

MABEL LAKE

RECONNAISSANCE TERRAIN STABILITY REPORT

(T.S.I. LEVEL 'D')

to accompany

Terrain Stability Maps
82L.046; 047; 056; 057; 058; 067; 068; 077; 078; 088

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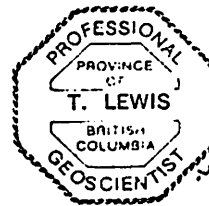
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INTRODUCTION

The Mabel Lake project area, located approximately 25 kilometers southeast of the town of Sicamous, in south-central British Columbia, is comprised of two distinct areas located on the opposite sides of the north-south trending Mabel Lake (Figure 1). The northeastern 'Mabel Range' area lies on the western fringe of the Monashee Mountains and extends from the shores of Mabel Lake in the west to the spine of the Sawtooth Range in the East. From north to south, this northeastern component encompasses the Derry, Dale, Devil, Iron, Napasis and Tsuius Creek drainages as well as several smaller intervening drainages. In marked contrast to this rugged, high-relief area, the comparatively hilly southwestern 'Trinity Hills' area lies to the south of the Shuswap River and extends from the drainage divide of the Trinity Hills in the west to the shore of Mabel Lake in the east. This area includes the Sowsap Creek drainage as well as several smaller unnamed creeks to the north. In total, the project area covers approximately 49,870 hectares of the Vernon Forest District, and, until now, the surficial geology of the Mabel Valley has remained unmapped.

Reconnaissance mapping of the terrain stability conditions within the Mabel Lake project area was conducted over 1996/1997 and are presented on the 10, 1:20,000 TRIM mapsheets which accompany this report. The maps and report, together, provide background information to be used as an aid for planning and development purposes and are intended to guide future forestry activity in the Mabel Lake area. In particular, the report and maps are intended to highlight areas in which Terrain Stability Field Assessments are warranted prior to road construction and/or logging activity.

OBJECTIVES

The overall objective of the project is to collect, collate and present data on the surficial geology, geomorphology and slope stability of the Mabel Lake project area. Specific deliverables in achieving this objective include the production of: a series of pretyped airphotos of the project area; digital and hardcopy 1:20,000 Terrain Survey Intensity Level (T.S.I.L.) "D" terrain stability maps; and, a final report in support of the reconnaissance maps.

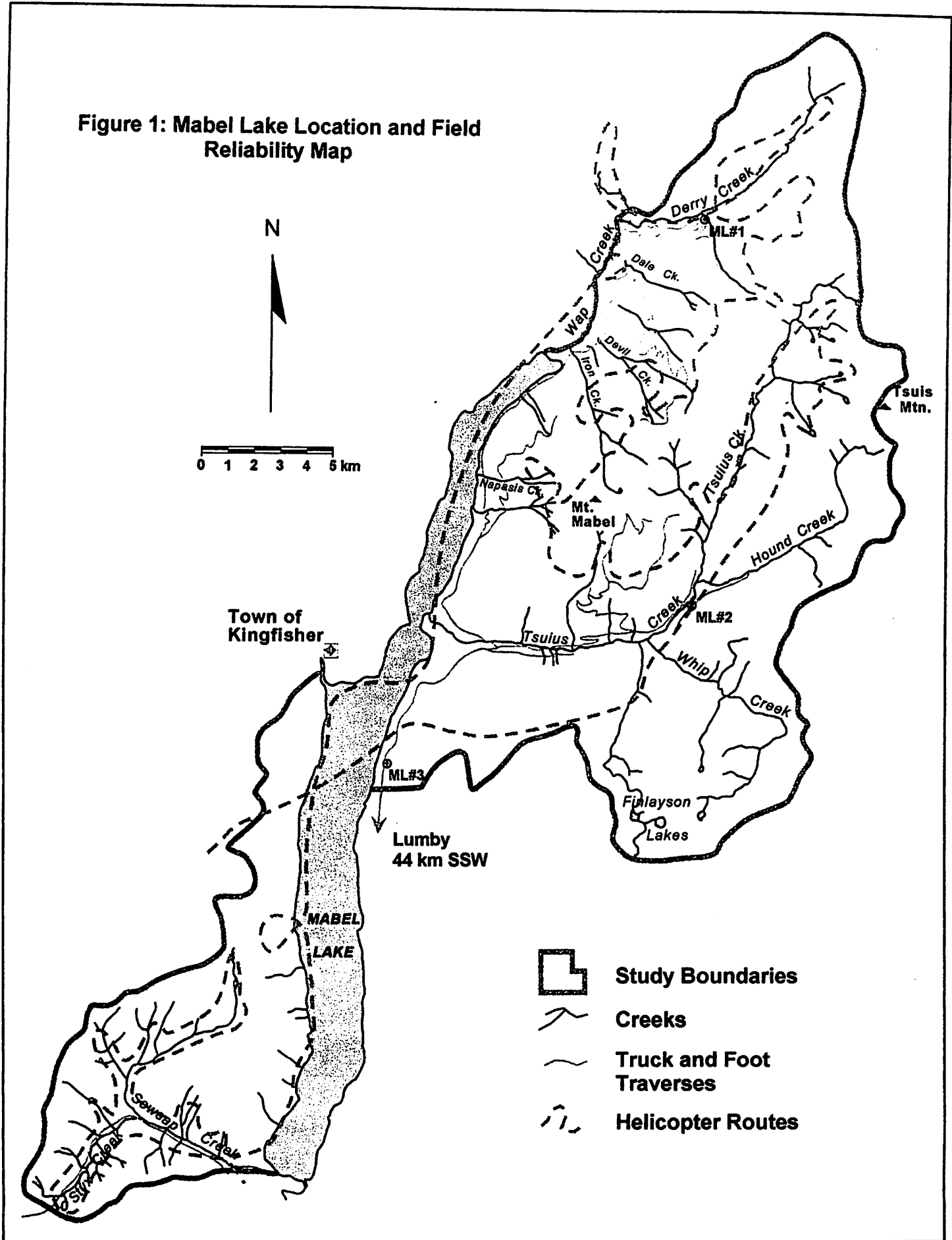
PHYSIOGRAPHY

The physiographic nature of the two project areas are, comparatively, quite distinct and fall on either side of what Holland (1964) identified as the boundary between the Monashee Mountain and Shuswap Highland physiographic divisions. Ranging in elevation from 394 meters above sea level (a.s.l.) at Mabel Lake, to 2,450 meters a.s.l. at the summit of Tsuius Mountain, the 'Mabel Range' area is a typically mountainous area characterised by sharp, steep, frequently failing,

bedrock headwalls, scarps and peaks at elevation, and thick sequences of unconsolidated surficial material along the valley bottoms. The Derry Creek valley, in the north of the project area, is a particularly narrow, steep, high relief drainage which exemplifies these characteristics, and like the Dale, Devil, Iron and intervening drainages to the south, it exhibits an increasingly incised channel along its lower reaches before culminating in a large alluvial fan complex on the floor of the Wap Creek valley. The Tsuius Creek drainage to the south and east, is the largest of the drainages in the northeast area and exhibits a broad U-shaped morphology with a significant blanket of Holocene colluvium along the valley walls. The Tsuius Creek culminates in a large, terraced fan-delta complex on Mabel Lake's eastern shore at Tsuius Narrows. The larger tributaries of Tsuius Creek, notably Hound and Whip Creeks, also display a U-shaped morphology but are not as wide and some channel gullying occurs in the valley bottom. Smaller tributaries of the Tsuius, Hound and Whip Creeks are typically steep and gullied.

In contrast to the 'Mabel Range' area, the more subdued terrain found in the 'Trinity Hills' component of the project area exhibits a lower relief topography comprised of glacially rounded bedrock draped by surficial materials of various depths. Elevations in this area range from 394m a.s.l. at Mabel Lake to a maximum of just over 1,550m a.s.l. along the crest of the Trinity Hills - almost 1,000m lower than the terrain on the opposite side of the lake. The Sowsap and tributary Styx Creek drainages, the largest features within the southwestern area, have wide valley bottoms and exhibit several fluvial and glaciofluvial features, including significant terracing and numerous meltwater channels, throughout the valley.

Figure 1: Mabel Lake Location and Field Reliability Map



Bedrock Geology

In the Mabel Range area, from Derry Creek south to Tsuius Creek, the bedrock consists of Shuswap Assemblage gneiss; biotite, quartz schist; amphibolite; quartzite; marble and skarn deposits. Also in abundance are pegmatite and muscovite rich granites, granodiorites and granodioritic gneisses and inclusions of marble, diopside marble, hornblende gneiss and quartzite (Jakobsen, 1995). Bedrock failure in the Mabel Range area is concentrated in the undivided gneiss, schist and marble of the Shuswap Assemblage particularly south of Derry Creek, along the southeastern side of the north Tsuius Valley fault; just south and east of Finlayson Lakes, in the southeast; and in the tightly folded Shuswap Assemblage quartzites on the northwest side of Paintbrush Ridge.

In the Trinity Hills area, the northern Sowsap Creek overlies andesitic and basaltic volcanics (Kamloops Group), while the southern portion of Sowsap Creek and the western Mabel Lake margin is underlain by Kootenay Assemblage quartz mica schist, chloritic schist, phillites, amphiboles and lesser limestones (Jakobsen, 1995). The majority of the bedrock failure in the Trinity Hills area appears to occur in the Kamloops Group volcanics, particularly on the southwest side of Bobbie Burns Mountain and the upper reaches and north side of Sowsap Creek.

Faulting in the Mabel Range area is dominated by an unnamed fault beginning four kilometers southwest of the Tsuius, Hound confluence and trending northeastward, up the Tsuius valley, across Garnet Ridge to the Shuswap River (Owsiacki, 1994). The influence of this fault on the surrounding Shuswap Assemblage rocks should be studied in more detail prior to long term road development in the valley.

Climate

Climatic conditions within the two physiographic divisions of the project area are regionally quite distinct and can be locally highly variable, especially in the high relief areas east of the lake. No meteorological stations are located within the project area itself, however, data from surrounding stations characterise the Trinity Hills climate as having a moderate temperature and precipitation regime; and the Mabel Range climate as a moderate temperature and high precipitation regime (Environment Canada, 1981).

Trinity Hills Area:

Although the Mabel Lake meteorological station, located 6 km south of Mabel Lake (50° 23' N; 118° 47' W; 399m asl), is the closest to the project area, no temperature data is available from this site. Therefore, the climate of the Trinity Hills area is best characterised as an average of the

data recorded at the Mabel Lake, Lumby (50° 15' N; 118° 58' W; 509m asl) and Enderby Ashton Creek (50° 33' N; 118° 55' N; 351m asl) meteorological stations (Environment Canada, 1981). Mean daily temperatures, based on these two sites, vary from a minimum of -6.4°C in January to a maximum of 18.5°C in July. Considered a moderate continental temperature regime, a number of freeze and thaw cycles can be anticipated during the spring and fall, resulting in on-going mechanical weathering of bedrock, particularly along exposed bluffs. Average monthly rainfall ranges from 4.1 mm in January to 59.4 mm in June, while average snowfall ranges from 0.0 cm, May through September, to 49.1 cm in January. Combined, the total precipitation in the area is essentially bimodal, with the largest winter contributions occurring in January, primarily in the form of snow, and the largest summer contributions occurring in June, almost exclusively as rain. The driest months, in terms of falling precipitation, are actually March and April. It is important to note, however, that these are not the driest months in terms of moisture contribution to the soils and hillslopes.

Rainfall occurs year round in the Trinity Hills area and spring rains falling onto an existing snowpack can present considerable slope stability hazard. These rain-on-snow events, given optimal wind and temperature conditions, can generate melt rates in the order of 2 mm/hr (R.P. Willington, Pers. Comm.) thereby augmenting input of water to slope soils considerably. Given the 47 year record of extreme rainfall events at the Mabel Lake site and the documented 24 hour extreme rainfall contributions of between 21.3 mm and 55.4 mm occurring in the months of January, February, March and April (Environment Canada, 1981), these events are likely to lead to both shallow and deep-seated failures in the project area.

Mabel Range Area:

The regional climate of the Mabel Range, can best be characterized by the nearest meteorological station in the Monashee Mountains located in Revelstoke, British Columbia (51° 0' N; 118° 12' W; 456 m asl), some 25 kilometers to the northeast of the project area. Based on this regional data, the Mabel Range area exhibits a similar temperature regime to that of the Trinity Hills area, while the total annual precipitation received by the area is roughly twice that found on the southwest side of Mabel Lake (Environment Canada, 1992). Mean daily temperatures in the Monashees vary from a minimum of -6.1 degrees Celsius in January to a maximum of 19.0 degrees Celsius in July with a mean daily average of 6.9 degrees Celsius. Average monthly rainfall varies from a February low of 21.5 mm to a mid-summer high of 78.4 in June and a mid-fall high of 92.0 mm in October - all significantly higher rainfall levels than found in the Trinity Hills. The average annual snowfall for the area is three times that found in the Trinity Hills (421.8cm versus 139.4cm) and this higher winter snowfall at mid to upper elevations, leads to substantial snow avalanching and extreme runoff events. At Revelstoke, extreme 24-hour rainfall in the October to March period

ranges from 78.0- 36.3 mm, respectively. From November to January, extreme 24-hour snowfall at Revelstoke ranges from 48.0 - 96.0 cm - and this is undoubtedly exceeded at the higher elevations of the Mabel Range.

With the high precipitation and moderate continental temperature regime exhibited in the Mabel Range, the climate-related stability hazards outlined for the Trinity Hills area are exacerbated and become primary factors contributing to slope instability in the Monashees. Mass wasting in the Mabel Range area results 1) from freeze-thaw cycles mechanically breaking down bedrock at elevation; and 2) from extreme storm events, especially rain-on-snow occurrences, predisposing unconsolidated surficial sediments to failure.

METHODOLOGY

Pretyping

Existing surficial and bedrock geologic resources were reviewed to familiarize the mappers with the project area and to identify terrains unique to the Mabel Lake area. The 1:15,000 monochrome air photos were prepared in accordance with standardized techniques detailing principal points, conjugate principal points and control points to aid in mapping and map transfer accuracy (Resources Inventory Committee, 1996a). Following air photo preparation, terrain pretyping was undertaken to identify terrain map units according to British Columbia's most recent surficial mapping conventions and definitions (Howes and Kenk (1997); Resources Inventory Committee (1996b) and the Mapping and Assessing Terrain Stability Guidebook - Forest Practices Code, (1995). Preliminary airphoto typing of the surficial materials was completed in the Fall of 1996 and the preliminary slope stability assessments (S - stable, P- potentially unstable, U - unstable) were used to guide the focus of the ensuing fieldwork.

Fieldwork

The Mabel Lake project area was field checked in late July 1997 under fair weather conditions and no snow cover. In accordance with the procedures for level 'D' terrain stability mapping, polygon checks were conducted following the methods outlined by the Resources Inventory Committee (1996b), Howes and Kenk (1997) and (Forest Practices Code of British Columbia, 1995). An average of 20% of the potentially unstable (P) and unstable (U) polygons, identified in pre-typing, were visited and their attributes verified in the field. Field verification was conducted by truck along roads and by foot along selected traverses (figure 1). Given the poor ground accessibility to most of the project area, helicopter support was used to verify terrain attributes and to meet the terrain survey intensity level 'D' standards (10 - 25 per cent polygon checks). Ground checks along accessible roads, allowed verification of terrain and surficial material properties along the valley floors, while aerial reconnaissance allowed verification of the primarily large-scale failures of

the region. Detailed section descriptions allowed stratigraphic analysis of unit associations and enabled some insight to the glacial and post-glacial history of the region (Appendix 1). Pretyped air photos were edited and updated to reflect fieldwork findings prior to the requisite provincial review and the subsequent transfer onto the 1:20,000 TRIM base.

Field verification sites, including detailed description sites, reconnaissance inspection sites, visual check sites and traverse routes are plotted on the air photos and reproduced on the location and survey reliability map (figure 1). Detailed descriptions (Appendix 1), include information on unit thickness, consolidation, drainage, organic content, oxidation, overall colour, clast and matrix content, and texture. Section descriptions also include information on primary sedimentary characteristics (stratification and structure) and secondary features such as loading, de-watering, faulting and deformation structures to aid in determination of genetic origin (Resources Inventory Committee, 1996b). Photographs and/or sketches were taken of all sections and features unique to, or of specific concern to the area.

Map Production

Terrain pre-typing from the air photos was transferred by monorestitution to the TRIM base maps by Hugh Hamilton Ltd. All line work and attribute labels were edited by the original mappers twice prior to the final production of the paper, mylar and digitally (IGDS and ARC/INFO) formatted maps. Map attribute tables, symbols and terrain unit descriptions are presented in accordance with the provincial mapping standards as outlined by the Resources Inventory Committee (1996a).

Mapping Constraints and Reliability

Map reliability is predominantly constrained by the accuracy of airphoto interpretation, the extent of field checking, and the precision of linework transference. The accuracy of airphoto interpretation depends on a number of factors, including the quality and scale of the airphotos used; the type, density, and extent of vegetative cover; the type, complexity and distribution of the surficial material; and, the experience of the mappers. The 1994, colour, 1:15,000 airphotos provided were of an appropriate scale for overview mapping; were of good quality; were free of cloud cover, yet had some sizable shadows obscuring terrain in the lee of the mountains in Mabel Range area. Much of the operable terrain was forested to some degree, so initial interpretations were based on terrain morphology as well as forest cover 'tone' and 'texture' as indicators of surficial material, depth to bedrock and drainage.

The helicopter support afforded good aerial attribute verification of the Trinity Hills area and fair aerial coverage of the Mabel Range area. Visual checks of the larger features and terrains by

helicopter provided a solid, if hasty, overview of the project area and were especially useful in verifying terrain attributes in unvegetated areas. Due to the reconnaissance nature of the project and given the limited accessibility, ground checks, first in the fall of 1996 and then again in the summer of 1997, were limited by temporal and financial constraints. Adequate field verification in the Mabel Range area was conducted along the eastern slopes above Mabel Lake and the lower tributary drainages. Ground verification of polygon attributes in the back of drainages (specifically, the Derry, Tsuius, Hound and Whip drainages), and on the mid to upper slopes of the entire Mabel Range area was poor. Similarly, in the Trinity Hills area, while fair ground verification of Styx and Sowsap Creek valley bottoms was completed, ground checks of the mid to upper slopes in these drainages and of the western slopes above Mabel Lake was inadequate considering the nature of the terrain. A terrain survey intensity level 'C' would be appropriate for the terrain conditions encountered in the project area.

As noted earlier, polygon transference was conducted by the provincially approved method of 'monorestitution'. Inherent to this process though are minor registration discrepancies which arise for various reasons, and which are accentuated in high relief areas. Every effort was made to correct for these discrepancies but users of this data should be aware of potential registration anomalies. Similarly, it bears noting that the width of the mapped polygon lines represents a real distance of approximately 20 m. End-users, therefore, must be cognizant of both these factors when utilizing this information, and field workers in particular must make allowances for these variables on the ground.

Finally, the information presented on the maps and in this report are based on observations of current terrain conditions in the project area and the prevailing understanding of geomorphic processes. Slope stability, however, is strongly influenced by, not only surficial materials and slope configuration, but also by 1) subsurface conditions not readily apparent in surface observations; 2) unpredictable extreme weather; and 3) inappropriate land management practices. Therefore, the information presented herein can not completely mitigate against landslide occurrence. The maps and this report are intended to highlight potentially hazardous areas in which detailed on-site investigations by a qualified terrain specialist are required.

SURFICIAL MATERIALS

Though the entire mapped area was glaciated up to four times during the Pleistocene (the last 2 million years) (Kelowna Geology Committee, 1995), the surficial materials found in the Mabel Lake area are predominantly derived from the events of the last glaciation (the Fraser Glaciation) (Fulton and Smith, 1978). The Fraser Glaciation produced a suite of large scale glacial features

including the U-shaped Mabel Lake and Tsuius valleys, the glaciofluvial terraces of the upper Sowsap, Styx and Tsuius Creeks and the widespread deposition of till throughout the region.

Post-glacial events have created both erosional and depositional landforms in the Mabel Lake area, particularly in the eastern Mabel Range. On low slopes, toeslopes and valley floors; depositional landforms generally consist of fluvial fans, plains, terraces, organic plains, and colluvial aprons and blankets. Generally, these landforms tend to have a low potential of landslide initiation and are rarely identified in reconnaissance terrain stability mapping, however, for the purpose of aggregate extraction, thick deposits of glaciofluvial sediments can be found throughout the lower Mabel Lake area. These deposits are commonly located low in the valleys and in close association with modern creeks as found in the upper Styx Creek (polygons 185, 186, and 188 map sheet 82L.046); in the upper Sowsap Creek (polygons 111, 108 and 144, map sheet 82L.046); at the mouth of the Sowsap Creek, (polygons 82, 84, 85, 90, and 103 map sheet 82L.047); on the northeast side of Mabel Lake (polygons 20 and 23, map sheet 82L.077); in the lower Hound Creek (polygons 555 and 589, map sheet 82L.068); at the confluence of the Hound and the Tsuius Creeks (polygons 525, 605 and 634, map sheet 82L.068); west of Whip Creek, to the upper Whip Valley (polygons 694, 723 and 724, map sheet 82L.068); and throughout the mouth of the Tsuius Creek (polygons 209, 211 and 214, map sheet 82L.067).

Silty sediments (including glaciolacustrine and, to some extent, silt to clay rich tills) though depositional in origin and stable on level terrain, pose unique stability and road building problems:

- their fine grained nature prevents rapid drainage, thus creating a failure plane above which overlying sediments may be washed down slope,
- the structure of clay minerals promotes lateral slip, thus decreasing their angle of repose and,
- their poor drainage and fine texture creates drainage, compaction and sediment erosion problems during road construction.

Where fine textured materials and heavy sub-surface seepage (-L) converge on moderately steep slopes (i.e. greater than slope class 3 or 50-55%), there results a marginally stable to unstable slope that is prone to failure when disturbed by road construction and/or logging.

In the Mabel Lake area the majority of silty tills and glaciolacustrine sediments are found between the elevations of 580 and approximately 1,500 meters a.s.l. in the lower Tsuius Valley, west of Whip Creek, on the small upland plateau three kilometers northwest of the Tsuius/Whip confluence (e.g. polygons 684, 685 and 815, map sheet 82L.068) and in the upper Sowsap Creek area (e.g. polygon 143, map sheet 82L.057).

Erosional post-glacial landforms result from gravity driven colluviation and/or fluvially driven erosion. On upper slopes and steep rock faces colluviation is the primary factor contributing to bedrock failures. This is particularly notable on the steep faces of the Mabel Range area, from Derry Creek south to Tsuius Creek, where bedrock consists of Shuswap Assemblage gneiss; schist quartzite and marble, as well as pegmatite and muscovite rich granites, granodiorites and granodioritic gneisses (Jakobsen, 1995). This bedrock instability is best exemplified south of Derry Creek (e.g. from polygon 315 northeastward to polygons 259, 260, 268, 201 and on to polygons 186, 176 to 165, map sheet 82L.078); along the southeastern side of the north Tsuius Valley fault (e.g. polygons 909, 978, 665 and 603, map sheet 82L.078); on the east and west side of the main Tsuius Valley (e.g. polygons 29, 31, 34, 54, 118, 121, and 257, map sheet 82L.068); south and east of Finlayson Lakes (e.g. polygons 190, 199 and 243, map sheet 82L.058); and, in the tightly folded Shuswap Assemblage quartzites north of Hound Creek, on the northwest side of Paintbrush Ridge (e.g. polygons 390, 391, 392, 437 and 440, map sheet 82L.068). In contrast, the majority of the bedrock failures in the Trinity Hills area appear to occur in the Kamloops Group volcanics. Most notable are the failures on the southwest side of Bobbie Burns Mountain and along the north side of Sowsap Creek (e.g. polygons 17, 46, 38, 84 and 89, map sheet 82L.046).

Thin veneers of morainal and colluvial material are also common on steep, upper slopes. These veneers are predominantly less than one meter thick overlying steep bedrock or till, but can include localized areas that are 1-3 meters thick (e.g. Cv:Rhs, Cw). Such colluviated sediments overlying an impermeable material, such as bedrock or till, may form a failure plane between the upper and lower materials. This failure plane, in steep terrain, may prove unstable during heavy runoff, if undermined by road cuts, or if weakened by post-logging loss of root strength. These materials are predisposed to shallow gravitational slides and are generally identified as potentially unstable or unstable terrains. Examples of such colluviated terrain can be found throughout the steep upland area of the Mabel Ranges (e.g. polygons 350, 361, 695 and 696, map sheet 82L.078); in the Trinity Hills area along the Mabel Lake shore (e.g. polygons 1, 36 and 61, map sheet 82L.047); and, throughout the upper Sowsap Valley (e.g. polygons 17 and 36, map sheet 82L.046).

Fluvial erosion occurs where combinations of high overland flow, steep gradients and erodible materials are found. Strong fluvial activity and/or glacial outwash activity (-E) erodes into thick sequences of glacial and post glacial materials (till, glaciofluvial and glaciolacustrine sediments) over-steepening slopes, gullies and creek cutbanks, demonstrating a close linkage between fluvial erosion and mass wasting. Downcutting of streams through glaciofluvial or fluvial plains often result in oversteepened terrace fronts (Fbs, FGbs), susceptible to dry raveling. This is best

exemplified at the mouth of the Tsuius Creek (e.g. polygon 220, map sheet 82L.067) and in the upper Sowsap Valley (e.g. polygon 51, map sheet 82L.046).

Undifferentiated sediments (typically mapped as Us-V or Us-VR"s) generally consist of interbedded silts, gravels and tills such as those found in the lower Tsuius Valley. They are generally found low in the valley profile and towards the valley's mouth and their erosion generally leads to deep-seated slumps and/or surface failures. Undifferentiated sediments provide a major stability concern wherever they are undercut by active fluvial processes and are an ongoing problem on the east side of Mabel Lake, in the lower Tsuius Creek (e.g. polygons 76 and 215, map sheet 82L.067 and polygons 695 and 670 (section ML#2), map sheet 82L.068); and to some extent in the Trinity Hills area through the lower Sowsap Valley (e.g. polygon 91, map sheet 82L.047).

Thick till units subject to channellized, overland flow exhibit steep, V-notch gullies (Mbs-V) and are prone to gully side-wall failures, debris flows and torrents. Steeply gullied till can be found primarily below 1,800 meters a.s.l., on either side of the main Mabel Valley and its tributary valleys (e.g. polygons 9, 10, 81 and 156, map sheet 82L.057; polygons 29 and 37, map sheet 82L.077; and polygons 519, 556, 629 and 739, map sheet 82L.068).

TERRAIN STABILITY RATINGS

The Terrain Stability Ratings applied to each terrain polygon are based on an assessment of the texture of surficial material(s), depth of material(s), slope angle, slope configuration, drainage (permeability), the regional climate and the active geomorphic processes impacting the area. Each map unit is influenced to a varying degree by some or all of the above factors and therefore each map unit is largely unique. However, generalizations can be and were established by the mappers to guide both the application and interpretation of the stability ratings in the Mabel Lake area. These generalizations are outlined below in a three class stability rating system (S - stable; P - potentially unstable; and, U - unstable). The criteria used in establishing each of the ratings is also provided:

Rating Stability Criteria and Descriptions

U Map units rated as Unstable are those units within which some form of natural mass movement is evident. In rare situations, steep slopes with no evident failures are given this rating if slope failure due to an identifiable factor is imminent (e.g. an oversteepened till blanket is undergoing basal sapping along a stream cutbank).

P

Generally, identifies select materials on slopes with gradients between 60 and 85%, particularly those exhibiting long, steep, unbroken slopes, where ground disturbance due to the removal of forest cover and/or road building may cause stability problems. Stability class P polygons often exhibit active processes such as gullying. Any failures evident in stability class P terrains are generally attributable to existing road construction or harvesting practices. Criteria for stability class P materials include:

Morainal Deposits * - characterised by poorly sorted, non-stratified, mixed particles containing clasts as large as boulders in a matrix of various portions of sand, silt, and clay. Minor sorted sand and gravel stringers may be found within the deposit. Potentially Unstable morainal materials include:

- moderate to well drained tills with slopes greater than 55-60%,
- moderately drained tills, gullied during the immediate post-glacial period, that have stabilized gully walls up to 65-70%
- imperfectly drained tills with slopes-greater than approximately 50-55%
- gullied morainal blankets, actively incising, with oversteepened gully walls greater than 60-65%.
- siltier tills, common in the Trinity Hills area, which reduce the stability threshold angle by ~ 5%;

* Morainal veneers typically overly bedrock and are no thicker than about 1 m. Morainal blankets typically have an unweathered till front within approximately 1 m of the surface. Both veneers and blankets, therefore, exhibit an impermeable layer within 1 m of the surface, and, for stability interpretation purposes, are treated similarly.

Colluvial Deposits - characterised by a moderately to poorly sorted and stratified mix of rubbly to blocky clasts, with discontinuous infillings of silty to sandy matrix. Potentially Unstable colluvial materials include:

- rubbly to blocky, well to rapidly drained, colluvial blankets and cones greater than 65%
- finer grained (silty-sand to silty) metamorphic and volcanic colluvial blankets and cones greater than 60%
- well drained colluvial veneers on slope greater than 60%
- complexed colluvium and bedrock slopes >80-85%, particularly on irregular bedrock surfaces

Glaciofluvial (Glacial Stream) Deposits - characterised by well to moderately-well sorted and stratified sands and gravels. These materials are considered Potentially Unstable when found as:

- glaciofluvial blankets and veneers on slopes greater than 60%

Glaciolacustrine (Glacial Lake) Deposits - characterised by well sorted and stratified clays and silts with rare infillings of till, gravel and/or drop stones. These are considered Potentially Unstable as:

- Silty, moderately to imperfectly drained slopes greater than approximately 50- 55% (Pack, 1995); as clay and water content increases within the materials of a map unit, this threshold decreases.

Undifferentiated Sediments - includes terrains with exposed, stratified (layered) units comprised of two or more of the above materials outcropping on a steep, erosional slope.

- steep slopes typically ranging between 65 and 90%, with a complex stratigraphy, often exhibiting seepage along contacts with impermeable units

S

Map units rated as Stable are those which do not fall into either the Potentially Unstable or Unstable categories.

Note: In many instances, steep, failing rock bluffs (Stability Class U) rise directly above the well drained and relatively stable colluvial blanket slopes below (Stability Class S). In such cases, while there is a low likelihood of post development landslides on the class S terrain unit, there may be significant rockfall hazard and risk to persons working in these areas.

Management Implications

General management implications of the stability classes are outlined in the following two tables; these are by no means prescriptions and cannot replace site-specific evaluation. The level of detail inherent in 1:20,000 mapping is insufficient to operationally plan for the development of sensitive (U - unstable terrain) or suspected sensitive terrain (P - potentially unstable terrain). In part this arises because 1:20,000 mapping of terrain stability is conservative by design. Map units are rated for stability based on the most sensitive identified terrain component; there are no complexes of stability ratings as there are for terrain components. In addition, no distinction is made between various types of potential instability (i.e. potential instability due to logging and potential instability due to road construction). Furthermore, the mapper is required to rate a map unit as class P if there is significant uncertainty as to the stability of the unit. Therefore, any proposed development within unstable and potentially unstable terrains requires a Terrain Stability Field Assessment (TSFA) be completed by a qualified terrain specialist prior to actual development.

Table 1: Road-related implications of the stability classes.

STABILITY CLASS	ROAD-RELATED IMPLICATIONS
S	<ul style="list-style-type: none"> • Little to no slope instability is expected due to road construction. • Roads crossing slopes of less 5-10% will usually be built by overlanding and little to no cutslope is created. • Roads crossing slopes of up to 25 - 30%, with cutslopes up to 2m high in angular, heterogeneous material or, less commonly, in bedrock, can expect to exhibit minor sloughing and raveling of cutslopes during the first winter and spring following construction. • Roads crossing slopes of up to 50 - 55%, with cutslopes greater than 2m high in

	<p>unconsolidated materials, can expect small cutslope failures (small sloughs and/or dry raveling into the ditches) particularly during the first two winters following construction. Emphasize clean subgrade construction (i.e. do not incorporate weathered soil, organics or debris into the subgrade; strip and dispose of these materials) and regular road maintenance. Promptly retire/deactivate road upon completion of logging and/or the cessation of regular road maintenance.</p>
P	<ul style="list-style-type: none"> • Minimize road construction through potentially unstable terrains. • Anticipate the use of special construction methods, including full benching, endhauling, use of controlled blasting in heavy rock-cuts, support of high cutslopes, French drains etc. Such techniques will greatly reduce the likelihood of fillslope failures, providing there is adequate water control. Plan for the higher cost of construction that these methods require. • Expect some on-going cutslope instability, particularly in high cuts (> 2m) through surficial materials. Plan for the higher level of maintenance that this requires. • Consider pull-back of any marginally stable fillslopes (e.g. tension-cracked road edges). Pile the pull-back material along inside of road if loss of road access can be tolerated; otherwise, endhaul to a safe disposal site. • Promptly retire/deactivate road upon completion of logging and/or the cessation of regular road maintenance.
U	<ul style="list-style-type: none"> • Avoid road construction through unstable terrains. • Anticipate the use of special construction methods, including full benching, endhauling, use of controlled blasting in heavy rock-cuts, support or terracing of high cutslopes, French drains etc. Such techniques will greatly reduce the likelihood of fillslope failures, providing there is adequate water control. Plan for the higher cost of construction that these methods require. • Expect on-going cutslope instability, particularly in high cuts (> 2m) through surficial materials. Plan for the higher level of maintenance that this requires. • Ensure water control is monitored and drainage is maintained. • Consider pull-back or re-sloping of any marginally stable sections of road. Place the retrieved material onto the road bench and ensure adequate cross drainage, with minimal ponding of water. • Promptly deactivate road upon completion of logging and/or the cessation of regular road maintenance. Leave a rough, irregular surface to reduce sheetwash and sediment production, and to facilitate revegetation.

Table 2: Cutblock, planning and safety implications of stability classes.

Stability Class	Clearcut	Logging/Windfall	Planning	Safety
S	No clearcut-related slides.	Disturbance by logging/windfall does not contribute to slides.	Terrain Stability Field Assessments are not necessary unless the layout crew identifies elements of risk.	No weather-related operating restrictions.
P	Moderate risk of small clearcut failures as root decay reduces root strength. Slides are likely to initiate at vulnerable microsites (e.g. seepage concentrations, below rock faces, in minor hollows and depressions).	Disturbance by logging or windfall can contribute to slides. Avoid/minimize falling lines through or adjacent to potentially unstable areas. Generally not suited for ground-based logging systems. Ensure adequate deflection/lift during yarding.	Further evaluation required to assess if there is a stability issue. Terrain Stability Field Assessment required to devise road construction and logging strategies to minimize risk and impact of slides.	Use of available alternate road headings on stable terrain is advisable. Suspend operations on or downslope of Potentially Unstable terrain during major rainstorms, particularly if roots have been disrupted by windfall or are being disturbed by yarding.
U	High risk of clearcut failures as root strength decreases, especially 6-10 years after harvesting. Normally set aside as protection forest. Keep in mind that windfall can trigger slides along boundaries and within leave areas on wind exposed sites/slopes.	Disturbance by windfall can contribute to slides. Avoid the location of falling lines adjacent to unstable areas; design adequate buffers.	Avoid road construction and logging activities in unstable terrain. Terrain Stability Field Assessment required prior to any planned disturbance of the terrain.	Suspend operations on or downslope of Unstable areas during major rainstorms.

SUMMARY AND CONCLUSIONS

Over the last century, several studies have looked at the Quaternary deposits of the Okanagan Valley - one valley west of the Mabel Lake area (Dawson, 1878; Flint, 1935; Mathews, 1944; Jones, 1959; Nasmith, 1962; Fulton, 1969, 1974; Fulton and Smith, 1978), but little of the literature refers to the Mabel Valley itself and, then, only peripheral mention is made (Jones, 1959; Fulton, 1969, 1974; Fulton and Smith, 1978). This reconnaissance mapping project is one of the first surficial geology reconnoiters in the Mabel valley. It identifies the surficial materials and potentially sensitive terrains within two distinct physiographic areas: a steep, high relief mountainous area located to the northeast of Mabel Lake (the Mabel Range area); and, a more subdued 'hilly' topography found to the southwest of Mabel Lake (the Trinity Hills area).

The Mabel Range area topography is typical of that found in the Monashee Mountains, and its features reflect the area's alpine glacial history. Past glacial and fluvial erosion have differentially eroded the Mabel Range drainages, largely as a function of lithological factors, and the last glaciation has draped the valley bottoms and sides with till and superimposed glaciofluvial deposits. Glacial deposits are thickest on the valley bottoms and lower slopes and thin out further upslope. Substantial post-glacial weathering and erosion in response to the regional climate and steep topography, has added various glaciofluvial, fluvial, colluvial and organic deposits over the Late Pleistocene drift. Recent fluvial activity has produced floodplains and terraces along Derry and Tsuius Creeks and broad fans at their mouths.

The rounded, yet steeply dissected topography of the Trinity Hills area is largely a function of the fine-grained and more erodible underlying volcanic bedrock. Ice from the recent Fraser glaciation overrode and sculpted the bedrock, subsequently draping it with till and associated glaciofluvial sediments. Like Tsuius and Derry Creeks to the northeast, recent fluvial activity in the Sowsap Creek drainage has produced sizable floodplains and terraces and a broad alluvial fan at the creek's mouth.

Much of the operable forest in the Mabel Lake project area lies on low to moderate hazard slopes. On 'rapid' to 'moderately' drained lower angled slopes (<55%), not otherwise influenced by some geomorphic process, there is a low likelihood of post-development landslides. Some cutslope raveling may occur in association with roads and, depending on the materials, on-going ditch maintenance may be required.

The potentially unstable and unstable terrain units are generally found on the steeper (>60%) mid to upper slopes, and in deeply incised, valley bottom materials. Potentially unstable and unstable slopes found on mid to upper slopes typically reflect:

- failing bedrock units;
- steep and/or finer-grained colluvium-bedrock complexes.

Potentially unstable and unstable slopes found lower on the slopes are typically associated with:

- Tills exhibiting: slopes in excess of 60%; intensive gulying; and/or substantial seepage;
- Steep, unconsolidated colluvial veneers overlying impermeable layers (Cv or Cv:Mb);
- Steeply dissected or gullied till, glaciofluvial and/or undifferentiated blankets (Mbs-V; FGbs-V; Us-V).

These terrain units, identified as unstable or potentially unstable units, either exhibit signs of pre-existing slope movement or demonstrate a combination of factors which likely predispose the

slope to failure. If any development plans are proposed for these terrain units, a Terrain Stability Field Assessment is required by a qualified terrain specialist.

Users of terrain, and slope stability information on the associated maps must be aware that conditions within a particular terrain polygon mapped at 1:20,000 scale are locally variable. Attributes indicate typical conditions for each polygon, yet locally steeper slopes, atypical drainage, and other factors may predispose site specific portions of a polygon to reduced stability. Consequently, layout crews should be alert to variable conditions and seek the advice of a qualified terrain specialist in any areas of concern.

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APPENDIX I: Detailed Section Descriptions

Terrain and Soils Data Collection Form

QUATERRA Environmental Consulting Ltd. (06/97)

Project:

Name: Mabel Lk "D"
 Collector: JS + MS
 Date: July 5/97
 Wx: Cur. Temp: 16°C Cloud Cover: 2/10 Wind Speed & Direction: C Cur. Ppt: 0
 Last Ppt: >2d Snow Cover: 0

Location:

Site #: ML#1 Airphoto #: BCC94847#094 Aspect: N 50° E
 Elevation: 970m Geographic Location: 3 of Derry Cr. ; Near mouth of

Site Description: Cutbank Roadcut Gravel Pit Dug Pit Scarp/Headwall Root hollow
 Slope Position: Apex Upper Midslope Lower
 Section Height: 20m Section Width: 275m
 Photo #: 13 Description: Mark in section - close
 Photo #: 14 Description: " " " - wide
 Dominant Vegetation: Douglas Fir / 15% Cedar

Surface Expression:

Down: Concave Convex Straight Complex
 Across: Concave Convex Straight Complex
 Configuration: Uniform Benchd Terraced Undulating Ridged
 Irregular Single Gully Fan Cone Rolling
 Depression Domed Ribbed
 Slope Angles: Minimum: 23% Maximum: 32% Mean: +26% / -30%
 Gully Angles: Left GW: 55% Right GW: 90% Str min: 23% Str max: 32% Str mean: +26% / -30%
 Runoff: Standing water Surface Runoff Subsurface Runoff

Slope Condition:

Sloughs: Minor n. failures Minor cc failures Minor gw failures
 Landslides: Material: _____ Depth: _____ m
 Length: _____ m Width: (Upper) _____ m (Mid) _____ m (Lower) _____ m
 Open Slope POI: natural clearcut roadcut roadfill
 Gully POI: natural clearcut roadcut roadfill
 Slope Angle @ POI: _____ %
 Direction: _____

Road Condition:

Full Bench Half Bench No Side Cast
 Ditching: Waterbars / X-ditches / Berms
 Minor roadcut failures
 Minor roadfill failures
 Tension cracks
 Fill Slope Recovery
 Debuilt

Hydrology:

Seepage: Absent Present At Depth of: _____
 Mottles: Absent Some Abundant Below Depth of: _____
 Compacted Layers: Absent Present At Depth of: _____
 Soil Drainage: Rapid Well Moderate Imperfect Poor

Soil:

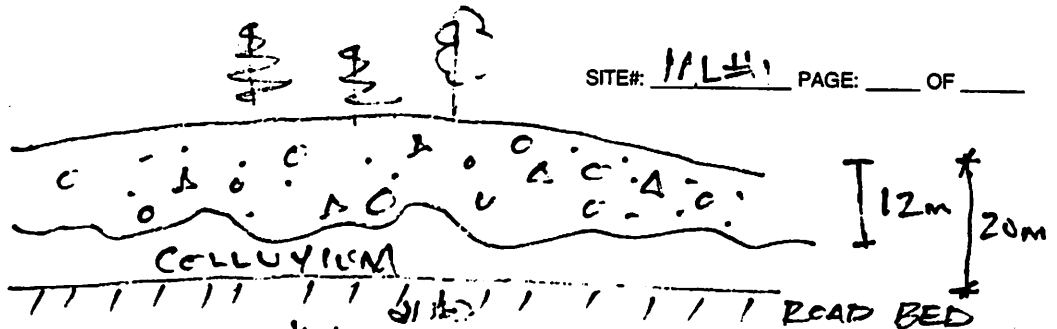
Genetic Material

Mineral Component: A C D E F F^A F^G L L^G (M) S V W W^o U
 Organic Component: I. Bog Fen Organic, Undifferentiated Swamp
 II. Fibric Mesic Humic Woody

L, F, H Horizon: Absent Present Thickness of: 2cm
 Weathering Front: Sharp (depth of: _____) Gradational Unseen
 A-Horizon: Ah Ae
 B-Horizon: Bc Bf Bt Bh Bn Bm Bg
 C-Horizon: Cg Cca Cs Csa
 Pedogenic Cementation: None Moderate High Top: _____ cm Base: _____ cm

Section Sketch:

SITE#: 11L#1 PAGE: OF



Materials/Facies Description:

Unit of Thickness: 12 m Sample Taken: Yes / (No) #:

Lower Contact: I. Depth from surface: Not Exposed
 II. Form: Sharp Gradational Conformable

Fabric: I. Matrix supported Clast supported Induration: high / mod / slight / none
 II. % Matrix 80 % Clasts 20
 III. Massive Stratified (well/mod./weak) Graded

Texture: Matrix: %sand 20 %msand 65 %csand 10 %Silt 5 %Clay 0
 Clasts: %Pebbles 70 %Cobbles 15 %Boulders 5
 %Rubble 10 %Blocks 5

Dominant Clast Shape: A SA SR R WR
 Lithology of Largest Clasts: Granodiorite

Structure: Rippled (asymmetric/symmetric) Planar Faulting
 Trough X-bedded Planar X-bedded Dewatering
 Laminated Cut and Fill Ripup Clasts
 Fines upwards Coarsens upwards Dropstones

Origin of materials: Till

Unit of Thickness: m

Lower Contact: I. Depth from surface: Not Exposed
 II. Form: Sharp Gradational Conformable

Fabric: I. Matrix supported Clast supported Induration: high / mod / slight / none
 II. % Matrix % Clasts
 III. Massive Stratified (well / mod / weak) Graded

Texture: Matrix: %sand %msand %csand %Silt %Clay
 Clasts: %Pebbles %Cobbles %Boulders
 %Rubble %Blocks

Dominant Clast Shape: A SA SR R WR
 Lithology of Largest Clasts:

Structure: Rippled (asymmetric/symmetric) Planar Faulting
 Trough X-bedded Planar X-bedded Dewatering
 Laminated Cut and Fill Ripup Clasts
 Fines upwards Coarsens upwards Dropstones

Origin of materials:

Bedrock: Not SEEN Type Block Size: Formation:

Comments: Greater than 2m erratic at section base

Erosion Potential: VL L M H VH

(in polygon)

Polygon Terrain Label: Us - Y Stability: u Is section representative of polygon? yes / no

Terrain and Soils Data Collection Form

QUATERRA Environmental Consulting Ltd. (06/97)

Project:

Name: MABEL LAKE LOW D
 Collector: JS & JIS
 Date: July 6 1997
 Wx: Cur. Temp: 25°C Cloud Cover: 1/10 Wind Speed & Direction: _____ Cur. Ppt: 0
 Last Ppt: 15.0003 Snow Cover: 0

Location:

Site #: ML#2 Airphoto #: PCC94092 No. 014 Aspect: Facing 344° NW
 Elevation: 985 m Geographic Location: South of Junction of Howard R. + Tsuius R.

Site Description: Cutbank Roadcut Gravel Pit Dug Pit Scarp/Headwall Root hollow
 Slope Position: Apex Upper Midslope Lower
 Section Height: 15-20 m Section Width: 100 m
 Photo #: _____ Description: _____
 Description: _____
 Dominant Vegetation: Hemlock + Cedar

Surface Expression:

Down: Concave Convex Straight Complex
 Across: Concave Convex Straight Complex
 Configuration: Uniform Benched Terraced Undulating Ridged Hogback
 Irregular Single Gully Fan Cone Rolling
 Depression Domed Ribbed
 Slope Angles: Minimum: _____% Maximum: _____% Mean: 70%
 Gully Angles: Left GW: 100% Right GW: 78% Str min: _____% Str max: _____% Str mean: 55%
 Runoff: Standing water Surface Runoff Subsurface Runoff

Slope Condition:

Sloughs: Minor n. failures Minor cc failures Minor gw failures
 Landslides: Material: _____ Depth: _____ m
 Length: _____ m Width: (Upper) _____ m (Mid) _____ m (Lower) _____ m
 Open Slope POI: natural clearcut roadcut roadfill
 Gully POI: natural clearcut roadcut roadfill
 Slope Angle @ POI: _____%
 Blowdown: Direction: N/NE

Road Condition:

Full Bench Half Bench No Side Cast
 Ditching: Waterbars / X-ditches / Berms
 Minor roadcut failures
 Minor roadfill failures
 Tension cracks
 Fill Slope Recovery
 Debuilt

Hydrology:

Seepage: Absent Present At Depth of: _____
 Mottles: Absent Some Abundant Below Depth of: _____
 Compacted Layers: Absent Present At Depth of: _____
 Soil Drainage: Rapid Well, Moderate Imperfect Poor } oxidized at l.c. (Unit 2)

Soil:

at lower contact (Unit 2)
 Genetic Material
 Mineral Component: A C D E F F^A F^G L L^G M S V W W^G U
 Organic Component: I. Bog Fen Organic, Undifferentiated Swamp
 II. Fibric Mesic Humic Woody
 L,F,H Horizon: Absent Present Thickness of: _____
 Weathering Front: Sharp (depth of: _____) Gradational Unseen
 A-Horizon: Ah Ae
 B-Horizon: Bc Bf Bt Bh Bn Bm Bg
 C-Horizon: Cg Cca Cs Csa
 Pedogenic Cementation: None Moderate High Top: _____ cm Base: _____ cm

Section Sketch:

SITE#: 1.2 PAGE: 2 OF 2

Materials/Facies Description:

• Unit 1 of _____ Thickness: 2.5 m Sample Taken: Yes (No) #:

Lower Contact: I. Depth from surface: covered Not Exposed
II. Form: Sharp Gradational Conformable

Fabric: I. Matrix supported Clast supported Induration: high/mod slight / none
II. % Matrix 1% % Clasts _____
III. Massive Stratified (well/mod/weak) Graded

Texture: Matrix: %fsand 15 %msand 5 %csand 5 %Silt 60 %Clay 10
Clasts: %Pebbles _____ %Cobbles _____ %Boulders _____
 % Rubble _____ %Blocks _____

Dominant Clast Shape: A SA SR R WR
Lithology of Largest Clasts: _____

Structure: Rippled (asymetric/symetric) Planar Faulting
 Trough X-bedded Planar X-bedded Dewatering
 Laminated Cut and Fill Ripup Clasts
 Fines upwards Coarsens upwards Dropstones

Origin of materials: LG

• Unit 2 of _____ Thickness: 6m m

Lower Contact: I. Depth from surface: 6m Not Exposed
II. Form: Sharp Gradational Conformable

Fabric: I. Matrix supported Clast supported Induration: high / mod / slight / none
II. % Matrix _____ % Clasts _____
III. Massive Stratified (well / mod / weak) Graded

Texture: Matrix: %fsand _____ %msand _____ %csand _____ %Silt _____ %Clay _____
Clasts: %Pebbles _____ %Cobbles _____ %Boulders _____
 % Rubble _____ %Blocks _____

Dominant Clast Shape: A SA SR R WR
Lithology of Largest Clasts: Syanite *Pebble concentration on lower contact.*

Structure: Rippled (asymetric/symetric) Planar Faulting
 Trough X-bedded Planar X-bedded Dewatering
 Laminated Cut and Fill Ripup Clasts *Horizontally Bedded*
 Fines upwards Coarsens upwards Dropstones

Origin of materials: Fluvial Glacial

Bedrock: Type _____ Block Size: _____ Formation: _____

Comments: N/A.

Erosion Potential: VL L M H VH

Polygon Terrain Label: _____ Stability: Unstable Is section representative of polygon? yes / no

Mabel 2-4

Terrain and Soils Data Collection Form

QUATERRA Environmental Consulting Ltd. (06/97)

Project:

Name: MABEL LAKE LEVEL 'D'
Collector: JS - HP
Date: JULY 6, 1997
Wx: Cur. Temp: 25°C Cloud Cover: 10 Wind Speed & Direction: _____ Cur. Ppt: _____
Last Ppt: 15 hrs Snow Cover: 0

Location:

Site #: MLA 2 Airphoto #: BCC 94092 No. 14 Aspect: Facing 344°NW
Elevation: 985m Geographic Location: South of Jnc of Howard R + Tsuinus R.

Site Description: Cutbank Roadcut Gravel Pit Dug Pit Scarp/Headwall Root hollow
Slope Position: Apex Upper Midslope Lower
Section Height: 15-20m Section Width: 100m
Photo #: R-23 Description: Rise up of deformed clay + silt beds
Description: _____
Dominant Vegetation: Hemlock + Cedar

Surface Expression:

Down: Concave Convex Straight Complex
Across: Concave Convex Straight Complex
Configuration: Uniform Benched Terraced Undulating Rugged
 Irregular Single Gully Fan Cone Rolling
 Depression Domed Ribbed
Slope Angles: Minimum: _____% Maximum: _____% Mean: 70%
Gully Angles: Left GW: 100% Right GW: 78% Str min: _____% Str max: _____% Str mean: 55%
Runoff: Standing water Surface Runoff Subsurface Runoff

Slope Condition:

Sloughs: Minor n. failures Minor cc failures Minor gw failures
 Landslides: Material: _____ Depth: _____m
Length: _____m Width: (Upper) _____m (Mid) _____m (Lower) _____m
 Open Slope POI: natural clearcut roadcut roadfill
 Gully POI: natural clearcut roadcut roadfill
 Slope Angle @ POI: _____%
 Blowdown: Direction: _____

Road Condition:

Full Bench Half Bench No Side Cast
 Ditching: Waterbars / X-ditches / Berms
 Minor roadcut failures
 Minor roadfill failures
 Tension cracks
 Fill Slope Recovery
 Debuilt

Hydrology:

Seepage: Absent Present At Depth of: _____
Mottles: Absent Some Abundant Below Depth of: _____
Compacted Layers: Absent Present At Depth of: _____
Soil Drainage: Rapid Well Moderate Imperfect Poor

Soil:

Genetic Material
Mineral Component: A C D E F F^A F^G L L^G M S V W W^G U
Organic Component: I. Bog Fen Organic, Undifferentiated Swamp
II. Fibric Mesic Humic Woody
L, F, H Horizon: Absent Present Thickness of: _____
Weathering Front: Sharp (depth of: _____) Gradational Unseen
A-Horizon: Ah Ae
B-Horizon: Bc Bf Bt Bh Bn Bm Bg
C-Horizon: Cg Cca Cs Csa
Pedogenic Cementation: None Moderate High Top: _____cm Base: _____cm

Section Sketch:

SITE#: 52 PAGE: 4 OF 4

Materials/Facies Description:

• Unit 3 of _____ Thickness: 2-3+ m Sample Taken: Yes / No #:

Lower Contact: I. Depth from surface: 2m Not Exposed
II. Form: Sharp Gradational Conformable

Fabric: I. Matrix supported Clast supported Induration: high / mod / slight / none
II. % Matrix _____ % Clasts _____
III. Massive Stratified (well/mod./weak) Graded
Interbedded silt/sand/clay

Texture: Matrix: %sand 5% %msand _____ %csand _____ %Silt 50 %Clay 40
Clasts: %Pebbles 15% %Cobbles _____ %Boulders _____
 % Rubble _____ %Blocks _____

Dominant Clast Shape: A SA SR R WR
Lithology of Largest Clasts: Gneiss

Structure: Rippled (asymmetric/symmetric) Planar Faulting
 Trough X-bedded Planar X-bedded Dewatering
 Laminated Cut and Fill Ripup Clasts
 Fines upwards Coarsens upwards Dropstones
*Fining Up
Horizontally Bedded
Massive
Disturbed*

Origin of materials: Glacial Lacustrine

• Unit _____ of _____ Thickness: _____ m

Lower Contact: I. Depth from surface: _____ Not Exposed
II. Form: Sharp Gradational Conformable

Fabric: I. Matrix supported Clast supported Induration: high / mod / slight / none
II. % Matrix _____ % Clasts _____
III. Massive Stratified (well / mod / weak) Graded

Texture: Matrix: %sand _____ %msand _____ %csand _____ %Silt _____ %Clay _____
Clasts: %Pebbles _____ %Cobbles _____ %Boulders _____
 % Rubble _____ %Blocks _____

Dominant Clast Shape: A SA SR R WR
Lithology of Largest Clasts: _____

Structure: Rippled (asymmetric/symmetric) Planar Faulting
 Trough X-bedded Planar X-bedded Dewatering
 Laminated Cut and Fill Ripup Clasts
 Fines upwards Coarsens upwards Dropstones

Origin of materials: _____

Bedrock: Type _____ Block Size: _____ Formation: _____

Comments: _____

Erosion Potential: VL L M H VH

Polygon Terrain Label: _____ Stability: _____ Is section representative of polygon? yes / no

Terrain and Soils Data Collection Form

QUATERRA Environmental Consulting Ltd. (06/97)

Project:

Name: MABEL LAKE
 Collector: JS, HB
 Date: JULY 16 1997
 Wx: Cur. Temp: 20°C Cloud Cover: 110 Wind Speed & Direction: _____ Cur. Ppt: 0
 Last Ppt: 15 hrs Snow Cover: 0

Location:

Site #: M43 Airphoto #: m- BCC94091 #048 Aspect: Facing 310° NW (4km south)
 Elevation: 740m Geographic Location: Mabel Lake main Mine South of (Eastside) Tsuius Narrows

Site Description:

Cutbank Roadcut Gravel Pit Dug Pit Scarp/Headwall Root hollow
 Slope Position: Apex Upper Midslope Lower
 Section Height: 35m Section Width: 2300m
 Photo #: 24 Description: M3 Ter + Shadow on scale.
 Description: _____
 Dominant Vegetation: Cedar, Birch & Fir

Surface Expression:

Down: Concave Convex Straight Complex
 Across: Concave Convex Straight Complex
 Configuration: Uniform Benched Terraced Undulating Ridged
 Irregular Single Gully Fan Cone Rolling
 Depression Domed Ribbed
 Slope Angles: Minimum: _____% Maximum: _____% Mean: _____%
 Gully Angles: Left GW: _____% Right GW: _____% Str min: _____% Str max: _____% Str mean: _____%
 Runoff: Standing water Surface Runoff Subsurface Runoff

Slope Condition:

Sloughs: Minor n. failures Minor cc failures Minor gw failures
 Landslides: Material: _____ Depth: _____ m
 Length: _____ m Width: (Upper) _____ m (Mid) _____ m (Lower) _____ m
 Open Slope POI: natural clearcut roadcut roadfill
 Gully POI: natural clearcut roadcut roadfill
 Slope Angle @ POI: _____%
 Blowdown: Direction: _____

Road Condition:

Full Bench Half Bench No Side Cast
 Ditching: Waterbars / X-ditches / Berms
 Minor roadcut failures
 Minor roadfill failures
 Tension cracks
 Fill Slope Recovery
 Debuilt

Hydrology:

Seepage: Absent Present At Depth of: _____
 Mottles: Absent Some Abundant Below Depth of: _____
 Compacted Layers: Absent Present At Depth of: _____
 Soil Drainage: Rapid Well Moderate Imperfect Poor

Soil:

Genetic Material
 Mineral Component: A C D E F F^A F^G L L^S M S V W W^S U
 Organic Component: I. Bog Fen Organic, Undifferentiated Swamp
 II. Fibric Mesic Humic Woody
 L,F,H Horizon: Absent Present Thickness of: _____
 Weathering Front: Sharp (depth of: _____) Gradational Unseen
 A-Horizon: Ah Ae
 B-Horizon: Bc Bf Bt Bh Bn Bm Bg
 C-Horizon: Cg Cca Cs Csa
 Pedogenic Cementation: None Moderate High Top: _____ cm Base: _____ cm

Section Sketch:

SITE#: M3 PAGE: 2 OF 2

Materials/Facies Description:

• Unit 1 of 2 Thickness: 7 m Sample Taken: Yes / (No) #:

Lower Contact: I. Depth from surface: 10m. Not Exposed
II. Form: Sharp Gradational Conformable

Fabric: I. Matrix supported Clast supported Induration: high / mod / slight / none
II. % Matrix % Clasts interbedded sands & gravel
III. Massive Stratified (well/mod./weak) Graded

Texture: Matrix: %fsand %msand %csand %Silt %Clay
Clasts: %Pebbles %Cobbles %Boulders
 %Rubble %Blocks

Dominant Clast Shape: A SA SR R WR
Lithology of Largest Clasts: GNEISS

Structure: Rippled (asymmetric/symmetric) Planar Faulting
 Trough X-bedded Planar X-bedded Dewatering
 Laminated Cut and Fill Ripup Clasts Horizontal - Cross trough bedded.
 Fines upwards Coarsens upwards Dropstones

Origin of materials: Fluvial 400m. Fine sand this is interbedded by thin bedded sands

• Unit 2 of 2 Thickness: 3-4 m

Lower Contact: I. Depth from surface: 4m Not Exposed
II. Form: Sharp Gradational Conformable

Fabric: I. Matrix supported Clast supported Induration: high / mod / slight / none
II. % Matrix 70 % Clasts 30
III. Massive Stratified (well / mod / weak) Graded

Texture: Matrix: %fsand %msand %csand %Silt %Clay
Clasts: %Pebbles %Cobbles %Boulders
 %Rubble %Blocks

Dominant Clast Shape: A SA SR R WR
Lithology of Largest Clasts: GNEISS

Structure: Rippled (asymmetric/symmetric) Planar Faulting
 Trough X-bedded Planar X-bedded Dewatering
 Laminated Cut and Fill Ripup Clasts Looks sandy
 Fines upwards Coarsens upwards Dropstones

Origin of materials: Glacial

Bedrock: Type _____ Block Size: _____ Formation: _____

Comments: _____

Erosion Potential: VL L M H VH

Polygon Terrain Label: Fgbs Stability: P Is section representative of polygon? (yes) no

Vertical section