CORE Geotechnical Inc.

10 June 2022

Our Ref: 722

722 letter 2022-06-10

Mr. Cam Fox
P.O. Box 847 Garibaldi Highlands, B.C. V0N 1T0

Re: Limited Geotechnical Assessment

Proposed Residence at 6824 Stoney Hill Road, North Cowichan

Dear Sir,

Introduction

At your request, we have carried out a Limited Geotechnical Assessment at the site of a Proposed Residence at 6824 Stoney Hill Road, North Cowichan, British Columbia.

The Municipality of North Cowichan (MNC) may require this report for consideration of a Development Permit.

The site reconnaissance assessment comprised a limited walkover, the results of which are summarized herein, including recommendations for foundations and a landslide assurance statement.

This work was carried out in accordance with our proposal, the Canadian Foundation Engineering Manual and the relevant EGBC Guidelines for "Geotechnical Engineering Services for Building Projects"[1] and "Legislated Landslide Assessments for Proposed Residential Developments in British Columbia"[2].

You provided the following data for this work:

- A set of drawings titled "Permit Copy" for the project "6824 Stoney Hill Rd. Maple Bay" dated May 6, 2021. The drawings were initialed by "D.W.". The sheets in the set include the following:
  - A0.1 "Project Data and General Notes";
  - A1a "Site Plan";
  - A1b "Site Plan";
  - A2 "Foundation Plan Top of Wall Elevations";
  - A3 "Foundation Plan";
  - A4 "Main Floor Plan";

[1] https://www.egbc.ca/app/Practice-Resources/Individual-Practice/Guidelines-Advisories/Document/01525AMW3TOQNN4XY2VREZTQK3GI2GUGNQ/Geotechnical%20Engineering%20Services%20for%20Building%20Projects

[2] https://www.egbc.ca/app/Practice-Resources/Individual-Practice/Guidelines-Advisories/Document/01525AMW2FC5GZAROI4ZBZ7KMIRPIFG7JN/Legislated%20Landslide%20Assessments%20for%20Proposed%20Residential%20Development%20in%20BC

- A5 "Main Floor Plan";
- A6 "Upper Floor Plan";
- A7 "East West Elevation";
- A8 "North South Elevation";
- A9 "Section";
- A10 "Roof Plan";
- A11 "Garage";
- L1 "Landscape Site Plan"; and
- L2 "Landscap (sic) Planting and Lighting Plan".

- A topographic survey plan prepared by Kenyon Wilson. The scale is shown as 1:500 but the plan provided appears to be a PDF of a DXF (or similar).
- Requirements from the MNC (per email from Mr. Rob Conway, P.Eng.). as follows:

"Driveway (full prove-out) required: The alternative option suggested (letter of agreement for driveway access for construction purposes) is not a legally binding agreement and therefore could not be held up in a court of law. In addition the alternative option would not address the future desire to have a separate driveway of your own (subject to DPA-4 and possible DPA-3 guidelines).

- Please proceed with a full prove-out of the driveway, with associated geotechnical review (Professional Report with Design Drawings)
- The professional report must speak to DPA-4 General and Steep Slope guidelines
- The driveway proposed must be sensitive to the natural topography and hydrology regime of the property

Once you have the professional report and drawings (finalized), an updated Environmental Assessment (EA) Report will be required to document the proposed development in its entirety (residence, driveway, septic field, etc.) and any associated impacts to environmentally sensitive areas/features (see DPA-3 guidelines).

- Please have your EA speak to any drainage features observed within 15m of land alterations (as per MNC's Watercourse definition):
  "watercourse" means any natural or man-made channel through which water flows, serving to give direction to a current of water;

  Any feature that can be identified as a "watercourse" (see above) is subject to Section 13(1)(c) requiring a 15m setback

  - Proposed variances to the "watercourse" setback must be sufficiently rationalized
- Please ensure that the updated EA contains realistic/feasible protective measures and actionable recommendations for the restoration of any impacted areas (e.g. hydrology regime, sensitive species, etc.).
- The recommendations must be **detailed** and coincide with the development proposed (residence, driveway, septic field, etc.)
- The DPA-3 EA requirements are outlined here, in order to satisfy applicable DPA-3 guidelines.

Please note; all report(s)/materials must collectively demonstrate the fulfillment of the intentions of the applicable development permit area guidelines."

Site Visit

We visited the site on 9 April, 2022.

Location

The legal address of the property is Lot A Plan VIP51112 Section 3 Range 6 Land District 63. Figure 1, below, shows the location of the lot within the region.

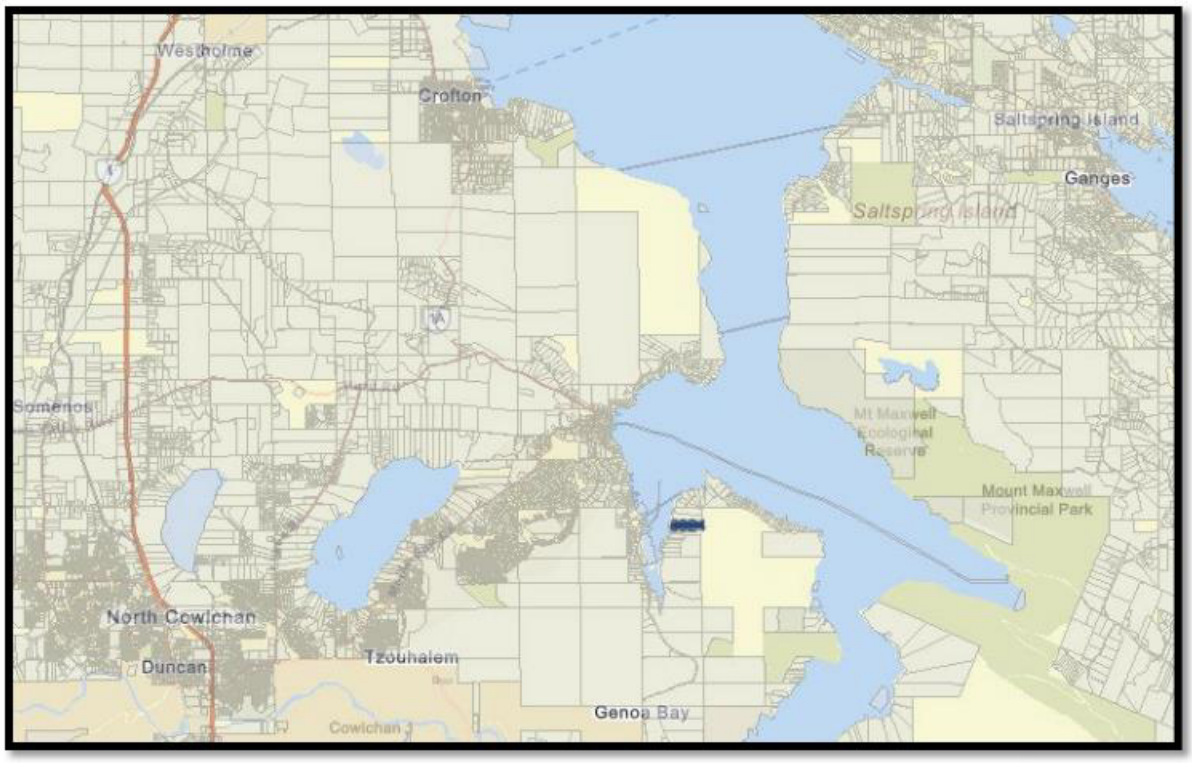


Figure 1: Site Location (From BC Assessments).

Topography

The natural topography may be described as sloping down towards the West from Stoney Hill Road.

The site lies with a "Steep Slope Hazard" Development Permit Area of the Municipality of North Cowichan.

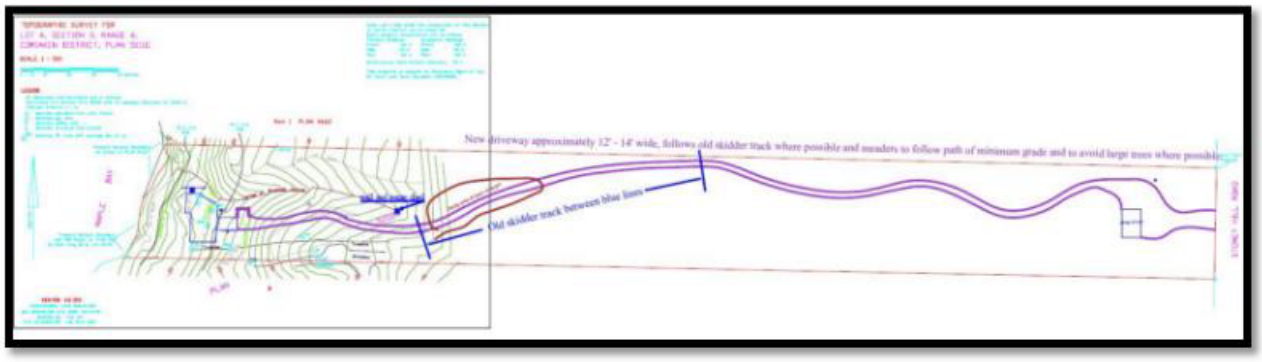


Figure 2: Surface contours (at 1m intervals over part of the site) (from the Topographical Survey Plan provided).

Vegetation

The lot is moderately densely vegetated, as shown on Figures 3 and 4.

Drainage

A small creek (possibly ephemeral) was observed to the in the central part of the site near the proposed residence, flowing towards the West and North-West.

Existing Development

No development currently exists on the site. No logging appears to have taken place within approximately 20 years.

Figure 3: View of part of the steep slope area (sloping at 26° / 50% / 2H:1V). Note forest vegetation.

Figure 4: View of the lower part of the site. The outstretched arm is indicating the location of the proposed residence.

Geology

Reference to published geology maps indicates that the site is underlain by sedimentary rocks of Nanaimo Group, deposited in the Late Cretaceous Period of Geological Time (from about 66 million to about 100 million years ago).

No Quaternary sediments were mapped.

Reference to BC Imap indicates that the soil series at the site comprises Fairbridge, Kulleet and Mill Bay soils. The Soils of Southern Vancouver Island suggests the following:

"Some of these soils may contain 20 to 50% coarse fragments in the upper surficial 25 cm.

There may be a seasonal perched water table.

Some of the soils may contain weakly cemented soil horizons.

They are shallow soils, 50 to 100 cm, over bedrock.

- silt loam marine deposits, Kulleet and Mill Bay soils consist of 50 to 100 cm of silt loam material over coarse-textured subsoil.

- Imperfectly drained, intermittent perched water table.

- Stone free."

No groundwater seepage was observed. It should be noted that groundwater levels and flows are transient, and are affected by such factors as preceding climatic conditions and soil and rock permeability. The published geology also shows a fault striking in the North-West/South-East direction in the vicinity of the site, as shown on Figure 5, overleaf.

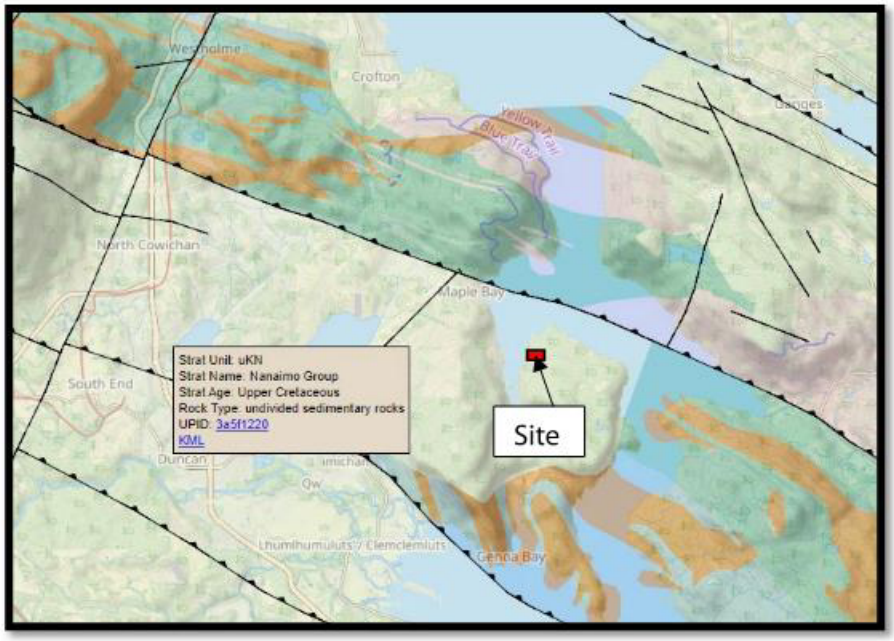


Figure 5: The geology map showing the site approximate location. The strikes of faults are shown around the site. The yellow shading represents the Nanaimo Group rocks.

Evidence of Instability

No evidence of past or incipient instability was observed at the time of the site visit.

Proposed Development

We understand that the proposed development is to comprise a residential building within a proposed subdivision. No further details are known at this stage.

Discussion and Recommendations

Ground conditions

Some outcrops were observed on and near the site, consistent with the published geology.

Based on the mapped geology, which did not show any Quaternary sediments, we anticipate that the ground should comprise rock at shallow depths, overlain by a veneer of dense glacial deposits (e.g. sand, silt and gravel). Softer soils may well be found in low-lying areas and in depressions.

Slope Stability

Building Area – Qualification of Slope Instability Risk

All slopes are unstable in Geological Time. In the assessment of the risk of slope instability, we consider the present climatic conditions and that the extrapolation of those as being representative of the next 50 years as being reasonable. However, the effect of Climate Change is an unknown, although many scientists and engineers believe that these effects may include the likelihood of increased humidity, which could adversely affect slope instability through increased soil pore water pressures. It would be prudent to take cognizance of this with respect to subsurface drainage.

It is possible that ground creep is occurring on the steep slope. Ground creep is a phenomenon where downslope movement occurs within the upper metre of the ground profile closest to the ground surface. Additionally, slope regression will take place over time, and slopes will recede to their angle of repose of about 2H:1V.

On the basis of the results of the field work, we consider that the site of the proposed residence would have a **Low Risk** of slope instability, as defined on the attached "Landslide Risk Assessment" sheet. Therefore, provided that the development is carried out in accordance with the recommendations of this report, we consider that the site is safe for its intended use. A Landslide Assessment Assurance Statement is attached, describing the anticipated hazard and consequence levels for life and property.

Drainage

We recommend that the site is drained and maintained so that storm water and effluent are not permitted to flow over the crest of the steep slope. As mentioned above, due to the possible effects of Climate Change, it would be prudent to provide more drainage capacity than the minimum required at present.

Seismic Hazard

The site seismic hazard calculation is attached. This shows that the Peak Ground Acceleration (PGA) for this site under the action of the design earthquake (1 in 2,475 years) is 0.48g. The Building Code of British Columbia requires that the occupants should have safe egress.

The Site Classification for Seismic Site Response, from Table 4.1.8.4.-A of the British Columbia Building Code, would be Class C, "Very Dense Soil and Soft Rock".

Building Footings

We recommend that the building footings are founded on engineered fill, native soil or undisturbed rock. Footings should not be founded on non-engineered fill.

Footings should be proportioned for the maximum dependable bearing capacity for the relevant design case, as outlined in Table 3, below:

Table 3: Bearing Capacity and Minimum Footing Depth to Mitigate Frost Heave

Foundation Material	Bearing Capacity for Design Case (kPa)		Minimum Footing Depth (m)
	Ultimate Limit State	Serviceability Limit State	
Rock	750	500	0
Engineered Fill or Native Soil	225	150	0.45

The foundation conditions should be confirmed by a geotechnical engineer prior to pouring concrete (and preferably before placing reinforcement).

Site Preparation Measures

We suggest that the following measures would be appropriate for preparation of the site for building and road construction.

- Install temporary and/or permanent drainage so that excavations do not become saturated.
- Excavate to design level in areas of cut;
- In fill areas, request a geotechnical engineer to confirm that the exposed foundation material does not contain obvious soft or loose zones; then place approved fill material in layers not exceeding 200mm loose thickness, and compact with appropriate compacting equipment to the satisfaction of the geotechnical engineer. No fill shall be placed when the fill material or subgrade is wet or frozen.

Earthworks

We expect that some earthworks will be required for the development of this site. The following recommendations should be observed:

1. Cuts are not to exceed 1.2m height without specific engineering comment, which may include recommendations for support.
2. Cuts should be limited to a maximum height of 3m.
3. Cut slopes in soil are not to exceed 1V:2H without specific engineering appraisal during construction, and should be protected against erosion and covered with appropriate vegetation or else supported by an engineer-designed retaining wall.
4. Cut slopes in Rock are not to exceed 1V:1H or 1.2m height without specific engineering comment.
5. Fill should not exceed 1.5m depth.
6. Fill slopes should not exceed 1V:3H, and should be protected against erosion and covered with appropriate vegetation or else supported by an engineer-designed retaining wall and protected against erosion.
7. Fill placed for the support of buildings and services should be placed in accordance with the Site Preparation Measures, and would then be regarded as "engineered fill".

Retaining Walls

Retaining walls, if required, should be designed in accordance with the Engineers and Geoscientists of BC "Retaining Wall Design[3]" Guidelines.

We would be pleased to provide lateral earth pressures for retaining walls and shoring at your request. We would need to be provided with the proposed building plans and cross-sections for this purpose.

The engineering properties of the soil, for the purposes of lateral earth pressure calculations, would be as follows:

Table 4: Soil Properties for Lateral Earth Pressure Calculations

Soil Property	Design Value
Angle of Internal Friction, ϕ'	35°
Effective Soil Cohesion, c'	0kPa
Dry Density, γ'	19kN/m^3

All retaining structures should be provided with adequate drainage.

Further Geotechnical Engineering

It is possible that a regulatory authority (e.g. MNC) may require a geotechnical engineer to provide a letter of assurance for Construction Review. If this is the case, then we will need to be engaged to prepare a British Columbia Building Code Schedule B, and you will need to provide us with your design drawings, the relevant geotechnical requirements, Building Permit (including the BP number), and your proposed construction schedule.

We request a minimum of 24 hours' notice prior to attending the site. Following satisfaction with the construction monitoring, we would prepare a BC Building Code Schedule C-B.

Should a different building be proposed than that for which this report was prepared, or if a building is to be located elsewhere on the lot, then further geotechnical input may be required.

You should immediately advise us should subsurface conditions be encountered during construction that vary from those anticipated by this report.

Closure

This report has been prepared for our client, Mr. Cam Fox, for the specific purpose of addressing the concerns and requirements of the MNC. Notwithstanding the above, our client may use the report to support Building Permit and Development Permit Applications. It is possible, however, that the relevant authorities may require updates and / or confirmations, as conditions can change over time.

[3] https://www.egbc.ca/app/Practice-Resources/Individual-Practice/Guidelines-Advisories/Document/01525AMWY4Z2M2MLWMPBFIY35PONDMBKJR/Retaining%20Wall%20Design

Core Geotechnical Inc:

- acknowledges that MNC and its Approving Officer(s) may rely upon the Report when making a decision on the application for the development of the land;
- acknowledges that the MNC, its Approving Officer(s) may rely upon the Report when making a decision on the application for the building on the land; and
- states that the land is safe for the use intended with the probability of a geotechnical failure resulting in property damage of less than 10 percent (10%) in 50 years; with the exception of geohazards due to a seismic event which are based on a 2 percent (2%) probability of exceedance in 50 years.

We trust that this meets your present requirements. Should you have any questions, please do not hesitate to contact the undersigned at your earliest convenience.

Yours truly,

Core Geotechnical Inc.

Bruce Grayson, P.Eng.
Director 2022-06-10

Attach:

I. General Notes
II. Landslide Risk Assessment Sheet
III. Landslide Assurance Statement
IV. Seismic Hazard Calculation

GENERAL NOTES

This report comprises the results of a site investigation carried out in accordance with normally-accepted methods for a specific purpose and client as defined in the introductory section(s) of the document. The report should not be used by other parties or for other purposes without prior consultation with this firm, as it might not contain adequate or appropriate information for extrapolation.

LOGGING

The information on the Logs (Test Bores, Test Holes, Natural Exposures etc.) has been based on a visual and tactile assessment except at the discrete locations where test information has been reported (eg field and/or laboratory results).

Reference should be made to our standard sheets for the definition of our logging procedures (Soil and/or Rock Descriptions, as appropriate).

GROUNDWATER

Unless otherwise indicated, the water levels given on the logs are the levels of free water or seepage in the test hole recorded at the given time of measuring. The measured ground water level may be affected by the method of investigation (for example, if rotary drilling is utilised, drilling fluids will be pumped into the ground).

The actual groundwater level may differ from the recorded level depending on material permeabilities. Further variations of this level could occur with time due to such effects as seasonal and tidal fluctuations or construction activities. Final confirmation of levels can only be made by appropriate instrumentation techniques and programmes.

SAMPLING

Samples extracted during the fieldwork phase of a site investigation may be 'disturbed' or 'undisturbed' (as indicated on the logs) depending on the intended mature and purpose of the sample as well as the practicable method of extraction, transportation, extrusion and testing. This aspect should be taken into account when assessing test results which must of necessity reflect the effects of such disturbance.

Generally, 'disturbed' samples would be suitable for visual identification, moisture content determination, Atterberg Limits testing, compaction and California bearing ratio (CBR) testing, amongst others.

The amount sampled is also a limiting factor in the suitability for testing purposes, for example, a minimum of 10 kg is necessary for compaction and CBR testing.

'Undisturbed' samples are normally necessary for laboratory testing such as shrink-swell tests. These samples are obtained by pushing a thin-walled, mild steel tube with a machined cutting edge into the soil, and extracting the assembly. The soil (normally of nominal 50 mm diameter) is extruded at the laboratory prior to testing.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with appropriate standards (or specific ones, if requested). All testing will be carried out in a sub-contracted laboratory. Where tests are used which are not covered by standard procedures, details are given in the report.

All soil properties (as measured by laboratory testing) exhibit inherent variability and thus a certain statistical number of tests is required in order to predict an average property with any degree of confidence. The site variability of soil strata, future changes in moisture and other conditions and the discrete sampling positions must also be considered when assessing the representative nature of the laboratory programme.

Certain laboratory tests provide interpreted soil properties as derived by conventional mathematical procedures. The applicability of such properties to engineering design must be assessed with due regard to the site, sample condition, procedure and the proposed development.

INTERPRETATION OF RESULTS

The discussion and any recommendations contained within this report are normally based on a site evaluation from discrete test hole data. Generalised or idealised subsurface conditions (including any cross-sections contained in the report)have been assumed or prepared by interpolation and /or extrapolation of these data. As such, these conditions are an interpretation and must be considered as a guide only.

CHANGE IN CONDITIONS

Local variations or anomalies in the generalised ground conditions used for this report can occur, particularly between discrete test hole locations. Furthermore, certain design or construction procedures may have been assumed in assessing the soil-structure interaction behaviour of the site. Any change in design, in construction methods, or in ground conditions as noted during construction, from those assumed in this report should be referred to this firm for appropriate assessment and comment.

FOUNDATION DEPTH

Where referred to in the report, the recommended depth of any foundation (piles, caissons, footings, etc.) is an engineering estimate of the depth to which they should be constructed. The estimate is influenced and perhaps limited by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The depth remains, however, an estimate and therefore liable to variation. Foundation drawings, designs and specifications based upon this report should provide for variations in the final depth depending upon the ground conditions at each point of support.

REPRODUCTION OF REPORTS

Where it is desired to reproduce the information contained in this report for the inclusion in the contract documents or engineering specification of the subject development, such reproduction shall include all of the report, including appendices (if any).

SOIL DESCRIPTION

Core Geotechnical Inc. describes a soil in terms of its visual and tactile properties. This sheet is intended to complement test logs and, relates to field samples and exposures as applicable. The description involves an evaluation of each of the items listed below and is in general agreement with the Canadian Foundation Engineering Manual.

SOIL TYPE

The soil type is described according to its estimated grain size composition and the tactile behaviour (plasticity) of fines (silt and clay fraction). The following table provides a guideline for the basis of the soil description:

Soil Classification	Particle Size
Silt and Clay (differentiated by Atterberg Limits Tests)	< 0.06 mm (the 0.075 mm sieve size is commonly used in practice)
Sand	0.06 - 0.2 mm (fine), 0.2 - 0.6 mm (medium), 0.6 - 2 mm (coarse)
Gravel	2 - 6 mm (fine), 6 - 20 mm (medium), 20 - 60 mm (coarse)
Cobble	60 - 200 mm
Boulder	> 200 mm

Where a soil contains one main soil type with up to 5% of a secondary soil type, it is described as having a trace of the secondary soil type. Similarly, if the proportion of the secondary soil type is within the range of 5 - 12%, it is described as having some of the secondary soil type. If the soil has 12 - 50% of the secondary soil type, the secondary soil type is used as an adjective in the description, eg Sandy CLAY, where the main soil type is clay, with up to 50% sand by weight. A soil with, say, 20% gravel, 30% sand and 50% clay would be described as a Gravelly Sandy CLAY.

STRENGTH (CONSISTENCY/RELATIVE DENSITY)

This assessment is based on the effort required to penetrate and/or mould the soil, and is an indicator of the shear strength.

Granular soils are generally described in terms of relative density (density index) as listed in the Canadian Foundation Engineering Manual. These soils are inherently difficult to assess, and normally a penetration test procedure (SPT or CPT) is used in conjunction with published correlations. Alternatively, in-situ density tests may be carried out in conjunction with minimum and maximum density (laboratory) tests.

Cohesive soils can be assessed by direct measurement (eg shear vane, pocket penetrometer [shown as PP* on the logs]) or estimated approximately by tactile means and/or the aid of a geological pick as given in the following table. It is emphasised that a 'design' shear strength must take cognisance of the in-situ moisture content and the possible variation of moisture with time, climate, and other factors.

Term	Tactile Properties	Unconfined Compressive Strength, q_u (kPa)
Very Soft	Extrudes from fingers without difficulty. Soil may tend to flow.	<25
Soft	Extrudes from fingers when squeezed.	25 -50
Firm	Thumb may penetrate with moderate effort. Moulded by light finger pressure.	50 - 100
Stiff	Moulded by moderate finger pressure.	100 - 200
Very Stiff	Moulded by strong finger pressure.	200 - 400
Hard	Depending on moisture condition, may be moulded by very strong finger pressure or may tend to	>400
Friable	Soil is sugary, or crumbles without meaningful result on a pocket penetrometer.	

MOISTURE

The moisture condition of the soil is most applicable for cohesive soils as an aid to the assessment of consistency and workability. The moisture condition may be related to the estimated plastic limit (Wp or PL) eg m<Wp where the soil is assessed as being drier than the estimated plastic limit (In the field, this is often assessed by an inability for the soil to roll out into threads of 3 mm diameter.); m=Wp where the soil is assessed as being approximately at the plastic limit, ie it may just be rolled out into threads of 3 mm diameter; and m>Wp, where the soil is assessed as being wetter than the plastic limit (ie the soil is able to be rolled into threads of less than 3 mm diameter).

Non-cohesive soils may be described as being either Dry (dusty, dry to the touch), Moist (damp, no visible water) or Wet (visible free water, saturated condition). Ground water observations are noted on all test logs.

COLOUR

Colour may be an aid to the correlation of data between test locations and for subsequent excavation operations. The prominent colour is noted, followed by (mottled, streaked, stained etc) secondary colours as applicable. Colour is usually described at field moisture condition, however, both wet and dry colours may be recorded.

OTHER TERMS

Some other terms which the layperson may not be familiar with might be used in the description of a soil. In most cases these would be referenced in The Canadian Foundation Engineering Manual. Some of the more common of these terms are outlined below:

Fill - soil which has not been laid down by nature, ie it has been man-made.
Till - natural soil compacted and abraded under the weight and movement of a glacier.
Alluvium - natural soil laid down in streams, lakes, estuaries, dunes etc.
Residual - soil derived from rock weathered in-situ
Colluvium - soil deposited by natural transport down a slope (also called slopewash)
Talus- debris such as cobbles and boulders, generally at the toe of a slope
Glacio-Marine – soil deposited in a marine environment beneath a glacier

ROCK DESCRIPTION

Core Geotechnical Inc. describes a rock based on methods described in the Canadian Foundation Engineering Manual, together with local practice. This sheet is intended to complement test logs, and relates to cored rock, field samples and exposures as applicable. The description involves an evaluation of each of the items listed below and is in general agreement with the Canadian Foundation Engineering Manual.

ROCK TYPE

The rock type is described according to its assessed origin (ie sedimentary, igneous volcanic/hypabyssal, pyroclastic, igneous plutonic, and metamorphic) and estimated grain (crystal, clast, phenoclast etc) size composition. The following table provides a guideline for the basis of the rock type description:

SEDIMENTARY			IGNEOUS					METAMORPHIC
Clastic	Non-Clastic *Chemical*	Non-Clastic *Organic*		Acid	Intermediate	Basic	Pyroclastic (e.g. Ash / Bombs)	
Conglomerate Sandstone Siltstone Claystone Shale	Limestone Chert Gypsum	Coal	**Volcanic** (e.g. Lava) *Fine Grained*	Rhyolite	Trachyte	Basalt	Agglomerate Volcanic Breccia Tuff	Grade: Low ⇒ High Gneiss Quartzite Schist Slate Phyllite
			Hypabyssal (e.g. Sill) *Medium Grained*	Porphyry: Quartz/Orthoclase	Porphyry: Plagioclase	Dolerite		
			Plutonic (e.g. Batholith) *Coarse Grained*	Granite	Syenite, Diorite	Gabbro		

SEDIMENTARY ROCKS

Sandstone and Conglomerate are defined as rocks containing more than 50% of sand sized grains and gravel sized fragments, respectively. Similarly, Claystone and Siltstone are defined as rocks containing more than 50% of clay or sericitic material, and silt sized granular particles, respectively, AND where the rock is not laminated. Laminated rocks containing more than 50% of clay and/or silt sized particles are defined as shale. Rocks possessing characteristics of two groups are described by their predominant particle size with reference also to the minor constituents, eg clayey sandstone, sandy shale.

STRENGTH

This assessment refers to the strength of the rock substance, not the strength of the rock mass. The strength of the rock substance is estimated by the Point Load Strength Index $I_{s(50)}$ and normally refers to the average of the strength measured in the direction perpendicular to the bedding, and the strength measured parallel to the bedding, for sedimentary rocks. The table below describes the strength classifications used by this firm:

Term	Abbr.	Field Guide	$I_{s(50)}$ (MPa)
Extremely Low	EL	Easily remoulded by hand to a material with soil properties.	<0.03
Very Low	VL	May be crumbled in the hand. Sandstone is "sugary" and friable.	<0.1
Low	L	The core* may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	<0.3
Medium	M	The core* can be broken by hand with considerable difficulty. Readily scored with knife.	<1
High	H	The core* cannot be broken with unaided hands, can be slightly scratched or scored with knife.	<3
Very High	VH	The core* cannot be broken readily with hand held hammer. Cannot be scratched with pen knife.	<10
Extremely High	EH	The core* is difficult to break with hand held hammer. Rings when struck with a hammer.	>10

*A piece of core 150 mm long and 50 mm diameter

WEATHERING

The assessment of weathering does not imply engineering behaviour, however it may assist in identification. No distinction is drawn between chemical weathering and alteration for most engineering purposes. These procedures are collectively described as weathering using the following terms which do not describe the related strength change. Carbonate rocks may not necessarily conform to this classification.

Term	Abbreviation	Definition
Extremely Weathered	EW	The rock exhibits soil-like properties though the texture of the original rock is still evident.
Highly Weathered	HW	Limonite staining or colour change affects the whole of the rockmass and other signs of chemical or physical decomposition are evident.
Moderately Weathered	MW	Staining extends throughout the whole of the rockmass and the original colour is no longer recognisable.
Slightly Weathered	SW	Partial staining or discolouration of the rockmass, usually by limonite, has taken place.
Fresh	Fr	Rockmass unaffected by weathering.

FRACTURING and BEDDING

These important features can control the overall behaviour of a rockmass. All types of natural fractures across which the core is discontinuous are noted. These fractures include bedding plane partings, joints and other defects but exclude artificial fractures such as drilling breaks. The nature of the defects (joints, partings, seams, zones and veins) is also noted with description, orientation, infilling or coating, shape, roughness, thickness, etc. given generally in accordance the Canadian Foundation Engineering Manual. The spacing of natural fractures excludes bedding partings unless there is evidence that they were separated prior to drilling. This notwithstanding, bedding partings may be considered planes of weakness in an engineering assessment.

Term	Description
Fragmented	The core is comprised primarily of fragments of length less than 20 mm, and mostly of width less than the core diameter.
Highly Fractured	Core lengths are generally less than 20 - 40 mm with occasional fragments.
Fractured	Core lengths are mainly 30 mm - 100 mm with occasional shorter and longer sections.
Slightly Fractured	Core lengths are generally 300 mm - 1 m with occasional longer sections and occasional sections of 100 mm - 300 mm.
Unbroken	The core does not contain any fractures.

Bedding Spacing may be described based on the thickness of the layering, as follows:

Thinly Laminated	Laminated	Very Thinly Bedded	Thinly Bedded	Medium Bedded	Thickly Bedded	Very Thickly Bedded
<6mm	6mm - 20 mm	20mm - 60 mm	60mm - 200 mm	200mm - 600 mm	600mm - 2 m	> 2m

LANDSLIDE RISK ASSESSMENT

Landslide assessments for Residential developments are carried out in accordance with the APEGBC document "Guidelines for Legislated Landslide Assessments for Proposed Residential Developments in BC".

Definitions for qualitative assessments are as follows:

Qualitative Measures of Likelihood

Level	Descriptor	Description	Indicative Annual Probability
A	Almost Certain	The event is expected to occur	$>\sim10^{-1}$
B	Likely	The event will probably occur under adverse conditions	$\sim10^{-2}$
C	Possible	The event could occur under adverse conditions	$\sim10^{-3}$
D	Unlikely	The event might occur under very adverse circumstances	$\sim10^{-4}$
E	Rare	The event is conceivable but only under exceptional circumstances	$\sim10^{-5}$
F	Not Credible	The event is inconceivable or fanciful	$\sim10^{-6}$

Note: "~" means that the indicative value may vary by, say, ± ½ of an order of magnitude, or more.

Qualitative Measures of Consequence to Property

Level	Descriptor	Description
1	Catastrophic	Structure completely destroyed or large-scale damage requiring major engineering works for stabilisation
2	Major	Extensive damage to most of structure, or extending beyond site boundaries requiring significant stabilisation works.
3	Medium	Moderate damage to some of structure, or significant part of site requiring large stabiliization works.
4	Minor	Limited damage to part of structure, or part of site requiring some reinstatement/stabilization works.
5	Insignificant	Little damage

Qualitative Risk Analysis Matrix – Level of Risk to Property

Likelihood	Consequences to Property				
	1: Catastrophic	2: Major	3: Medium	4: Minor	5: Insignificant
A – Almost Certain	VH	VH	H	H	M
B - Likely	VH	H	H	M	V-M
C - Possible	H	H	M	L-M	VL-L
D - Unlikely	M-H	M	L-M	VL-L	VL
E - Rare	L–M	L-M	VL-L	VL	VL
F – Not Credible	VL	VL	VL	VL	VL

Risk Level Implication

Risk Level		Example Implications
VH	Very High Risk	Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to acceptable levels; may be too expensive and not practical.
H	High Risk	Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable levels.
M	Moderate Risk	Tolerable provided treatment plan is implemented to maintain or reduce risks. May be accepted. May require investigation and planning of treatment options.
L	Low Risk	Usually accepted. Treatment requirements and responsibility to be defined to maintain or reduce risk.
VL	Very Low Risk	Acceptable. Manage by normal slope maintenance procedures.

Note:
(1) the implications for a particular situation are to be determined by all parties to the risk assessment; these are only given as a general guide.
(2) Dual descriptors for Likelihood, Consequence and Risk may be used to reflect the uncertainty of the estimate in particular cases.

CORE Geotechnical Inc.

LANDSLIDE ASSESSMENT ASSURANCE STATEMENT

Note: This Statement is to be read and completed in conjunction with the *"APEGBC Guidelines for Legislated Landslide Assessments for Proposed Residential Development in British Columbia"*, March 2006/Revised September 2008 (*"APEGBC* Guidelines") and the "2012 BC Building Code (BCBC 2012)" and is to be provided for *landslide assessments* (not floods or flood controls) for the purposes of the Land Title Act, Community Charter or the Local Government Act. Italicized words are defined in the *APEGBC* Guidelines.

To: The *Approving Authority*
Municipality of North Cowichan

Date: Friday, June 10, 2022

With reference to:

- ☒ Land Title Act (Section 86) - Subdivision Approval
- ☒ Local Government Act (Sections 919.1 and 920) - Development Permit
- ☒ Community Charter (Section 56) - Building Permit
- ☐ Local Government Act (Section 910) Flood Plain Bylaw Variance
- ☐ Local Government Act (Section 910) Flood Plain Bylaw Exemption
- ☐ British Columbia Building Code 2012 Sentences 4.1.8.17 and 9.4.4.4.(2)

For the Property: Lot A Plan VIP51112 Section 3 Range 6 Land District 63., 6824 Stoney Hill Road, North Cowichan, BC

The undersigned hereby gives assurance that he/she is a *Qualified Professional* and is a *Professional Engineer* or *Professional Geoscientist*.
I have signed, sealed and dated, and thereby certified, the attached *landslide assessment* report on the property in accordance with the *APEGBC Guidelines*. The report must be read in conjunction with this statement. In preparing that report I have:

Check to the left of applicable items

- ☒ 1. Collected and reviewed appropriate background information
- ☒ 2. Reviewed the proposed *residential development* on the Property
- ☒ 3. Conducted fieldwork on and, if required, beyond the Property
- ☒ 4. Reported on the results of the fieldwork on and, if required, beyond the Property
- ☒ 5. Considered any changed conditions on and, if required, beyond the Property
- 6. For a *landslide hazard analysis* or *landslide risk analysis* I have:
  - ☒ 6.1. reviewed and characterized, if appropriate, any *landslide* that may affect the property
  - ☒ 6.2. estimated the *landslide* hazard
  - ☒ 6.3. identified existing and anticipated future *elements at risk* on and, if required, beyond the Property
  - ☒ 6.4. estimated the potential consequences to those elements at risk
- 7. Where the *Approving Authority* has adopted a *level of landslide safety*, I have:
  - ☐ 7.1. compared the *level of landslide safety* adopted by the *Approving Authority* with the findings of my investigation
  - ☐ 7.2. made a finding on the *level of landslide safety* on the Property based on the comparison
  - ☐ 7.3. made recommendations to reduce *landslide hazards* and/or *landslide risks*
- 8. Where the Approving Authority has **not** adopted a level of landslide safety, I have
  - ☒ 8.1. described the method of *landslide hazard analysis* or *landslide risk analysis* used

☒ 8.2. referred to an appropriate and identified provincial, national or international guideline for *level of landslide safety*
☒ 8.3. compared this guideline with the findings of my investigation
☒ 8.4. made a finding on the *level of landslide safety* on the Property based on the comparison
☒ 8.5. made recommendations to reduce *landslide hazards* and/or *landslide risks*
☒ 9. Reported on the requirements for future inspections of the property and recommended who should conduct those inspections

Based on my comparison between

Check one
☐ the findings from the investigation and the adopted *level of landslide safety* (item 7.2 above)
☒ the appropriate and identified provincial, national or international guideline for *level of landslide safety* (item 8.4 above)

I hereby give my assurance that, based on the conditions[1] contained in the attached landslide assessment report,

☐ for subdivision approval, as required by the Land Title Act (Section 86), "that the land may be used safely for the use intended"
  ☐ With one or more recommended registered covenants
  ☐ Without any registered covenant.

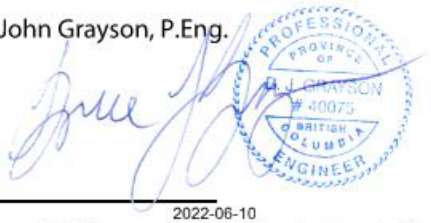
☒ for a development permit, as required by the Local Government Act (Sections 919.1 and 920), my report will "assist the local government in determining what conditions or requirements under [Section 920] subsection (7.1) it will impose in the permit".

☒ for a building permit, as required by the Community Charter (Section 56), "the land may be used safely for the use intended"
  ☐ With one or more recommended registered covenants
  ☒ Without any registered covenant.

☐ for flood plain bylaw variance, as required by the "Flood Hazard Area Land Use Management Guidelines" associated with the Local Government Act (Section 910), "the development may occur safely".

☐ for flood plain bylaw exemption, as required by the Local Government Act (Section 910), "the land may be used safely for the use intended".

Name: Bruce John Grayson, P.Eng. Date: Friday, June 10, 2022

Signature: 

2022-06-10

[1] When seismic slope stability assessments are involved, level of landslide safety is considered to be a "life safety" criterion as described in the National Building Code of Canada (NBCC 2010), Commentary on Design for Seismic Effects in the User's Guide, Structural Commentaries, Part 4 of Division B. This states:

"The primary objective of seismic design is to provide an acceptable level of safety for building occupants and the general public as the building responds to strong ground motion; in other words, to minimize loss of life. This implies that, although there will likely be extensive structural and non-structural damage, during the DGM (design ground motion), there is a reasonable degree of confidence that the building will not collapse nor will its attachments break off and fall on people near the building. This performance level is termed 'extensive damage' because, although the structure may be heavily damaged and may have lost a substantial amount of its initial strength and stiffness, it retains some margin of resistance against collapse".

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 48.899N 123.606W **User File Reference:** 6824 Stoney Hill Rd, Maple Bay 2022-06-10 21:10 UT

Requested by: Mr. Bruce J. Grayson, P.Eng., Core Geotechnical Inc.

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.583	0.423	0.313	0.141
Sa (0.1)	0.892	0.650	0.478	0.216
Sa (0.2)	1.113	0.811	0.600	0.267
Sa (0.3)	1.141	0.831	0.614	0.268
Sa (0.5)	1.030	0.738	0.532	0.221
Sa (1.0)	0.587	0.402	0.278	0.105
Sa (2.0)	0.350	0.232	0.155	0.055
Sa (5.0)	0.109	0.062	0.035	0.011
Sa (10.0)	0.038	0.022	0.012	0.004
PGA (g)	0.484	0.352	0.260	0.115
PGV (m/s)	0.748	0.512	0.357	0.134

Notes: Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information