Percentage of Hydrologic Recovery
0 to <3	0%
3 to <5	25%
5 to <7	50%
7 to <9	75%
9+	90%

Table 8-1. First approximation of snow recovery in the southern interior for fully stocked stands in the snow zone that reach a maximum crown closure of 50-70%

3.3 Low Flow

In the interior of British Columbia, the lowest stream flows normally occur in late summer. Summer low flows are significant to both human use and fish habitat. During late summer, water demands for irrigation and domestic use tend to be high and supply limited.

Low flows in summer or winter can harm fish populations by reducing the amount of available habitat. During the summer, this is exacerbated by the added stress of higher oxygen needs of fish and lower dissolved oxygen concentrations when the water is warmer. During the winter, low flows cause less oxygen stress, but overwintering eggs can be damaged by freezing or ice movement.

Both summer and winter low flows result from long periods during which the water being discharged from soils and bedrock is not replenished by rain or snowmelt. Trees affect low flows by intercepting rain and snow, by reducing the amount of water entering the soil and, through transpiration, by removing water from the soil.

Transpiration, however, is directly related to moisture availability. Consider what happens in a clearcut under different conditions. During a wet summer, interception loss in a clearcut is low, resulting in more water entering the soil than would occur under a forest canopy. In addition, the water that would have been transpired from the soil by trees is available for groundwater recharge and stream flow. As a result, under wet conditions, the summertime low flow after clearcutting is greater than the low flow that would have occurred in the forest.

In contrast, during a summer without rain, water input to the soil is zero regardless of whether the site is forested or not. Transpiration losses in the clearcut would probably be less than in the forest, but the forested site would have very low transpiration losses anyway. Consequently, stream flow from both sites would be very low and clearcutting would have little effect on the water balance.

There is a general public perception that clearcutting dries out soils. This is probably because the top layers of soil do, in fact, become drier upon exposure to stronger sunlight and wind. However, the deeper soil layers in the rooting zone of trees have been shown to have higher moisture content after clearcutting. The net effect is that total soil moisture tends to increase after clearcutting. This effect diminishes as a site becomes revegetated until there is no detectable difference within 10 to 15 years after logging.

Low flows may occasionally also be observed to decrease as a result of channel aggradation. In some cases, water continues to be discharged from a basin. However, it moves below the surface through the stream bed where channel aggradation has occurred.

Watershed studies have shown that tree removal tends to result in increasing mean monthly flows in August, September, and October by a moderate amount during the 10- to 15-year revegetation period. This is probably beneficial in cases where water can be impounded for human use or for delayed release downstream. However, in most cases, there may be no benefit to fish, since the very lowest flows are not increased by harvesting.

In summary, timber harvesting appears to have a negligible, or slightly positive, effect on summer low flows in most cases. Winter low flows are probably not affected by forestry activities.

3.4 Annual Water Yield

In the United States, where most forestry-related watershed runoff studies have been done, harvesting has been found to increase annual water yield by 100-500 mm per year. The smallest increases have occurred on warmer, drier sites where soil moisture is limited. In these areas, the removal of trees does not make much more water available to streams. The largest increases have been observed in the Oregon Cascades where rainfall is high. Under these conditions, trees intercept a considerable portion of rainfall, allowing it to evaporate. The high rainfall also enables trees to take up and transpire large amounts of soil water. Timber harvesting reduces these large water losses and makes more available to streams.

In the Alberta Rockies and the interior of British Columbia, research has also shown increases in water yield after timber removal. In an Alberta study, harvesting 50% of the forested area resulted in a water yield increase of 27%, or 40 mm. In a paired watershed study in British Columbia’s southern interior, clearcutting 30% of a watershed resulted in a 21% increase in yield.

The 1973 Eden fire near Salmon Arm burned 50% of a watershed and caused a 24% increase in the April to August runoff. The effects of this fire on water yield are assumed to be similar to those that would result from timber harvesting.

One difference between the studies in the U.S. and the ones in western Canada is that most runoff in the British Columbia interior and Alberta Rockies occurs during spring snowmelt. Because of the snow-dominated regime in these areas, tree removal effects on the annual water balance are not limited to changes in evapotranspiration, but include increases in snow accumulation and spring discharge levels.

In summary, timber harvesting can be expected to produce the largest increases in water yield in areas that have an ample supply of moisture during the growing season. In areas where runoff is dominated by snowmelt, a large part of the annual yield increase can be associated with increased snow storage in openings, faster snowmelt, and thus an increase in spring runoff volume.

3.5 Peak Flow Index Tables

The equivalent clearcut area (ECA) is defined as the area that has been clearcut, with a reduction factor to account for the hydrological recovery due to forest regeneration. To estimate this value, determine the height of regeneration in each logged polygon below the H60 line on the 1:20 000 forest cover map. Heights may need to be extrapolated if reference material is not up-to-date. The area of each opening will then have to be reduced by the appropriate percent hydrological recovery, as shown below.

The following assumptions can be made for the ECA calculations:

- NSR (not sufficiently restocked): - clearcut with 0% recovery
- Partial cutting:
    - <30% basal area removal - expect 100% recovery
    - 30-60% basal area removal - clearcut x 0.5
    - 60% basal area removal - clearcut with 0% recovery
    - clusters of trees - apply appropriate recovery to area occupied by clusters
- Private land:
    - The Guidebook indicates that private land should be excluded from total sub-basin area (Form 1) and ECA calculations (Form 2) where it forms <15% of total sub-basin area.
    - This is overridden by the District Guidance which indicates that private land should be included in the IWAP.
- Cultivated land: - same as for private land
- Open range: - include in total sub-basin area (Form 1) but exclude from ECA calculations (Form 2)
- Burn sites: - clearcut with 0% recovery; extrapolate if regeneration
- Large slides: - clearcut with 0% recovery
- Hydro line: - clearcut with 0% recovery

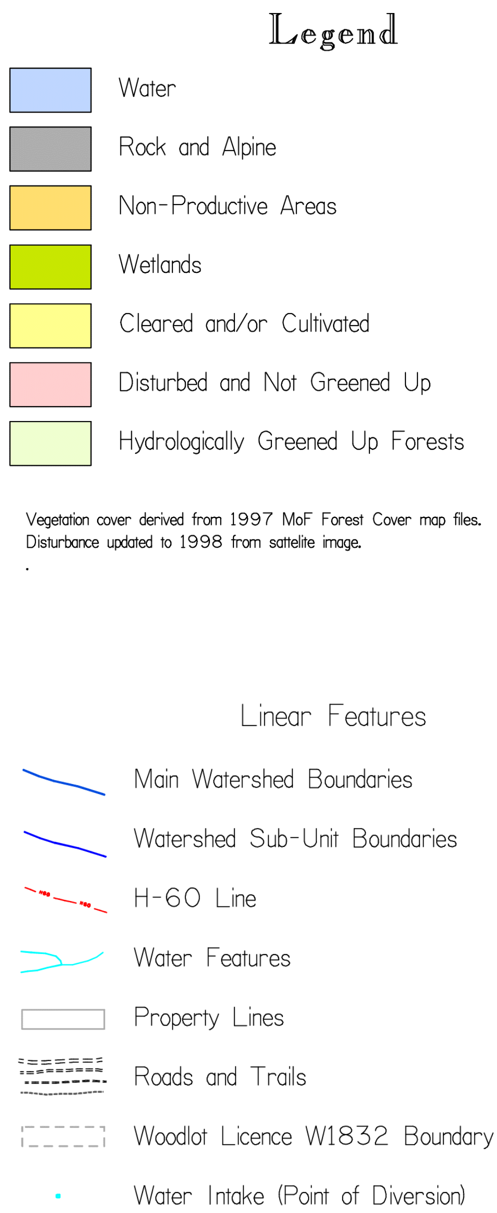

Figure 6: Legend for cover class maps in Figure 7 to Figure 10.

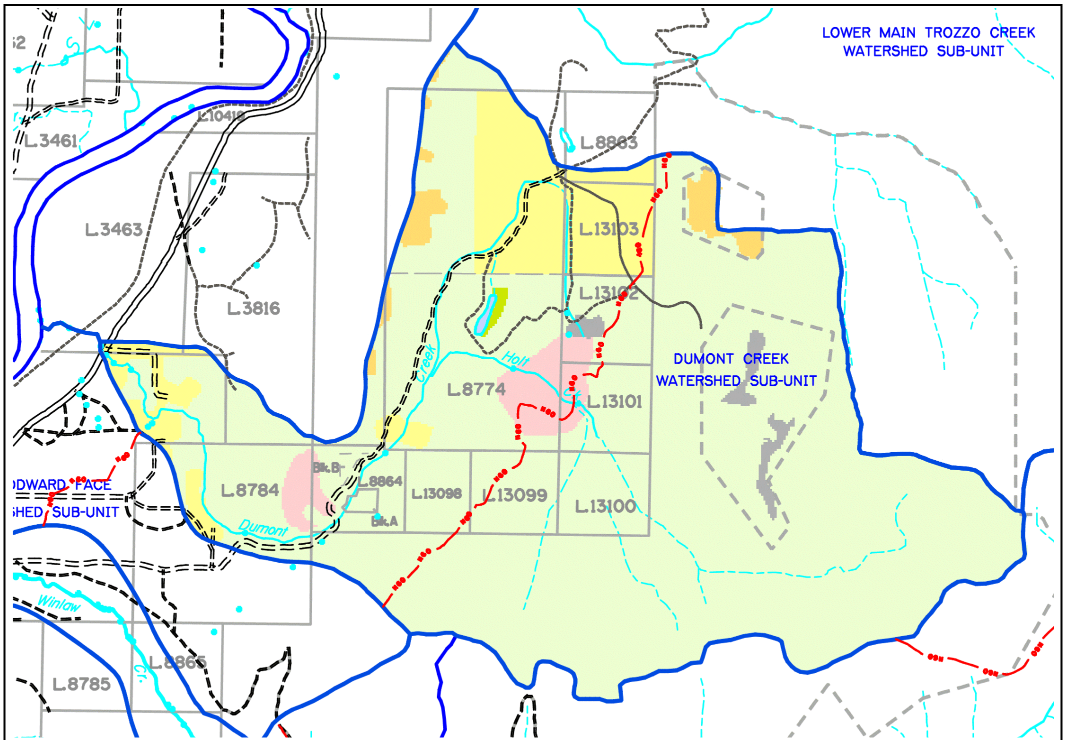

Figure 7: Map of Hydrologic cover classes in Dumont Creek Watershed.

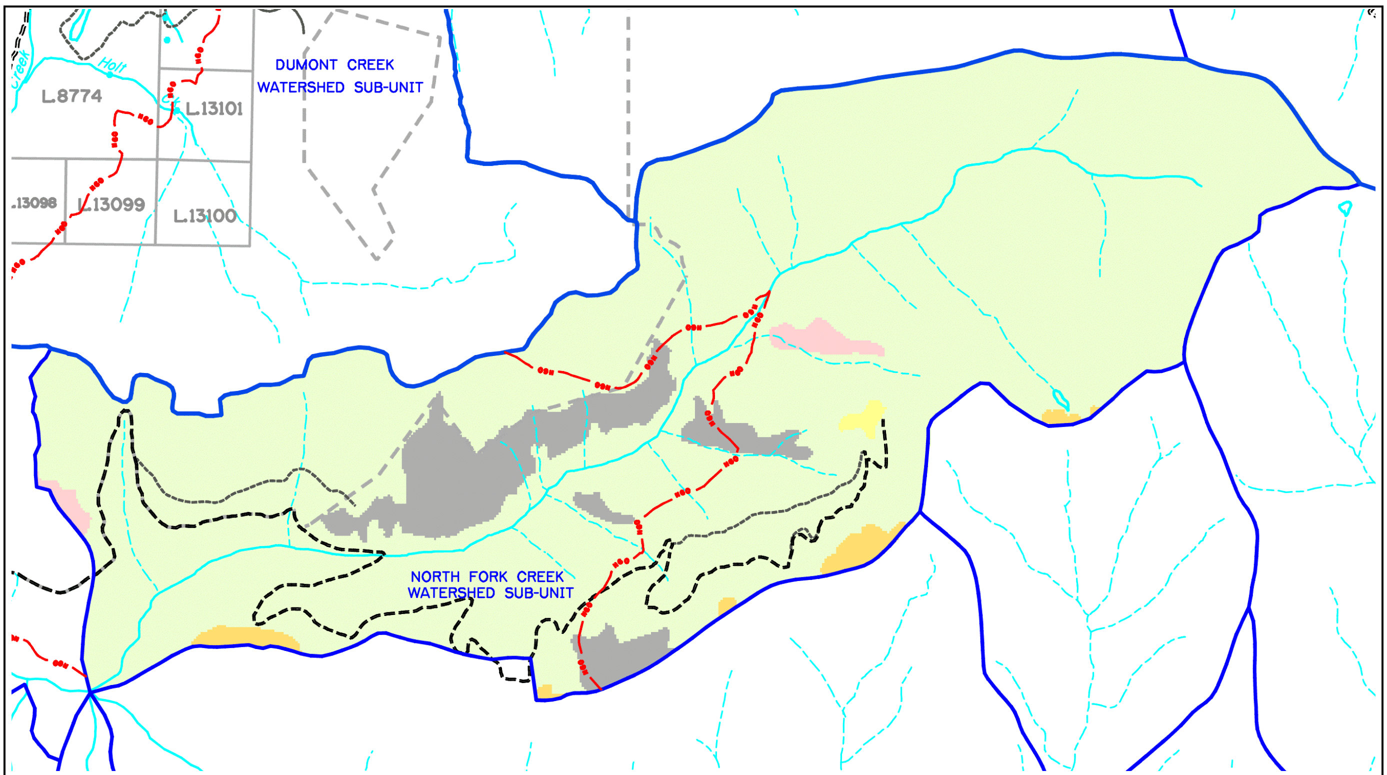

Figure 8: Map of Hydrologic cover classes in North Fork Watershed.

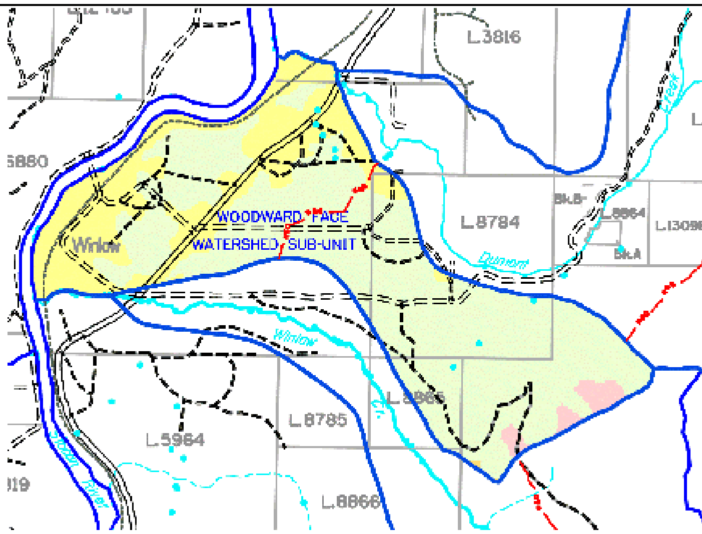

Figure 9: Map of Hydrologic cover classes in Woodward Face Watershed.

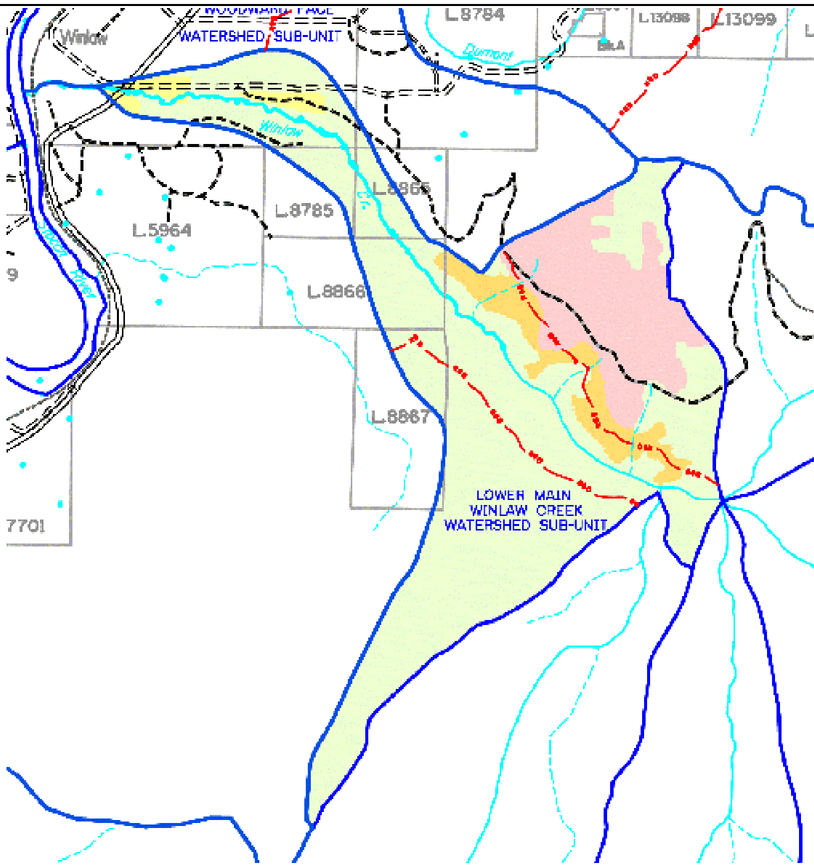

Figure 10: Map of Hydrologic cover classes in Lower Main Winlaw Creek Watershed.

Sub-Basin Name	Sub-Basin Area (hectares)	Area Below H60 Line			Area Above H60 Line			Peak Flow Index
		A ECA (hectares)	B ECA ÷ Total Sub-basin Area	C Weighted ECA (B x 1)	D ECA (hectares)	E ECA ÷ Total Sub-basin Area	F Weighted ECA (E x 1.5)	***Indicator #1*** (C + F)
Dumont Creek	589	78.4	0.13	0.13	5.0	0.01	0.01	0.15
North Fork Creek	798	2.1	0.00	0.00	6.4	0.01	0.01	0.01
Woodward Face	180	49.9	0.28	0.28	6.5	0.04	0.05	0.33
Lower Main Winlaw Creek	271	7.8	0.03	0.03	43.5	0.16	0.24	0.27

Form 2: Peak Flow Index Calculation by Sub-Basin.

During peak flow, snow is beginning to disappear from the mid-elevations and is actively melting at the higher elevations of a watershed. Therefore, harvesting at high elevations will have the greatest impact and is, hence, of greater concern than at lower elevations. Therefor, additional emphasis is applied to ECA above the H60 line (column E) by multiplying column E by an ECA weighting factor of 1.5.

4 Forestry Impacts on Surface Erosion

4.1 Surface Erosion

Increases in suspended sediment concentrations above natural levels have a detrimental impact on fish and fish habitat. High levels of suspended sediment can abrade and clog fish gills, reduce feeding and survival, and decrease overall stream productivity. Deposition of fine sediment on the stream bottom eliminates living space for juvenile trout and salmon and reduces populations of important fish food organisms. Sedimentation also degrades spawning habitat by filling in the spaces between the gravel particles where fish deposit their eggs, thereby reducing water percolation and oxygen levels and smothering the eggs.

Increases in suspended sediment concentrations can also reduce the value of water for domestic and agricultural use. High suspended sediment levels can reduce the effectiveness of treatment processes and increase maintenance costs by clogging or reducing the capacity of filtration systems. Visible turbidity is aesthetically undesirable for domestic use and can be associated with higher bacterial concentrations. Suspended sediment can also be deposited in, and reduce, the capacity of irrigation ditches, storage ponds, and water tanks.

Most of the time, streams are capable of carrying more suspended sediment than they actually contain. In such cases sediment concentration is "supply limited" and an increase in erosion by running water anywhere in a watershed will usually cause an increase in suspended sediment load downstream. In studies where researchers have considered the effects of both increased peak flows and increased sediment supply, the increases in sediment supply have been consistently judged to be more important in causing an increase in suspended sediment concentrations.

Roads are one of the most significant causes of increased erosion. Road construction exposes large areas of mineral soil to removal by rainwater and snowmelt. Sediment is easily delivered to water courses during wet periods because roads and their drainage ditches frequently intersect stream channels. Generally, the greater the number of stream crossings, the greater the number of sites where sediment can readily be delivered to channels. Fine-grained soils are particularly sensitive to such surface erosion.

The erosion and transport of sediment from roads is exacerbated by the greatly reduced infiltration capacity of mineral soils on cut banks, running surfaces, and fill slopes, caused by compaction and the loss of organic horizons. Roads and skid trails also intercept and concentrate surface runoff so that it has more energy to erode even stable soils. Roads in areas with higher rainfall and snowmelt rates tend to exhibit higher levels of erosion than roads in drier areas. Roads can also cause rapid mass movements and result in very large increases in sediment loads.

The negative effects of roads and skid trails can be moderated by laying them out to avoid the more sensitive sites, using appropriate road and drainage structure construction techniques, installing waterbars on non-permanent roads, and adopting a variety of other erosion control techniques.

4.2 Road Inventory

Road density above H60 (Indicator #2): To obtain this value, measure the total length of all roads above the H60 line and divide by the total sub-basin area. Roads include all hauling and in-block roads.

Road density for total sub-basin (Indicator #3 and #8): Measure the total length of all roads in the watershed[1] and divide by the total sub-basin area.

Sub-Basin Name	Sub-Basin Area	Road Above 60 Line		Road for Entire Sub-Basin	
			Indicator #2		**Indicator #3 and #8**
	(hectares)	Length (meters)	Density (km/km2)	Length (meters)	Density (km/km2)
Dumont Creek	589	421	0.07	6,769	1.15
North Fork Creek	798	3,835	0.48	10,176	1.28
Woodward Face	180	3,758	2.09	10,999	6.12
Lower Main Winlaw Creek	271	1,299	0.48	3,588	1.32

Form 3: Road Inventory and Density.

4.3 Surface Erosion Hazard

Density of roads on erodible soils (Indicator #4): Measure the total length of all roads located on erodible soils[2] and divide by the total sub-basin area.

Road density within 100 m of a stream (Indicator #5): Measure the total length of all roads located within 100 m of any stream identified on the TRIM or forest cover maps and divide by the total sub-basin area.

Road density within 100 m of a stream and on erodible soils (Indicator # 6): This is probably the most important indicator in the surface erosion section. The two most important factors in determining how much fine sediment will be delivered to streams from road running surfaces are the proximity of the road to the stream and the parent material on which the road was built. This indicator attempts to quantify this hazard.

To obtain this value, measure the total length of roads that are located within 100 m of any stream and on erodible soils and divide by the total watershed area.

Density of active stream crossings (Indicator # 7): It has been frequently documented that stream crossing are often a chronic source of fine-textured material to streams. This can be either directly from the building of the stream crossing or indirectly from delivery of fine sediments along road ditches that empty directly into a stream. To obtain this value, count the total number of stream crossings in the watershed (of all streams visible on TRIM or forest cover maps) and divide by the total watershed area. Active stream crossings are

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[1] All roads shown on forest cover mapping were used. This excludes private driveways in settled areas and some overgrown, old trails in forested areas.

[2] Identified as slopes over 60% in this assessment because sufficient coverage of terrain assessment data is not available.

defined as those crossings that are still presently being used or will be maintained in a coordinated access management plan.

Sub-Basin Name	Sub-Basin Area (hectares)	Road on Erodible Soils		Road within 100 m of a Stream	
		Length (meters)	**Indicator #4** Density (km/km2)	Length (meters)	**Indicator #5** Density (km/km2)
Dumont Creek	589	394	0.07	5,259	0.89
North Fork Creek	798	1,353	0.17	3,039	0.38
Woodward Face	180	394	0.22	2,245	1.25
Lower Main Winlaw Creek	271	0	0.00	2,343	0.87

Sub-Basin Name	Sub-Basin Area (hectares)	Road within 100 m of a Stream on Erodible Soils		Density of Stream Crossings	
		Length (meters)	**Indicator #6** Density (km/km2)	Number	**Indicator #7** Density (number/km2)
Dumont Creek	589	394	0.07	5	0.85
North Fork Creek	798	349	0.04	4	0.50
Woodward Face	180	24	0.01	0	0.00
Lower Main Winlaw Creek	271	0	0.00	3	1.11

Form 4: Roads Adjacent to Streams.

5 Riparian Buffers

Riparian zones are defined in the Forest Practices Code as the land adjacent to the normal high water line in a stream, river, lake, or pond and extending to the portion of land influenced by the presence of the adjacent ponded or channeled water.

The riparian zone is of critical importance to stream ecosystems. The riparian vegetation: contributes nutrients and fish food by providing plant material and insects to the stream, regulates stream water temperatures (tree canopy shading), and delivers large woody debris (LWD) to the stream. The LWD provides much of the fish habitat and also contributes to stream channel stability. The roots of streamside vegetation tend to resist stream erosion by helping to hold the bank materials together. Streamside vegetation promotes overbank sediment deposition and also provides hiding cover or refuge for fish.

Logging in riparian zones has led to increased bank erosion, loss of in-channel islands, increased size and frequency of sediment wedges, and altered stream shape. Logging camps, storage areas, and dumps are commonly located in floodplain areas because of the relative ease of access and construction and the readily available source of drinking water. These facilities have caused stream pollution problems, as well as changes to the stream channel itself.

Forestry activities influence some, but not all, factors that control channel conditions. Logging can influence flood characteristics, sediment delivery, and the nature and extent of riparian vegetation. Typically, if stream flows and sediment delivery to the channel are increased, it is expected that the channel would become wider, shallower, less sinuous, and steeper (within limits, depending on sinuosity). Changes in sediment supply to the channel can have a major influence on in-stream biological conditions. For instance, increased sediment supply can result in reduced fish rearing and overwintering habitats (loss of pools and underbank areas), decreased juvenile fish survival and smolt production, and impaired spawning and incubation environments (degraded riffle sites). Changes in the species, size, amount, distribution, and orientation of LWD also have a significant effect on stream channel conditions (e.g., pools can infill and riffles can become more extensive).

The influence of logging will also vary depending on stream size. Small streams can be affected directly by landslides, particularly in headwater areas, and this can result in complete disruption of the normal shape of the channel. Medium-sized channels are usually influenced strongly by in-stream woody debris. The LWD characteristics are influenced by both streamside and upslope logging. Altered LWD characteristics have been shown to lead to changed channel morphology, sediment characteristics, and hydrologic conditions. Logging activities have less obvious direct influence on the larger stream channels. Exceptions include direct disturbances of streambanks (crossings, streamside logging, yarding, etc.), bed conditions (obstructions, sediment, and debris removal), and mid-channel islands.

Sub-Basin Name	Length of Stream Logged (meters)	Total Stream Length (meters)	**Indicator #4** Proportion of Stream Logged	Length of Fish-Bearing Stream Logged (meters)	Total Fish Bearing Stream Length (meters)	**Indicator #5** Proportion of Fish Bearing Stream Logged
Dumont Creek	300	10,018	0.03	0	0	0
North Fork Creek	0	15,704	0	0	0	0
Woodward Face	0	322	0	0	0	0
Lower Main Winlaw Creek	0	4,193	0	0	3,500	0

Form 5: Riparian Buffer Impacts.

6 Landslide Hazard

6.1 Definition of Unstable Slopes

The potential for slopes to experience landsliding is determined by terrain (surficial geology) mapping, and the subsequent interpretation of the terrain mapping information into slope stability classes using, as defining criteria, slope angle, materials and landforms, material texture, active geomorphological processes, and soil drainage.

Terrain maps provide information about the distribution and characteristics of surficial materials, landforms, and geological processes in an area. The terrain classification system used for mapping in British Columbia is defined in Howes and Kenk (1988). The Resources Inventory Committee (1994) provides additional important information, including that on terrain survey intensity levels and interpretive products such as slope stability classification. The Mapping and Assessing Terrain Stability Guidebook provides detailed information on the standard procedures to be used for forestry-related purposes in British Columbia.

Terrain mapping and slope stability classification must be done by a registered professional who has extensive experience in terrain mapping and landslide hazard interpretations. Junior mappers can do this work under the close supervision of such an individual.

In British Columbia a five-class slope stability classification is most commonly used. The slope stability classes are as follows:

- I. No significant stability problems exist.
- II. There is a very low likelihood of landslides following harvesting or road construction.
- III. Minor stability problems may develop in some areas.
- IV. Terrain polygons contain areas with a moderate likelihood of landslide initiation following harvesting or road construction.
- V. Terrain polygons contain areas with a high likelihood of landslide initiation following harvesting or road construction.

6.2 Locating Areas of Potential Slope Instability

Slope stability Class IV and V are used as indicators of potentially unstable terrain. If slope stability maps are available for the watershed of concern, then the polygons identified as Class IV and V should be indicated on the overlay or entered into a GIS.

Where terrain mapping or slope stability classification is not available for a watershed, the potentially unstable terrain may be assessed as (in order of reliability):

1. Areas properly defined as Es1 and Es2, in environmental sensitivity mapping done as part of forest development planning, where the mapping was done by a registered professional with extensive experience in terrain mapping and landslide interpretation.

There are a large number of Es1 and Es2 maps in existence that were not produced by such individuals. These are not acceptable for use in IWAP, as there is no certainty that all areas of potentially unstable or unstable terrain have been identified.

2. Areas with slopes greater than 60% (31 degrees). In most cases, using a slope angle classification alone will largely over-estimate the area of potentially unstable terrain.

(Note: Complete coverage of terrain mapping is not available for any of the watersheds affected by this Forest Development Plan at the time of writing. Terrain stability mapping was used to identify unstable terrain where it is available, and slope greater than 60% based on analysis of the TRIM I digital terrain model was used to identify potentially unstable terrain in areas where mapping is not available.)

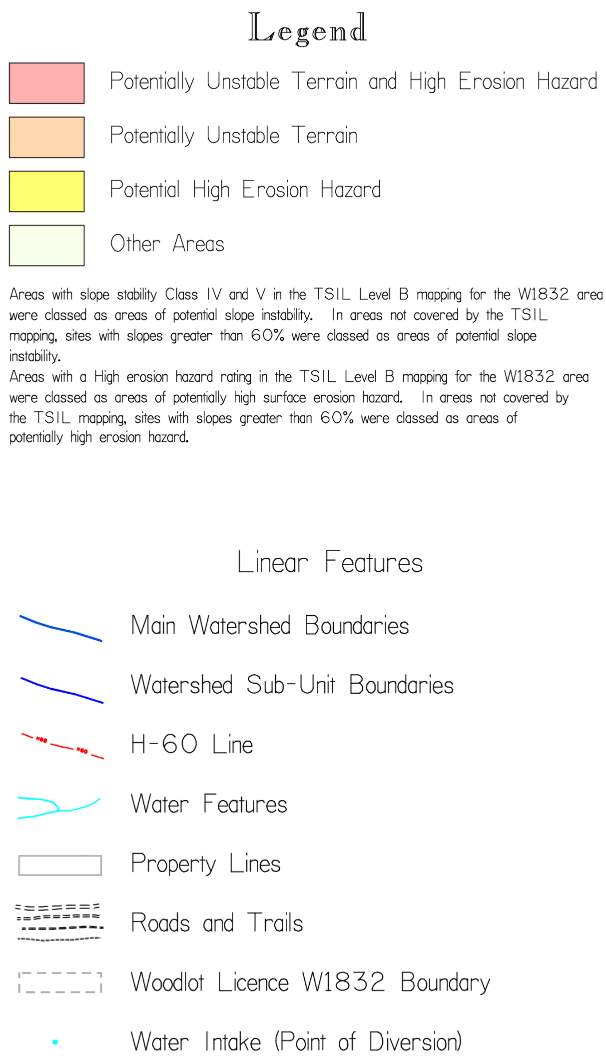


Figure 11: Legend for terrain class maps in Figure 13 to Figure 15.

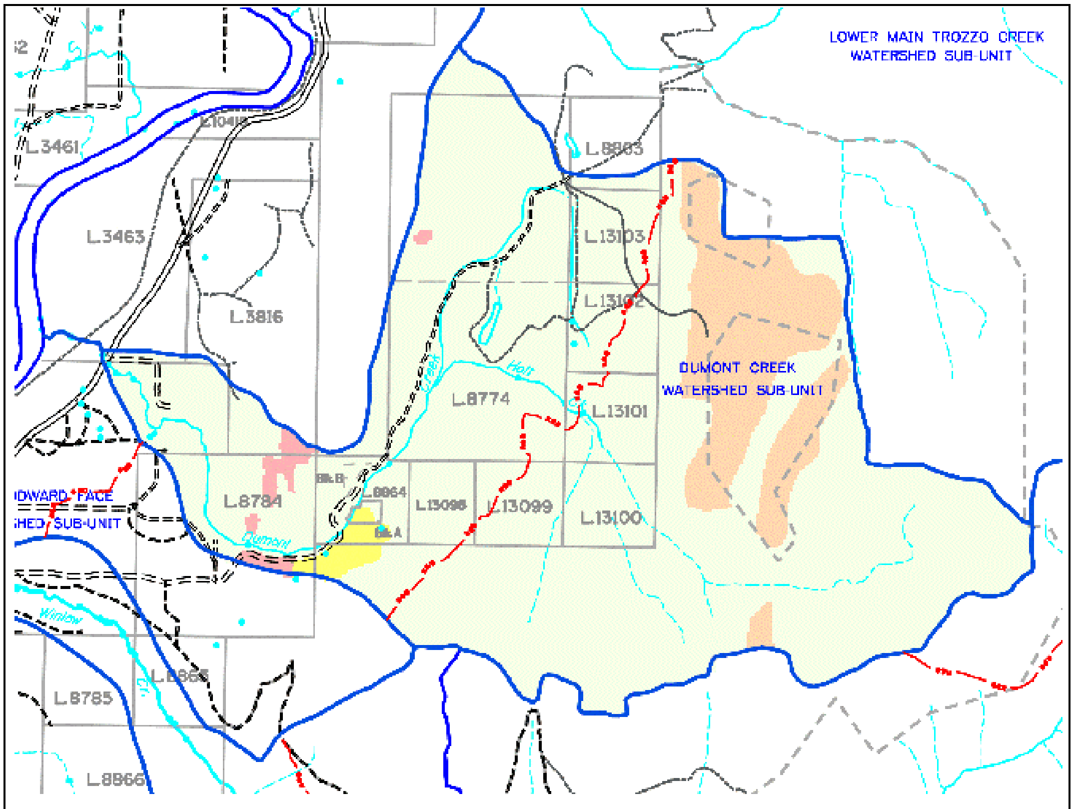


Figure 12: Map of Terrain classes in Dumont Creek Watershed.

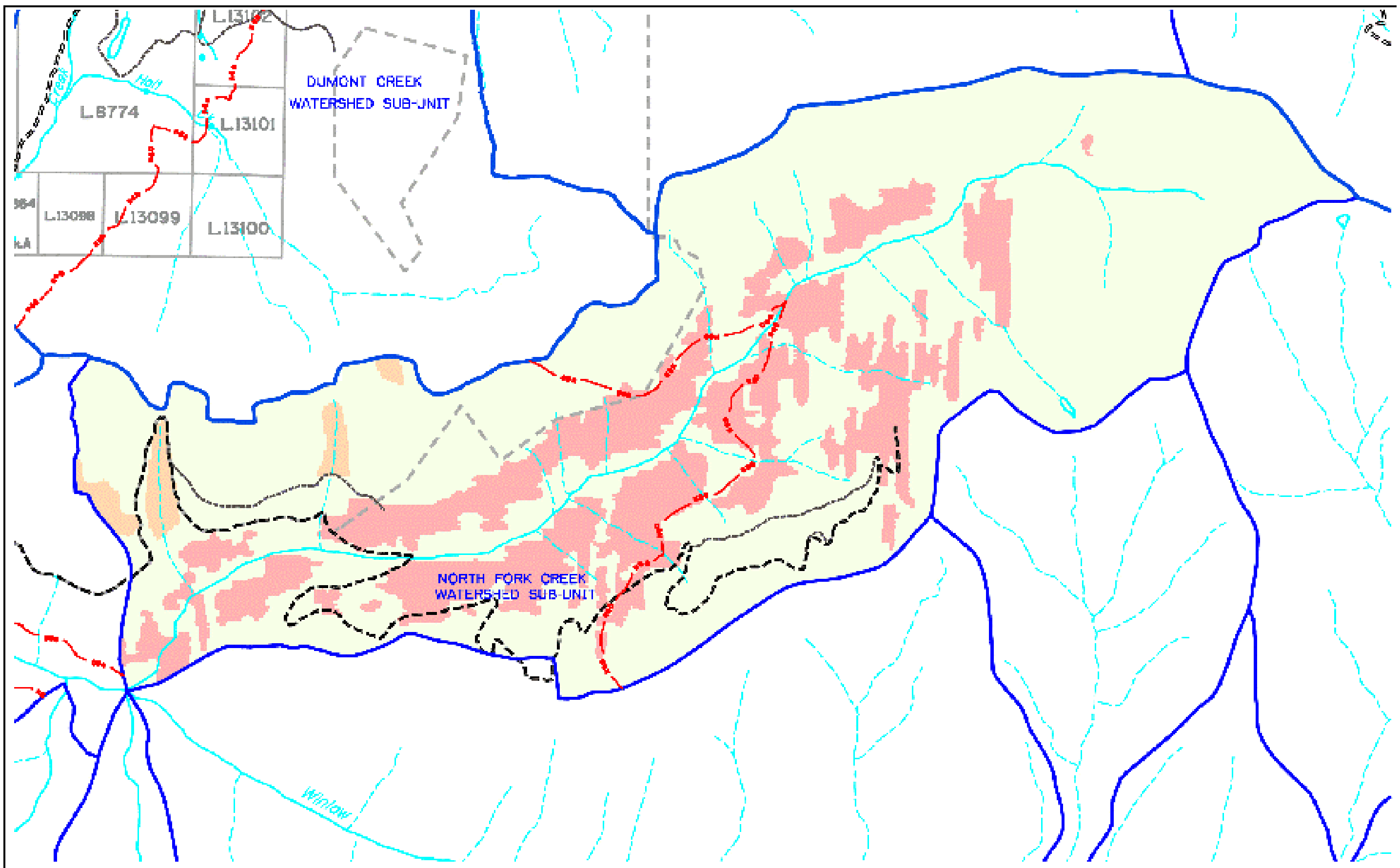


Figure 13: Map of Terrain classes in North Fork Watershed.

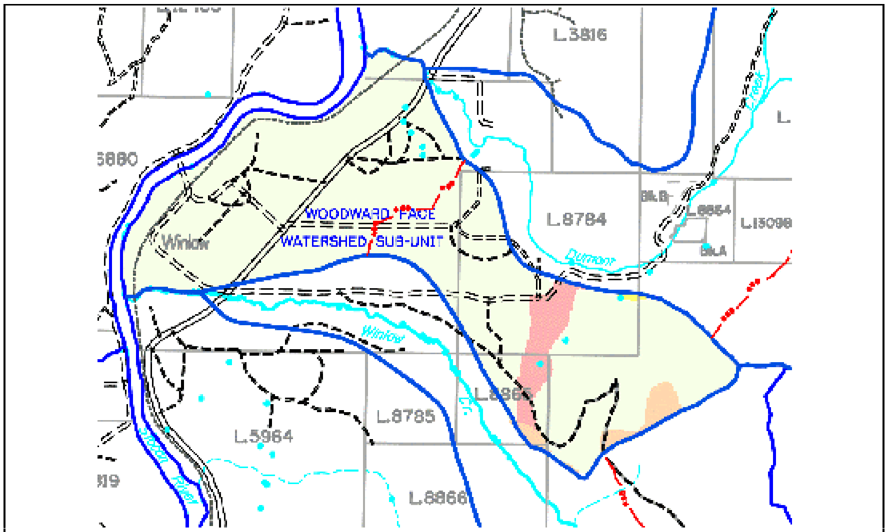


Figure 14: Map of Terrain classes in Woodward Face Watershed.

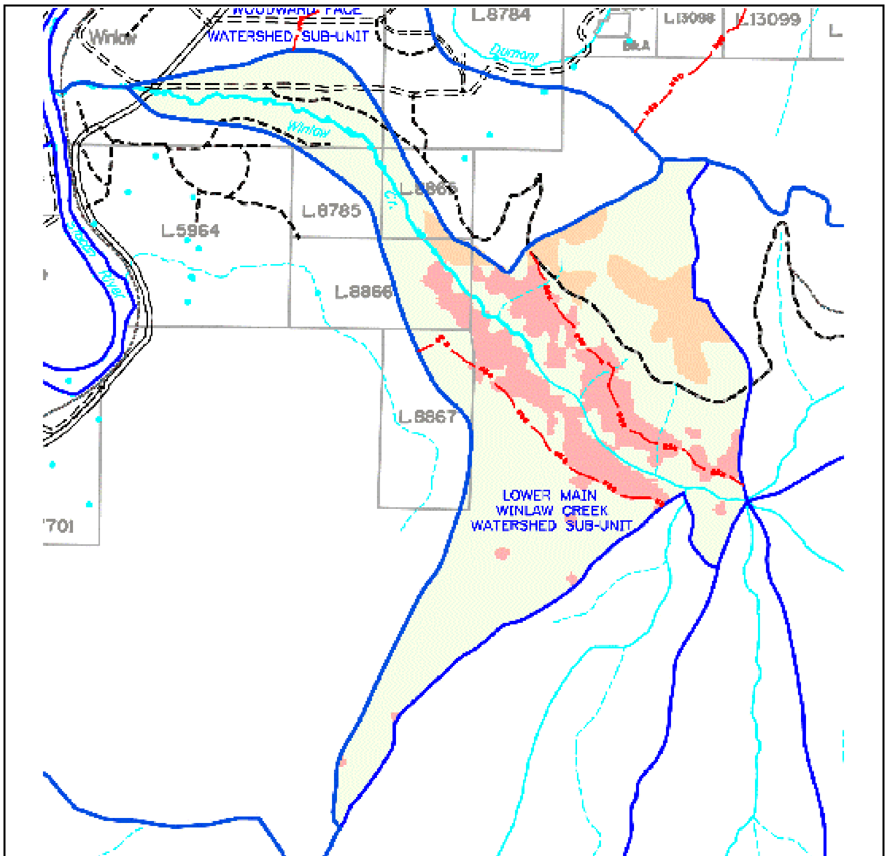


Figure 15: Map of Terrain classes in Lower Main Winlaw Creek Watershed.

6.3 Forestry Impacts on Landslides and Mass Wasting

Landslides indicate unstable terrain. The frequency of occurrence of landslides within a watershed is an indication of the presence of potentially unstable slopes. Forest development activities, particularly the construction of roads, can reduce slope stability and initiate slope failures. Impacts from a slide into a stream can range from minor water quality degradation to the initiation of a major debris torrent.

The increase in bedload and woody debris delivery to streams from mass wasting is probably the most important factor in creating stream channel change following logging.

Increased landslide rates are attributed to many factors. Road building disrupts and concentrates subsurface drainage, often creating points of water concentration. Road sidecast can overload and oversteepen already steep slopes. Tree removal increases the amount of rain that reaches the soil because of the loss of canopy interception, and also increases the rate at which snow melts during both rain-on-snow events and spring snowmelt. Soil strength is reduced by the decay of anchoring roots in the years following tree harvesting. Yarding operations can disrupt natural drainage pathways and can result in gullies infilled with woody slash, increasing the potential for or magnitude of debris torrents.

There are three landslide-related issues to be considered. The first issue is the potential for slides to occur in a particular area. This can be assessed on the basis of the number of events that has occurred both in natural settings and in association with forest development activities. The more slide sites there are, the greater the potential for future mass wasting events.

The second issue is that of delivery. Delivery is defined as the potential for the slide debris to enter a stream. The highest risk sites are those where there is a continuous slope to the edge of a stream. In these situations, opportunities to prevent a slide from impacting the stream are limited. The least risk sites are those where the stream is separated from the slope by a broad valley flat.

The final issue is the potential for transfer of material down the stream after it has entered a watercourse. Sediment transport, particularly of coarse material, is a function of stream gradient. The steeper the gradient, the more material moved and the greater the distance of travel. Low gradient sections of channel are typically braided (multi-channel) as a result of sediment deposition.

Sub-Basin Name	Sub-Basin Area (hectares)	Landslides		Road on Unstable Terrain		Streams with Logged Banks on Slopes > 60%	
		Number	**Indicator #11** Density (number/km2)	Length (meters)	**Indicator #12** Density (km/km2)	Length (meters)	**Indicator #13** Density (km/km2)
Dumont Creek	589	1	0.17	446	0.08	0	0
North Fork Creek	798	4	0.50	1,815	0.23	0	0
Woodward Face	180	1	0.56	485	0.27	0	0
Lower Main Winlaw Creek	271	1	0.37	252	0.09	0	0

Form 6: Landslide Hazard Assessment.

7 Watershed Characteristics

The watershed characteristics listed in Forms 8 and 9 are either required to derive one of the 13 impact indicators, or are otherwise easily acquired from a GIS analysis of digital watershed and forest cover data. The characteristics are not directly used to assess cumulative impacts in a watershed, but are valuable for use in assessing the impact results.

Sub-Basin Name	Sub-Basin Area	Crown Land		Private Land		Operable Land	
	Hectares	Hectares	Percent	Hectares	Percent	Hectares	Percent
Dumont Creek	589	422	72%	167	28%	0	0
North Fork Creek	798	798	100%	0	0%	0	0
Woodward Face	180	35	19%	145	81%	0	0
Lower Main Winlaw Creek	271	217	80%	54	20%	0	0

Form 7: Watershed Characteristics I.

Sub-Basin Name	Sub-Basin Area	Area with Unstable Slopes		Area with Erodible Soils		Are there fisheries temperature concerns?	Hydrological Zone	Dominant Bedrock Geology	Area there Glaciers in Sub-Basin?
	Hectares	Hectares	Percent	Hectares	Percent				
Dumont Creek	589	74	13%	13	2%	No	Southern Selkirk Mountains	Intrusive Granitic	No
North Fork Creek	798	183	23%	169	21%				
Woodward Face	180	13	7%	9	5%				
Lower Main Winlaw Creek	271	65	24%	43	16%				

Form 8: Watershed Characteristics II.

8 Other Land Uses That Potentially Affect Water Quality

In addition to forestry-related land uses, other activities on Crown land can potentially impact aquatic resources, and must be assessed as part of the IWAP. These include:

- livestock grazing
- all-terrain vehicle recreation (motorcycles and off-road trucks)
- mining (placer) activity.

Grazing animals affect water quality by trampling and disturbing streamside and lakeshore sediments, and by depositing fecal material in and adjacent to streams and lakes. As part of the level 1 IWAP, Forest Service range officers will provide an assessment of whether there are locations in a watershed where livestock potentially congregate near streams or lakes. If such locations exist, they must be examined in the field and assessed for sediment or fecal impacts. Where field assessment indicates that cattle congregation on Crown land could potentially affect water quality, prescriptions must be developed and implemented by the Forest Service and range licensees to reduce and eliminate the impacts.

All-terrain vehicle (ATV) recreation is not uncommon in interior watersheds. In forested watersheds, ATV use most commonly occurs along linear rights-of-way, such as for hydro or gas lines. Water quality is affected where ATVs expose mineral soil, allowing surface runoff of sediment-laden water to enter streams. As part of the level 1 IWAP, Forest Service recreation officers will provide an assessment of whether there are locations in a watershed where ATV recreation occurs. If such locations exist, they must be examined in the field and assessed for sediment impacts. Where field assessment indicates that ATV recreation on Crown land is contributing to water quality degradation in a watershed, the Forest Service should develop prescriptions to reduce and eliminate the impacts.

Placer mining can potentially have severe impacts on water quality. Where placer mining is occurring in a watershed, the specific locations must be assessed in the field for sediment impacts. Where impacts are found, the district inspector of mines, B.C. Ministry of Energy, Mines and Petroleum Resources (effective March 1996 - now Ministry of Employment and Investment - Energy and Minerals Division), should be notified and measures taken to reduce the placer impacts.

Sub Basin Name	Range Use Close to Streams?	Mining Close to Streams?	All Terrain Vehicles Close to Streams?
Dumont Creek	Yes	No	No
North Fork Creek	No	No	No
Woodward Face	No	No	No
Lower Main Winlaw Creek	No	No	Yes

Form 9: Other Land Uses which may impact water quality.

9 Watershed Report Cards

The preceding forms produce a set of raw data scores. The range of raw data for each indicator varies greatly from one indicator to another. Therefore, to make the indicators easier to interpret, the data are rescaled to fit between 0 and 1.0, with increments of 0.1. Zero means no impact, 0.5 means potential moderate impact, and 1.0 means potential high impact. This rescaling is performed automatically by the spreadsheet used to summarize the IWAP data.

The watershed report cards below present the raw data score for each indicator, the rescaled score for each indicator, and the hazard index for each of four impact categories for each sub-basin.

This report card is used as the basis for identifying watershed constraints and developing management recommendations.

Watershed Report Card for Dumont Creek Watershed

		Indicator		(5) Score	(6) Hazard Index
Peak Flow					
	Index above H60	0.01			
	Index below H60	0.13			
1	Total Peak Flow Index	0.15		0.24	
2	Road density above H60	0.07	km/sq.km.	0.07	
3	Total road density (See note below)	1.15	km/sq.km.	0.38	**0.24**
Surface Erosion					
4	Roads on erodable soils	0.07	km/sq.km.	0.13	
5	Roads within 100 m of a stream	0.89	km/sq.km.	1.00	
6	Roads that are both of the above	0.07	km/sq.km.	0.33	
7	Active stream crossings	0.85	no./sq.km.	0.95	
8	Total road density (See note below)	1.15	km/sq.km.	0.38	**0.97**
Riparian Buffer					
9	Portion of stream logged?	0.03	km/km.	0.10	
10	Portion of fish bearing streams logged?	0.00	km/km.	0.00	**0.10**
Landslides					
11	Landslide density	0.17	no./sq.km.	0.62	
12	Roads on unstable slopes	0.08	km/sq.km.	0.25	
13	Streams >60% and banks logged	0.00	km/sq.km.	0.00	**0.62**

Table 1: IWAP Report Card for Dumont Creek Watershed.

Watershed Report Card for North Fork Creek Watershed

		Indicator		(5) Score	(6) Hazard Index
Peak Flow					
	Index above H60	0.01			
	Index below H60	0.00			
1	Total Peak Flow Index	0.01		0.02	
2	Road density above H60	0.48	km/sq.km.	0.48	
3	Total road density (See note below)	1.28	km/sq.km.	0.43	**0.31**
Surface Erosion					
4	Roads on erodable soils	0.17	km/sq.km.	0.34	
5	Roads within 100 m of a stream	0.38	km/sq.km.	0.86	
6	Roads that are both of the above	0.04	km/sq.km.	0.22	
7	Active stream crossings	0.50	no./sq.km.	0.60	
8	Total road density (See note below)	1.28	km/sq.km.	0.43	**0.73**
Riparian Buffer					
9	Portion of stream logged?	0.00	km/km.	0.00	
10	Portion of fish bearing streams logged?	0.00	km/km.	0.00	**0.00**
Landslides					
11	Landslide density	0.50	no./sq.km.	1.00	
12	Roads on unstable slopes	0.23	km/sq.km.	0.66	
13	Streams >60% and banks logged	0.00	km/sq.km.	0.00	**1.00**

Table 2: IWAP Report Card for North Fork Creek Watershed.

Watershed Report Card for Woodward Face Watershed

		Indicator		(5) Score	(6) Hazard Index
Peak Flow					
	Index above H60	0.05			
	Index below H60	0.28			
1	Total Peak Flow Index	0.33		0.55	
2	Road density above H60	2.09	km/sq.km.	1.00	
3	Total road density (See note below)	6.12	km/sq.km.	1.00	**0.85**
Surface Erosion					
4	Roads on erodable soils	0.22	km/sq.km.	0.44	
5	Roads within 100 m of a stream	1.25	km/sq.km.	1.00	
6	Roads that are both of the above	0.01	km/sq.km.	0.07	
7	Active stream crossings	0.00	no./sq.km.	0.00	
8	Total road density (See note below)	6.12	km/sq.km.	1.00	**1.00**
Riparian Buffer					
9	Portion of stream logged?	0.00	km/km.	0.00	
10	Portion of fish bearing streams logged?	0.00	km/km.	0.00	**0.00**
Landslides					
11	Landslide density	0.56	no./sq.km.	1.00	
12	Roads on unstable slopes	0.27	km/sq.km.	0.74	
13	Streams >60% and banks logged	0.00	km/sq.km.	0.00	**1.00**

Table 3: IWAP Report Card for Woodward Face Watershed

Watershed Report Card for Lower Main Winlaw Creek Watershed

		Indicator		(5) Score	(6) Hazard Index
Peak Flow					
	Index above H60	0.24			
	Index below H60	0.03			
1	Total Peak Flow Index	0.27		0.45	
2	Road density above H60	0.48	km/sq.km.	0.48	
3	Total road density (See note below)	1.32	km/sq.km.	0.44	**0.46**
Surface Erosion					
4	Roads on erodable soils	0.00	km/sq.km.	0.00	
5	Roads within 100 m of a stream	0.87	km/sq.km.	1.00	
6	Roads that are both of the above	0.00	km/sq.km.	0.00	
7	Active stream crossings	1.11	no./sq.km.	1.00	
8	Total road density (See note below)	1.32	km/sq.km.	0.44	**1.00**
Riparian Buffer					
9	Portion of stream logged?	0.00	km/km.	0.00	
10	Portion of fish bearing streams logged?	0.00	km/km.	0.00	**0.00**
Landslides					
11	Landslide density	0.37	no./sq.km.	0.95	
12	Roads on unstable slopes	0.09	km/sq.km.	0.31	
13	Streams >60% and banks logged	0.00	km/sq.km.	0.00	**0.95**

Table 4: IWAP Report Card for Lower Main Winlaw Creek Watershed.

10 Level 2 Assessment

At this point in the Level 1 assessment, it must be decided whether further analyses on a particular watershed are required. As a rule of thumb:

- If all hazard indices (Form 11) are less than 0.5, there are no or limited perceived cumulative impacts and no further IWAP analysis is required to assess impacts of past forestry activity. However, if a forest development plan is proposed for the area, a second level 1 analysis must be completed to assess the potential impacts that may result from that forest development. The assessment can thus be used strategically to alter the plan, as necessary, to minimize watershed impacts.
- If the surface erosion hazard index is greater than or equal to 0.5, but all other hazard indices are less than 0.5, no further IWAP analysis is required.
- If any of the peak flow, mass wasting, or riparian buffer hazard indices are greater than or equal to 0.5, then a level 2 analysis (that is, a channel assessment) must be completed before the interpretations, as described, are developed. The results of the level 2 analysis should be used in the interpretation worksheets in the section “Making interpretations and recommendations,” under “channel instability.”

The level 2 WAP provides an overview assessment of stream channels in the watershed, and estimates the level of channel disturbance associated with forest practices for the most sensitive channel type within each watershed or sub-basin.

11 Interpretations

Previous text sections of this Appendix have been drawn from the IWAP manual. This section was written by the Licencees, and is not drawn from the IWAP manual, except for specific citations.

We have used the standard IWAP process to develop a series of measurements and assessments of human disturbance and associated risk to watersheds within which development activities are proposed. The next step is to interpret the results.

The first, most important, question to ask is "Are the assessments valid?"

Results from the Interior Watershed Assessment Procedure (IWAP) become less dependable in smaller watersheds, and the KBLUP IS notes that they should not be used by themselves to define hazards in watersheds under 500 hectares. KBLUP IS also notes:

> *IWAP is a very new procedure and will not be fully calibrated until many applications can be ground-truthed and analyzed. For example, current applications are experiencing numerous problems with "false highs". This occurs when high hazard scores are registered on the report card but are not confirmed by field investigation. Studies are currently underway to calibrate the reconnaissance level hazard ratings with actual on-the-ground hazards.*
>
> *…Therefore it is important that hazard scores be used only as a course filter to help identify potential problem areas and/or to aide in the prioritization of watersheds for application of a full IWAP.*[3]

All of the watershed units under consideration are relatively small, ranging in size from 180 to 798 hectares. A careful examination of the results suggests that many of the hazard ratings are skewed to the "high" end of the scale by watershed size, rather than by watershed-wide high hazard conditions. This is because a single "event" in a small watershed will result in high "events per km^2" rating, which is the basis for many IWAP risk assessments.

For example, the Woodward Face Sub-Unit has a landslide density of 0.56 landslides per km^2 , which results in a mass wasting category hazard rating of 1.00, or very high. However, this hazard rating is caused by a single landslide, which has been attributed to improper road maintenance. The high rating is not sound evidence of widespread high hazard of landslides in this low elevation, low slope gradient unit. The landslide itself is a significant feature and was a significant event for water users, but it is not a reliable indicator of the level of landslide risk at a watershed scale for this unit.

A review of the Woodward Face Report Card (Table 3) shows that the sub-basin also has high hazard index ratings for peak flow (0.85) and surface erosion (1.00). These ratings are largely due to high road density in the settled portion of the watershed.

The IWAP Guidebook states:

> *If any of the peak flow, mass wasting, or riparian buffer hazard indices are greater than or equal to 0.5, then a level 2 analysis (that is, a channel assessment) must be completed…*

[3] KBLUP IS Chapter 3 Page 37 and 38.

Thus, technically speaking, a channel assessment is required for a watershed subunit which is largely devoid of surface water flow, due to a single landslide and established human use patterns. Neither of these factors is a sound indicator of widespread high geomorphological or forestry related hazard in this watershed, and a channel assessment appears spurious.

Examples of high hazard indexes which suggest that a stream channel stability assessment is required can be found in each watershed assessed. These high hazard ratings are generally related to high densities of old roads and suburban roads in the watersheds in question, not to alteration of forest cover. As the development activities proposed in this FDP are modification of an existing road and partial cutting of 27 hectares of forest, both activities largely in areas remote from surface water flow, a full channel assessment does not appear warranted at this time.

As an alternative to the full IWAP process, The Kootenay Boundary Land Use Plan Implementation Strategy suggests that a subset of IWAP variables on a Watershed Report Card be interpreted using the parameters set out in Table 5.

Impact Indicators	Hazard rating		
	low	medium	high
a) peak flow index	<0.3	0.3-0.42	>0.42
b) road density for entire sub-basin (km/km^2)	<1.5	1.5-2.1	>2.1
c) no. of stream crossings ($no./km^2$)	<0.4	0.4-0.6	>0.6
d) no. of landslides ($no./km^2$)	<0.1	0.1-0.18	>0.18
e) roads on unstable slopes (km/km^2)	<0.15	0.15-0.25	>0.25

Table 5: Interpretation Guide for IWAP Report Card Scores.

This appendix has provided the basic data input into the IWAP assessment, and basic summaries and interpretations of that data. The body of the Forest Development Plan contains:

- interpretations of the IWAP report card results,
- assessments of the relationship between hazards suggested by IWAP and hazards noted in the field, and
- discussion of the relationship between proposed development activities and watershed hazards.

Appendix 4: Detailed Drainage Plan and Terrain Stability Assessment: Proposed Silica Mine Forest Road

Detailed Drainage Plan and Terrain Stability Assessment
Winlaw Woodlot
Proposed Silica Mine Forest Road
Winlaw Creek
Map reference 82F070,80

Synopsis

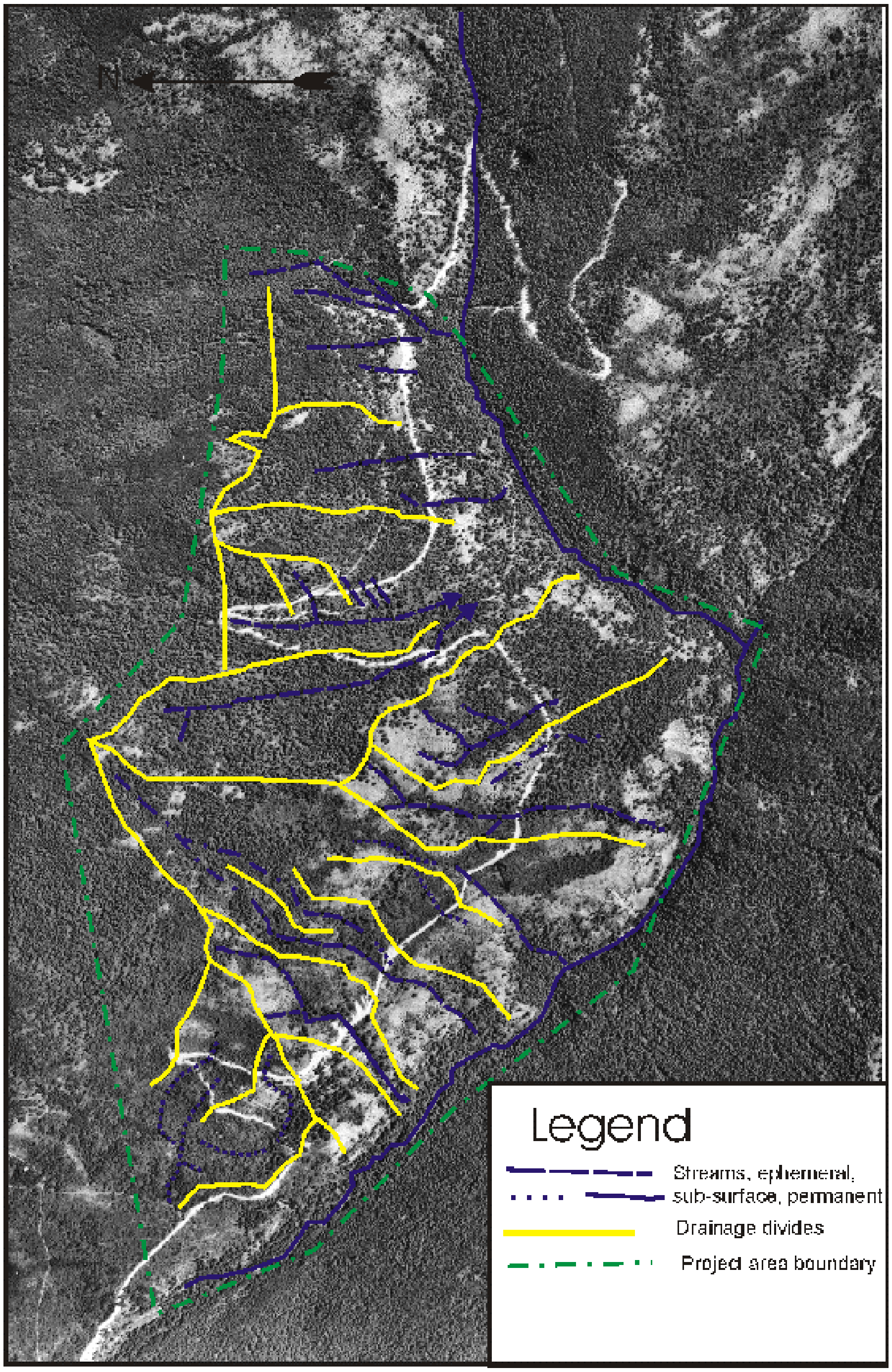
This drainage plan was completed on proposed and existing roads (section of the Silica mine road that will be upgraded to access timber on the Winlaw woodlot. The road is upslope of reaches 2 and 3 of Winlaw Creek and the lower reach of the North Fork of Winlaw Creek. The road is, for the most part, located on gently sloping, dry, south facing terrain upslope of steeper slopes. Previous studies have indicated that this section of the Silica mine road is stable. The large "slide" that occurred in 1971 is an erosion gully that was caused by a unique circumstances including the diversion of a manmade spring. Realignment of the road to avoid the 1971 slide location is not necessary. If culverts are placed as proposed there is a low likelihood of landslide initiation associated with construction of the road.
Presently the water from the manmade spring is flowing under the road and in a cross-ditch that has caused significant erosion and debris slides below the road. The erosion and debris slides have a impact to Winlaw Creek.

Introduction

Tom Bradley, forest planner for the Winlaw woodlot requested that Apex Geoscience Consultants Ltd. complete a detailed drainage plan of a portion of proposed Forest access road (locally known as the Silica Mine Road) on the north side of Winlaw Creek. A detailed drainage plan was requested because "slides" had occurred off the road and because the road passes through and is upslope of class IV and V terrain stability polygons as defined by detailed terrain mapping (level B - Utzig). Winlaw Creek is fish bearing and a consumptive use watershed which serves the community of Winlaw. There are a 55 water licenses registered on Winlaw Creek. The Resource value at risk is water quality along the lower reaches and fish habitat.

Limitations and Reliability;

The detailed drainage plan made in this report is based on observations made in the field and detailed airphoto interpretation. Terrain stability is determined from observations and inferences of materials in soil pits, road cuts and tree churns along and downslope of the proposed road. The slope drainage pattern is inferred by evidence of waterflow, subtle swales, watercourse channels, and moisture indicator plants in conjunction with the drainage plan map completed for this area. Culvert locations are proposed at areas of surface flow, seeps, by drainage divides (to keep water within the correct sub-basin) and to disperse flows in areas of naturally dispersed flows. If, during road construction, materials or conditions are encountered which are substantially different from those inferred the author should be notified. Stability assessments made in this report assume that all Ministry of Forests/ Forest Practices Code road construction standards are met and the drainage plan is followed. Even if all standards are met there is still a possibility of landslides. Terrain assessment, good road layout and good construction methods can reduce the risk of landslides not eliminate it.



Methods:

Previous studies reviewed include;

- Detailed terrain stability map (level B) -Utzig,
- Winlaw Creek Channel conditions and Prescriptions Assessment- Apex

- Road Stability Assessment and Prescription Plans Winlaw Creek Forest Service Road - EBA,
- Geotechnical Review, Proposed Level II Road Deactivation Prescriptions Winlaw Creek Forest Service Road Winlaw, B.C (DRAFT).-EBA
- bedrock geology map,
- 1:15,000 scale airphotos,
- and biogeoclimatic maps

Sub-basin Drainage boundaries were defined on 1:15,000 airphotos. Field work was conducted by W. Halleran P.Geo. on May 7 and Sept 6, 2001. The road and proposed road P-line was walked and observations tied into hipchain stations, previous road traverse stations, and EBA road hubs. Proposed culvert locations were marked in the field by pink flagging stamped "CULVERT". Unless otherwise stated the culverts are 450 mm. The drainage boundaries were adjusted on the airphotos to reflect information collected during the field work. Figure 1 shows the boundaries and streams on the airphoto. The culvert locations were tied into the road survey by Mr. T. Bradley, drainage boundaries, streams and culvert locations were digitized by Mr. T. Bradley.

Physiography and Climate.

Winlaw Creek lies within the Moist Climatic Region of the Nelson Forest region. The project area lies within the Warm Dry Interior Cedar-Hemlock Subzone (ICHdw). This area can be expected to have a light snow pack and hot summers.

Observations

Observations are summarised in table 1 in the appendix and figure 1.

Slope drainage: For the most part the terrain crossed by the road is southfacing, rocky, and well drained. The slope is drained by short duration ephemeral streams. At the time of assessment in early May most of the ephemeral streams were dry. The notable exception is the stream at 2+552. The source of this stream is a spring that appears to come to surface through a mineral exploration drill hole. The spring is in a small bowl that is drained by a "cat" road. Presently the flow from the spring flow goes subsurface under the road through the fill. A cross ditch just down road gradient carries significant flows during peak flow periods. There is extensive erosion below the cross-ditch were it discharges onto a 70 percent gully sideslope. The gully has a 58 percent gradient and is well-confined. The stream flows out onto the valley flat 30 meters from Winlaw creek channel.

Terrain stability: Previous studies of the road (EBA) assigned a low likelihood of fillslope failure for the section of road included in this study. The Winlaw channel assessment (Apex) identified only one sediment source along the section of stream downslope of the road sections assessed. This sediment source is an undercut kame terrace on the north side of the stream and is unrelated to the existing road. In this study the following areas of observed terrain instability along or below the proposed road alignment were noted.

1. An old failure scarp below, and slumping cutslope on, the existing road below 0+430 on the proposed road.

2. A series of slumps and slides below station 0+487 are associated with the stacked trail system constructed on ~80% slopes of zsrCb//Rs. The slumps initiate on a trail between the lower trail and road. The road likely sidecast onto the middle trail (which is cut into rock), overloaded it and caused the trail to slump onto the lower trail. The scarp is 2 meters high and is still unstable. There is no stream channel in the valley (Curve Creek).
3. Small fillslope slumps at 0+781 along the road.
4. There are tension cracks along the fill of the road at 2+351, the slope is –45%.
5. There are a number of debris slides and some extensive erosion below the discharge of a stream at 2+552. The stream, presently carried by a cross ditch, is discharged on to the sideslopes of the swale and has eroded a 0.75 meters deep gully to the swale bottom. In addition to the debris slides there are tension cracks along the slope an in the fill material below the road. None of the debris slides reached Winlaw Creek channel. Erosion of the sideslopes does not appear to contribute any significant amount of sediment to Winlaw Creek.
6. The very large “slide” that occurred in 1971 at the corner at 3+410 is an erosion gully caused by the diversion of the stream at 2+552.

The large slide/erosion scar at 3+410 is a significant feature and stakeholders have concerns that the slide could be retriggered by additional development. As a result of this concern the feature was investigated to determine the cause and mechanism of formation. Features on the ground indicate that the feature was formed by erosion caused by the diversion of the stream at 2+552. The likely sequence of events that caused the erosion can be determined by features noted on the ground. The small bowl in which the drill hole was located has a fairly large catchment area. The drill intersected an aquifer below the ground water flow. The water flowed up through the drill hole and pooled in the bowl. It is likely that there was some sort of barrier such as a pile of debris that restricted the water from flowing out of the bowl or that there was a significant increase in the rate of flow from the flow significantly increased out of the drill hole (the drill hole casing may have been capped originally and then the cap was removed) it may have been capped). It appears that there was a short duration very high flow perhaps caused by breaching the barrier (dam burst). The water flowed down the cat trail that was constructed to service the drill pad. Scour from the dam burst event eroded the road bed to cobble sized material (this road bed is now a stream channel). The water was then deflected down the Silica Mine road. There is evidence of extensive scour along the road. There are a number of areas where water flowed off the road and deeply eroded the fillslope and down slope areas depositing cobble cones on lower trails and slopes. Photo #1 below shows a cone that completely covers an old trail. There are numerous old slides and erosion features below the road that appear to be about 30 years old, suggesting that all the features occurred in a relatively short period of time. At first most of the flow was diverted to 3+410 resulting in the large erosion gully (“slide”) in a sandy gravel terrace.

Recommendations

Placement of the proposed culverts will be sufficient to maintain natural drainage patterns. Presently the slope below 2+552 is unstable and is being eroded by flow from the spring,. The placement of the 500 mm culvert in the center of the gully will reduce the amount of sideslope erosion. The fill along here is oversteep and contains an significant amount of organic debris. It is recommended that when the culvert is placed this material (~ 6 meters either side of the crossing) is cleaned of organic debris and the fillslope angle reduced. If additional slides occur along here it is highly unlikely that they would reach Winlaw Creek Channel. Subsequent sediment delivery to the stream channel would be minor. Although the hazard is high, the consequence is low resulting in a moderate risk.

The slides below 0+487 is the result of cutslope/fillslope failures on the old stacked trail/road system. The bottom of the draw (Curve Creek valley) below the slides is wide with no stream channel. Construction of the road will not significantly increase the likelihood of landslide initiation. Presently there is a high hazard, low consequence and moderate risk of impacts to the North Fork of Winlaw Creek resulting from road related instability.

The large slide/erosion gully at 3+410 is an erosion feature that was a result of unique circumstances. There is a low likelihood of a repeat of the events which caused the erosion. With the exception of minor raveling from the steep headwalls, the area is stable. There is no need to re-align the road.

The construction of the proposed road and modification of the section of the Silica Mine road poses a low risk to the water quality and fish habitat of Winlaw Creek.

Closure:

The risk assessment and terrain stability assessment of this report assumes that all culverts will be function properly and that the works recommended by Apex Geoscience Consultants Ltd. will be completed.

Respectfully Submitted

Reviewed by

Will Halleran P.Geo

Kim Green, M.Sc., P.Geo.

Appendix I
Apex Geoscience Consultants Ltd.

Table #1 Culvert Locations Silica Road

Distance	Culvert	Notes
0+00m		POC on proposed road.
0+019.9m	450mm	Small partial swale at edge of paleo-fan
0+072.0m		= 0+623 “road traverse”
0+076m	Grade dip	Swale – no channel-cedar, joins up with larger swale ahead just below road- grade dip from 0+065m to 0+ 105m
0+092.4m	450mm	=0+602 “road traverse” Swale – larger upslope, convergent swales onto bench then below becomes more defined, dead zones should be more visible on newer photos.
0+105.1m		= 0+ 588 “road traverse”
0+ 113 m		shoulder
0+ 143 m		End of shoulder into swale
0+158 m	Optional culvert	Subtle swale, optional culvert, old road just below has no evidence of flows.
0+166 m		Onto old existing road
0+185 m		Change of aspect
0+212 m	450mm	Cedar grove, slope still convex across, large old road downslope
0+279 m		0+ 418 m “road traverse”
0+320 m	450mm	Subtle swale before aspect change.
0+356 m		Open dry slope, old road just below, drainage divide?
0+382 m		No scour on any of the three stacked roads
0+391 m		0+294 “road traverse”.
0+410.9 m		Broad “swale” junction of Silica Mine road and old road just below.
0+432.4 m	450mm	Short “gully” swale just above road, minor slumping of cutslope on lower road, feeds old failure scarp, likely okay –cross ditch lower road.
0+453m		Another “swale” old sloughs from 65% slope, some cedar, sgF^{G}
0+487m		Onto Silica mine road (0+193 “road traverse”) Blk #2 boundary, slope – 80% cut by old trails, small outcrops and bluffs.
0+507m		Rock cutslope, road grades toward gully.
0+580m	450mm	(? 42) low point in road, wet swale upslope
0+ 629m	450mm	Swale (near drainage boundary)
0+645m		Road in from below
0+658m	450mm?	Gully bottom, divide correct on airphoto
0+662m		Road off down Dumont Creek.
0+682m	450mm	Present cross-ditch location, cutslope seeps, improve ditch to Winlaw side.
0+699m		End of obvious seeps, improve ditch to direct water to culvert at

		682
0+761m		Oversteep fill
0+781 m		Oversteep fill with stumps, old slumps
0+828 m		On ridge between the two gullies.
0+850 m		Road grades down to other gully.
0+889m		Back and forth over divide on top of "ridge" between gullies.
0+944m		Just over divide start down into gully.
0+989m		Ditch on downslope side.
1+038m		Ditch discharges onto gully sideslope (okay), road now cutting gully side slope (55% slope gradient).
1+087m		Wet area on road.
1+091m	450mm	
1+ 161m	600 mm	Road 10 % gradient through crossing (no dip present)
1+162m		? 40 (2+930m)
1+261m	450mm	Back up culvert to ensure divide isn't crossed, pushout already here.
1+321m		14% road gradient onto face
1+345m		Mahonia in ditch line
1+418m	450mm	Corner and ditchblock (actually ditch ends), new? Cross ditch, minor scour on road down gradient, bench below. (? 38, 2+660m)
1+544m		Some evidence of flow in ditch, low point in road, steep section of road (favourable) just ahead
1+547m	450mm	Willow, subtle swale just past ?36
1+596m	450mm	Evidence of flow in ditch and over forest floor (over cutslope), down road grade evidence of old rutting, ditch is blocked here, partial cross ditch and downed tree, just before corner, (?35), past no ditch, rock cutslope, road had good flow down at one time
1+728m		Crossing rocky slope to here, trails upslope and downslope, gradient change, occasional Cottonwood.
1+762m		Razor back just above road parallel to road.
1+ 796m	450mm	Low point in road, swale upslope, about to enter gentling sloping open terrain (old clear-cut?). ? 33
1+887m		Water on road to 1+907m where it pools, road on edge of 45 to 55% gradient slope, maple willow, birch, cottonwood, poplar.
1+907	450mm	Looks like old channel still moist, just coming around the corner, I can see treed meadows to west, old cross-ditch (wood culvert) just ahead.
1+ 948m		Old crossditch (wood culvert) with evidence of eroded fillslope.
1+970m	450mm	A little water on road, marked with "creek" flag
2+026m	450mm	Swale, cottonwood, ~40%, open meadow just below, cross-ditch (wood culvert). Marked on airphoto.
2+039m		Old wood culvert for flow at 2+026.

2+146m		Dry rocky slope (? 30)
2+165m		Evidence of flow in ditch
2+173m		Water flowing in ditch from seeps along cutslope
2+202m	450mm	Seeps along cutslope to here, maybe place more culverts
2+319m	EBA-450mm	? 28 EBA 450 mm culvert, at pushout upslope, cross ditch (wood culvert) here – evidence of erosion, right on divide
2+351m		Tension cracks in fill, -45%
2+376m	EBA-450mm	? 27 EBA 450 mm culvert, because of old cross drain?
2+410m		EBA – possible borrow pit, ? 26
2+552m	EBA-500mm	EBA 500 mm. Man made creek result of trail construction and exploratory drilling on flats upslope. There are debris slides below road and the fill is failing. There is significant organic debris within the fill. At the time of inspection most of the flow went subsurface below the road, a cross ditch just down road gradient directs flow onto the 70% gradient side slope of the gully during high flows. The discharge from the cross-ditch has eroded down to bedrock, material from the erosion and debris slides are piled up behind trees within a 58% gradient section of the gully. Additional tension cracks are present downslope of the road. Debris slides have occurred both directly below the crossing and below the cross ditch. There is significant old scour down the road, it is obvious that the stream was completely diverted down the road at one time.
2+600m		High rock cutslope
2+616m		Erosion and slides off road where water from diversion at 2+552m
2+642m		Erosion and slides off road where water from diversion at 2+552m
2+648m		Ditch starts still evidence of old scouring of road and ditch
2+713m		High rock cutslope, erosion of fill slope
2+725m		Looks like where a lot of the flow went off, just before corner ? 21
2+775m	EBA	EBA culvert ? 20
2+835m	EBA	EBA culvert ? 19
2+877m	EBA	EBA culvert ? 18, “swale” animal trail rCb
2+915m	EBA	EBA culvert, ? 17 upslope continuation of swale
2+945m	EBA	? 16 EBA culvert, road is directly below
2+990m		? 15 1km board
3+012m		Switchback no flow
3+056.8m	EBA	? 13 EBA culvert swale, lines up with ? 16
3+087m	EBA	? 12 EBA culvert swale, lines up with ? 17
3+122m		Swale downslope no evidence of flow on road
3+ 150m	EBA	? 11 Flow on road, EBA culvert.

3+191m		Round corner
3+199m		Major old erosion feature on fillslope, water may have flowed down old trail
3+217m	EBA	? 10, EBA culvert, large amount of water previously flowed out onto road here. Scour is old no evidence of recent flows.
3+282m	EBA	? 09, EBA culvert, move to 3+297 to catch swale and flow from upslope trail diversions, flow may move over time
3+336m	EBA	? 08 EBA culvert, large swale, old extensive old scour of ditch starts here to 3+410m
3+410 m		Corner, top of erosion – failure gully (1971), ditch feeds into it. Old road lines up with new road, road was likely re-aligned after failure. (when old road crossed swale upslope of present road) it has failed in a number of places, there is no hard evidence of high flows down swale, but there is some old scaring of trees ~30 yrs old.
3+438m		Low point, still on "failure" scarp, little berm on outside edge, failure is V shaped, 77% sideslope gradient in sandy gravel, looks more like an erosion gully.
3+460m		Eot.

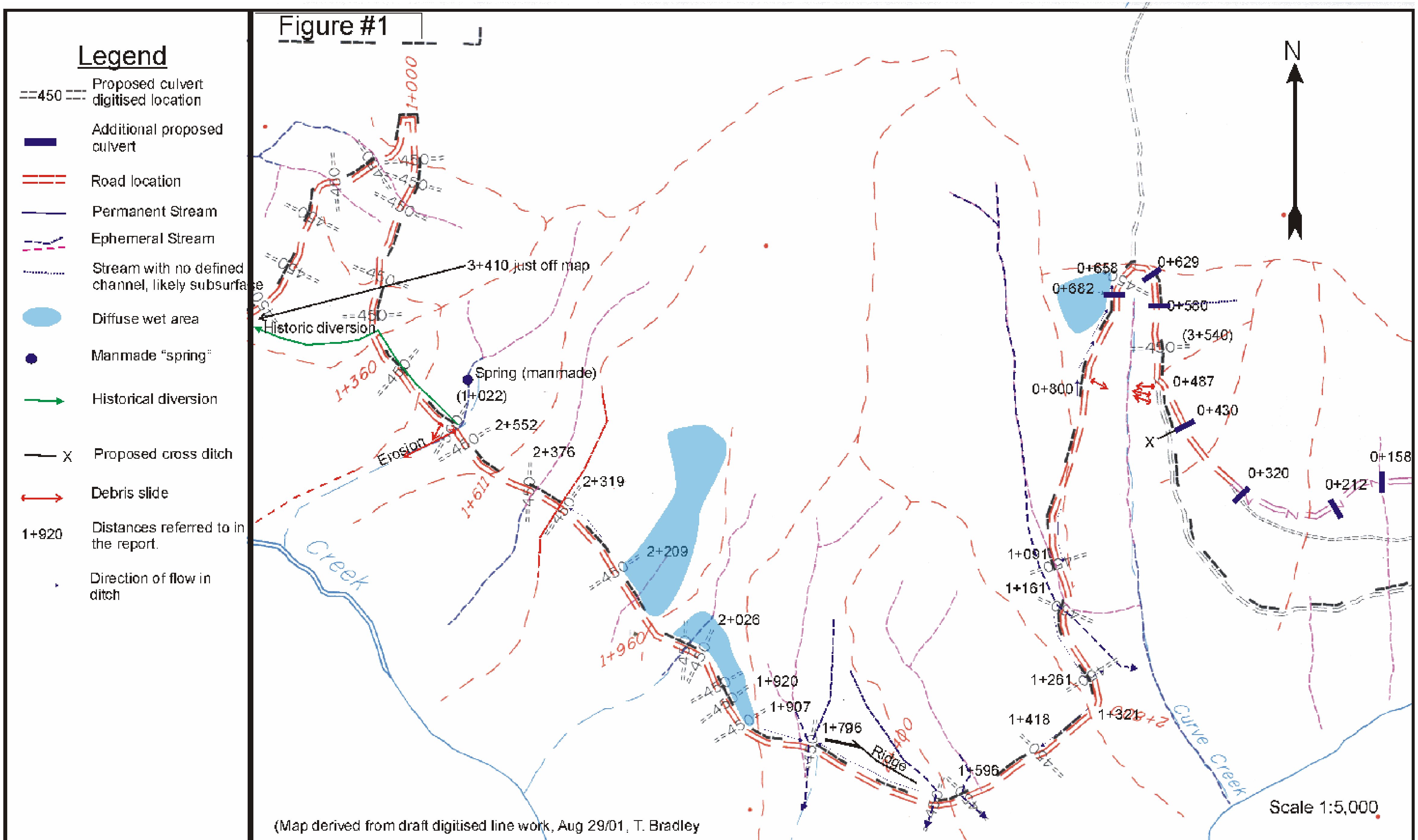


Figure #1
Legend
==450== Proposed culvert digitised location
Additional proposed culvert
Road location
Permanent Stream
Ephemeral Stream
Stream with no defined channel, likely subsurface
Diffuse wet area
Manmade "spring"
Historical diversion
Proposed cross ditch
Debris slide
1+920 Distances referred to in the report.
Direction of flow in ditch
N
3+410 just off map
Historic diversion
Spring (manmade)
(1+022)
1+000
1+360
2+552
Erosion
2+376
2+319
1+611
2+209
2+026
1+960
1+920
1+907
1+796
Ridge
1+596
1+418
1+321
1+261
1+161
1+091
0+800
0+658
0+629
0+682
0+580
(3+540)
0+487
0+430
0+320
0+212
0+158
Creek
Curve Creek
Scale 1:5,000
(Map derived from draft digitised line work, Aug 29/01, T. Bradley

Appendix 5: Excerpts from the Forest Practices Code Riparian Management Area Guidebook

Appendix 5: Excerpts from

Riparian Management Area Guidebook

The following selections are excerpted from the Forest Practices Code *Riparian Management Area Guidebook* (December 1995). Some sections which do not apply to W1832 or which do not discuss management practices in riparian ecosystems have been omitted. Text in smaller font indicates additions or comments pertaining specifically to W1832. The complete *Guidebook* is available at http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/riparian/rip-toc.htm

1 Introduction

This guidebook is provided to help managers, planners, and field staff comply with the Forest Practices Code of British Columbia Act and to set and achieve the management objectives for riparian management areas (RMA) specified in operational plans. It provides guidance on planning and conducting operations within the RMA and fisheries- and marine-sensitive zones. It should be used in conjunction with other guidebooks such as those developed for forest development plans, biodiversity, managing identified wildlife, and range use.

Riparian areas occur next to the banks of streams, lakes, and wetlands and include both the area dominated by continuous high moisture content and the adjacent upland vegetation that exerts an influence on it. Riparian ecosystems contain many of the highest value non-timber resources in the natural forest. Streamside vegetation protects water quality and provides a "green zone" of vegetation that stabilizes streambanks, regulates stream temperatures, and provides a continual source of woody debris to the stream channel. The majority of fish food organisms come from overhanging vegetation and bordering trees while leaves and twigs that fall into streams are the primary nutrient source that drives aquatic ecosystems. Riparian areas frequently contain the highest number of plant and animals species found in forests, and provide critical habitats, home ranges, and travel corridors for wildlife. Biologically diverse, these areas maintain ecological linkages throughout the forest landscape, connecting hillsides to streams and upper headwaters to lower valley bottoms. There are no other landscape features within the natural forest that provide the natural linkages of riparian areas.

The RMA consists of a riparian management zone and, where required by regulation, a reserve zone (Figure 1). Within the management zone constraints to forest practices are applied. The width of these zones is determined by attributes of streams, wetlands or lakes, and adjacent terrestrial ecosystems. Inventory information as well as clarification of these guidelines may be obtained from the appropriate resource agencies.

Lakeshore management areas and wildlife habitat areas will frequently be associated with riparian management areas. In that situation, the guidebook that affords the greatest protection should be considered the authoritative document.

While marine-sensitive zones and fisheries-sensitive zones do not require classification they should be identified in operational plans. This document provides guidance on management strategies adjacent to these features.

This document applies to the entire province. Cases where a guideline is specific to either the coast or interior of British Columbia have been indicated.

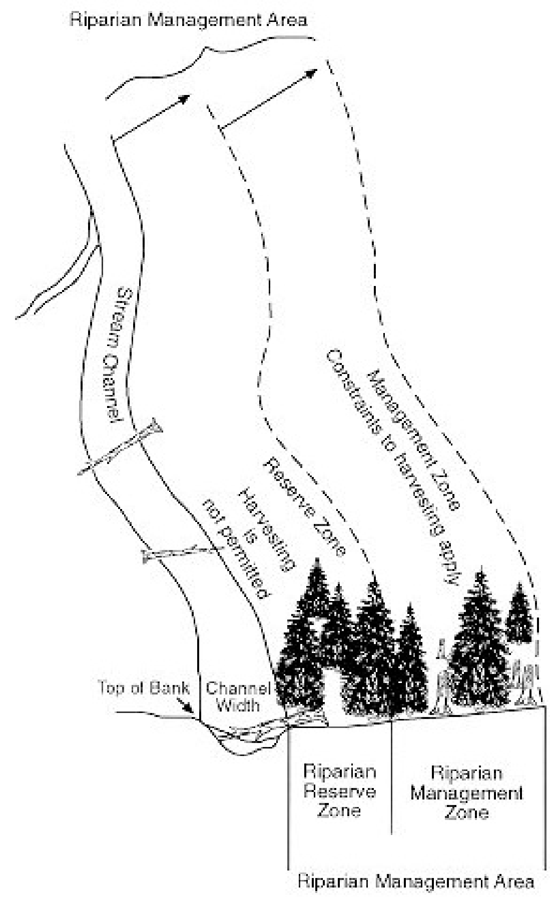


Figure 1: Riparian Reserve Zone and Riparian Management Zone.

1.1 RMA objectives

The identification, riparian classification, and mapping of streams, wetlands, and lakes and the description of appropriate practices is the responsibility of the proponent of the operational plan. This guidebook describes and refers to standard approaches and methodologies that can aid in developing prescriptions for riparian areas. In the absence of government approved permits and plans, the approaches and guidelines described here will be used by government to assess riparian classification, management, and mapping.

Riparian management area objectives are implemented:

- to minimize or prevent impacts of forest and range uses on stream channel dynamics, aquatic ecosystems, and water quality of all streams, lakes, and wetlands
- to minimize or prevent impacts of forest and range use on the diversity, productivity, and sustainability of wildlife habitat and vegetation adjacent to streams, lakes, and wetlands with reserve zones, or where high wildlife values are present
- to allow for forest and range use that is consistent with 1 and 2 above.

To achieve riparian management area objectives, forest practices within the management zone should:

- Where a riparian management area has both a management zone and a reserve zone:
    - reduce the risk of windthrow to the reserve zone

    - retain important wildlife habitat attributes including wildlife trees, large trees, hiding and resting cover, nesting sites, structural diversity, coarse woody debris, and food sources characteristic of natural riparian ecosystems.
- Where a riparian management area has only a management zone:
    - retain sufficient vegetation along streams to provide shade, reduce bank microclimate changes, maintain natural channel and bank stability and, where specified, maintain important attributes for wildlife
    - adjacent to wetlands and lakes, retain key wildlife habitat attributes characteristic of natural riparian ecosystems.

2 Streams

3 Wetlands

4 Lakes

5 Modifying the RMA

6 Forest practices within the RMA, fisheries-sensitive zones, and marine-sensitive zones

This section provides recommendations regarding silviculture, harvesting, and road construction practices within the RMA. Range use guidelines are contained in the section "Range in riparian areas."

(Discussion of retention levels follows in original. Policy under the KB HLP[1] calls for a 30 meter both sides riparian management zone on streams directly related to domestic water intakes. This RMZ is to be managed to the best practices set out in this Guidebook, which call for a maximum overall retention level of 25% of forest basal area.

The riparian management approach set out in the Management Plan for W1832 is to direct 50% of timber yield within Riparian Management Zones to the creation and maintenance of old growth habitat and coarse woody debris. Leave trees, old growth structures, and coarse woody debris will be concentrated in the riparian ecosystem within the Riparian Management Zone. This management goal will be implemented using a 10 meter Riparian Reserve Zone around all creeks and wetlands, regardless of adjacency to water intakes, and by partial cutting in the remaining 20 meter width of the Riparian Management Zone

The 10 meter riparian reserve zone will result in approximately 30% basal area retention in the required 30 meter RMZ. The remainder of the forest in the RMZ, as will the forest in the cutblock, will be managed using partial cutting approaches which maintain functioning forest ecosystems and forest structures. This will result in additional retention within the RMZ, with total retention within the 30 meter RMZ likely significantly exceeding the stated target levels.)

The following section applies to all riparian areas plus FSZ and MSZ and are to be viewed as 'Best Management Practices' to guide development of prescriptions for the RMA of each riparian class.

[1] Kootenay Boundary Higher Level Plan Order, December 2000, Government of B.C. and Strategies for the Kootenay Boundary Higher Level Plan, May 14 2001, Ministry of Forests.

6.1 General guidelines

Riparian features may be encountered in the field that have not been identified in the silvicultural prescription or logging plan. In such circumstances, forest harvesting adjacent to the stream, wetland or lake should cease until the appropriate feature is classified and the practice is implemented. For audit purposes and where appropriate, changes should be reflected in an amended silvicultural prescription/logging plan. If environmental damage has occurred, the appropriate government agency should be contacted.

6.1.1 Activities within streams and wetlands

No activities within streams or wetlands are planned under this FDP.

Streams, wetlands, and lakes should not be entered. Instream activities on fish streams, or on stream reaches that could affect fish habitat, or on stream reaches that could affect fish habitat or water quality downstream, may only be undertaken when constraints relative to fish life history or expected streamflows allow. Refer to Appendix 2 for general windows for instream work by regional area and species.

In addition to classified streams, wetlands, and lakes, there are wet depressions or receiving sites that are not classified. The tracks and wheels of ground-based equipment should not be operated within 5 m of any stream, wetland, or lake feature whether classified or not.

6.1.2 Roads and crossings

Roads within an RMA that are parallel to a stream, wetland, or lake should be designed to minimize short- and long-term impacts on the RMA. This can be done by methods such as minimizing road bed width, minimizing right-of-way width, end-hauling, full bench construction, constructing temporary roads, and deactivating roads after harvesting is completed. Temporary and permanent stream crossings should not damage fish habitat or create blockages to fish passage. This includes small channels that provide access to fisheries-sensitive zones. Temporary stream crossing methods should include crossing streams at right angles and the use of box culverts to avoid damage to streambanks. Temporary crossing sites should have stable banks and avoid instream, stable LWD. Remove all temporary structures once operations are completed. When streambank disturbance is evident and erosion is likely to occur, bank armouring and streamside vegetation must be re-established.

Existing main roads within the RMA can continue to be used. Spur roads within the RMA should be permanently deactivated once they are no longer used.

Streams and side channels should not be artificially channeled to reduce the number of culverts required. Each channel should be adequately culverted. Extra and oversized culverts should be installed where roads cross the active floodplain. In addition, fill heights should be minimized within the active floodplain and the fill protected from erosion. Avoid fill construction on floodplains that parallel the stream.

6.1.3 Falling and yarding

Falling and yarding should be away from, or parallel to, a stream, wetland, or lake.

(The section continues with a discussion of techniques for yarding over creeks. Logs will not be moved over or through creeks or wetlands in W1832.)

6.1.4 Uphill falling

(This section discusses falling directly beside streams. Streams and wetlands will be surrounded by a 10 meter Riparian Reserve Zone in the proposed development, so this section does not apply.)

6.1.5 Stream clean-out

(This section discusses cleanup after falling or yarding across streams. . Streams and wetlands will be surrounded by a 10 meter Riparian Reserve Zone in the proposed development, so this section does not apply.)

6.1.6 Fisheries-sensitive zones

Fisheries-sensitive zones (FSZs) are side and back channels, ponds, swamps, seasonally flooded depressions, lake littoral zones, and estuaries that are seasonally occupied by over-wintering fish.

(There are no fisheries sensitive zones in or adjacent to W1832.)

6.1.7 Marine-sensitive zones

Marine-sensitive zones (MSZs) include herring spawning areas, shellfish beds, marsh areas, existing aquaculture sites, juvenile salmonid rearing areas, and adult salmon holding areas.

(There are no marine sensitive zones in or adjacent to W1832.)

6.1.8 Windthrow hazard management

Riparian management areas in stands of moderate or high windthrow hazard require special management practices to reduce windthrow potential when logging is proposed within and adjacent to them. Where a reserve zone is required, windthrow hazard management should be designed primarily to protect the reserve zone and only secondarily to protect trees within the management zone.

6.1.8.1 Assessing windthrow risk

The Windthrow Handbook for British Columbia Forests (Research Program Working Paper 9401) should be consulted for guidance when assessing windthrow risk or developing prescriptions to reduce the risk of windthrow. Windthrow risk assessments should incorporate local knowledge and experience and should be assessed for the general area and, in greater detail, for each area with significantly different soil depth or drainage, stand structure, and tree species composition. Windthrow risk assessment should be a best judgment interpretation based on an evaluation of regional, local, and site-specific available information.

Windthrow risk is determined by the interaction between factors that affect the force of the wind acting on the tree and factors that affect the resistance of the tree to overturning. Force of the wind is increased by higher wind velocity and turbulence, increased exposure to wind, greater tree height-to-diameter ratio, greater crown size and crown density, and reduced stand density. Resistance to overturning is reduced by poor root anchorage due to saturated soils and restricted rooting depth, occurrence of root or bole rot, extent of interlocking root systems, and past exposure to winds. Soil factors that control rooting depth contribute most significantly to windthrow risk.

High risk stands generally occur where high wind force is likely to occur and resistance to overturning is low. Moderate risk stands occur where root anchorage is poor but wind force is low, root anchorage and wind force is moderate, or root anchorage is good but wind force is likely high. Low risk stands occur where there is a high resistance to overturning and wind force is moderate or low.

Windthrow risk is generally greatest on the windward edge of a stand and decreases a short distance into the stand, although turbulence can result in windthrow several tree heights into the stand. Most windthrow occurs within the first three years following harvesting. However, windthrow risk can increase over time as management activities affect windflow and soil conditions.

Local knowledge is an important consideration when assessing windthrow risk. Certain areas are known to be particularly windy. A history of frequent windthrow and evidence of windthrow or stem breakage in natural stands is an indication that windthrow is likely to occur after harvesting.

6.1.8.2 Windthrow management strategies

Strategies to reduce the risk of windthrow should be considered wherever trees are retained and windthrow risk is moderate or high along all or a portion of the RMA. Windthrow management strategies include locating the tree retention boundary to reduce the risk of windthrow, selecting the most windthrow resistant trees within the management zone for retention, and reducing the force of the wind on the crowns of retained trees. Selected strategies should not only address windthrow risk but also the other values that are being protected in the RMA.

<u>Options to reduce windthrow risk to reserve zone</u>

Where windthrow risk is moderate or high in the reserve zone, a sufficient number of trees should be retained within the management zone to protect the windfirmness of the reserve zone. Options include:

- location and design of logging boundaries:
    - realign RMA boundary to a windfirm edge such as rock bluffs, non-merchantable timber, or soil type change
    - leave a buffer at least 20 m wide of well-drained, deep soils between areas of poorly drained or shallow soils of the RMA and the edge of the harvested opening
    - where no natural windfirm features are available, consider widening the management zone to a moderate to low windthrow risk stand and align the boundary so that it is at an angle or parallel to the prevailing storm winds
    - leave relatively straight boundaries on the outer edge of the RMA; this can be accomplished adjacent to meandering streams by leaving variable width patches of trees in the management zone; do not leave any sharp corners or indentations that are exposed to the wind

  - where the management zone is more prone to windthrow than the reserve zone, low tree retention in the management zone may be the most appropriate option.
- edge stabilization treatments:
  - feather the outer edge of the management zone by removing trees prone to windthrow
    - preference should be given to removing the following trees:
      - unsound trees including diseased, deformed, forked, scarred, mistletoe infested, and root rot infested trees;
      - trees with asymmetric or stilt roots;
      - trees growing on unstable substrates such as rocky knolls, large boulders, nurse logs, or wet depressions;
      - tall non-veteran trees, especially those with disproportionately large crowns
    - Preference for retention should be given to sound, well-rooted veterans (e.g., snag-top cedars) or deciduous trees; sound trees (strong roots and good taper) with relatively small, open crowns; and sound snags when safety is not compromised.
    - In multi-storied stands, the outer wind-exposed edge of the management zone may be additionally feathered by removing dominant trees from the leading edge, partially retaining codominant trees, and fully retaining suppressed trees within 20–30 m of the edge. This practice is not recommended in single-storied, high density stands.
  - top and/or prune (limb) individual trees with a high windthrow risk in the management zone and/or reserve zone
    - reduce the crown of these trees by 20–30 per cent
    - topping or pruning in the reserve zones should include only high windthrow risk trees that may cause significant detrimental effects to stream channels or wildlife habitat if they were windthrown;
  - combine edge feathering and topping or pruning in high hazard areas.

<u>Options to reduce windthrow risk in the management zone</u>

Options to reduce the risk of windthrow to trees retained in the management zone include topping or pruning (see above) and selection of the most windfirm trees for retention. Trees with the following characteristics tend to be the most windfirm:

- small, open crowns
- good root anchorage in deep, well-drained soils
- no root or bole rot
- low height-to-diameter ratio for stand (relatively large taper)
- short trees
- trees that have been growing in relatively open stands
- broad-leafed deciduous species

- specific conifer species
- sound snags
- sound, well-rooted veteran trees.

6.1.8.3 Removal of windthrown trees

When windthrow occurs within a RMA, the remaining standing trees should be left as a protective buffer for other trees of the RMA. Windthrown trees should not be removed from the RMA, as they provide valuable wildlife habitat. Windthrown trees should be removed only if habitat would be improved by their removal and removal will not result in damage to the surviving trees. Windthrown trees should be assessed for removal by a forest health specialist where there is a risk of increasing bark beetle populations and the resultant increase in tree mortality. Windthrown trees that have entered a stream should be removed only if they will destabilize the streambank or channel. Unnecessary removal of windthrown trees from streams can result in significant channel destabilization. All removal of windthrown trees from an RMA must be as specified in an approved silviculture prescription or logging plan.

6.1.9 Wildlife tree management

A wildlife tree is a standing live or dead tree with special characteristics that provide valuable habitat for conservation or enhancement of wildlife (large diameter and height for site, current use, declining or dead, valuable species type, location, and relative scarcity). High quality wildlife trees are frequently present in riparian areas and are used by a variety of species. The proximity of these trees to the edge of streams, wetlands, lakes, and marine-sensitive zones increases their value for some wildlife species. Wildlife trees also provide a source of coarse woody debris used by many riparian species and large woody debris for maintaining stream channel characteristics.

The Biodiversity Guidebook and Managing Identified Wildlife Guidebook provide recommendations for the amount, type, and distribution of wildlife trees to be left within a cutblock and area adjacent to the perimeter of the cutblock. Although wildlife trees should be distributed across the planning area, riparian habitats are priority sites for meeting these recommendations. Not only are high quality wildlife trees present in many riparian areas, but the riparian management area also provides an opportunity for leaving wildlife trees with the least effect on timber harvesting operations.

6.1.9.1 Wildlife trees in the reserve zone

Reserve zones adjacent to streams, wetlands, and lakes protect many wildlife trees and provide a source of future wildlife trees. However, some wildlife trees within the reserve zone can pose a risk to workers operating in the management zone or the cutblock outside the RMA (see Figure 17). These include standing dead trees that are vertical or lean towards the management zone, as well as some live trees with large dead branches or tops. The best strategy for protecting these trees is for a qualified wildlife tree assessor to mark them as wildlife trees and establish no-work zones around them. The size of the no-work zone will vary by tree and site. Generally, the size of the no-work zone will be one or two tree lengths.

Not all wildlife trees in the reserve zone that pose a risk to workers in the management zone need to be protected by a no-work zone. If wildlife tree requirements have been met outside of the RMA and no eagle, osprey, or great blue heron nest trees or high value wildlife trees are present, wildlife trees deemed hazardous to worker safety within the reserve zone may not need to be protected. Mitigative measures should be taken to protect high value wildlife trees (consult the Wildlife/Danger Tree Assessor's Course Workbook).

When making a determination to remove a wildlife danger tree from a reserve zone, as provided for in the Operational Planning Regulation, a wildlife tree assessment should be completed by a qualified wildlife tree assessor. If a tree is determined to be unsafe and of low wildlife value it may be felled. Trees felled in the reserve zone should be left as coarse woody debris. Trees killed by bark beetles, where beetles remain under the bark, that pose a high risk to adjacent stands should be removed or treated to kill the bark beetles prior to emergence. Trees to be felled should be identified in an approved silviculture prescription and/or logging plan.

6.1.9.2 Wildlife trees in the management zone

All dead wildlife trees that do not pose a risk to workers should be left within the management zone adjacent to the reserve zone or adjacent to the stream, wetland, or lake where no reserve zone is required. Trees retained within the management zone should emphasize wildlife tree attributes. In addition, consider establishing wildlife trees within management zones to meet wildlife tree objectives described in the Biodiversity Guidebook. If harvesting is done by feller buncher, consider felling some wildlife trees at a height near 3 m to create "stubs."

6.1.10 Silviculture treatments

Forest harvesting within the management zone should minimize disturbance to understorey vegetation and avoid damage to remaining trees. Disturbance should be limited to that necessary to achieve successful regeneration.

The following guidelines outline recommendations for silvicultural treatments within the riparian management area:

- Carry out single-tree forest health treatments when damaging agents such as bark beetles threaten the integrity of the RMA or the forest adjacent to the RMA stands. Preferred strategies for managing bark beetles in the RMA include "Prevention, Suppression, and Maintain Low" strategies (see Bark Beetle Management Guidebook).
- Minimize the impact on the naturally occurring understorey vegetation within the management zone of streams, wetlands, and lakes.
- Maintain natural levels of coarse woody debris within the RMA.
- Address root diseases in the RMA through the use of alternative tree species or other options, rather than stump removal.
- Choose silvicultural strategies and equipment to minimize ground disturbance within the RMA.
- Conduct broadcast burning within the RMA only where no treed reserve exists unless specified in an approved silviculture prescription or burning permit.

6.1.11 Vegetation management

When selecting treatment options for vegetation management within the RMA, consider the potential impact of the treatment on all resources. The following measures are recommended for all vegetation management applications.

- Where vegetation management is required to meet reforestation or restoration objectives, treatment within the RMA should be restricted to selective treatment of vegetation in direct competition with desirable trees.

(Remainder of section addresses pesticide use issues. Pesticides will not be used in W1832.)

6.2 Specific guidelines

In addition to the general guidelines outlined above, specific measures have been developed for each riparian class, active floodplain, and for large rivers.

A watershed assessment using the Interior Watershed Assessment Procedure or the Coastal Watershed Assessment Procedure may be required for community watersheds or watersheds with high fishery values (as determined by B.C. Forest Service and BC Environment). The results of these assessments may influence the best management practice within these RMAs. However, "RMA objectives" found in this guidebook should not be compromised. Consult the WAP guidebooks for the specific recommendations that apply.

6.2.1 S1, S2, and S3 streams

There are no S1, S2, or S3 streams in the area of W1832 affected by development activities proposed in this FDP.)

6.2.2 Active floodplains

(There are no active floodplains within W1832.)

6.2.3 Large rivers

(There are no large rivers within W1832.)

6.2.4 S4, S5, and S6 streams

Forest practices in the management zone adjacent to S4, S5, and S6 streams should be planned and implemented to meet riparian objectives including wildlife, fish habitat, channel stability, and downstream water quality.

(While W1832 contains mostly Class S6 streams or smaller unclassified streams, the KB-HLP Strategies require implementing the best management practices for S4 streams (interior). These are set out in the Guidebook Table 11, reproduced below.)

The primary objective of the management zone of S4 streams in the interior is to provide for the protection and management of fisheries, important wildlife habitats, and water quality associated with these streams. These streams provide important furbearer as well as fisheries habitat and significantly influence downstream fisheries values. Timber harvesting and other activities should be consistent with the requirement to maintain stream channel processes, stream temperatures, wildlife trees, and habitat for furbearers and other wildlife.

Best Management Practice

- Retain all trees within 10 m of the streambank.
- Retain wildlife trees within 10 m of the streambank by establishing safe work zones within the remainder of the management zone. Retain wildlife trees consistent with the section "Wildlife trees in the management zone."
- Fall and yard away.

Where the best management practice cannot be achieved due to moderate or high windthrow hazard:

- Harvest windthrow-prone trees and maintain as many of the windfirm trees as possible that have the characteristics described in "Options to reduce windthrow risk in the management zone," within 10 m of the channel.
- Fall and yard away. Remove slash and debris inadvertently deposited in the stream at the time of harvest (see "Falling and yarding"). Where a shallow rooted, wind-prone leaner is felled, fell the tree so that the butt clears the channel or the stem spans both streambanks. Remove only those stems that can be lifted without damage to the channel or bank. For those stems that cannot be lifted clear, leave the portion of the stem that spans the channel. Ensure the stem and limbs do not obstruct stream flow or fish passage.
- Retain wildlife trees consistent with the section on "Wildlife trees in the management zone."
- Retain nonmerchantible conifer trees, understorey deciduous trees, shrubs, and herbaceous vegetation within 10 m of the channel to the fullest extent possible.

Figure 2: Guidebook Table 11: Best management practices for Class S4 streams.

6.2.5 Wetlands and lakes

The following guidelines apply to the management zone of all wetlands (W1 to W5) and lakes (L1 to L4).

The objectives of the management zone adjacent to wetlands and lakes is to protect the integrity of the reserve zone where one is required, and to maintain important wildlife values where no reserve zone is required.

Tables 14 through 16 outline guidelines for management zones adjacent to all wetlands and lakes. Wetlands and lakes have been separated according to their frequency on the landscape. In biogeoclimatic units where wetlands and lakes are uncommon, individual wetlands or lakes have greater importance for wildlife than where they are common.

Retention percentages for the management zone for dominant and codominant trees in Tables 14, 15, and 16 are for the harvest area (cutblock) and not the entire wetland RMA. Residual trees should be concentrated near the wetland or reserve zone but should also be used to provide no-work zones to protect wildlife hazard trees, and other wildlife features such as trails, moist sites, and deciduous patches.

(Table 15 in the guidebook is the appropriate table for the W183, based on biogeoclimatic subzone.)

Wetlands and lakes are moderately common in these biogeoclimatic units. Consequently, protection of individual wetlands and lake RMAs should generally be greater than in other landscapes where wetlands and lakes are more common (Table 16). In local landscapes where few wetlands are present or where a high proportion of wetland RMAs have been harvested with lower retention levels than specified here, the retention guidelines contained in Table 14 should be considered. Reserve zones are required on wetlands and lakes greater than 5 ha (except L1 lakes > 1000 ha) in these biogeoclimatic units and a management zone is required on wetlands and lakes 1–5 ha. Wetlands and lakes < 1 ha do not have an RMA. Management strategies should maintain the integrity of the reserve zone and maintain important wildlife habitat values of the management zone where a reserve zone is not required. Significant numbers of dominant and codominant trees, understorey vegetation, and wildlife trees should be retained for wildlife habitat.

Best Management Practice

- Manage windthrow risk to the reserve zone consistent with the section "Windthrow management strategies."
- Retain at least 40% of the codominant conifers having the characteristics described in "Options to reduce windthrow risk in the management zone" and all deciduous trees concentrated near the reserve zone or near the wetland or lake edge where no reserve zone is required and/or in patches to buffer important wildlife features. Distribution of the specified retention levels may vary within the management zone to reflect site characteristics, stand conditions, windthrow hazard management, and wildlife habitat features. For example, sections of the management zone may have low retention if adjacent sections have full or high retention.
- Retain wildlife trees within the reserve zone of these wetlands and lakes by establishing safe work zones within the management zone. To the extent reasonable, retain wildlife trees either in patches or as single trees, within 10 m of the wetland or lake edge where a reserve zone is not present, to help meet landscape level wildlife tree objectives (see "Wildlife trees in the reserve zone" and "Wildlife trees in the management zone").
- Retain most nonmerchantible conifer trees, understorey deciduous trees, shrubs, and herbaceous vegetation within 10 m of reserve zone, or 20 m of the wetland or lake edge where there is no reserve zone.
- Buffer important wildlife features such as major game trails, licks, denning sites, and moist understorey habitats with vegetation to maintain cover or visual screening.

Appendix 6: Archeological Overview Assessment and Archeological Impact Assessment

Not available as a digital file at this time.