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January 13, 2013
File No.: ECON-12-7

ECON Consulting
PO Box 329
Merville, BC
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Attention: Erik Holbek, RPF

RE: TERRAIN STABILITY ASSESSMENT FOR CUTBLOCKS C3UX, C3H8 & C2XU, MCNAB CREEK AREA, BCTS LICENSE A90229

1 INTRODUCTION

At the request of Erik Holbek, RPF of ECON Consulting (ECON), Maritime Pacific Engineering (MPE) carried out a terrain stability assessment for cutblocks C3UX, C3H8 & C2XU located in the McNab Creek area of Howe Sound (Figure 1). These cutblocks will be harvested under BC Timber Sales License A90229.

This report identifies potential terrain stability hazards and potential unsafe conditions with respect to harvesting and road construction within the assessed area, and provides recommendations with the objective of minimizing the potential for harvesting and road construction-related slope instability. This investigation takes the form of a reconnaissance–level field assessment and involves the observation of topographic maps and surface conditions, as well as the examination of soil exposures and natural soil disturbances. Otherwise, no subsurface investigation was done. These procedures are accepted methodology for terrain stability assessments. This report satisfies the requirements of Occupational Health & Safety Regulation (OHSR) 4.1.1 (Avalanches, Worksafe BC 2010).

2 BACKGROUND

The field assessment of cutblocks C3UX, C3H8 & C2XU was performed on July 12 & 13, 2012 by Jamie Alguire, RPF P.Eng. of MPE, accompanied by Erik Holbek, RPF of ECON (approximately 7 hours on site each day). The traverse route is shown on the attached TSA Map. At the time of the fieldwork, surface water was at low levels, with clear weather with good visibility. Cutblock layout and mapping was complete at the time of the assessments.

Cutblocks C3UX, C3H8 & C2XU were not entirely assessed due to lack of obvious terrain instability indicators triggering requirement for a terrain analysis (as per ECON). Cutblocks C3UX, C3H8 & C2XU are comprised of 2nd growth Hw/Fd/Cw timbered polygons with a total approximate area of ~40 Ha. The cutblocks are accessed by planned branch MC067A (cutblock C3UX), McNab East Main (cutblock C3H8) and branch 1115-026 & 024 (cutblock C2XU), all planned for new construction & reconstruction; not all roads or spurs were assessed due to lack of obvious terrain instability indicators (as per ECON). Cutblocks C3UX, C3H8 & C2XU are planned for conventional ground based grapple yarding/hoe forwarding harvest systems. Areas of potential terrain instability were identified by ECON previous to the assessment; 1:5000 scale harvest plan maps including terrain stability & resource mapping and 1:20,000 & 1:250,000 scale location maps were provided which formed the reference for this assessment. Landform & terrain definitions are as per recognized, industry-accepted Provincial Government publications[1]. Streams are classed by ECON. Google Earth[2] was utilized for remote sensing. No higher-level plan restrictions such as CWAP etc. exist associated with this cutblock (as per ECON). Concurrent terrain assessments were conducted by David Melville, P.Geo. of Simitar Enterprises Corporation for adjacent cutblocks.

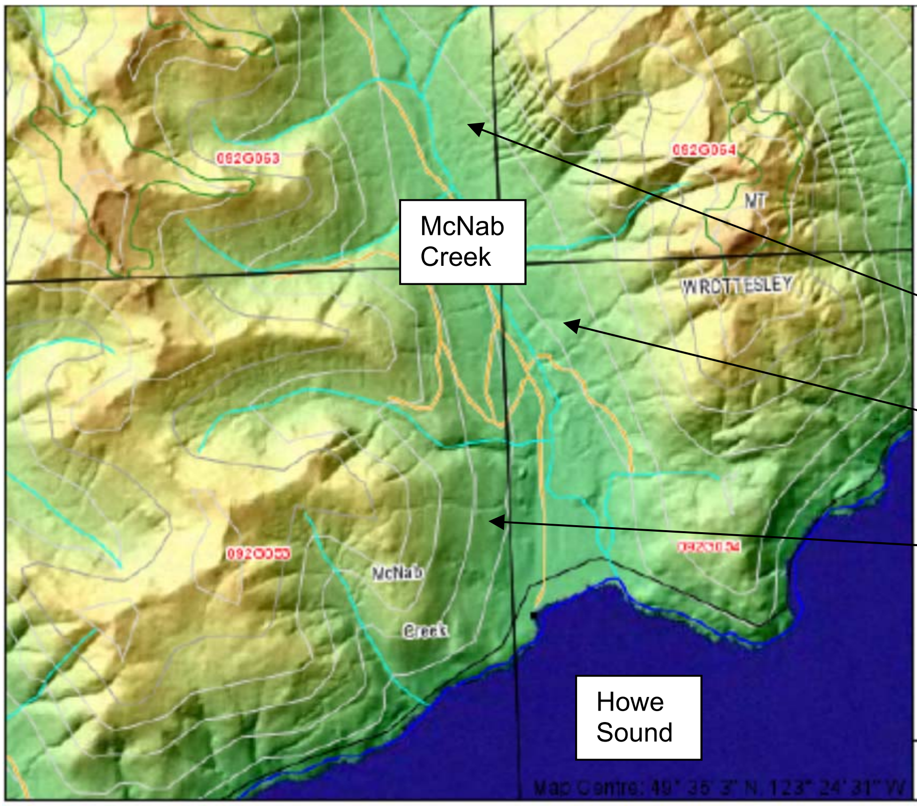

Figure 1: Location map showing cutblocks C3UX, C3H8 & C2XU in McNab Creek area (BCmap Online Store) ~1:60,000 scale

Cutblocks C3UX, C3H8 & C2XU are located on lower slopes of the McNab Creek (class S2[3]) drainage that eventually flows into Howe Sound ~1-3km downstream. This marine ecosystem provides habitat for an abundance of marine life in addition to being an important and frequented recreational water body for year-round outdoor activities such as sightseeing, hunting, boating, fishing, etc.

3 OBSERVATIONS & DISCUSSION

Hazard, consequence and risk rationale are included in Appendix B. Interpretations are extrapolated from field & aerial (ortho) photo observations and comparisons of existing and post-harvest/road construction instability in similar terrain and harvest/road construction systems, either nearby or generally BC coastal (i.e. slide length, size, soil & terrain conditions, road construction method, harvest method etc).

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[1] Forest Practices Code 'Mapping & Assessing Terrain Stability' Guidebook, 2nd ed., MoF 1999. Terrain classification as per 'Terrain Classification System for British Columbia', MOELP, ver 2, 1997.
[2] Google Corporation
[3] Forest Practices Code 'Channel Assessment Procedure' Guidebook, December 1996. Streams classed by ECON.

A Fortis BC natural gas pipeline is located beneath McNab Forest Service Road (FSR). All streams in the cutblock areas eventually empty into McNab Creek, which with associated habitat & recreational values, including the gas pipeline would result in a judgment of ***high consequence*** for landslides or significant sedimentation events impacting these systems. Timbered slopes and deactivated roads exist below the cutblocks, considered ***moderate consequence*** for landslide impact. No other resources have been identified in the area which could be impacted by terrain instability.

3.1.1 Topography and Geomorphology

Cutblocks C3UX, C3H8 & C2XU and access roads are located on typically benched, concave to irregular terrain on lower slopes of the McNab Creek drainage. The cutblocks C3UX & C3H8 harvest areas have a western aspect and an elevation ranging from ~100m to ~300m. The cutblock C2XU harvest area has an eastern aspect and an elevation ranging from ~300m to ~550m. The drainage patterns in the cutblock areas consists of class S6/S5 streams that empty directly into McNab Creek below. Slopes above the harvest area are similarly forested with steeper, concave to irregular slopes. Elevations reach ~1400m above the cutblock, with exposed, fractured bedrock which has deposited moderate amounts of rubble & block in aprons & cones in the cutblocks. Rockfall and debris flows in creek systems originating from upslope crevices are common in the area. Occasional benched, gentle to moderate slopes throughout the cutblocks could mitigate landslide runout length and energy from directly impacting McNab Creek below, or deactivated roads & forested stands. Landslides entering local streams would impact McNab Creek due to close proximity and sometimes moderate transportability of these stream systems.

In cutblocks C3UX, C3H8 & C2XU, general surficial soil material consists of a well drained, silty, rubbly, gravely sand colluvial veneer (with ~30-50% rubble component) overlying a consolidated silty, gravelly sand till & bedrock, the tills being more obvious in lower elevations. The bedrock geology in the area has been classified as granite of the Western Coast Plutonic Suite[4]. Observed bedrock is considered relatively competent but frequently fractured with 0.3-0.5m joint spacing.

3.1.2 Referenced Terrain Stability Data[5]

Reviewing supplied terrain mapping, no portions of cutblocks C3UX, C3H8 & C2XU and access roads are located within mapped polygons indicating terrain stability class IV (potentially unstable) or class V (unstable).

3.2 CUTBLOCK OBSERVATIONS & STABILITY DISCUSSION

Terrain Polygon 1 (TSA map) is located on gentle to moderate terrain in cutblocks C3UX & C3H8. Gentle to moderate slopes and concave, benched terrain would help mitigate landslide initiation, runout length & energy from impacting McNab Creek below. The surficial soil material in the area consists of well drained silty, rubbly, gravely sand colluvial veneer (with ~30-50% rubble component) overlying a consolidated silty, gravelly sand till & bedrock.

Cutblock C3UX: Shooter Creek (S5 considered moderate/high WTP[6]) is located within a shallow draw with ~4m x 0.8m channel which could easily re-channel due to introduced

[4] Wheeler and McFeely, 1991. Geological Survey of Canada, Map 1712A.
[5] Terrain Mapping supplied by ECON.

blockages and cause significant erosion. Cross-stream falling & yarding is planned for this stream; a hazard exists that introduced debris could cause blockages and significant erosion.

Streams crossing the access road branch MC067 such as X6 & X7 exhibit debris fan activity, where debris flows initiating on upper slopes have deposited rubble & gravel in a fan feature which has not destroyed these roads.

Cutblock C3H8: Royal Flush Creek (S5 considered very high WTP) is located within a gullied draw with 2-12m walls @ 85%, with ~10-30m channel width, exhibiting severe channel avulsion and debris deposition amongst standing timber within the wide flood channel. Soils in the area are consolidated silt till. Debris wedges & scouring indicate past debris flows initiating on upper slopes, depositing debris along the entire length of the stream within the cutblock area; rockfall and raveling banks exist in V-shaped crevices located on the highest reaches, a function of bedrock weathering, snowpack loading and likely weak, incompetent rock fracture planes. Debris flows in this system typically deposit debris in this lower reach which splits cutblock C3H8. A retention zone surrounding this stream is likely sufficiently wide to prevent significant windfall impact on the stream; trees within the retention area are mostly immature Fd/Hw/Cw and relatively short, considered *moderate windfall potential*, but would be exposed to endemic winds paralleling McNab Creek running south-north, which is not considered significant. Trees could blow over across the stream, potentially blocking the channel, however this eventuality is not considered significant.

A hazard exists on Royal Flush creek that trees harvested within the stream draw could allow the channel to further meander and cause erosion, increasing avulsion and bed deposition in standing timber. Trees within the draw should therefore be retained.

Considering the proposed conventional grapple yarding/hoe forwarding harvest method, landslides initiating within Terrain Polygon 1 are considered ***low hazard***, due to well drained, coarse soils and gentle, benched slopes. Potential landslide size would be estimated as small due to the relatively short ~150m potential runout length. Landslides could impact McNab Creek below, however benched lower slopes could mitigate landslide runout length & energy, unless entering local streams.

Terrain Polygon 2 (TSA map) is located in cutblock C2XU on moderate to moderately steep, concave to irregular terrain. The surficial soil material in the area consists of a thin, rubbly, gravelly colluvial veneer overlying a consolidated silt till & bedrock. Occasional loose rubble & blocks were observed scattered throughout the area, a product of weathering from bedrock outcrops above. In the FC-U5 area, adjacent to stream #U3, old yarding scour or avalanche debris has resulted in a younger stand type mixed with alder, with dry swales and obvious alder type above the backline, suggesting past disturbance.

Stream #U1 (S5 gully considered moderate WTP & low DFIP, Appendix A) shows no signs of instability; however trees remaining along the gully edge would be susceptible to winds paralleling the McNab Creek drainage, considered a *moderate probability* of occurrence. However, significant windfall was not observed, resulting in a *low risk* for windfall-related landslides.

Stream #U8 (S5 considered high WTP) is contained within a shallow 1-3m draw and exhibits channel scouring & avulsion, which could result in re-channeling and severe erosion if the flow

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[6] WTP: *Water transport potential.* DFIP: *Debris flow initiation potential*. FPC *Gully Assessment Guidebook*, MoF 1997.

was blocked and re-directed by debris or blocked culvert. Both streams U1 & U8 exhibit instability at old deactivated road crossings on upper slopes which should be assessed for potential to impact lower slopes; these streams do not exhibit instability associated with this identified instability.

In the FC-U12 to FC-U13 area, locally steep slopes for ~100m exist with loose rock and talus which would easily be disturbed by grapple yarding; benched slopes immediately below would mitigate any landslide initiating here.

Considering the proposed conventional grapple yarding/hoe forwarding harvest method, landslides initiating within Terrain Polygon 2 are considered ***low hazard*** due to gentle to moderate, concave slopes. Potential landslide size would be estimated as small due to the relatively short ~150-200m potential runout length. Landslides would impact Terrain Polygon 1 below, with gentle, concave slopes which would likely mitigate landslide runout length & energy from impact on McNab Creek, unless entering local streams, which would create some sedimentation.

3.2.1 Windfall

Significant windfall was not observed in the McNab Creek area. Winds paralleling the McNab Creek drainage oriented south-north are considered endemic in the assessed area, due to historic occasional windfall observed locally. Boundaries sensitive to potential windfall-related terrain instability exist along stream #U1 gully in cutblock C2XU, which is perpendicular to endemic winds, considered ***moderate hazard*** but ***low risk***. Royal Flush creek is perpendicular to endemic winds, however remaining trees are immature and considered ***low hazard.*** Similarly oriented cutblocks exist in the general area, which exhibit significant windfall history but do not exhibit obvious windfall-related instability.

Other remnant boundaries are considered ***low hazard*** potential of initiating windfall and ***low windfall-related hazard & risk*** for terrain instability.

3.2.2 Historic Landslide Characteristics & Impact

Debris torrents and avalanches are frequent in the McNab Creek area, typically occurring within existing stream channels characterized by avulsion and debris deposition, a function of rock fractures or weak rock joint weathering on upper slopes, snow pack and precipitation. These events typically are contained within incised channels and cause destructive scouring and channel avulsion, depositing boulders, cobble, gravels and woody debris on levees and fans or cones on lower slopes. The initiation zones of these stream systems are located in crevices on high elevation peaks.

Areas surrounding the proposed cutblocks C3UX, C3H8 & C2XU were previously logged in the Twentieth Century using skidder or cable methods and were then burned as a regeneration technique; these methods tended to cause much more frequent terrain instability compared to better modern harvest techniques. Several recent cutblocks in the lower McNab Creek drainage of various ages and states of regeneration have been logged using similar ground-based harvest methods and are larger in size to cutblocks C3UX, C3H8 & C2XU. These cutblocks are located on similar terrain and forest cover as cutblocks C3UX, C3H8 & C2XU and do not typically exhibit terrain instability.

3.3 ROAD OBSERVATIONS & STABILITY DISCUSSION

Landslides initiating from roads in cutblocks C3UX, C3H8 & C2XU could impact McNab Creek, a Fortis gas pipeline or regenerating forest on lower valley slopes, however significantly benched terrain on lower slopes below portions of these roads could mitigate this eventuality.

3.3.1 Cutblock C3H8, McNab East ML 0+000-0+357 – Reconstruction

From stations 0+167-0+357 below FC-23 to FC-24 in cutblock C3H8, this road is generally located on steep, uniform slopes leading directly into McNab Creek below. The surficial soil material in the area consists of a consolidated gravely, sandy silt till blanket. Landslides initiating from this road section would directly impact fish habitat in McNab Creek below. Potential landslides initiating within this area are estimated as small in size due to the ~150m potential runout length.

An ~8m raveling, timbered overhanging cutbank exists at ~0+167; unsupported boulders and soils would be hazardous to crews if dislodged. Raveling till has covered a portion of the road surface. A boulder buttress wall may help mitigate the hazard of raveling debris here. Additionally, old sidecast has failed & sloughed into McNab Creek from 0+167-0+236, now covered with young alder. Further sidecasting would cause similar instability.

Sufficient benched terrain *does not* exist to support sub-grade fill using standard conventional road construction practices*. It is recommended that ***Full bench endhaul road construction**** is used with excess material being end-hauled, which is not anticipated to increase the existing ***high potential for landslide occurrence****.

3.3.2 Cutblock C2XU, Branches 1115-026 & 1115-024 – New Construction

Within cutblock C2XU, these roads are generally located on concave, irregular to benched terrain interspersed with benches with moderate slopes. The surficial soil material in the area consists of a thin, rubbly, gravelly colluvial veneer overlying a consolidated silt till & bedrock. Sufficient benched terrain exists to support sub-grade fill using standard conventional road construction practices*. These roads are considered ***low landslide hazard*** for *standard conventional ½ bench road construction** due to benched terrain, coarse soils, moderate slopes and good drainage characteristics.

Landslides initiating from these roads would deposit in terrain polygon 1 with benched terrain attributes below which would mitigate landslide runout length & energy from impact to McNab Creek below. Potential landslides initiating within this area are estimated as small in size due to the ~150m potential runout length.

4 RECOMMENDATIONS

The following recommendations are intended to mitigate the above assessed hazards to provide the lowest possible risk associated with potential terrain instability.

4.1 HARVESTING RECOMMENDATIONS

- A hazard exists on Royal Flush creek that trees harvested within the stream draw could allow the channel to further meander and cause erosion, increasing avulsion and bed deposition in standing timber. Trees within the draw should therefore be retained**.**

- Avalanche activity exists on several stream systems within the assessed cutblocks, which could create unsafe conditions. Instability exists on old roads above cutblock C2XU which may impact the cutblock. Avalanches are most active in winter & spring months during times of heavy precipitation such as rain-on-snow events.

- In cutblock C2XU, loose rubble & talus rock exists below the FC-U12 & FC-U13 area; **It is recommended that crews be aware of this potential hazard, use caution and plan work accordingly when working within this area.**

Table 1. Stream Prescription for cutblocks C3UX & C2XU

Stream #	*Class**	*Risk*	*Falling Strategy*	*Yarding Strategy*	*Debris Management Strategy*
C3UX Shooter Ck	S5	Mod	Fall away where practicable, limit debris entry, maintain natural stream flow. Debris entry could lead to re-channeling and significant erosion.	Yard away where practicable, limit debris entry, maintain natural stream flow. Disturbance or debris entry could lead to re-channeling and significant erosion.	Maintain natural stream flow by limiting debris introduction, debris jams could lead to re-channeling and significant erosion; **clean inadvertently introduced debris post-harvest.**
C2XU U8					

* *Forest Practices Code 'Channel Assessment Procedure' Guidebook, December 1996. Streams classed by ECON.*

4.2 ROAD CONSTRUCTION RECOMMENDATIONS

Refer to *timing/weather restrictions* and *general cutbank/fillslope requirements* in Appendix B* and Figures 3 & 4. The planned road construction is not expected to increase the probability of slope instability, provided standard forest operations practices will be used including local BCTS rainfall shutdown guidelines and natural watercourse drainage patterns are maintained.

Table 2. Road Construction Recommendations

McNab East ML	**Hazard rating***	**Consequence or Impact**	**Road Reconstruction Recommendations**
0+167-0+236 Reconstruction	High	Slides would impact McNab Creek below	***Hazardous overhanging & raveling cutbank at ~0+167 – remove trees and scale back – boulder buttress wall can be used as debris catch.*** ***P.Eng monitoring recommended*** ***Full bench endhaul construction**,*** move road into cutbank, no side-casting, endhaul unsuitable (silty/organic) soils & excess.
Branch 1115-024	**Hazard rating***	**Consequence or Impact**	**Road Construction Recommendations**
0+600	Moderate	Slides would impact lower slopes, sediment would impact McNab Creek	***Remove culvert crossing on stream U8 post-harvest*** ***If over-wintering, seasonally deactivate by installing failsafe to prevent washout.***

**pre-construction*
***<u>Full Bench Endhaul Construction</u>*: This method utilizes a full bench cut using shot rock, angular boulders or rubble to construct a stable subgrade, utilizing micro-benches for 'sliver fill' where practicable. Sidecasting of fine soil material and organics or use of puncheon in construction is **not** permitted (remnants are acceptable). This material should be endhauled to designated spoil areas.

- Road deactivation (or assessment for same) should be carried out as soon after completion of harvest activities as practicably possible. When installing drainage structures (ie. culverts, cross ditches, waterbars etc.), the objective should be to maintain the natural drainage pattern, not concentrate water in any one area, and not introduce water onto the slope where it has not historically drained. During road deactivation (which should follow harvest operations as soon as practicably possible) and road construction, existing drainage courses should be utilized for culverts, cross ditch and waterbar placement (where practicable).

- This report compares consistency of the road design to road construction-related terrain stability in accordance with the OHSR section 20.78[7] regulation. Where cutbanks are higher than designed, or overhanging/loose soils/rock slabs exist (especially at borrow pits), cutbank scaling can be used to mitigate potential unsafe conditions. ***This report does not guarantee cutbank safety; monitoring by BCTS personnel should be implemented to ensure cutbank safety. If conditions are different than described, a professional re-assessment is recommended.***

[7] http://www2.worksafebc.com/Publications/OHSRegulation/GuidelinePart20.asp. (June 29, 2006)

- A risk assessment is required (where applicable) for sustained road grades (≥150m section per Ministry of Forests *Forest Road Engineering Guidebook, 2002, p.27*) greater than 18% in accordance with the OHSR Guideline 26.2-2[8], which basically requires a risk assessment for road grades steeper than 18% (per Ministry of Forests *Forest Road Engineering Guidebook*) before any hauling is conducted.

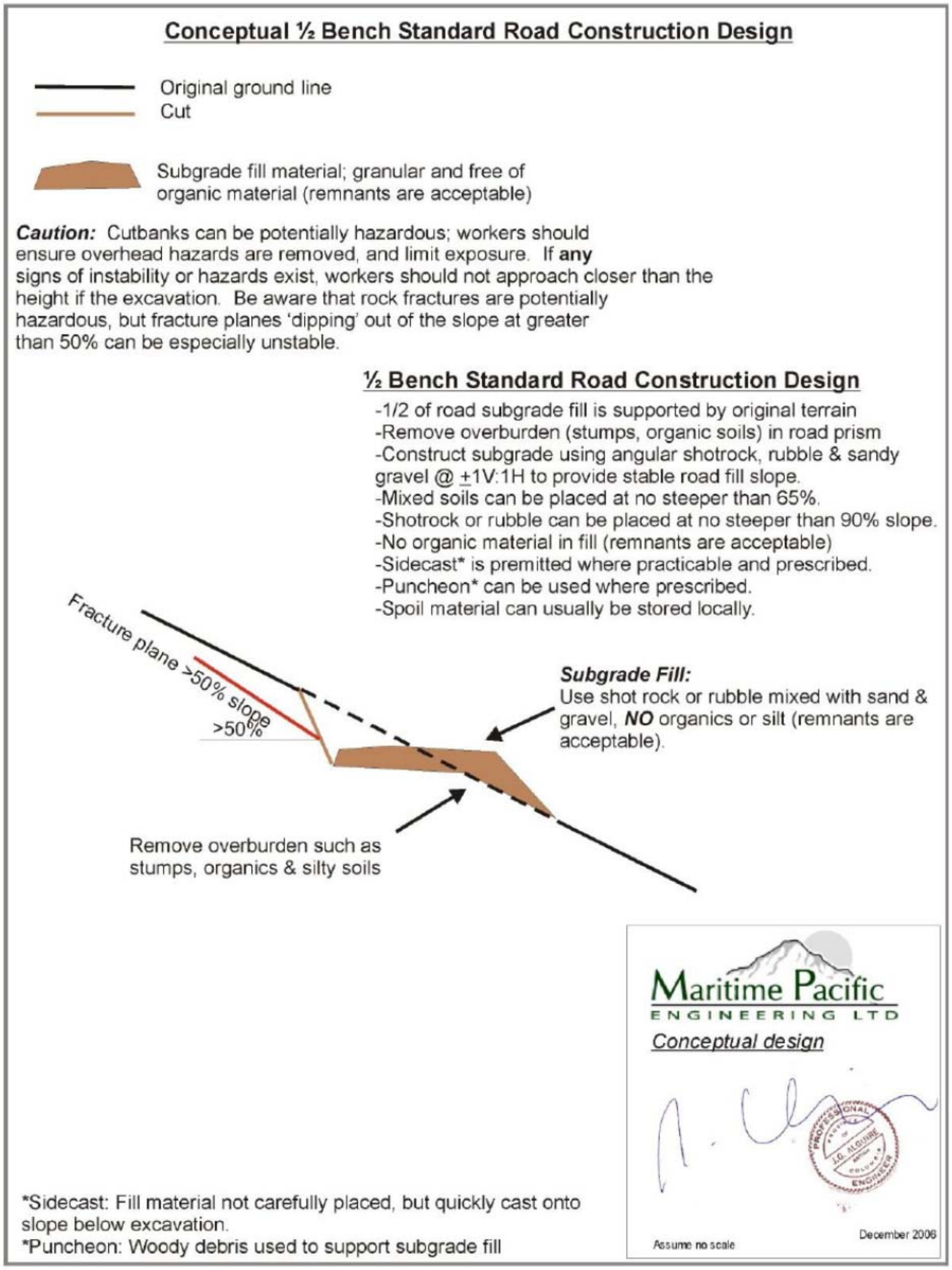


Figure 3. Conceptual road design showing typical standard ½ bench road construction.

8 http://www2.worksafebc.com/Publications/OHSRegulation/GuidelinePart26.asp. (June 29, 2006)

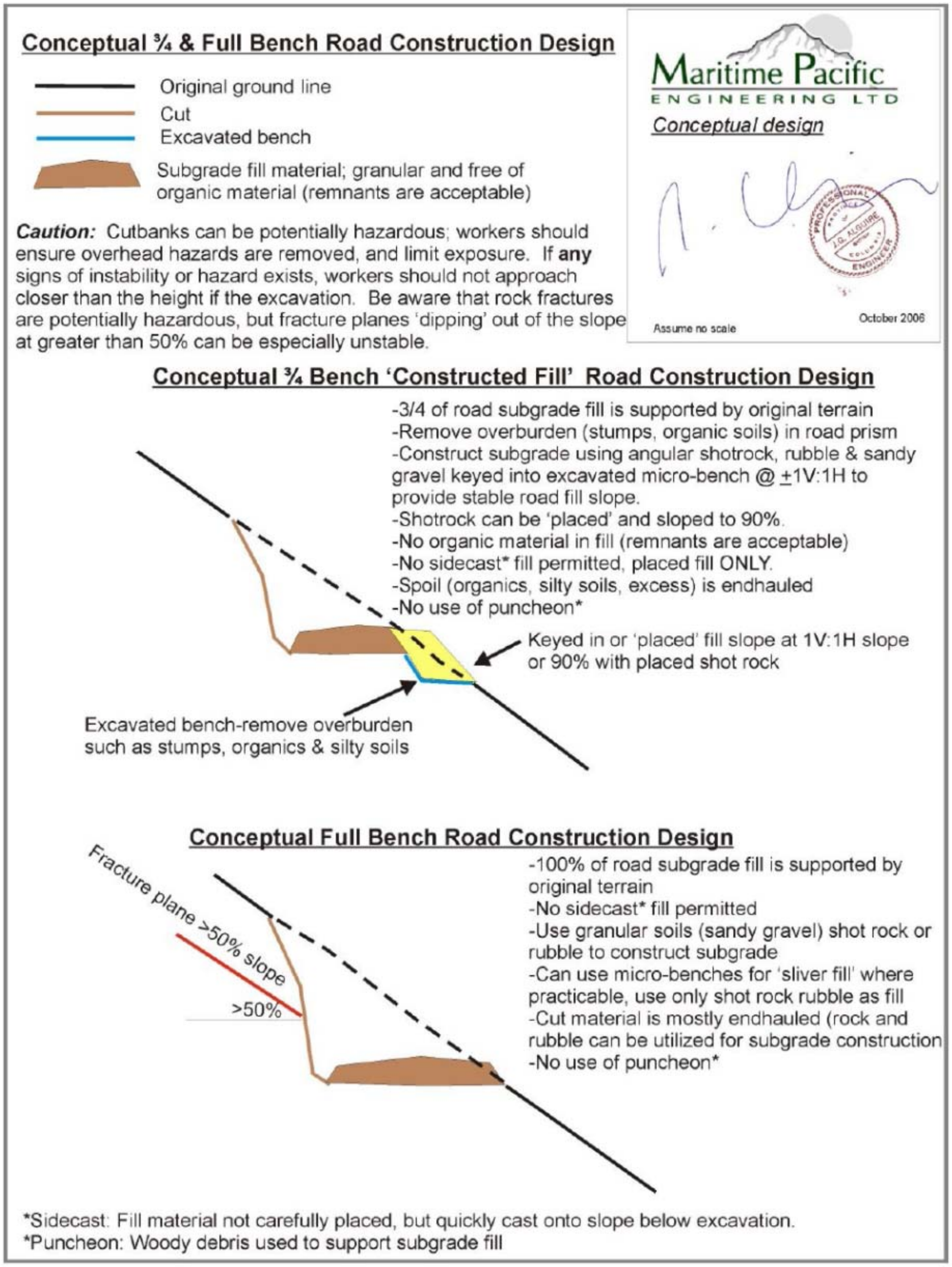


Figure 4. Conceptual road design showing typical ¾ and full bench road construction

5 CLOSURE & SURVEY LIMITATIONS

This report was prepared for ECON Consulting for use in planning the operational harvesting of cutblocks C3UX, C3H8 & C2XU and access roads as required by the Forest and Range Practices Act and Forest Planning and Practices Regulation and in accordance with APEGBC Guidelines for Terrain Stability Assessments in the Forest Sector (October 2003).

Because terrain evaluation has a limited exposure to subsurface conditions, failure potential ratings are achieved through a highly interpretative summation. Ratings are not intended as a definitive calibration, but rather a statement of probability. It is possible that conditions are different from those interpreted under this assessment, and subsequently this could affect the recommendations presented in this report; the undersigned should be notified immediately in this event.

Respectfully submitted,

MARITIME PACIFIC ENGINEERING LTD.

Jamie Alguire, RPF, P.Eng
Forest Engineer
Jga

Appendix A. Field form for gully assessment

Section 1. Gully system identification		
Watershed: McNab Creek	Cutblock: C2XU	Date: July 13, 2012
Gully No. U1	Road No. Branch 115-026	Recorded by: J Alguire
Reach No.	Dist. (start/end) (m)	Roll/photo No.

Fans assessments: complete Sections 2, 3, 4, 5 (and 7 if post-harvest).
Transport zone and headwall assessments: complete Sections 2, 3, 4, 6 (and 7 if post-harvest).
Enter the results in Management Strategies Tables 2–5.

Section 2. Downstream impact potential	L	M	H
Connection to a community watershed intake	None	Indirect	Direct
Dwellings, major installations, safety	No		Yes
Connection to fish streams or lakes or sensitive marine zones	None	Indirect	Direct

Section 3. Upslope debris flow potential	L	M	H
Stability class upslope (from terrain mapping)	I–III, or S	IV or P	V or U
Slope gradient upslope (if no terrain mapping)	<50%	50–60%	>60%
Evidence of landslides or debris flows in gully systems	N	N/C	Y

Section 4. Water transport potential (WTP)	L	M	H
Channel width (m)	≤2	>2–≤3.5	>3.5
Size of water transported woody debris	SWD	LWD	Logs or no WD
Largest sediment in storage wedges (mm)	≤100	>100–≤200	>200

Section 5. Fan destabilization potential (FDP)			
Channel incision (CI) (m)	Number of channels (CN) (If there are no channels on the fan, the FDP is L, low)		
	1	2–3	>3
<0.5	H	H	H
0.5–<1	M	H	H
1–<2	L	M	H
≥2	L	L	M

Table A1. Headwall failure potential (HWFP)					
Headwall slope angle (%)	Headwall surficial material				
	R	C	M, F	W, L	FS
>70	L	H	H	H	H
>60–70	L	M	H	H	H
>50–60	L	L	M	H	H
≤50	L	L	L	M	H
Enter the results in Table C					

FS197B RVA 2002/03

Table A2. Sidewall Failure Potential (SWFP)					
Sidewall slope angle 70-80 (%)	Sidewall surficial material				
	R	C	M, F	W, L	FS
>70	L	H	H	H	H
>60–70	L	L	M	H	H
>50–60	L	L	L	H	H
≤50	L	L	L	M	H
Enter the results in Table C					

Table B. Gully geometry potential for debris flow hazard (GGP)			
Sidewall slope distance 3-4(m)	Channel gradient _40_(%)		
	≤30	>30–≤40	>40
>15	L	M	H
7–<15	L	L	M
0–<7	L	L	L
All headwalls	M	H	H
Enter the results in Table C			

Table C. Debris flow initiation hazard (DFIH)			
HWFP or SWFP (Table A1 or A2)	Gully geometry potential for debris flow initiation (Table B)		
	L	M	H
H	L	M	H
M	L	M	M
L	L	L	L
Enter the results in Section 5			

Section 6. Debris flow initiation potential (DFIP)	L	M	H
Debris flow initiation hazard (Table C)	L	M	H
Past debris flow initiation in this reach	No	not clear	Yes

Section 7. Post-harvest conditions				
Years since harvesting	<1	2–5	6–10	>10
Logging debris in channel	Sparse	Moderate	Heavy	Very heavy
Sediment stored behind logging debris	Sparse	Moderate	Heavy	Very heavy

Appendix B – Qualitative Ratings

Subjective Landslide Probability (Hazard) Rating

Landslide hazard rating	*Terrain stability classification (Five class system, FPC, 1999)*	*Cascadia Terrain Hazard Definition (Terrain Mgmt Code of Practice, Dec 2004)*	*Definition*
Negligible	I	-	A landslide will not occur, or very remote possibility a landslide would occur.
Very Low	II	<1 failure per 100ha logged on steep terrain	Remote possibility a landslide would occur.
Low	III	1-3 failures per 100ha logged on steep terrain	A landslide is not anticipated, however conditions exist that if combined may contribute to causing a landslide.
Moderate	IV or IVR (ie. low harvest related hazard, moderate road-related hazard)	3-5 failures per 100ha logged on steep terrain	A landslide is possible during the lifetime of the road or cutblock under the current conditions. Conditions exist that if changed slightly or combined may contribute to causing a landslide.
High	V	>5 failures per 100ha logged on steep terrain	A landslide will occur during the lifetime of the road or cutblock.

This table is for MPE use and does not necessarily reflect the same ratings as other Professionals

Subjective Windfall Probability (Hazard) Rating

Tree susceptibility	**Wind characteristics**		
	Low	Moderate	High
Low	L	L	M
Moderate	L	M	M
High	M	M	H

This table is for MPE use and does not necessarily reflect the same ratings as other Professionals
Tree susceptibility: include tree species, crown size, height, soil conditions such as drainage and depth, considering historic windfall.
Wind characteristics: include boundary orientation and exposure compared to damaging winds, wind force, direction, and historic conditions.

Subjective Risk Analysis:
Where referred to, risk is product of hazard and consequence

Terrain Hazard	**Consequence**			
	Very Low	Low	Moderate	High
Very Low	VL	L	L	L
Low	L	L	M	M
Moderate	L	M	M	H
High	M	M	H	H

Landslide size

Landslide size	Landslide size (ha)
Very small	0.05 – 0.1 ha
Small	<0.1 – 0.25 ha
Medium	<0.25 – 0.5 ha
Large	<0.5 – 1 ha
Very large	>1 ha

Definitions:

Slopes:
0-5% planar
>5-27% gentle
>27-50% moderate
>50-70% moderately steep
>70% steep

- *Standard conventional ½ bench road construction* typically includes approximate ½ bench balanced cut & fill utilizing immediately available materials, with no endhauling, importing of aggregate or specialized fill or cutslope prescriptions.

- *Standard conventional road reconstruction* typically includes installation of culverts, ditching, brushing, balanced cut & fill utilizing immediately available materials, with no endhauling, importing of aggregate or specialized fill or cutslope prescriptions. Endhauling of spoil material and cutbank material is not considered standard.

Time Restrictions

The assigned ratings are not infinite, and are assumed to cover a 5 year duration period from the date of assessment. This assessment covers this **5 year period**; further investigation is required to extend this duration.

Weather Restrictions

Rainfall shutdown guidelines should be strictly adhered to. Crews should be aware that periods of intense precipitation may cause instability in freshly excavated cutbanks/fill slopes.

General Fill Slope Requirements

Fill slopes should utilize granular sand, gravel or rubble/shotrock material and be relatively free of organic soils. Some degree of compaction should be achieved by utilizing thin (<0.5m thick) lifts of fill placed horizontally, and compacted with an excavator bucket and caterpillar tracks. Compacted granular soil should be placed with side slopes no steeper than **65%**. Broken rock or rubble should also be placed in horizontal layers and bladed and rolled to a compact condition. Broken rock or rubble fills should be placed with side slopes no steeper than **90%.**

General Cutslope Excavation Requirements:

Cutslopes excavated into solid bedrock should achieve a **4V:1H** excavation (as experienced in locally built roads). Colluvium (or any unconsolidated soils) experienced should be excavated to no steeper than **1V:1H**. Compacted morainal till can be excavated to **2V:1H**. If rock cuts reveal a prominent set of joints, or two intersecting sets of joints dip out of the cutbank at 50% or greater, this cutslope could cause unsafe conditions and ***a professional field review is recommended***.

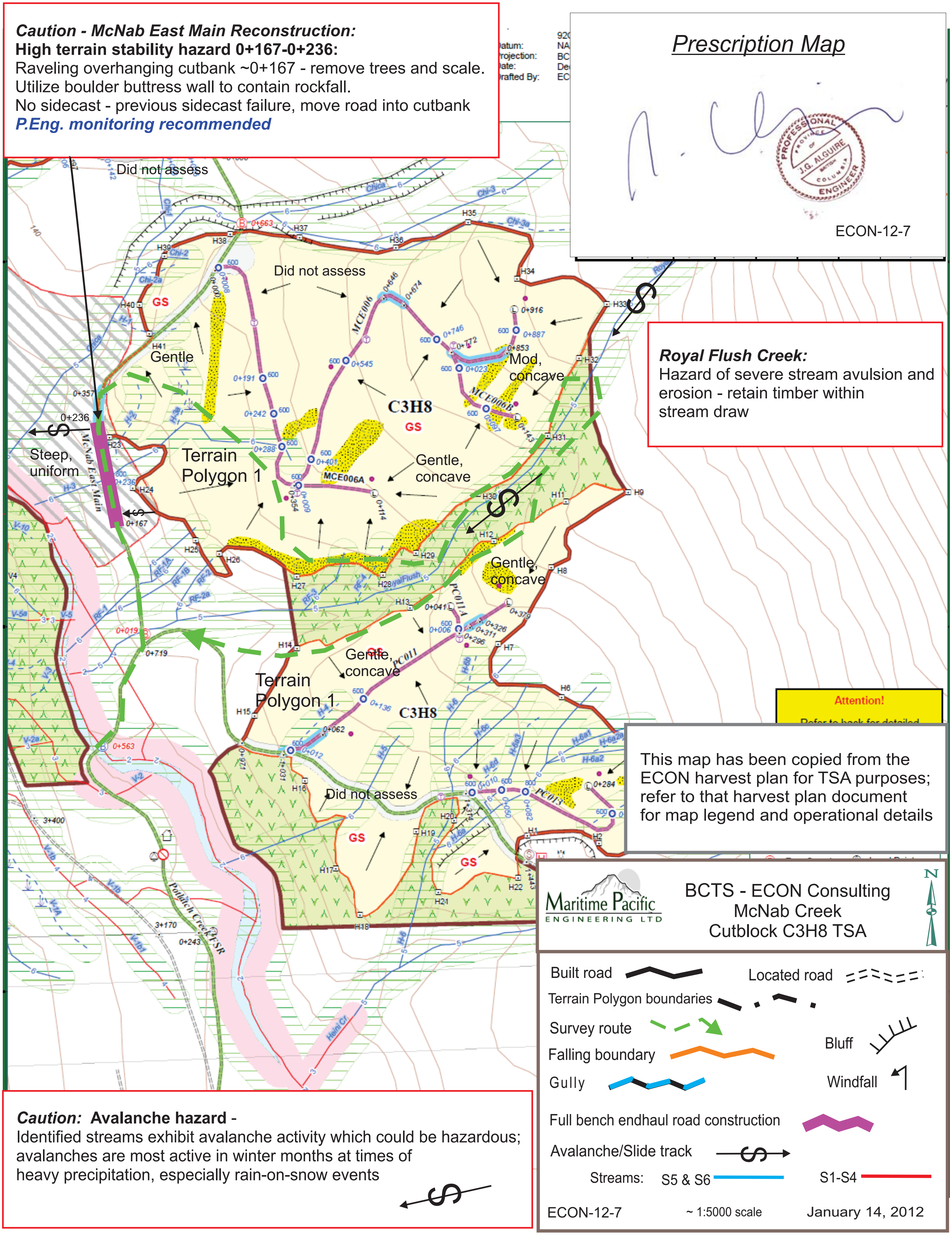
Where cutbanks are higher than designed, or overhanging/loose rock slabs exist (especially at borrow pits), scaling can be used to mitigate potential unsafe conditions.

Workers should be aware that **any road cutbank** can present an overhead hazard from falling rocks, soils or debris. The hazard increases with increasing bank height and cut bank angle. This risk can be mitigated by limiting exposure to working directly under cutbanks and adequate scaling of the exposed face to remove loose (rock, soil, debris) material. Areas with fractured rock faces should be assessed after blasting and after each winter to check for hazards, especially areas of water piping, wet, fine (silt, organic) soils, and known avalanche or landslide areas. Areas of obvious overhangs and raveling slopes can be posted with signage to identify potential hazards to workers. If signs of cutbank instability are present, workers should **not approach the cutbank** closer than the distance equal to the height of the cutbank.

Timber:
Fd: Douglas fir
Cw: Western red cedar
Hw: Western hemlock
Ba: Balsam
Cy: Yellow cypress
D: Alder

Liability Insurance Declaration:
As required by APEGBC bylaw 17 (a), the client is hereby notified that Maritime Pacific Engineering Ltd. carries Professional Liability Insurance (Errors & Omissions) which covers all employees and subcontractors, in addition to Commercial General Liability Insurance.

Use of Report:
This report is intended for the sole use of the client. Other parties should notify MPE before using or relying on this report or any part thereof. MPE takes no responsibility for damages suffered by unauthorized parties using or relying upon this report.



Caution - McNab East Main Reconstruction:
High terrain stability hazard 0+167-0+236:
Raveling overhanging cutbank ~0+167 - remove trees and scale.
Utilize boulder buttress wall to contain rockfall.
No sidecast - previous sidecast failure, move road into cutbank
P.Eng. monitoring recommended
Prescription Map
ECON-12-7
Royal Flush Creek:
Hazard of severe stream avulsion and erosion - retain timber within stream draw
Did not assess
Gentle
Mod, concave
C3H8
GS
Gentle, concave
Steep, uniform
Terrain Polygon 1
McNab East Main
Attention!
This map has been copied from the ECON harvest plan for TSA purposes; refer to that harvest plan document for map legend and operational details
Maritime Pacific ENGINEERING LTD
BCTS - ECON Consulting
McNab Creek
Cutblock C3H8 TSA
N
Built road
Located road
Terrain Polygon boundaries
Survey route
Bluff
Falling boundary
Gully
Windfall
Full bench endhaul road construction
Avalanche/Slide track
Streams: S5 & S6
S1-S4
ECON-12-7
~ 1:5000 scale
January 14, 2012
Caution: Avalanche hazard -
Identified streams exhibit avalanche activity which could be hazardous; avalanches are most active in winter months at times of heavy precipitation, especially rain-on-snow events