

PRELIMINARY GEOTECHNICAL TERRAIN ASSESSMENT

for

PROPOSED SUBDIVISION FAIRWINDS NEIGHBOUHOOD 2 NANOOSE BAY, B.C.

PREPARED FOR

Fairwinds Real Estate Management Inc. 3455 Fairwinds Drive Nanoose Bay, BC V9P 9K6

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Prepared by:

Trow Associates Inc.

7025 Greenwood Street Burnaby, British Columbia Canada V5A 1X7

Telephone:

604-874-1245

Fax:

604-874-2358

web site:

www.trow.com







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1.0 INTRODUCTION

Authorization to proceed with a preliminary geotechnical assessment of existing terrain within the Fairwinds Neighborhood 2 area was issued to Trow Associates Inc. (Trow) by Mr. Russell Tibbles on 2008 January 8. Our scope of work was presented in the Trow proposal dated 2007 December 10.

The purpose of our assessment is to identify and provide a characterization of areas where naturally occurring geologic events, in particular slope instabilities and rockfall hazards, within or adjacent to proposed development areas, have influenced the proposed development in recent history. In addition, we have identified areas where anthropologic changes to the natural terrain have created potential geologic hazards. This preliminary report is intended to provide guidance to the designers for siting housing and roadways with respect to avoiding the influence areas of identified potential geologic hazards.

Information used during our assessment includes:

- recent (1992) aerial photographs;
- topographic plans showing 1 metre contour intervals, areas of slopes with inclinations greater than 40%, on the proposed road alignments and development areas;
- Observations noted during site reconnaissance.

Due to the large area of the subject site we have focused our work on areas of proposed development (Drawing 081-01028-00 – yellow shading). Attached to this report are a Regional Location Plan, Key Plan and Site Plans showing zones of potential hazards and their influence areas.

2.0 SITE DESCRIPTION

The proposed Fairwinds Neighborhood 2 development is located approximately 25 km northwest of Nanaimo on a peninsula of land bordered by Nanoose Bay to the south and the Ballenas Channel and the Strait of Georgia to the north (see Drawing 081-01028-LP). Access to the property is via Fairwinds Drive which, via Powder Point Road and Northwest Bay Road, connects to the Island Highway (Hwy 19) about 6 km to the west.

The subject site is bordered by existing subdivisions along the northern and eastern boundaries, the Fairwinds golf course to the southeast, provincial lands to the northwest and a Department of National Defence area to the south. Topography throughout the site is generally bedrock controlled and undulating with small hills and frequent steeply inclined slopes. Overburden soil generally consists of thin veneers overlying bedrock with thicker soil deposits in valleys and ravines; however thick granular deposits were noted near the southwest shore of Enos Lake. Numerous bedrock outcrops were observed throughout the site with bedrock in the eastern portion being granitic and the western portion consisting of meta-sediments. Water bodies within the subject site include Enos Lake and Dolphin Lake with several smaller unnamed lakes and ponds. The most significant hill is "The Notch", located in the southwest corner of the proposed development. A more detailed description of zones with potential geologic hazard influences



areas (hatched and numbered areas attached Drawings 081-01028-01 thru 08) that may affect proposed development (yellow shaded areas – Drawing 081-01028-00) are provided below.

- **Zone 1** This zone appears to be the site of previous gravel extraction and has since been used for stockpiling wood waste, excavated soils and other waste material. The southerly portion of this zone contains oversteepened east facing gravel banks, remnant of gravel extraction, with the northern portion containing stockpiled material described above. The southern edge of the stockpiled material indicates potential thicknesses of greater than 10 metres.
- **Zone 2** The terrain within this zone is hummocky and exposed soil deposits appear to be of glacial/ fluvial origin with rounded boulders and cobbles. Vegetation generally consists of evergreen trees with trunk diameters of about 200 cm, ferns and sparse underbrush. Some of the trees exhibited curvature of their trunks possibly indicating some movement of surficial soils.
- **Zone 3** This zone contains steeply inclined, north facing bedrock slopes overlain with localized thin soil veneers. Existing residential dwellings were observed at the crest of the slope east of the proposed development area. The bedrock face consists of a 'benched' topography with both steep areas and near horizontal sections. Loose rock fragments, apparently originating from nearby bedrock outcrops, with diameters of about 0.5 metres were observed on the slope.
- **Zone 4** This zone appeared to consist of rolling bedrock topography with slopes of varying steepness. An old roadway (now a walking path) with bedrock cut slopes up to about 3 metres in height was observed within this zone. Localized zones of thin soil veneers were also observed.
- **Zone 5** Topography within this zone consists of steep northeast facing bedrock controlled slopes. The slopes are heavily vegetated with evergreen trees, alders and thick underbrush. Many of the trees were observed to have some curvature to their trunks indicating possible surficial soils movement. A possible small slide fan, about 10 metres in length, was observed near the end of Swallow Crescent covering the walking trail. Loose rocks on the slope generally consisted of angular metasediments with a maximum block size of about 0.3 metres.
- **Zone 6** This zone consisted of glaciated bedrock steeply inclined towards Enos Lake. The bedrock is generally moss covered with few observed loose boulders.
- **Zone 7** This zone is similar to Zone 6 with some heavier vegetation and thin soil veneers overlying the bedrock in some areas.
- **Zone 8** Steep south facing bedrock controlled slopes form the general topography for this zone. A small gully generally oriented in a east-west direction is located at the toe of the slope. The gully is relatively shallow (< 1 metre depth) and narrow (about 2 metres wide) at the west end; becoming deeper and wider to the east. At the time of our review the gully was dry; however it appeared that at times water does flow to the east through the gully. Occasional loose boulders were observed on the slope and at the toe of the slope, but very few were observed on the south side of the gully. Boulders were angular in shape and less than 0.6 metres in diameter.
- **Zone 9** This zone is comprised of a steeply inclined, north facing bedrock controlled slope. Areas with a thin veneer of soil overlying bedrock were observed on the slope. A wide naturally occurring bench feature is located at the toe of this zone and is a proposed development area.



Some loose rocks (generally less than 0.5 metres in diameter) were noted on the bench near the toe of the slope.

Zone 10 – Slopes within this zone are north facing and bedrock controlled with high steep, moss covered, bedrock bluffs below the proposed development area. Major discontinuities within the meta-sedimentary bedrock generally dip steeply to the south.

Zone 11 – Topography in this area is described as benched with near vertical bedrock bluffs (generally less than 4 metres in height) and near horizontal areas. Bedrock is comprised of granitic rock with open joints and loose rock fragments being common. Vegetation generally consists of moss with widely spaced coniferous and Arbutus trees.

Zone 12 – Terrain within the upper elevations of this zone is comprised of glaciated bedrock with some natural benches. Lower portions of the slope in this zone consist of locally steeply inclined talus slopes with rock fragments up to 0.3 metres diameter being observed. Vegetation includes moss, thin underbrush and widely spaced coniferous and arbutus trees.

Zone 13 – This zone is a small locally steep bedrock controlled south facing slope. Small loose rock fragments were observed within the zone.

Zone 14 – Topography within this zone consists of steep south facing bedrock slopes generally terminating at the lake shore.

3.0 DISCUSSION

As discussed above the proposed development contains numerous areas of steeply inclined slopes, occasionally with a thin soil veneer overlying bedrock. Loose rock fragments were often noted at the base of slopes, indicating that rockfall has occurred in the past. In most cases rockfall appears to have been limited to a relatively small area at the toe of the slopes generating the rockfall. In particular it was noted that a gully at the toe of a slope in Zone 8 has limited the influence area of rockfall originating from the slope. Areas exposed to the influence of potential rockfall are shown on attached drawings. Due to the limited influence area of identified rockfall sources beyond the bases of existing slopes, several options may be considered to mitigate the extent of rockfall hazard. Options available include, but are not limited to:

- Rock stabilization methods (rock anchors, buttresses, etc.) in rockfall source areas;
- Construction of catchment areas at the toe of slopes;
- Avoidance of rockfall hazard by limiting building envelopes locations to areas outside the extent of historic rockfall events.

The majority of steep slopes within the subject site are bedrock controlled, and hence are generally considered stable; however a building setback from the crest of the slopes is recommended to protect future dwellings from the adverse influence from small areas of raveling rock near the slope crest or erosion of soil veneers. For proposed developments at the crest of steep slopes greater than 6 metres in height a preliminary setback for building envelopes should be established in the field, once lot boundaries are confirmed.



For planning purposes we recommend a preliminary building envelope setback of 3 metres from the crest of slopes and 6 metres from the toe of slopes where such recommended setbacks are shown on the attached drawings. It should be noted that adjustment of proposed setbacks from the crest or toe of slopes is possible subject to a more detailed assessment by a geotechnical engineer of record working on a specific lot.

Some zones with specific geologic hazard concerns are noted below:

Zone 1 – Is presently considered unsuitable for development due to the presence of unsuitable fill material and oversteepened slopes. Further assessment of this zone using intrusive geotechnical investigative techniques (drilling, test pits, etc.) may result in the development of recommendations that would provide suitable subgrades for development; however removal of the unsuitable fill material and an extensive program of placement and compaction of structural fill in areas of oversteepened slopes would likely be required.

Zone 2 – The hummocky nature of the topography indicate that slope stability may be an issue in this zone. Rounded cobbles and boulders observed may indicate an ancient event occurring at the time of glacial retreat. Further geotechnical investigation is likely to be required in this area to characterize subsurface soil conditions and assess potential slide mechanisms in order to provide recommendations, if possible, to mitigate slope instabilities. However, we are currently of the opinion that recent slope instabilities are surficial in nature.

Zone 5 – In addition to rockfall mitigation at the toe of the slope additional mitigative works for potential small scale slides may be required (higher berms, raised building pads, etc.).

Zone 11 – The broken nature of the bedrock and benched topography may result in some requirements for rock stabilization and/or excavation of broken bedrock to provide adequate foundations for structures and roadways.

4.0 CLOSURE

The above noted and attached information presents our understanding of the proposed development, interpretations of site conditions and opinions as to the existence of geologic hazards and their potential influence areas within or adjacent to the development site. We would point out that there is an inherent level of uncertainty associated with the prediction of long-term stability of natural mountain slopes. This uncertainty combined with the lack of comprehensive historical record(s) within and adjacent to the proposed development site, significantly limits our ability to complete a quantitative risk assessment of specifically identified hazard events. As such we are providing a qualitative assessment of potential hazards that may influence proposed development areas. Therefore, we have provided a qualitative assessment of the identified hazards which may affect the proposed development based on our experience and interpretations of existing site conditions. Some understanding of terminology and associated ranges of annual probability of occurrence connected with this approach is provided in a reference prepared by the Resource Inventory Committee, Government of British Columbia, Slope Stability Task Group (1996) and shown in Table A below.



TABLE A
Relative Terms and Ranges of Annual Probability of Hazard Occurrence
(Resource Inventory Committee, 1996)

Relative Term of Probability	Range of Annual Probability	Comments
	of Occurrence (Pa)	
Very High	>1/20	Indicates that hazard is
-		imminent and well within the
		lifetime of a person or typical
	77	structure. Event occurring
		with a return interval of 1/20
720		or less generally have clear
		and relatively fresh signs of
	27)	disturbance.
High	1/100 to 1/20	Indicates that the hazard can
100		happen within the approximate
		lifetime for a person or typical
		structure. Events are clearly
		identifiable from deposits and
		vegetation, but may not appear
		fresh.
Moderate	1/500 to 1/100	Indicates that the hazard
		within a given lifetime is not
		likely, but possible. Signs of
		previous events, such as
		vegetation damage may not be
		easily noted.
Low	1/2500 to 1/500	Indicates the hazard is of
		uncertain significance.
Very Low	>1/2500	

In addition, only events with an interpreted return period less than 475 years (greater than 10% chance in 50 years) have been considered in our hazard assessment. This approach is consistent with the terms of reference presented in the subdivision guidelines proposed by the Ministry of Transportation. We expect that the approving authority will use a similar guideline during their review of the proposed development.

Based on our work, and the above mentioned criteria, we have determined certain of the proposed development areas considered as unsuitable for the construction of habitable dwellings. Our determination relates to anticipated potential influence areas from identified hazard events. Areas outside of hatched zones as shown on the attached Site Plans are considered to have low to very low geologic hazard probability. With appropriate geotechnical works areas within the hatched zones may be mitigated such that they would be considered to have low to very low hazard probability. Development areas that may require mitigative works prior to the commencement of construction of habitable dwellings are also noted.



This report was prepared for the exclusive use of our client, Fairwinds and their designated consultant, agents or lenders, and may not be used by other parties without written consent of Trow Associates In. This report contains our *Interpretation and Use of Study and Report*. These interpretations form an integral part of this report and must be included with any copies of this report.

Yours truly,

TROWASSOCIATES INC.

Evan Sykes Reng. Geotechnical Engineer

ES/es

Reviewed by:

Jim O'Brien, P.Eng. Senior Engineer



INTERPRETATION & USE OF STUDY AND REPORT

1. STANDARD OF CARE

This study and Report have been prepared in accordance with generally accepted engineering consulting practices in this area. No other warranty, expressed or implied, is made. Engineering studies and reports do not include environmental consulting unless specifically stated in the engineering report.

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 SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. WE CANNOT BE RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF THE REPORT

The Report has been prepared for the specific site, development, building, design or building assessment 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 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". The contents of the Report remain our copyright property and we authorise only the Client and Approved Users to make copies of the Report only in such quantities as are reasonably necessary for the use of the Report by those parties. The Client and Approved Users may not give, lend, sell or otherwise make the Report, or any portion thereof, available to any party without our written permission. Any use which 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 unauthorised use of the Report.

5. INTERPRETATION OF THE REPORT

- a. Nature and Exactness of Descriptions: Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature and even comprehensive sampling and testing programs, implemented with the appropriate equipment by experienced personnel, may fail to locate some conditions. All investigations, or building envelope descriptions, utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarising such investigations will be based on assumptions of what exists between the actual points sampled. 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 are subject to 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 sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- 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.
- C. To avoid misunderstandings, Trow Associates Inc. (Trow) should be retained to work with the other design professionals to explain relevant engineering findings and to review their plans, drawings, and specifications relative to engineering issues pertaining to consulting services provided by Trow. Further, Trow should be retained to provide field reviews during the construction, consistent with building codes guidelines and generally accepted practices. Where applicable, the field services recommended for the project are the minimum necessary to ascertain that the Contractor's work is being carried out in general conformity with Trow's recommendations. Any reduction from the level of services normally recommended will result in Trow providing qualified opinions regarding adequacy of the work.

6.0 ALTERNATE REPORT FORMAT

When Trow submits both electronic file and hard copies of reports, drawings and other documents and deliverables (Trow's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by Trow shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancy, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by Trow shall be deemed to be the overall original for the Project.

The Client agrees that both electronic file and hard copy versions of Trow's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Trow. The Client warrants that Trow's instruments of professional service will be used only and exactly as submitted by Trow.

The Client recognizes and agrees that electronic files submitted by Trow have been prepared and submitted using specific software and hardware systems. Trow makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.



















