

An Overview Assessment of Forest Development- Related Issues in the Deroche Creek Area, Forest License A74688

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Introduction

Eleven cutblocks (the blocks) covering an area of 108 ha are currently proposed under Forest License (FL) A74688 for harvesting in the Deroche Creek area (the area) in the Chilliwack Forest District (DCK). The proposal is part of the 2002-2006 Forest Development Plan (FDP), Major Amendment #5 (the proposed development).

At the request of Allan Johnsrude, District Stewardship Officer for the DCK Ministry of Forests and Range, I conducted an overview assessment of the potential geomorphic and hydrologic impacts of the proposed development. The purpose of this assessment is to provide information and recommendations to guide the FDP with respect to the management of potential development-related impacts – particularly with respect to water quality and quantity on which numerous licensed water users depend, and terrain stability hazards.

The assessment will be focused within the residual sub-basin areas where the development is proposed to take place. It is not a detailed watershed assessment as outlined by the Coastal Watershed Assessment Procedure (CWAP) and will not provide a detailed assessment of the impacts of historic logging. Non geomorphic and hydrologic issues of concern such as potential impacts to wildlife habitat are beyond the scope of this document.

Background

Location

The proposed blocks are located in the Deroche Creek area approximately 20km northeast of Mission on the north side of the Fraser River. The area consists of several small sub-basins situated between Norrish Creek to the west and Siddall Creek to the east, on slopes draining into Nicomen Slough.

Forest Management

Presently, management of the area still falls under the Forest Practices Code (FPC) of British Columbia. The chart area between Norrish Creek and Siddall Creek is currently held by Teal Cedar, however the current FDP proposal is by 606546 BC Ltd. (the licensee). The area is potentially up for provision under replacement volume as part of the reallocation and may also fulfill volume requirements from local First Nations under their Forest and Range Agreement.

The proposed development areas are not located in designated Community Watersheds. Therefore, a CWAP is not legally required in this case and at the time of this assessment DCK did not deem it necessary to carry out a detailed CWAP.

Proposed Development, Major Amendment 5

A total of eleven cutblocks totaling 108 ha are proposed by 6060546 BC Ltd. Six of the eleven blocks covering an area of 38.5 ha are located in a residual area (RA1) west of Deroche Creek consisting of three small unnamed creek sub-basins. The remaining five blocks occupy 69.1 ha in a second residual area (RA2) to the east of Deroche Creek. RA2 consists of two main sub-basins: Pye Creek and Barnes Creek.

Deroche Creek, the largest sub-basin in the area, contains an area designated as a community watershed. The community watershed boundary begins at the point of interest (POI) approximately 1.7 km upstream from where Deroche Creek joins Nicomen Slough. No blocks are proposed in the community watershed or the larger Deroche Creek sub-basin.

Information Sources

Information on site conditions provided below for this assessment was collected primarily from airphotos, topographic maps, and communications with DCK staff. In particular, the following information sources are referenced:

- 1) 1968 Airphotos – BC7056, Nos. 143-150; 194-198. (Approx. 1:17,000 scale)
- 2) 1996 Airphotos – BCC96083, Nos. 100-103; 170-175. (Approx. 1:17,000 scale)
- 3) 2002 Airphotos – SRS 6629, Nos. 16-18; 123-126; 160-162. (Approx. 1:15,000 scale)
- 4) Productive Crown Forest Watershed Overview Map, Hatzic/Deroche. Ministry of Forests, Chilliwack Forest District. July, 2006. 1:25,000 Scale.
- 5) Forest Development Plan 2002-2006, Major Amendment #5, Forest License A74688. 1:20,000 Scale.

Site Conditions

Terrain Characteristics

The Deroche area occupies south to south-east facing residual slopes overlooking Nicomen Slough. Terrain is forested and ranges from gentle toe slopes and fans to steep and gullied mid and upper slopes. From airphoto observations it is apparent that slopes east of Pye Creek are irregular, bedrock controlled, and likely covered with a combination of till and colluvial veneers. Surficial materials appear to increase in depth from Pye Creek west and gullies become more deeply incised with steep headwalls. Creeks in the area typically emerge from steep gully walls onto small to moderate sized fans, with Deroche Creek having the largest sub-basin and fan.

Surficial materials on upper slopes appear to consist of well-drained till and colluvial veneers. Midslopes consist of variable mantles of till and colluvial veneers. Lower slopes consist largely of deep fluvial fan, floodplain deposits and terraces. Bedrock in the area is dominantly Lower Jurassic andesitic volcanic rock of the Harrison Lake formation. Middle Jurassic quartz diorite intrusive may be found at the margins of the Deroche area¹.

Hydrology

The proposed development area forms part of a residual area of the Fraser River watershed, and as such, is composed of several smaller sub-basins rather than one or more large, well-defined watersheds. These sub-basins are less than 300 ha in size with several less than 100 ha. As a result, slope drainage is dispersed and drains to several points of interest where the sub-basin channels join Nicomen Slough. The exception to this is the Deroche watershed which is a larger basin about 970 ha in area with a community watershed portion of about 720 ha.

For the purpose of this assessment, the Deroche area has been sub-divided into two assessment areas:

- 1) Residual Area 1 (RA1) - consisting of five or more small tributary basins all approximately 200 ha and smaller. This 626 ha area is located just west of the Deroche Creek watershed.
- 2) Residual Area 2 (RA2) - consisting of the Pye Creek and Barnes Creek Sub-basins, respectively 290 and 460 ha in area. The 750 ha total residual area is located immediately east of Deroche Creek. .

¹ BCTS Geology map accessed online on August 17, 2006.
<http://webmap.em.gov.bc.ca/mapplace/minpot/bcgs.cfm>

Natural Hazards

Landslides are a natural geomorphic phenomena throughout mountainous areas of British Columbia. The rate at which such instability occurs can be exacerbated by logging and road construction on steep slopes, but are usually triggered by intense periods of high rainfall.

A significant portion of the proposed development area consists of steep, gullied slopes. Scarred gully channels and disturbance vegetation indicate evidence of past debris flow activity in the two largest gully systems in RA1, and in both Pye and Barnes Creeks. Small to moderate sized fans formed by both fluvial and colluvial deposition have formed at the mouths of these sub-basins. Sub-basin characteristics in both Pye and Barnes Creeks support the conclusion that their fans are naturally prone to debris flow activity, as both sub-basins were determined to have a Melton ration of 0.79 (Table 1 and 2). The two largest un-named creek sub-basins in RA1 have similar physical characteristics and are also likely prone to natural debris flow events. Open slope landslides appear to be rare.

Table 1: Pye Creek Sub-basin Characteristics and the Melton Ratio

Relief max (km)	1.18
Relief min (km)	0.01
Total Relief (km)	1.34
Area (km ²)	2.9
*Melton Ratio	0.79

Table 2: Barnes Creek Sub-basin Characteristics and the Melton Ratio

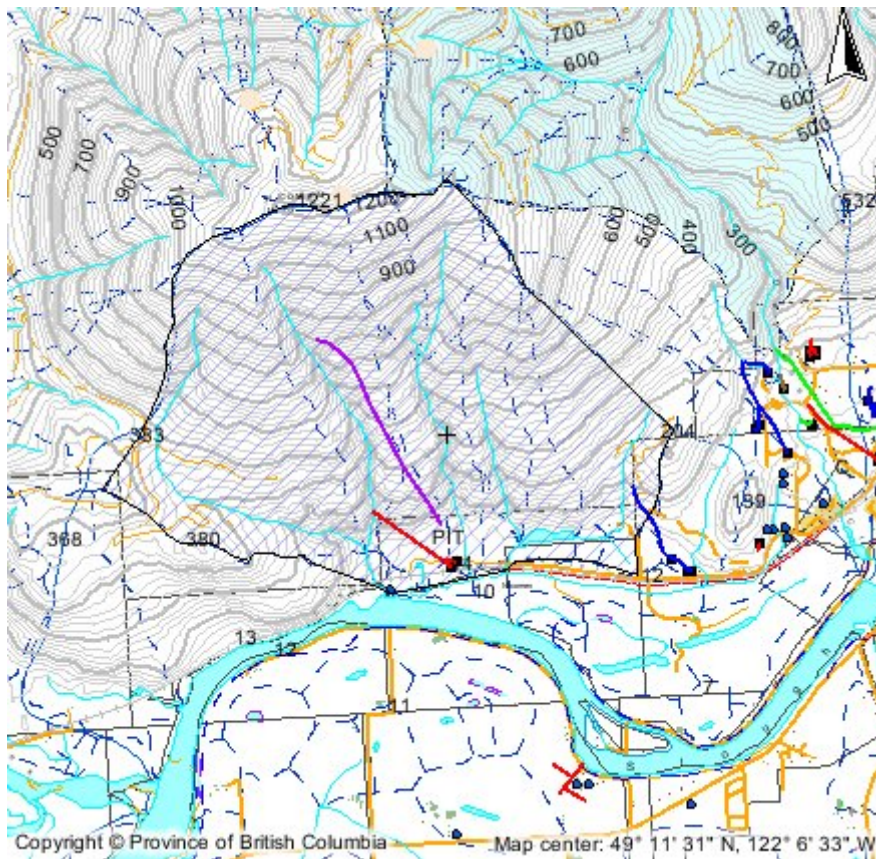
Relief max (km)	1.16
Relief min (km)	0.02
Total Relief (km)	1.34
Area (km ²)	2.9
*Melton Ratio	0.79

* The Melton Ration is a measure of the watershed relief divided by the square root of the watershed area. A Melton Ratio of < 0.3 indicates a fan that is most prone to flooding, a ratio of 0.3-0.6 indicates a fan prone to debris flooding events, and a ratio of >0.6 indicates a fan prone to debris flows (Wilford et. al. 2004).

Water Users

Outside of the Deroche Creek community watershed, water users draw water from dispersed point sources, likely from a combination of wells and direct intakes (Figures 1 and 2). It is my understanding that there are no large, shared community water sources. Licensed water users in the area are identified on the Hatzic/Deroche Productive Crown Forest Land Watershed Overview Map (MOF, July 2006) and on the iMap (Figures 1² and 2³) and BC Water Resources Atlas webpage⁴. In RA1, there are three active water licenses identified on the Watershed overview map to be drawing water from the catchment area (Figure 1). In RA2 there are 15 water licenses visible on the map (Figure 2). Several water users may draw from each active water license (Figures 1, 2 and 3) and unlicensed water users are also likely dispersed throughout the area.

Figure 1: Residual Area 1 showing residential development and water intakes



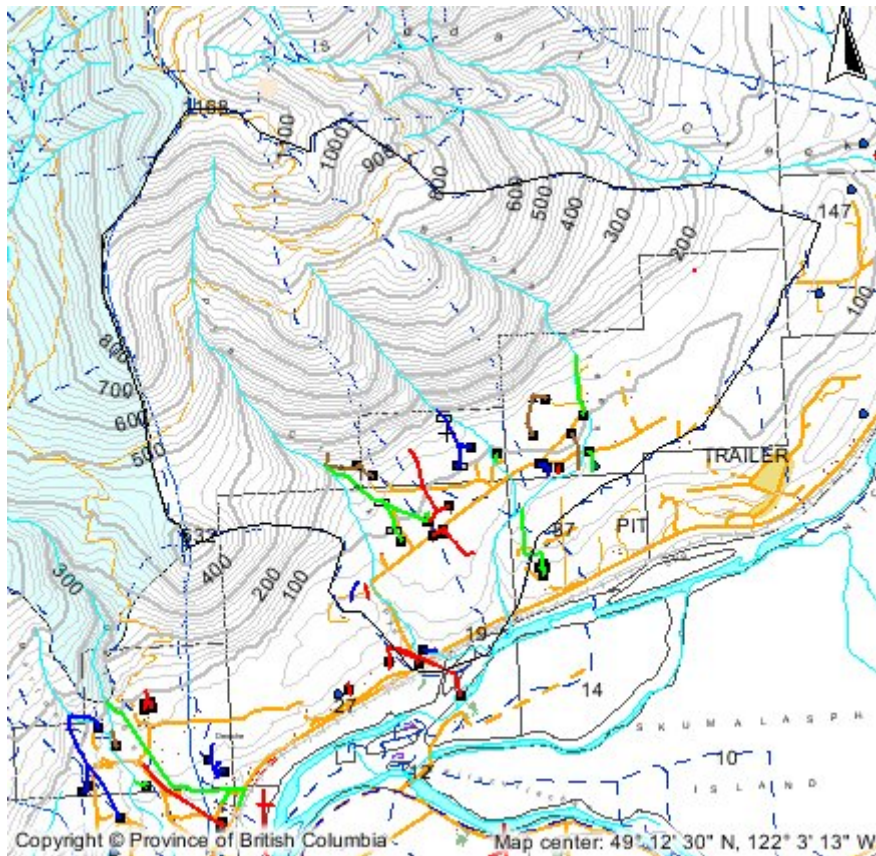
Note: Water intakes are represented by coloured lines connecting the water user to the intake source, and may be located far upslope of the water user. The RA1 boundary is outlined in black.

² <http://wma.gov.bc.ca/imf50/imf.jsp?session=7479>

³ <http://wma.gov.bc.ca/imf50/imf.jsp?session=7554>

⁴ <http://maps.gov.bc.ca/imf50/imf.jsp?site=wrbc>

Figure 2: Residual Area 2 (Pye and Barnes Creeks) showing residential development and water intakes



Note: Water intakes are represented by coloured lines connecting the water user to the intake source, and may be located far upslope of the water user. The RA2 boundary is outlined in black.

Fisheries

Watershed codes and fish species present are as reported on the Fish Wizard website⁵.

Residual Area 1: Unnamed Creeks, Watershed Codes 100-066400 including 100-066400-13500 and 100-066400-13500-41500, No fish recorded; 100-066500, No fish recorded.

Residual Area 2: Pye Creek, Watershed Code 100-072000, Coho present; **Barnes Creek,** Watershed Code 100-072400, Coho and Chum present.

Creeks in both RA1 and RA2 flow directly into Nicomen Slough, which is part of the Fraser River system. Fish species present in this portion of Nicomen Slough, also referred to as the Bishop Reach, are identified in Fish Wizard as follows:

⁵ http://maps.gov.bc.ca/imf406/imf.jsp?site=libc_awiz

Fraser River, Big Eddy, The Bishop Reach (Nicomen Slough) – Watershed Code 100, Listed fish present - American Shad, Black Crappie, Brassy Minnow, Bridgelip Sucker, Brown Catfish (formerly Brown Bullhead), Bull Trout, Burbot, Carp, Chinook Salmon, Chiselmouth (formerly Chiselmouth Chub), Chub (General), Chum Salmon, Coastal Cutthroat Trout, Coastrange Sculpin (formerly Aleutian Sculpin), Coho Salmon, Cutthroat Trout, Cutthroat Trout (Anadromous), Dolly Varden, Emerald Shiner, Eulachon, Green Sturgeon, Kokanee, Lake Chub, Lamprey (General), Largescale Sucker, Leopard Dace, Longfin Smelt, Longnose Dace, Longnose Sucker, Minnow (General), Mountain Whitefish, Northern Mountain Sucker, Northern Pikeminnow (formerly N. Squawfish), Pacific Lamprey, Peamouth Chub, Pink Salmon, Prickly Sculpin, Pygmy Whitefish, Rainbow Trout, Redside Shiner, River Lamprey, Salmon (General), Sculpin (General), Slimy Sculpin, Sockeye Salmon, Spottail Shiner, Staghorn Sculpin, Starry Flounder, Steelhead, Stickleback (General), Sucker (General), Surf Smelt, Threespine Stickleback, Westslope (Yellowstone) Cutthroat Trout, White Sturgeon, White Sucker.

Infrastructure and Property

Residential and other buildings were identified using the iMap⁶ online mapping tool. In Residual Area 1, there appear to be only two residential buildings on the lower slopes (Figure 2). Development in the Pye Creek and Barnes Creek sub-basins of Residual Area 2 is more widespread. In the Pye Creek sub-basin there are approximately seventeen buildings located on lower slopes below 100m elevation and two homes located on mid to lower slopes above 150m elevation (Figure 3). The Barnes Creek sub-basin contains 25 or more buildings (Figure 3). The majority of the buildings in these sub-basins are likely private residential homes and appear to be accessible by paved road, with some homes likely accessed by gravel roads. A comprehensive inventory of infrastructure and private property is beyond the scope of this report.

An Overview of Forest Practices and Potential Impacts

Potential Logging-Related Impacts

Logging practices can have a greater effect on watershed values than the total area of harvesting, or Equivalent Clearcut Area (ECA) alone. A list of potential logging-related hydrologic and geomorphic hazards are as follows:

- Terrain stability (harvesting or road related landslides)
- Fan destabilization (From logging or poor road building on fans, debris flow deposition, aggradation, flooding and debris floods.)
- Wind throw (Windthrow related sedimentation and landslides)
- Erosion from yarding and skidding, or poorly managed road drainage
- Sedimentation (landslides, windthrow, erosion, and other ground disturbance)

⁶ <http://wma.gov.bc.ca/imf50/imf.jsp?session=7527>

- Channel Degradation (Logging within riparian areas/channel banks)
- Damage to riparian vegetation
- Peak flow changes (related to ECA), regeneration, and rate of cut).

Equivalent Clearcut Area (ECA) and Watershed Impacts

- ECA related watershed impacts are watershed specific and generally limited to changes in peak flow volumes.
- High ECA values can result in increased peak flow volumes.
- Large areas of second growth can result in “over-recovery” whereby peak flow volumes are decreased.
- Impacts related to poor logging practices such as logging within riparian areas and along channel banks can be exacerbated by elevated peak flows related to high ECA values if channel banks are not bedrock controlled.

Elements at Risk (Watershed Values)

The elements at risk encountered in any watershed are site specific. A general list of potential elements at risk are as follows:

- Soil Resources (Related to terrain stability, erosion, road building, compaction and other soil disturbance.
- Forest Productivity
- Water quality (Primarily related to turbidity, temperature, and nutrient levels)
- Water quantity (Increase with high ECAs, decrease with large areas of dense second growth)
- Fisheries values (Primarily related to channel condition, turbidity, temperature (not significant on the coast), and nutrient levels)
- Wildlife values
- Property and life (Primarily related to terrain stability)

A Priority List of Potential Hydrologic and Geomorphic Issues

Potential logging related impacts are watershed and site-specific. However, as a general rule logging related geomorphic and hydrologic impacts can be eliminated or minimized best through proper management of the following issues in order from highest to lowest priority:

- Terrain Stability – including fan management and landslide triggering mechanisms such as windthrow.
- Logging in Riparian areas and along channel banks
- Control of drainage and erosion/sedimentation – particularly related to roads
- ECA - total and rates of logging
- Other watershed specific issues – windthrow, turbidity

Historic and Current Forest Practices

Logging practices prior to the implementation of the Forest Practices Code (FPC, the code) in June 1995 were not as focused on managing landslide hazards, riparian areas and streams, or peak flow impacts as are current practices; hence the impacts of past development have been significant in some watersheds in B.C. However, these historic practices and related impacts are not representative of the current management regime under the FPC, currently transitioning to the Forest and Range Practices Act (FRPA). Since the introduction of the FPC, logging practices have become more focused on eliminating the adverse impacts of harvesting and road construction, and managing to better protect non-timber values. In a 2005 report the Forest Practices Board concluded that there has been a “significant improvement in the reduction of landslides from forest practices after the code took effect” and that the “total number of landslides declined, and those that did occur were less likely to damage streams”⁷.

Forest Development and Related Impacts in the Deroche Area

Historic Development and Related Impacts

Forest development in the area took place in the mid 1900's to approximately the 1980's. During this time large portions of the upper and lower slopes of the residual areas were logged. The majority of clearcut areas appear to have been logged without the occurrence of related post-logging landslides. However, it is apparent in the 1968 airphotos that logging in the upper gully headwalls of both Barnes Creek and Pye Creek may have triggered landslides which resulted in debris flows in both creek channels which impacted the alluvial fans. A second older debris flow in Pye Creek may have been initiated within a clearcut on the west side of the gully sidewall. Disturbed vegetation may indicate that a third debris flow impacted the Pye Creek fan.

The Barnes Creek debris flow visible on the 1968 airphotos impacted the fan but stopped within 100m short of the closest of three buildings located on the fan. These buildings likely remain at some risk from large debris flow events in the future. Two new buildings are visible on the 2002 photos on the distal end of the fan where the risk of significant debris flow impacts is less. This assessment is based solely on historic airphotos. A detailed, site-specific hazard and risk assessment would be necessary to gain a clear understanding of the risk to homeowners.

The most recent debris flow from the Pye Creek channel was large and impacted approximately 30% of the fan area visible on the 1968 airphotos, mostly confined to the west fan area. Evidence in the form of disturbed forest areas from two other debris flows impacting the fan was also observed. Three houses appear on the 2002 airphotos

⁷ Forest Practices Board, July, 2005. Managing Landslide Risk from Forest Practices in British Columbia, Special Investigation. FPB/SIR/14
<http://www.fpb.gov.bc.ca/news/releases/2005/07-13.htm>

to have been constructed on the east side of the Pye Creek fan within the runout length of two large debris flows visible on the 1968 airphotos. These houses could be impacted by future debris flows. Several more houses are located on the distal end of the fan where the risk of significant debris flow impacts is lower. This assessment is based solely on historic airphotos. A detailed, site-specific hazard and risk assessment would be necessary to gain a clear understanding of the risk to homeowners.

ECA and Hydrologic Recovery

Peak flow increases are related to the percentage of forest canopy removed from the watershed following logging, or the equivalent clearcut area (ECA). Currently, the ability of researchers to accurately quantify this relationship and the degree to which ECA related peak flow increases can negatively affect channel condition is limited. Appropriate ECA levels should be determined by experienced, qualified professionals on a site specific basis; however, as a general guide where CWAPs have not been carried out, an ECA of 30% and under is considered an acceptable level of harvest⁸.

A detailed assessment of ECA is beyond the scope of this report. However, it is apparent from most recent airphoto observations and the forest development plan map that the watershed has been recovering as advanced second growth forest cover has become re-established. An assessment of the forest cover characteristics and the application of research on hydrologic recovery of second growth forests can provide a better overview of the general hydrologic condition of RA1 and RA2.

Research by Robert Hudson (2003) in Gray Creek on the Sunshine Coast has provided useful information on the hydrologic recovery of watersheds following harvesting that is applicable throughout southwestern coastal BC. In order to assess the current general watershed condition of RA1 and RA2, a determination of the degree of hydrologic recovery with respect to larger storms is considered to be appropriate since it is these storms which have the greatest potential to impact stream channels. As storm size increases, recovery of the canopy's rainfall interception potential (rainfall recovery) of second growth forests at a height of 18 m become "progressively over-recovered compared to old growth". At a storm threshold of 45 mm, the rainfall recovery effect of second growth stands 18 m tall reaches 139% relative to old growth stands. This over-recovery is due to the increased uniformity and density of these second growth canopies relative to old growth.

RA1 and RA2 slopes range from approximately 20 to 1200 m a.s.l. occupying the rain (<300m), rain on snow (300-800m), and snowmelt (> 800m) zones. Hence, it is appropriate to also assess the hydrologic recovery of the area using a fully integrated rainfall-snowmelt-rain-on-snow model as provided by Hudson (2003). Using the same

⁸ Anonymous. 1996. Community Watershed Guidebook. Government of British Columbia, Forest Practices Code.

<http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/WATRSBED/water1.htm>

tree height threshold of 18m, it can be expected that second growth stands should achieve approximately 90% overall recovery at 18m height and greater.

Forest stands in the Deroche area are composed primarily of Douglas Fir with minor components of Western Red Cedar and Western Hemlock; an average site index for the area would be approximately 25⁹. Following standard site index curves for coastal species¹⁰ it was determined that these three coastal tree species would be expected to reach a height of 18 m when stands reach an age of between 30 and 33 years old.

In RA1 the majority of forest cover is identified as age classes 3 to 9, or 41 to greater than 121 years old. More recent cutblocks are located in the west side of RA1 with age classes of 2 and less are dominant (trees are between 0 and 40 years old). In RA2 the majority of forest cover is also identified as age class 3 and greater, with the greatest portion being age class 5 and higher (greater than 81 years old). The most recently logged areas are located in the headwaters of Pye and Barnes Creeks where a small portion of forest cover is identified as age class 2. Forest development plan maps do not contain age class data for a small portion of the lower slopes of RA1 and RA2 that are located outside the forest license area.

Considering that the majority of the RA1 and RA2 areas contain age classes that would be expected to contain forest cover with tree heights of at least 18 m, it can be expected that second growth forests in these areas are likely in an advanced stage of hydrologic recovery near or exceeding the conditions of reference old growth stands. Breaking this down to hydrologic zones, the advanced second growth forest is likely up to 80% recovered in the rainfall zone, over-recovered in the rain-on-snow zone, and close to fully recovered in the snow zone.

Proposed Development - FL A74688, Major Amendment 5

Eleven cutblocks (the blocks) covering an area of 108 ha are currently proposed under Forest License (FL) A74688 for harvesting in the Deroche Creek area (the area) in the Chilliwack Forest District (DCK). The proposal is part of the 2002-2006 Forest Development Plan (FDP), Major Amendment #5. As currently proposed, the cutblocks will be harvest primarily as clearcuts using a combination of ground-based cable yarding on lower slopes and helicopter yarding of upper slopes. Approximately 5.2 km of new construction and 1.6 km of road reconstruction is proposed to access the lower slope areas. One major crossing structure is required on an S6 stream.

The total proposed cutblock area is 107.6 ha with 38.5 ha proposed in RA1 and 69.1 ha proposed in RA2. The proposed cutblocks and areas are listed for RA1 and RA2 in Tables 3 and 4, respectively.

⁹ Personal Communication with John Stevenson, Tenures Forester, Chilliwack Forest District. September 26, 2006.

¹⁰ Nussbaum, A.F. 1996. Site index curves and tables for British Columbia: coastal species. 2nd Ed. B.C. Min. For. Res. Br. Land Management handbook, Field Guide Insert 3.

Table 3: Cutblock Areas within Residual Area 1, FL 74688 Major Amendment A5

Residual Area 1 (RA1)	
Total Watershed area (km ²) =	6.265
Total Watershed area (ha) =	626.00
74688 Blk # 1	12.50
74688 Blk # 2	7.50
74688 Blk # 3	4.00
74688 Blk # 4	6.50
74688 Blk # 5	4.00
74688 Blk # 6	4.00
Total RA1 Block area =	38.50
% of watershed =	6.15

Table 4: Cutblock Areas within Residual Area 2, FL 74688 Major Amendment A5

Residual Area 2 (RA2 - Pye & Barnes Creeks)	
Total Watershed area (km ²) =	7.5
Total Watershed area (ha) =	750.00
74688 Blk# 1	10.00
74688 Blk# 2	20.00
74688 Blk# 3	6.00
74688 Blk# 51	11.40
74688 Blk# 52	21.70
Total RA2 Block area =	69.10
% of watershed =	9.21

In RA1 the total proposed cutblock area amounts to an ECA of 6.2% and in RA2 the proposed ECA will be 9.2%. Considering the advanced stage of second growth regeneration and associated hydrologic recovery, it is unlikely that the proposed logging will have a significant effect on peak flows in either residual area.

Conclusions

An overview watershed assessment was requested by the Chilliwack Forest District to address concerns and provide guidance regarding the potential geomorphic and hydrologic impacts from the proposed Amendment 5 development. Based on the information reviewed, this assessment has led to the following conclusions regarding the current site conditions and the potential effects of the proposed Major Amendment 5 in RA1 and RA2:

Terrain Stability

The Deroche area contains terrain that is prone to both natural and post-logging related landslides, particularly in gullies and on alluvial fan depositional areas. Post-logging landslides have a relatively greater potential to adversely impact channel morphology, water quality, property and human life than other impacts from forest practices. This considered, management of terrain stability hazards should be considered a priority – particularly at the interface between managed crown forest lands and residential development as in the Deroche area. The proposed development can be carried out with minimal associated hazard and risk if specific recommendations provided in the following section are followed.

Fan Degradation

Parts of proposed development appear to occur on or close to fans. Inappropriate development on these areas could result in fan destabilization and sedimentation impacting water quality, fish habitat and private property. However, the effects of the proposed development can be minimized by following procedures and guidance provided in Land Management Handbook No. 57: *Forest Management of Fans*.

Wind-throw

Cutblock edges windward to strong winds may be prone to windthrow while boundaries leeward to this are afforded some protection. If not properly managed, windthrow hazards can result in a loss of forest productivity and soil resources, and sedimentation impacting water quality and fish habitat. Where windthrow occurs on fans or unstable terrain, it can trigger fan destabilization or landslides which can directly impact fish habitat and populations. Windthrow assessments and prescriptions to mitigate effects can be applied to adequately manage this hazard.

Sedimentation

Sedimentation can occur as a result of new road construction, road reconstruction, existing roads, proposed heli drop sites, ground disturbance, erosion, landslides, fan degradation, channel degradation, and windthrow. It can result in loss of forest

productivity and soil resources from the source and at receiving areas, degrade fish habitat and spawning channels negatively impacting fish populations, and affect water quality through increased turbidity. However, if recommendations provided below regarding terrain stability, fan degradation, windthrow hazard and sedimenta management planning are followed, the proposed development should be able to proceed with minimal sedimentation risks.

Channel Degradation and Peak Flow Changes

It has been demonstrated that poor logging practices such as development in riparian areas, fan surfaces, and unstable terrain can cause significant channel degradation such as bank destabilization and aggradation. Such degradation is site specific and can be aggravated by peak flow increases, hence both logging practices and ECA should be managed with the goal of minimizing impacts to the watershed.

Current logging practices have improved significantly since the pre-FPC period when the previous logging related impacts were experienced in RA1 and RA2. Hazards related to terrain stability, development on fans, and windthrow can be identified and recommendations made available to help land managers to limit sedimentation and other development-related impacts associated with the amendment.

The majority of second growth forests in the Deroche area are at an advance stage of regeneration, hence hydrologic recovery is expected to be close to old growth reference conditions. Therefore, proposed ECAs of 6.2% in RA1 and 9.2% in RA2 are not expected to result in significant peak flow changes or related channel degradation.

Water Quality

Numerous licensed water supply intakes are located throughout RA1 and RA2. Figures 1 and 2 show that water intakes may extend far upstream where they may be impacted by the proposed development.

Sedimentation as a result of landslides and erosion have the greatest potential to impact water quality by increasing stream turbidity. However, with proper identification and management of potentially unstable terrain and erosion hazards through TSFAs combined with careful water and sediment management plans, and maintaining ECAs at acceptable levels, the potential for adverse water quality impacts in the Deroche area can be minimized.

Recommendations

Recommendations are provided below to mitigate or eliminate hazards and risk related to the proposed Major Amendment 5 in RA1 and RA2:

Terrain Stability

- Terrain Stability Field Assessments (TSFAs) should be carried out in any and all proposed cutblock areas and roads where terrain falls within the criteria identified in the Forest Practices Code (FPC) Regulations¹¹, Section 17 (1)¹² which states:

17. (1) A terrain stability field assessment must be completed before a cutting permit may be applied for, if the cutblock is located in an area other than an area referred to in section 16, and if the area is identified in the forest development plan as having

- (a) a high likelihood of landslides,
- (b) unstable terrain, or
- (c) a slope gradient greater than 60%.

- Criteria for triggering a TSFA in the Coast Forest Region must also be met as outlined in Section 37 (1) (b) and (2) (a)¹³ which states:

37. (1) Subject to subsections (4) and (5), a person preparing a silviculture prescription must carry out the following assessments and make available, upon request, to the district manager the following information:

(b) a terrain stability field assessment for the cutblock if

➡(i) Repealed. [B.C. Reg. 350/2002] ➡

(ii) the cutblock is not located in a community watershed, but is located in an area that has been identified in the forest development plan as having potentially unstable terrain or a moderate likelihood of landslides,

(iii) the cutblock has been identified by the district manager as requiring a terrain stability field assessment, or

(iv) indicators of potential slope instability in the cutblock are identified while carrying out field work for the purposes of section 39 (3) (a) (iii);

- If the above criteria does not apply, no TSFA is necessary.
- TSFAs should pay particular attention to gullies with connectivity to lower fan surfaces.

¹¹ B.C. Reg. 107/98 Deposited April 2, 1998; O.C. 0426/98 effective June 15, 1998 (Consolidated to December 12, 2003).

¹² <http://www.for.gov.bc.ca/tasb/legsregs/archive/fpc/fpcaregs/oplanreg/opr-3a.htm#17>

¹³ <http://www.for.gov.bc.ca/tasb/legsregs/archive/fpc/fpcaregs/oplanreg/opr-5.htm#37>

- Potential development-related fan and windthrow hazards should also be assessed in the TSFAs where necessary.
- Considering the proximity to residential development, it is appropriate that TSFAs clearly identify the consequences of logging related landslide hazards and provide an assessment of risk. Professionals responsible for these TSFAs should seek guidance from the following documents:
 - 1) Guidelines for Legislated Landslide Assessments for Proposed Residential Development in British Columbia, March 2006
 - 2) Thresholds for Development Approvals by Local Government, November 1993
- Even in the absence of logging operations, several residential developments on alluvial fans at the base of Pye Creek and Barnes Creek identified in this report may be at risk from natural debris flow events. The Fraser Valley Regional District should be notified of this risk and site-specific landslide hazard assessments are recommended for these homeowners in order to better identify and understand the risk they may be exposed to.

Fan Degradation

- Proposed development areas should be assessed to determine whether they occur on alluvial fan surfaces.
- Proposed development areas identified on fans should be assessed and managed using procedures and guidance provided in Land Management Handbook No. 57: *Forest Management of Fans*. Additional relevant fan management information is contained in Millard et al (2006). Contact David Wilford, Research Hydrologist for the Regional Service Centre in Smithers¹⁴ or Tom Millard, Research Geomorphologist for the Coast Forest Region¹⁵ for further information.

Wind-throw

- Windthrow assessments should be carried out in order to minimise windthrow hazards and related impacts.

¹⁴ <http://www.for.gov.bc.ca/rni/Research/GHstaff.htm#DW>

¹⁵ <http://www.for.gov.bc.ca/rco/research/vanstaff.htm>

Sedimentation

- Careful erosion and drainage management should be applied to limit this sedimentation hazard from new road construction, road reconstruction, existing roads, and proposed heli drop sites.
- A sediment management plan which clearly identify all water supply intakes in the development area should be carried out in order to preserve water quality for water users.

Channel Degradation and Peak Flow Changes

- ECAs should be maintained below 30% as recommended in the Community Watershed Guidebook unless it can be demonstrated by a qualified professional that a higher ECA is possible without causing channel degradation or excessive peak flow changes.
- Maintaining high standards of forest practice, particularly with respect to the protection of the integrity of stream channels and riparian vegetation, will be essential for preventing channel degradation.

Water Quality

- The numerous water supply intakes identified using iMap (Figures 1 and 2) should be clearly identified prior to the commencement of logging operations in order to avoid impacts to water quality or damage to infrastructure.
- Although not a community watershed, it is recommended that land managers seek guidance from the Community Watershed Guidebook in order to better protect water users in the area.
- Ensuring water quality will require that all related recommendations provided above are followed.

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