ALLENBY ROAD
SLOPE HAZARD OVERVIEW ASSESSMENT

Prepared by:

McQuarrie Geotechnical Consultants Ltd.

For

Cowichan Valley Regional District
&
Cowichan Tribes

c/o Kerr Wood Leidel

March 27, 2019
Project #17-5

Prepared by:

March 27/19

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1. INTRODUCTION

This report summarizes an overview assessment of the slope stability hazards along the slope above Allenby Road in Duncan BC, between Indian Road and Koksilah Road, a distance of approximately 1.4 km. This assessment is intended to provide a general description of the slope hazards for use in more detailed slope stability investigations and to assist Kerr Wood Leidal (KWL) with their broader stormwater management plan for the Cowichan Valley Regional District (CVRD) and Cowichan Tribes.

This report is subject to the attached Statement of General Conditions. These conditions should be clearly understood while reading or interpreting this report.

2. SCOPE OF WORK

A cursory field reconnaissance was conducted on March 18, 2019 by Eric McQuarrie, PEng, PGeo of McQuarrie Geotechnical Consultants Ltd., accompanied by Keith Lawrence with the CVRD. The assessment included visual observations and measurements of slope angles, slope lengths, exposed geology, groundwater and surface water discharge, forest and vegetative cover, and signs of past instability. This assessment did not include test pits or boreholes at this stage.

Background documents reviewed as part of this assessment included the following:

- E.C. Halstead, "Surficial Geology of Duncan & Shawnigan Map-Areas, British Columbia," Geological Survey of Canada Paper 65-24, published 1966.
- Geological Survey of Canada *Map 14-1965*, "*Surficial Geology, Duncan*," published 1966.
- Report by Levelton Associates addressed to Canadian Building Brokers, titled "*Lot 3, Allenby Road, Duncan, BC Report on Geotechnical Assessment*," dated December 4, 1991,

3. SITE CONDITIONS

3.1 Surficial Geology

The surficial geology along the plateau above the slope is mapped as marine or glacio-marine sediments, comprised of mostly silt and clay, with some till-like mixtures. These soils deposited during deglaciation or shortly after, when sea levels rose higher than present due to the melting continental ice. Some of the clay contains ice-rafted gravel, cobbles or boulders. The foundation excavation for the house at 5345 Miller Road reportedly encountered some clay. Silt or clay was also exposed at 2965 Phillips Road, but is at a much lower elevation and may be part of a different geologic unit.

The marine/glacio-marine clay overlies glaciofluvial sand and gravel, deposited as part of an ice-contact delta during advance and retreat of the ice sheet. Sand and gravel was found exposed in the over-steepened gully headwalls and in the headscarps of past failures. The deposit seems to comprise most of the upper 10 to 12 m of the slope.

The glaciofluvial sand and gravel overlies sandy silt or silty fine-grained sand, mapped as part of the Quadra Formation, which is an interglacial unit deposited between the last two ice ages. In the field, this unit is found to be varved with thin seams of silt and fine sand (Photo 1). The deposit has been glacially over-ridden and is typically very dense with a very low permeability. Past landslides on this slope generally appear to have initiated along the top of this unit where groundwater discharges.

Photo 1: Varved silt and fine sand exposed in a landslide on 5451 Allenby Road.

3.2 Slope Morphology

The slope height and angle changes across the study area. Near the northwest end of the study area, the slope is 20 m high, slopes at 60% (31°) overall, and is forested mostly with mature conifers. The slope height increases to the southeast and steepens, reaching 35 m high by 5405 Miller Road, sloping at 100% (45°). The slope begins to shorten again southeast of 3030 Allenby Road, reaching 25 m high along 3000 Allenby Road, and is less than 10 m high at 2965 Phillips Road. The slope also reduces slightly to between 70 and 80% (35 to 39°).

The slope is dissected by a few gullies that form headwalls near the crest. Gullies were noted along the northwest property line of 5405 Miller Road, a smaller headwall below 3107 Laurel Grove, and two gullies behind 5345 Miller Road. These gullies may have been created by concentrated surface water; however, any evidence has been obscured by development on the plateau above. More likely, the gullies are evidence of concentrated groundwater discharge. Regardless, the gully headwalls are well over-steepened at more than 100% and prone to small-scale failures.

3.3 Surface Water & Groundwater

No streams are mapped leading to the crest of the slope. Nor was any concentrated surface runoff observed, although the field reconnaissance was not extensive.

Groundwater appears to be more prevalent than surface water. Surface water naturally infiltrates the glaciofluvial sand and gravel and flows along the geologic contact with the underlying silt deposits. Minor groundwater discharge was apparent in all of the exposures of the Quadra silts, with discharge from the base of the overlying glaciofluvial sand and gravel, and from within the varved silt and fine-grained sand. More concentrated groundwater discharge was noted in each of the identified gullies, particularly the large gully behind 5345 Miller Road.

The gully headwalls behind 5345 Miller Road seem to be natural focal points for both surface water and shallow groundwater. The road grade also forms a low point opposite this property. The other gullies likely also formed at localized focal points for both surface water and groundwater, although the grades were less apparent in the field.

Groundwater discharge was also noted from the slope behind 2960 Allenby Road, where several Big 'O' pipes lead down the slope immediately behind the small house. The ground surface at the crest of this slope is poorly drained, indicating that the groundwater discharges from the upper slope.

Photo 2 : Big 'O' pipes draining down next to 2960 Allenby Road.

3.4 Landslides

The slope is prone to frequent small-scale failures from the nearly vertical exposures of Quadra silts and the over-steepened gully headwalls. Larger debris slides tend to initiate in the overlying glaciofluvial sand and gravel. At least six debris slide headscarps were noted during the field reconnaissance, each 10 to 15 m wide and readily discernible suggesting that they occurred within the last 10 to 20 years (Photo 3). Several older landslide scars are less discernible by vegetation and timber but could be delineated based on the surface form.

Photo 3: One of several landslide headscarps.

A large landslide reportedly occurred on December 3, 1975, destroying the Windsor Plywood building on Allenby Road (Photo 4). The property is assumed to have been at 3030 Allenby Road but may have been on 3050 Allenby Road. The landslide is no longer discernible but both slopes have been disturbed by past instability and are now forested with deciduous trees such as alder (Photo 5).

One smaller failure was noted to be actively developing at the crest of an 8 m high slope at the back of 2959 Phillips Road. Tension cracks were noted 1 to 2 m back from the slope crest and a mature Douglas fir tree has a slight back-lean, indicative of a small slump developing in the underlying fine-grained soils.

Photo 4: 1975 Landslide at Windsor Plywood (photo from Cowichan Valley Museum & Archives).

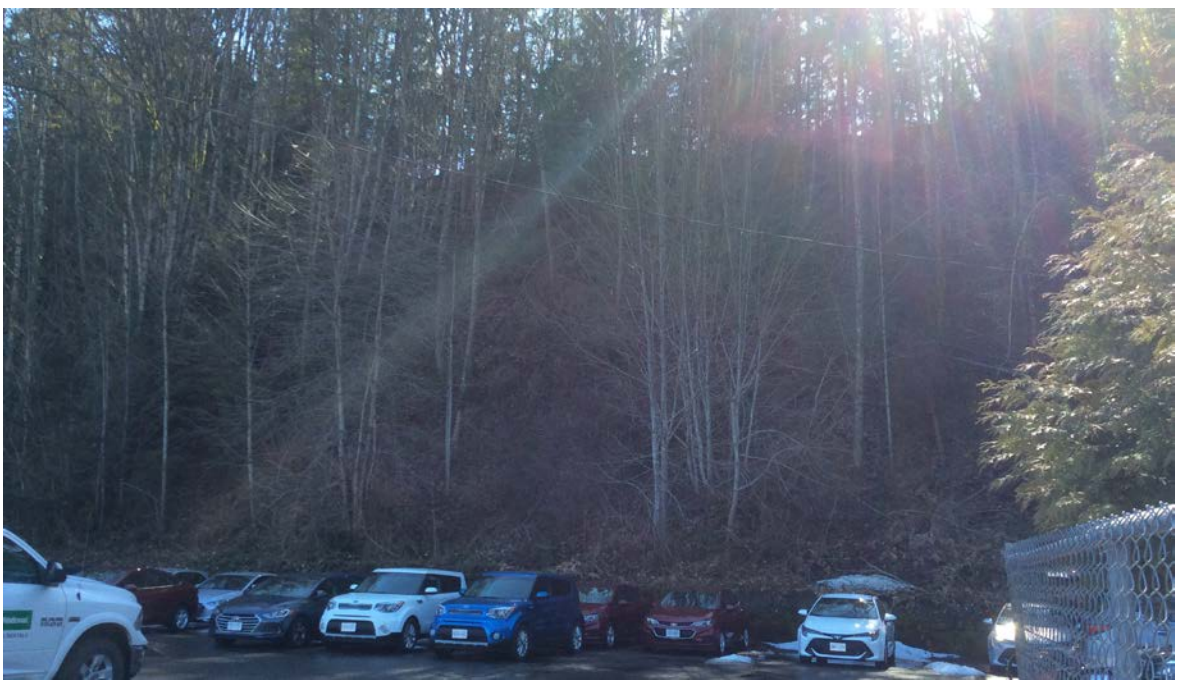


Photo 5: Slope above 3050 Allenby Road forested with alder instead of fir or cedar.

4. SLOPE HAZARDS

The slope above Allenby Road was formed by erosion and down-cutting of the Cowichan River. Landslides occur naturally on such slopes because, as the river eroded, the slope was over-steepened and responded by failing. Although fluvial erosion has not occurred for decades or possibly more than a century, such slopes are naturally just marginally stable and can become unstable in response to seemingly minor changes.

While the river has been separated from the toe of the slope preventing any further fluvial erosion, the slope has been modified in several more subtle means by development.

- A 250 m long section of Allenby Road, confined between the river and the bank, was constructed by excavating into the bank several decades ago. The cutslope above the road is over-steepened and exposes the Quadra silts.
- Mature conifers have been logged from several areas, most notably below 3107 to 3113 Laurel Grove, severely reducing root support and soil-matrix suction. The small deciduous trees cannot replace the lost benefits from the mature conifers.
- Fill has been placed along and over the slope crest in several locations, primarily associated with adjacent developments. The most recent example appears to be on 5367 Miller Road. Access to the property was denied; therefore, the slope disturbance could only be observed from the road below.
- Compost and yard waste has been disposed over the slope in several areas. Such materials suppress the natural vegetation and, as it decomposes, adds significant weight to the slope.
- Plastic sheeting was found on one property, which also suppresses the natural vegetation. Landscaping on other properties may also be suppressing vegetation.
- Rock pits can concentrate groundwater, which discharges onto the slope. The level of concentration of groundwater depends on the proximity of the rock pit to the slope crest.
- Discharging roof water directly onto the slope has a greater impact on slope stability than rock pits. While no drains were found to be directly discharging onto the slope, the field reconnaissance was limited. Solid PVC pipe was found running down one of the visible landslides at 5393 Miller Road. The pipe likely discharged directly onto the slope prior to the landslide occurrence.

Considering the slope angles, geologic conditions, and past evidence of landslides, the entire slope should be considered unstable or potentially unstable, creating a landslide hazard to any developments along the crest and toe.

The hazard to development along the crest will depend on the building setback and the potential magnitude of the failure or how far back the slope could retrogress over the life of a structure. Slope retrogression will be affected by future land use and stormwater management.

The hazard to development along the toe of the slope depends on the potential magnitude of the failure and its runout. With the possible exception of 3030 and 3050 Allenby Road, the run out for any potential failure would certainly reach the road. Even on 3030 and 3050 Allenby Road, the required setback from the toe of the slope would severely affect development. Creating a safe building area would most likely require construction of barriers to contain or deflect the potential hazards.

5. RECOMMENDATIONS

The study area is already included in the Allenby Road Development Permit Area, which requires a slope hazard assessment for any development. Considering the possible setback requirements, such assessments would be best completed at the subdivision stage prior to creating the lot boundaries; otherwise, some lots along the crest may not have sufficient setback to permit safe development.

The goal of stormwater management should be to maintain or reduce groundwater discharge on the slope. For example, collection of stormwater in a solid pipe is preferable to in-ground disposal; however, management of the stormwater once collected becomes a challenge. Where the stormwater main runs down the slope, it must be securely anchored. Still, slope movement could damage the stormwater main; therefore, a maintenance plan should be developed.

Containment ponds or storage tanks would preferably be located at least 10 m back from the slope crest to prevent loading the slope and to reduce the risk of a landslide undermining the storage tank. The pond or tank should also be regularly inspected for leaks and maintained.

An open channel may be viable provided the channel is well armoured and possibly lined to prevent erosion. The existing gullies provide logical locations for open stormwater channels but gully sidewall failures could plug or damage the channel. Efforts to stabilize these gullies could reduce such risks.

Rock pits or other means of in-ground disposal or infiltration can negatively affect slope stability and should be located as far from the slope as practicable.

Maintenance of the existing trees on the slope is important for stability and erosion control. Dead or leaning trees that pose a hazard to the houses should be removed as should any dead understorey that could pose a forest fire hazard. But a large majority of the trees and vegetation, particularly the mature conifers, should be maintained or enhanced.

No fill, garden waste, lawn clippings or household refuse should be disposed of onto the slope. Existing over-steepened fills and composting materials should be removed to reduce weight and allow natural vegetation to generate.

6. FURTHER STUDY

Further slope stability assessments will be required prior to any subdivision planning or development permit, as required by the Allenby Road DPA. Such studies would address specific developments and be limited to specific properties. The CVRD and these future studies could benefit from a more comprehensive review of the existing landslides to determine the potential magnitude of failure that should be considered when determining suitable building setbacks. An analysis of the potential runout distance would assist in assessing the risks to existing and potential downslope development as well as the risk to users of Allenby Road.

STATEMENT OF GENERAL CONDITIONS

1. STANDARD OF CARE

This study and Report have been prepared in accordance with generally accepted engineering consulting practices at described in the Association of Professional Engineers and Geoscientists of BC's "Guidelines for Legislated Landslide Assessments for Proposed Residential Development in British Columbia" (Revised May 2010). No other warranty, expressed or implied, is made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report which is of a summary nature and is not intended to stand alone without reference to the instructions given to us by the Client, communications between us and the Client, and to any other reports, writings, proposals or documents prepared by us for the Client relative to the specific site described herein, all of which constitute the Report.

In order to properly understand the recommendations and opinions expressed herein, reference must be made to the whole of the report. We are not responsible for use by any party of portions of the report without reference to the whole report.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purpose that were described to us by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the document are only valid to the extent that there has been no material alteration to or variation from any of the said descriptions provided to us unless we are specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT OUR WRITTEN CONSENT. We will consent to any reasonable request by the client to approve the use of this report by other parties as "approved users. Any use that a third party makes of the Report, or any portion of the Report, are the sole responsibility of such third parties. We accept no responsibility for damages suffered by any third party resulting from unauthorized use of the Report.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil Description: Identification of soils, rocks, terrain and geological units have been based on investigations performed in accordance with the standards set out in Paragraph 1. The field investigation cannot practically cover the entire area and will only identify soil conditions at the point and time of sampling. Identification of these factors are judgemental in nature and even comprehensive sampling and testing programs may fail to locate some conditions. All investigations involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual sample points. Actual conditions may vary significantly between the points investigated and all persons making use of such documents or records should be aware of, and accept, this risk. Some conditions change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the time of assessment.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to us. We have relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, we cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of persons providing information.

6. CONSTRUCTION INSPECTIONS

Our scope of work may include inspections of the work during construction or after completion. Such field reviews do not replace the need for appropriate construction inspection and supervision on the part of the client or his agents. We accept no responsibility for damages caused by unforeseen conditions unless we are on site during construction.

7. INHERENT RISKS

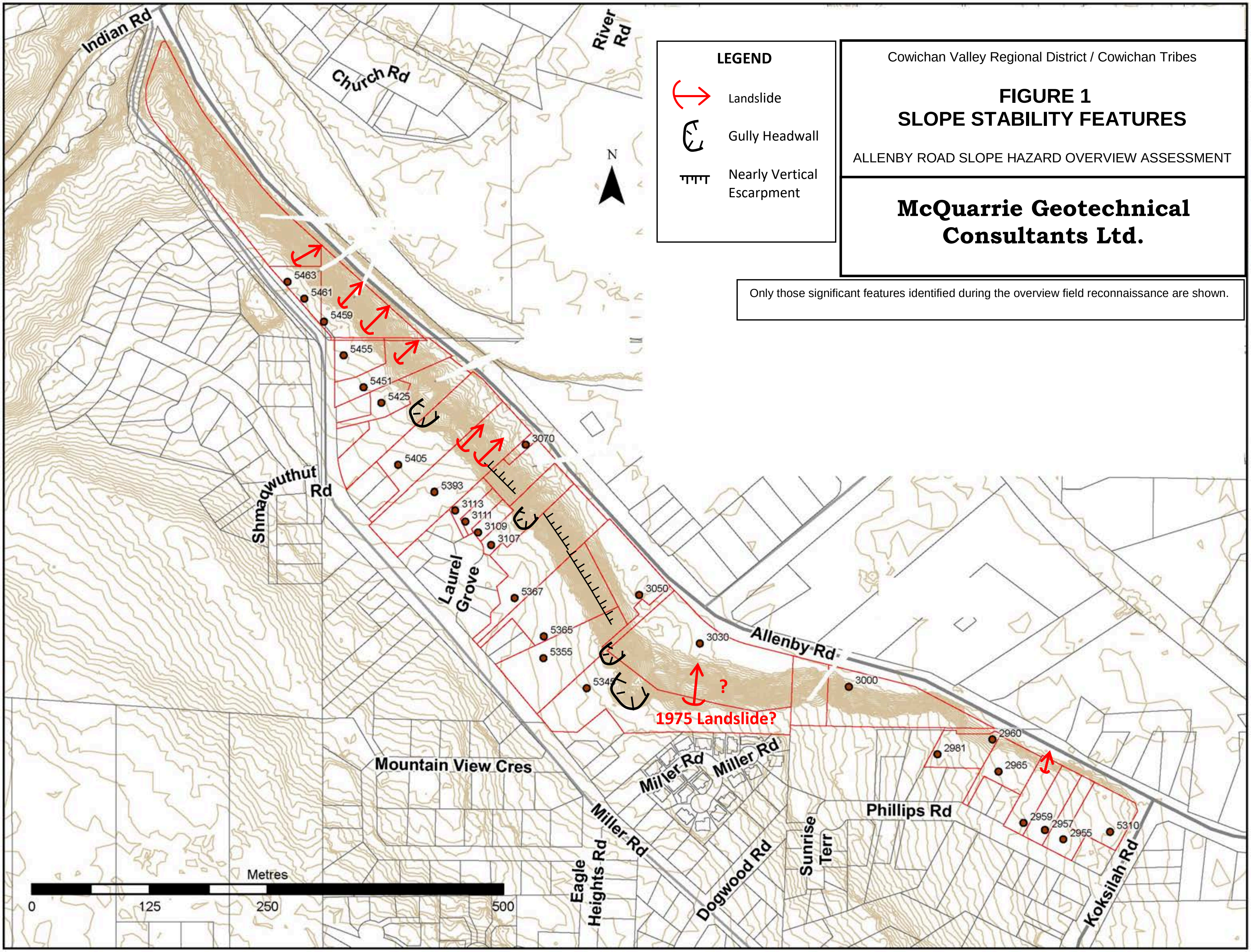
Landslide hazard assessments typically occur where there are hazards. As such, inherent risks exist and landslides or other geologic hazards can occur even where the likelihood of instability has been identified as low. The client must operate with an understanding of this risk.

8. CONTROL OF WORK AND JOBSITE SAFETY

We are responsible only for the activities of our employees on the jobsite. The presence of our personnel on the site shall not be construed in any way to relieve the Client or any contractors on site from their responsibilities for site safety. The Client acknowledges that he, his representatives, contractors or others retain control of the site and that we never occupy a position of control of the site. The Client undertakes to inform us of all hazardous conditions, or other relevant conditions of which the Client is aware. The Client also recognizes that our activities may uncover previously unknown hazardous conditions and that such a discovery may require that certain regulatory bodies be informed and the Client agrees that notification to such bodies by us will not be a cause of action or dispute.

9. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on our interpretation of conditions revealed through limited assessment conducted within a defined scope of services. We cannot accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes decisions made to either purchase or sell land.



LEGEND
Landslide
Gully Headwall
Nearly Vertical Escarpment
Cowichan Valley Regional District / Cowichan Tribes
FIGURE 1
SLOPE STABILITY FEATURES
ALLENBY ROAD SLOPE HAZARD OVERVIEW ASSESSMENT
McQuarrie Geotechnical Consultants Ltd.
Only those significant features identified during the overview field reconnaissance are shown.
N
Indian Rd
Church Rd
River Rd
Shmaqwuthut Rd
Laurel Grove
Allenby Rd
Mountain View Cres
Miller Rd
Eagle Heights Rd
Dogwood Rd
Sunrise Terr
Phillips Rd
Koksilah Rd
1975 Landslide?
?
5463
5461
5459
5455
5451
5425
5405
5393
3113
3111
3109
3107
3070
5367
3050
5365
5355
5345
3030
3000
2960
2981
2965
2959
2957
2955
5310
Metres
0
125
250
500