

TEXAS CREEK AREA
DETAILED TERRAIN MAPPING
WITH EVALUATIONS FOR SLOPE STABILITY
AND EROSION POTENTIAL

Prepared by

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For

B.C. Ministry of Forests
Lillooet Forest District

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Mr. Bruce Hupman
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Dear Bruce Hupman,

Detailed terrain mapping and assessment of slope stability (5 class) and erosion potential were carried out for the Texas Creek area at the request of the Ministry of Forests, Lillooet, in order to provide information for planning of future forestry activities. The results are presented in this report, which accompanies a terrain map and an interpretive map. This information is presented on 1:10 000 scale base maps that have been enlarged from 1:20 000 scale TRIM maps by Hugh Hamilton Ltd. Digital files will be sent to you from John Bunning at Hugh Hamilton Ltd. Terrain mapping was carried out by air photo interpretation and field checking at Terrain Survey Intensity Level (TSIL) B.

The report includes a general overview of the physiography of the area, descriptions of terrain mapping methodology and mapping reliability, descriptions of surficial materials and processes, and criteria used for slope stability and erosion potential interpretations. Implications and recommendations for forest land management that arise out of this terrain work are also provided. Field forms completed for each site are not included in the report, and can be sent upon request.

The information and analyses contained in the reports are based on observations of land-surface conditions and current understanding of slope processes. However, because slope stability is strongly influenced by subsurface conditions that are not apparent from surface observations or air photo interpretation (e.g., characteristics of subsurface materials, subsurface hydrologic conditions), by events whose time of occurrence cannot be predicted (e.g., extreme storms, earthquakes), and by land management practices, the results and recommendations provided in this report cannot guarantee that no landslides will occur in areas affected by forestry activities. Appropriate use of terrain information and implementation of recommendations will, however, reduce the risk of landslides and erosion.

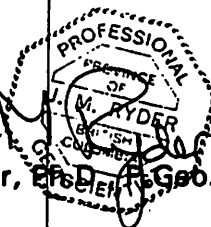
Please contact us at (604) 736-4211 if you have any questions or comments regarding these reports. Thank you for giving JMRATA the opportunity to carry out this terrain work.

Yours truly,

Jennifer Shypitka

J.M. Ryder

Jennifer Shypitka, B.Sc., G.I.T. and J.M. Ryder, P.Eng., P. Geo.



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1) INTRODUCTION

The objective of this project was to prepare terrain, slope stability and erosion potential maps as a basis for long term environmental planning, including forest management, in the Texas Creek area, about 55 ha (Figure 1). This brief report accompanies the terrain and interpretive map.

Terrain mapping and interpretations for slope stability and erosion potential were carried out according to provincial standards (Section 3). Terrain mapping was done on 1:15 000 scale colour air photos by air photo interpretation, followed by field checking. Terrain, slope stability and erosion potential information are presented on a 1:10 000 scale base map that has been enlarged from a 1:20 000 scale TRIM map (92I.041) by Hugh Hamilton Ltd. Two maps have been produced to display the information; a terrain map and interpretive map. The terrain map includes terrain classification, slope class, and drainage class for each polygon. The interpretive map includes erosion potential and slope stability ratings.

This report augments the information that is shown on the maps. It provides a general overview of the physiography of the study area (Section 2), a description of terrain mapping methodology and mapping reliability (Section 3), additional information about surficial materials and processes (Sections 4 and 5), and criteria applied for slope stability and erosion potential interpretations (Section 6). Implications and recommendations for forest land management that arise out of this terrain work are discussed in Section 7.

(2) PHYSIOGRAPHY

The study area is located near the headwaters of Texas Creek, which is situated in the eastern Pacific Ranges (Lillooet Range) of the Coast Mountains physiographic region in British Columbia (Holland, 1964). Texas Creek is small (less than 5 metres wide) and flows northeast to meet the Fraser River. Local relief in the study area is about 220 metres, with elevations ranging from 1480 to 1700 m a.s.l. The slopes just south of the study area are very steep, with a 500 m elevation gain in a 600 m horizontal distance. Although not part of the study area, these slopes contribute to some of the characteristics of the southern portion of the study area, such as colluvium deposited by avalanches.

Bedrock geology of the study area was mapped at a scale of 1:250 000, (Monger and McMillan, 1989). The area is underlain by intrusive igneous rocks of a late Cretaceous Age. The presence of the major rock type (granodiorite) was confirmed during field work.

In the study area, bedrock is mostly buried by variable thicknesses of glacial drift (see Section 4). The drift was deposited during the last major glaciation (Fraser Glaciation). At the glacial maximum about 15 000 years BP, all of the study area was buried by ice. During deglaciation, about 12 000 to 11 000 years BP, frontal recession of valley glaciers occurred.

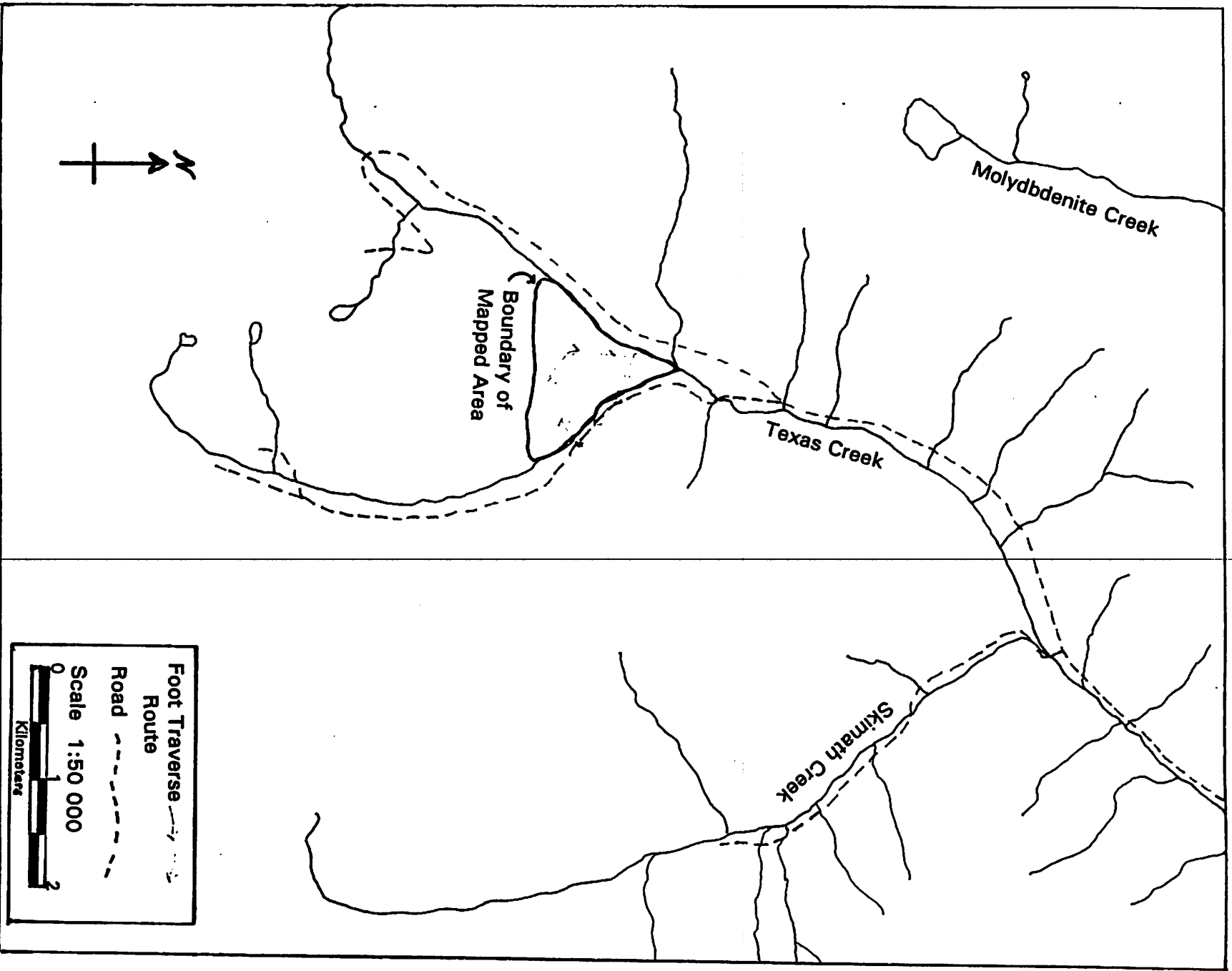


Figure 1. Location Map for Texas Creek study area.

During post-glacial time, floodplains, organic soils and colluvial deposits, including fans and talus, have developed on both bedrock and Quaternary deposits.

(3) METHODS

(3.1) Terrain Mapping

Terrain mapping followed the standard British Columbia procedures for terrain classification (Howes and Kenk, 1988), mapping methodology (Ryder, 1994) and slope stability (5-class system, Forest Practices Code, 1995).

Preliminary terrain mapping was done by interpretation of 1:15 000 scale colour air photos (BCC 674 No. 180,181). A half day of field work with two field crews (i.e., 1 crew-day) was carried out on October 22nd, 1995. Field work involved foot traverses of most of the polygons in the study area (Figure 1). Material characteristics were recorded at specific sites, and observations relevant to materials and slope stability were made continuously during traverses. Formal site description forms were completed for 8 sites (J63-70), and can be produced upon request. All field sites are shown on the terrain map. Soil pits were dug at most sites.

Back in the office, terrain mapping on air photos was corrected in light of field observations. Soil drainage and slope classes were added, the latter based partly on field measurements and partly on 1:20 000 scale topographic maps (20 m contour interval). Comparison with field measurements suggests that the topographic map is reliable, although some small, locally steep or gentle areas are not clearly represented by contours. Interpretations for slope stability and potential erosion were made according to criteria that are discussed in Section 6. Terrain polygon boundary lines were transferred to the 1:20 000 scale map by hand, using topography as indicated by contour lines, creeks, forest openings and roads as guides.

Terrain, slope stability, and erosion potential information was digitized by Hugh Hamilton Ltd. according to MoF specifications, and output onto a 1:10 000 scale, 50% screened topographic (TRIM) base. A digital file containing all the information was also compiled.

(3.2) Mapping Reliability

Air photo interpretation and field checking for this project were carried out at a level of detail and reliability that is appropriate for 1:20 000 scale terrain mapping. Approximately 73% of polygons within operability limits were checked (ground check sites), conforming to the standard for TSIL B (Terrain Survey Intensity Level B). Map users should be aware that many small areas (less than about 5 ha) of different materials, slope steepness and drainage conditions are unmapped.

The information and analyses contained in this report are based on observations of land-surface conditions and current understanding of slope processes. However, because slope stability is strongly influenced by subsurface conditions that are not apparent from surface observations or air photo interpretation (e.g., characteristics of subsurface materials, subsurface hydrologic conditions), by events whose time of occurrence cannot be predicted (e.g., extreme storms, earthquakes), and by land management practices, the results and recommendations provided in this report cannot guarantee that no landslides will occur in areas affected by forestry activities. Appropriate use of terrain information and implementation of recommendations will, however, reduce the risk of landslides and erosion.

(4) SURFICIAL MATERIALS AND ASSOCIATED LANDFORMS

The following descriptions are based on observations of materials exposed in soil pits and road cuts ranging in depth from 0.2 to 1.0 m.

(4.1) Till (M)

Till is material deposited directly by glacier ice. It typically consists of a fine-grained matrix (particles < 2 mm) that surrounds and supports clasts (particles > 2 mm) of a variety of sizes, shapes and rock types. Till characteristics such as texture (particle sizes) and consolidation (or bulk density) vary according to specific processes of deposition by glacier ice (e.g., subglacial vs. supraglacial tills).

Till is widespread throughout the study area on all but the steepest slopes. It is generally between 0.5 and 1.5 m in thickness, and thickness may vary abruptly over short distances (Mw). Till less than 1 metre in thickness (Mv) is present on convex slopes, spurs, and the crests of small hills, and till up to a few metres in thickness (Mb) underlies concavities and depressions. On flat and gently rolling terrain, bedrock mounds and hummocks have been partially buried by till, so that till is thin or absent on rises and thicker in depressions.

Most till in the study area is a moderately consolidated basal (subglacial) till with moderate to low permeability. Hand texturing indicated that the matrix texture is silty sand (Site J70). Clast content ranges from 35 to 70% by volume. The till appeared to become more bouldery (clasts > 256 mm diameter) and thinner with distance upslope. Pebbles (2-64 mm), cobbles (64-256 mm) and boulders are predominantly subangular to subrounded. Clasts consist of mainly igneous rocks, with minor metamorphic types.

(4.2) Colluvium (C)

Colluvial materials have accumulated during post-glacial time as a result of gravity-induced movements such as soil creep and avalanches, and as a result of slope wash by running water. The physical characteristics of colluvium are closely related to its site and mode of accumulation.

Colluvium is only found in the southern portion of the study area, where the slopes are relatively steep. On slopes that are steeper than about 60% (30°) and downslope from bedrock outcrops, bedrock and till are commonly overlain by a thin covering of colluvium (Cv). This material typically consists of loosely packed rubble or angular fragments with interstitial silty sand. It results from disintegration of local bedrock due to weathering, and slow downslope creep (rock creep) of the detached material. Colluvium in Cv terrain polygons is non-cohesive, highly porous and permeable. Blocky colluvium (aC) is found at the base of steep rock areas (Site J66) and is relatively well drained and dry.

Colluvial fans (Cf) are formed at the foot of gullies by the accumulation of materials moved by small steep creeks and slope wash. These colluvial deposits commonly include damp sites, particularly on the lower parts of fans or colluvial slopes where the water table lies close to the surface (Site J64).

(4.3) Other Materials (F, O, R)

Fluvial (F) sands and gravels have been deposited in post-glacial time by streams. Texas Creek and the unnamed tributary in the study area are generally narrow (approximately 1-3 m wide) and gravelly. Fluvial gravels and sands are loose, non-cohesive, and highly porous and permeable. Associated terrain units that are close to stream-level, such as floodplains, have high water tables and are moderately to imperfectly drained.

Organic soils (Ov) form where decaying plant material accumulates in very poorly drained areas. In the study area, discontinuous organic veneers were mapped along the valley floor beside Texas Creek (Site J69), and along a portion of the unnamed tributary (Site J63). At site J64, drainage is impeded by the underlying basal till. At site J69, organic soils have developed on the valley floor due to the high water table.

Bedrock (R) was not mapped within the study area but is exposed just south of the study area in steep bluffs (Rs).

(5) ACTIVE GEOMORPHOLOGICAL PROCESSES

(5.1) Snow Avalanches (-A)

Snow avalanche tracks are marked by swaths of shrubby vegetation. Avalanche tracks are hazardous areas in mid winter and early spring. In spring the lower slopes may be snow free, but still subject to avalanches from upslope.

Only very small avalanches occur within the study area, near its southern boundary. Further south, where slopes are steeper, runout zones reach the valley floor.

(6) INTERPRETATIONS FOR SLOPE STABILITY AND EROSION POTENTIAL

Ratings for slope stability and potential surface erosion are presented on a map overlay. "Slope stability" refers to gravitationally-induced mass movement, i.e., slumps, slides and debris flows; "erosion" refers to the removal of material particle by particle by running water from bare soil. Criteria used to assess slope stability and potential erosion are shown in Tables 6.1 and 6.2. Definitions for slope stability and erosion potential classes are shown in Table 6.3.

Criteria are based chiefly on slope steepness, and material type and texture.. It should be noted, however, that criteria were used as guidelines only: each terrain polygon was rated individually in order to permit additional local factors to be taken into account when necessary. These include:

- *Slope smoothness/irregularity*: the "bumps" on irregular slopes are usually formed by near-surface bedrock. This acts to pin surficial materials in place, thus the potential for instability is less than on a slope of similar overall steepness but with a smoother profile.
- *Moisture*: in general, wet slopes are more unstable and more erodible than dry ones. High pore water pressure, such as that which develops in a perched water table in weathered till, leads to reduction in normal stress and slope failure. Overland flow, which develops more readily in wet than dry areas, leads to surface erosion.
- *Slope position*: in general, lower slopes and concavities are relatively wet because they receive moisture from a large upslope; thus they tend to be potentially unstable if steep, and erodible even on moderate slopes.

All of the polygons within the study area are rated as stability class I to III, except for one class IV polygon in the south eastern portion of the study area..

With regard to surface erosion potential, most of the study area is rated low to moderate. In general, moderate ratings were given to polygons with slope steepness of class 3 or areas that are a receiving site for moisture.

Table 6.1: Guidelines for Assessment of Slope Stability

Slope Stability Classes	Dominant Slope Class*	Material and Landforms	Dominant Texture	Active Processes	Soil Drainage	Slope Morphology
I	1 and 2	F ^g tu; Cf; Ff	g; sr, g	none	poorly drained and wet soils are relatively susceptible; polygons with slopes within 5 or 7% of an upper class boundary may be assigned to the next highest class	slopes with irregular or benched topography controlled by bedrock are relatively stable; units with slopes close to a lower class boundary may be assigned to the next lowest class.
	1&2 mixed	Mv, Mb; Cv; R	§s, s; sr	none		
II	2	Mv, Mb	s§	none		
	2 and 3	Cf; F ^g ; R	sr; g;	none		
III	3	Mv, Mb; Cv	§s; sr	none		
	4	Ca, Ck, R, F ^g	sr, x; g	none		
IV	4 and 5	Mv, Mb, Cv, Cb	all	-V, -R ^b		
	4 and 5	Rk, Rs				
V	any gradient	all	all	-F, -R ^d , -R ^s **		

* Slope classes are defined as follows: Class 1: 0-5% (0-3°); Class 2: 5-27% (3-15°); Class 3: 27-49% (15-26°); Class 4: 49-70% (26-35°); Class 5: over 70% (35°).

** Refers to the initiation zones of rapid mass wasting (mostly debris flows) and slow failure, and active gullies.

Table 6.2: Guidelines for Assessment of Erosion Potential

Dominant Texture* or Material	Typical Material	Slope Steepness Classes				
		1 (0-5%)	2 (5-27%)	3 (27-49%)	4 (49-70%)	5 (>70%)
organics	Op, Ob	VL	L	-	-	-
c, m	W ^g v, L ^g v	L,M	M	H	VH	VH
fine s, coarse §	L ^g , Mv, Mw, Cv	L	M	H	H,VH	VH
coarse s, xs	Cv, F, F ^g , Mv, Mw, Mb, Vv	VL,L	L,M	M,H	H	H,VH
d§s	Mw, Mb, Mv	VL,L	M	M	M,H	H
g, ds, r	F, F ^g , Mv, Mb	VL,L	M	M	M,H	H,M
a, b	Ck, Cv, Cb	VL	VL	L	L	M,L
R (resistant rock)	R	VL	VL	VL	VL	VL

* Refer to Appendix 1 for definitions of texture symbols.

Table 6.3: Definitions for Slope Stability and Erosion Potential Classes

SLOPE STABILITY CLASSES	
I	No problems of instability expected.
II	No significant problems of instability expected.
III	Minor instability problems may develop in some areas; wet areas should be treated with caution.
IV	Moderate likelihood of slope failure as a result of logging activities. Terrain polygons include potentially unstable terrain; special precautions necessary. Site inspection by a slope stability specialist is required.
V	High likelihood of slope failure as a result of logging activities. Terrain polygons include unstable terrain; avoid these areas or require assessment by a slope stability specialist.

EROSION POTENTIAL CLASSES	
VL (very low, none)	No problems of erosion expected on flat or gently sloping terrain, organic soils and floodplain. Erosion of banks and channels may be initiated by the disturbance of streams.
L (low)	Chances of rilling or sheet erosion and subsequent sedimentation of lakes and streams are generally low, although care is required to avoid erosion along ditches with steep gradients. No significant problems of erosion expected.
M (moderate)	Problems of erosion associated with logging are similar to but less than terrain rated "high", although problems may develop if water flows unchecked along steep ditches, roadways, or on other bare soil surfaces. Exposures of fine textured till near creeks should be avoided.
H (high)	Expect problems of erosion to develop on bare soils and compacted surfaces along roads and ditches, on cut slopes adjacent to landings, and on disturbed soil in cut blocks. Take precautions necessary to minimize erosion as appropriate, such as immediate reseeding of exposed mineral soil. Site inspection by geomorphologist recommended.
VH (very high)	Natural movement of fine sediments into adjacent creeks. Potential erosion more severe than in "high" category. Site inspection by geomorphologist recommended.

(Source: modified from Forest Practices Code, 1995).

When using these ratings, it is essential to bear in mind that conditions are locally variable. The ratings (and information on the terrain map) indicate the mapper's impression of typical conditions for each terrain polygon, but locally steeper slopes, wetter soils, and emergence of water from seepage zones give rise to areas that are potentially more unstable and/or more erodible than their surroundings. Consequently, persons marking road alignments and cutblock boundaries should recognize and take account of these local conditions.

(7) RECOMMENDATIONS

In general, all of the Texas Creek study area except one polygon is located on stable (class I-III) terrain with moderate to low surface erosion potential.

The proposed cut block and road alignment is in terrain rated as slope stability class II and III, with a moderate to low surface erosion potential. Moderate ratings are given to poorly drained soils that are subject to overland flow, even on relatively gentle slopes. Where these soils exist in the proposed cutblock, the hazard can be offset by adequate planning of drainage measures along roads and minimizing disturbance of soil.

(8) CONCLUSIONS

Field and air photo observations suggest that terrain in the Texas Creek area is generally stable and has a moderate to low erosion potential. The proposed road alignments and the cutblock in the Texas Creek area are located on stable terrain with low to moderate surface erosion potential.

ACKNOWLEDGEMENTS

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APPENDIX 1: TERRAIN MAP LEGEND - TEXAS CREEK AREA

(1) TERRAIN UNIT SYMBOLS

Simple Terrain Units: e.g., $aCk-R$

texture → $aCk-R$ ← process
 surficial material ↙ ↘ surface expression

Note: Two letters may be used to describe any characteristic other than surficial material, or letters may be omitted if information is lacking.

Composite Units: Two or three groups of letters are used to indicate that two or three kinds of terrain are present within a map unit.

e.g., $Cv-Rs$ indicates that "Cv" and "Rs" are of roughly equal extent

Cv/Rs indicates that "Cv" is more extensive than "Rs" (about 2/1 or 3/2)

$Cv//Rs$ indicates that Cv is much more extensive than Rs (about 3/1 or 4/1)

Stratigraphic Units: Groups of letters are arranged one above the other where one or more kinds of surficial material overlie a different material or bedrock:

e.g., $\frac{Mv}{Rr}$ indicates that "Mv" overlies "Rr".

$\frac{/Mv}{Rr}$ indicates that Rr is partially buried by Mv

Slope Stability and Erosion Potential: Roman numerals for slope stability and upper case letters for erosion potential separated by a ".", e.g., I.L

(2) MATERIALS

C	Colluvium	M	Till
F	Fluvial materials	O	Organic materials
F^A	"Active" fluvial materials	R	Bedrock
F^G	Glaciofluvial gravels	V	Volcanic materials

Materials followed by an '*' indicates that the material is overlain by a veneer of sandy volcanic ash.

(3) TEXTURE

c	clay	m	mud	g	gravel	a	blocks
s	silt	p	pebbles	b	boulders	d	mixed g, b, r, a
s	sand	k	cobbles	r	rubble	x	angular fragments

(4) SURFACE EXPRESSION

a	moderate slope(s)	k	moderately steep slope	t	terrace(s)
b	blanket	m	rolling topography	u	undulating topography
f	fan	p	plain	v	vener
h	hummocky	r	ridges	w	variable thickness
j	gentle slope(s)	s	steep slope(s)		

(5) GEOLOGICAL PROCESSES AND MASS MOVEMENT SUB-CLASSES

F	Slow Mass Movement	Fx	Slump-Earthflow	Rr	Rockslide
F*	Slow Mass Movement (Initiation Zone)	R	Rapid Mass Movement	Rs	Debris slide
Fm	Slump in Bedrock	R*	Rapid Mass Movement (Initiation Zone)	V	Gully Erosion
Fu	Slump in Surficial Materials	Rb	Rock Fall		

(6) SOIL DRAINAGE CLASSES

r	rapidly drained	m	moderately well drained	p	poorly drained
w	well drained	i	imperfectly drained	v	very poorly drained

Where two drainage classes are shown, e.g., "wi", then no intermediate classes are present; if the symbols are separated by a dash, e.g., "w-i", then all intermediate classes are present.

(7) SLOPE CLASSES

1	0-3° (0-5%)	3	15-26° (27-49%)	5	>35° (>70%)
2	3-15° (5-27%)	4	26-35° (49-70%)		

(8) ON-SITE SYMBOLS AND BOUNDARY LINES

Boundary lines:	definite boundary —————	indefinite boundary - - - - -	assumed or arbitrary boundary	study area boundary —————
On-site Symbols:	⊙ J65 observation site		△ 0512 visual inspection site	