- Lot “A” -

Revised Application for Rezoning

City of Courtenay

Appendix D

Geotechnical Report

- Terran Geotechnical Consultants Ltd. -

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Project No.: 5074

Geotechnical Investigation Report

Proposed of Subdivision at 2602 Copperfield Road, Courtenay B.C.

Submitted to:

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Table of Contents

1.0 INTRODUCTION

Terran Geotechnical Consultants Ltd. (TerranGeo) has completed this *Geotechnical Investigation for the Proposed of Subdivision at 2602 Copperfield Road, Courtenay B.C.* Its legal lot description is provided in table 1 below. The purpose of the investigation was to identify the potential geotechnical hazards, subsurface soil and groundwater conditions, and to prepare geotechnical recommendations for site development, foundation design, including excavation, bearing capacity and settlement.

This report has been prepared in accordance with the standard geotechnical engineering principles and practices of similar projects in this region. The following government documents and publications were considered as part of this geotechnical report:

- 2012 British Columbia Building Code (BCBC 2012);
- Land Title Act Section 86 – Subdivision Approval;
- Development Application Procedures Bylaw No. 2790, 2014; and
- Subdivision Control Bylaw No.1401.

In summary, as per section 86 of the Land Title Act, this report finds there are no geotechnical issues that would prevent development of the subject property noted above. The proposed subdivision of the subject property may be safely used for its intended purpose.

Table 1 – Legal Lot Descriptions

Legal Description
REM. A, PLAN 2607, D.L. 138, COMOX DIST.

2.0 PROJECT DESCRIPTION

It is our understanding that the proposed site development consists of road construction and subdividing the lots for single family dwelling use. TerranGeo has reviewed the site plan prepared by *Current Environmental dated March 2016* and is attached to this report in Appendix A. From the site plan, it is understood that the site is located adjacent to multiple wetlands. The total project set is approximately 70,000 m^2 (about 753,000 ft^2) with approximately 525m by 90m dimensions. A total of 52 single family dwelling lots are proposed. The location and general layout of the site are illustrated in the attached figures in Appendix A.

3.0 SCOPE OF WORK

TerranGeo's scope of work includes:

- Background study to review geographical maps, and subdivision permitting requirements;
- Geotechnical subsurface soil investigation;
- Summary of the geotechnical investigation results including subsurface stratigraphy and groundwater conditions; and
- Recommendations regarding suitability of the site, soil bearing capacity and stripping depth requirements.

4.0 METHODOLOGY

TerranGeo had performed a background study in preparation of the site investigation work. The background study involved reviewing surficial geology maps, and accessing available geographic information system (GIS) data, and referencing previous experience in the area. A site investigation was coordinated with JR Edgett Excavation Ltd and performed on March 17,2 017. The investigation consisted of advancing a total of four (4) test pits utilizing a tracked excavator, two (2) auger holes using hand equipment and a Dynamic Cone Penetration Test (DCPT). The test pits were advanced to a depth between 0.6m and 2.1m as measured from the existing ground. The excavated soils were visually logged and classified on site. Soil samples were obtained for additional laboratory testing and assessment.

The locations of the test pits are illustrated in Figure 1 in Appendix A.

5.0 SITE DESCRIPTION

5.1 GENERAL TOPOGRAPHY

The subject property is located adjacent to Piercy Creek in Courtenay B.C. The site is bounded by a open trail route towards the southwest, and an undeveloped wetland and a dense woodland area is located towards the northwest. An existing development is located towards the northeast, and lastly new development area we under construction towards the southeast.

The site is covered with medium growth coniferous and deciduous trees. The site is covered with a foliage overburden. There are identified wetland areas in each corner of the subject property except for the southwest corner. Piercy Creek flows from the south west corner towards the north east corner of the subject property. The site grades are relatively flat with a gentle slope of less than 10% gradient. In general, the site is sloped down towards the northeast corner of the subject property.

5.2 SUBSURFACE AND GROUNDWATER CONDITIONS

Table 2 describes the general subsurface soil conditions. Detailed soil logs are provided in Appendix B.

Table 2 – General Site Soil Stratigraphy

Approx. Depth Below Existing Grade			**Soil Unit**
From		To	
0.0 m	to	0.15 m	SAND (TOPSOIL) – silty, organics foliage and roots, very loose to loose, moist, black
0.15 m	to	0.9 m	SAND – silty, some cobbles, trace gravel, loose to compact, moist to wet, reddish brown
	> 0.9 m		SILT (TILL-LIKE) – sandy, trace gravel, trace cobbles, trace clay, very stiff to hard, compressed, cemented, dry, light brown

The soil conditions are supported by published surficial geology maps and our understanding of the surficial geology of the area. The soils represent the regional till that consist of glacial deposited clay, silt, sand, gravel and cobbles. Groundwater seepage was noted entering the test pit excavations above the sandy silt till like interface approximately 0.9m below the ground surface.

The till like layer is nearly hydraulically impervious, and it is expected that the groundwater is perched and the water table is deeper in depth. The perched groundwater is expected to be present through the site to an approximate depth of 0.6 to 0.9m below the existing grade. Given the shallow depth of the till-like layer and the degree of saturation presented at the time of the investigation, percolation testing was omitted. Based on published literature the estimated percolation rates are between 1.0×10^{-3} to 10^{-2} mm/s for silty sand, and between 1.0×10^{-8} to 10^{-6} mm/s for the till-like soils.

6.0 DISCUSSION AND RECOMMENDATIONS

Based on our experience and site investigation, it is our opinion that subject property are suitable for subdivision site development for typical lightly loaded residential dwellings. The proposed development is geotechnically feasible and the land can be used safely for their intended purposes with provided that the recommendations covered below are followed.

6.1 SEISMICITY

The site classification for the property is 'C' – very dense soil and soft rock according to the 2012 B.C. Building Code and based on the soil undrained shear strength S_u > 100 kPa typically for the very dense sand and silt till observed within the upper layer in the site investigation. As interpolated from the 2015 National Building Code Seismic Hazard Calculation for the coordinates 49.669° N, 125.013° W with a 2% in 50 years probability of exceedance, the Peak Ground Acceleration can be taken as 0.548. A detailed summary of the spectral acceleration response values are provided in Appendix A of this report.

The acceleration and velocity based site coefficients, F_a and F_v, may both be taken as 1.0. There is negligible probability of liquefaction of the subgrade at this site during the design earthquake due to a low water table and the soil conditions.

6.2 ON-SITE PAVEMENT STRUCTURE

All fill, topsoil and loose soils should be removed, before placing the pavement structure. Pavement Subgrade is to be approved by the geotechnical engineer prior to placement of structural fill material. The following minimum pavement section for the onsite pavement road is provided below:

Table 3 – Minimum Pavement Structure

Road Designation	**Minimum Road Structure** (Lift Thickness)	(Material Type)
Local Road	75 mm	MMCD Upper Course #1
	100 mm	MMCD 25 mm minus crushed granular base
	200 mm	MMCD 75 mm minus crushed granular sub base
	Approved subgrade fill or approved native subgrade	

All granular and asphalt material should meet the requirements provided in the MMCD specifications. The granular base and sub base layers shall be compacted to a minimum of 95% of the material's Modified Proctor Maximum Dry Density[1] (MPMDD) value in compacted lifts no thicker than 300 mm. Subgrade soil should be excavated neat and should not be compacted unless otherwise directed by the geotechnical engineer. Placement of the granular construction material shall be placed as soon as possible to protect

1 (ASTM D1557) - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m3))

the native subgrade. Any disturbed or water soften subgrade soils should be removed prior to placement of structural fill material.

6.3 Foundation Design

The native subgrade soils at this site are competent to support the footing and floor loads associated with typical lightly-loaded buildings on conventional shallow strip footings. Footings should be designed in accordance with the 2012 B.C. Building Code and the minimum recommendations described below. Footings should be designed for equal contact pressure of nearly equal sizes to minimize potential total and differential settlement. Adjacent footings placed at different elevations should be constructed no closer than and be stepped at no more than a line projected at 2H:1V from the lower footing. Footings should be placed at least 450 mm below the finished ground surface for frost protection.

For the purpose of foundation design, the unfactored ultimate bearing capacity, factored Ultimate Limit State (ULS) design and Serviceability Limit State (SLS) design values are presented in Table 4. In accordance with the published Canadian Foundations Manual, a geotechnical resistance factor (ϕ) of 0.5 is recommended to be applied to the unfactored loads in determining the factored ULS bearing capacity. The presented maximum allowable soil bearing pressure presented in Table 4 may be used for the design of footings. This SLS is based on an estimated post-construction total settlement of less than 25mm with a differential settlement of less than 12.5mm of a horizontal distance of about 10m.

TABLE 4 – BEARING CAPACITY DESIGN VALUES

Bearing Capacity	psf	kPa (Approx.)
Unfactored Ultimate Bearing Capacity	6000	300
Factored Ultimate Limit State (ULS) Design	3000	150
Factored Serviceability Limit State (SLS) Design	1500	75

6.4 Foundation and Retaining Wall Lateral Earth Pressures

Basement walls and retaining walls should be adequately designed to resist the lateral earth pressures acting on them. Lateral loadings on foundation walls have been provided for a number of situations. Coefficients have been provide for At-Rest Pressure (K_O), Active Pressure (K_A), and Passive Pressure (K_P). Coulomb's theory was used to calculate the active and passive pressures, while a Mononobe-Okabe solution was used to calculate an earthquake induced active pressure. The following table lists the lateral earth pressures coefficients that should be used for the design of basement and/or retaining walls using the 'equivalent fluid pressure' method (unit weight).

TABLE 5 – LATERAL EARTH PRESSURES COEFFICIENTS

Pressure Coefficient	Symbol	Value
At-Rest Pressure	K_O	0.5
Active Pressure	K_A	0.3
Passive Pressure	K_P	3.0
Active Seismic Pressure	ΔK_{AE}	0.21

All coefficients were determined assuming a level, free draining backfill, with a unit weight of 20 kN/m^3.

In the event the water table is at ground surface, there is the potential for significant hydrostatic pressure buildup behind the foundation walls. This does not affect the pressure coefficients; however, the effective stress is reduced due to high pore pressures.

6.5 Site preparation

Areas of the building footing and slab area should be stripped and cleared of all loose, saturated, and deleterious (organic) materials or silt and sand to expose the underlying undisturbed native sand and silt till-like soil subgrade, as approved by the Geotechnical Engineer.

When site-grading and/or structural fill is required, it should consist of a clean granular engineered fill, such as 25mm well graded crushed granular sand and gravel base material. All engineered fills should be placed and compacted as approved by the Geotechnical Engineer to at least 100% of the material's Standard Proctor Maximum Dry Density[2] (SPMDD) value in compacted lifts no thicker than 300 mm.

6.6 Excavation, Trenching and Shoring

Where excavation is required and exceeds a depth of 1.2m, WorkSafe B.C. guidelines for stable excavations should be followed to ensure a safe working area. Temporary cut slopes deeper than 1.2 m may be cut with side slopes of 3H:4V in accordance with WorkSafe BC regulations unless specified by the geotechnical engineer. Should seepage be encountered, the slopes should be flattened. The geotechnical engineer should also be notified in advance in order to review the excavation to verify its stability and safety of workers entering the excavation. Alternatively, the excavation sides can be shored and braced for excavations deeper than 1.2m. During construction, temporary surcharge loads such as equipment and material stockpiles should not be allowed within 2m of unsupported excavation face.

2 (ASTM D698)-Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))

6.7 Permanent Drainage

Footing drains are recommended. Footing drains should consist of 100 mm (4 inches) perforated drain pipe surrounded on the top and sides by at least 150 mm (6 inches) of nominal 19 mm (3/4 inch) drain rock or clear crushed gravel wrapped in filter fabric.

Water collected in the footing drains and roof drainage should be discharged through a non-perforated pipe to a storm drain, drainage ditch, or storm sewer, in accordance with local building bylaws. The application of subsurface infiltration galleries is not recommended due to the shallow perched water table above the near impervious till-like soils. Roof drainage should be conveyed to discharge in a separate non-perforated pipe and should not be discharged into the footing drains around the buildings.

Open areas shall be vegetated and allow for rain water to infiltrate into the ground. For areas that are paved, water shall not be concentrated and shall flow away from buildings.

6.8 Slab on grade

Concrete floor slab-on-grade should be underlained by a minimum 50 mm layer of either a clean 25mm minus well graded sand and gravel with less than 5% passing the 0.075 mm sieve compacted to a minimum of 100% SPMDD or a 25mm clear crushed gravel to satisfaction of the Geotechnical Engineer.

6.9 Reuse of native site soils

Reuse of on-site inorganic material may be considered suitable as backfill, subgrade fill under pavements and foundations, subject to on site approval by the geotechnical engineer during stripping operations. Care must be taken to not mix the inorganics material with organic silts during the stripping and grading operations.

6.10 Field reviews

The discussions and recommendations presented in this report are based on interpretation of the site investigation. It is recommended that the geotechnical engineer complete field reviews to assess the actual soil conditions encountered and to confirm the design assumptions used in this geotechnical investigation report. The following construction reviews should be completed by TerranGeo.

- Review of excavations deeper than 1.2m and excavations near adjacent dwellings and structures for the stability of cut slopes.
- Review of potential groundwater seepage in the excavation.
- Subgrade review for proposed building(s) and driveways during site stripping, before placing any materials (gravel/structural fill) above it.
- Confirmation of subsoil bearing capacity for foundations before erecting the forms.
- Compaction testing of all fills under load bearing structures such as the concrete floor slab and footings.

TerranGeo cannot assume responsibility or liability for the adequacy of this report recommendations when they are used in the field without TerranGeo being retained to review and approve the field conditions during construction. The final assurance letter (BCBC Schedule C-B) will be issued on the conditions that all field inspections and test requirements have been fulfilled.

7.0 LIMITATION

This report was prepared and is subject to limitation and standard terms and conditions presented in Appendix C. The limitation should be reference in conjunction with this report. In lines with the detailed limitations, TerranGeo cannot accept responsibility for inaccuracies, misstatements, omissions or deficiencies in this report resulting from the sources of this information. This report assumes that TerranGeo will be retained to review the soil conditions during construction.

8.0 CLOSURE

We appreciate the opportunity to be of service to you. If you have any questions regarding the contents of this report, or if we can be of further assistance to you on this project, please call any of the undersigned.

Sincerely,
Terran Geotechnical Consultants Ltd.

PROFESSIONAL PROVINCE OF D. E. Y. LEE #45288 BRITISH COLUMBIA ENGINEER

MAY 29 2017

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