Coast Geotechnical
778-400-8090 | 917 Echo Valley Place | Victoria, B.C.

Adam Withers
Lot 31 Goldstream Heights
Malahat, BC V9Z 1E5

May 27, 2022
Project # 22-312

Attn: Adam Withers

Re: Geotechnical Report for Proposed Single Family Residence
Lot 31 Goldstream Heights, Malahat District

1.0 INTRODUCTION

As requested, Coast Geotechnical Consulting Ltd. (Coast Geotechnical) has completed a preliminary geotechnical investigation for the proposed single family residence. In completing this report, we have been provided preliminary plans for a single family residence featuring two above-grade levels and a lower level walkout basement design. Because the proposed development is located on steeply sloping land which exceeds 30% over a 10 meter run, we expect that a Development Permit will be required as per *Capital Regional District Bylaw No. 3721: Malahat Official Community Plan.* This geotechnical assessment has been prepared to assess the suitability of the site and provide appropriate recommendations for the proposed development.

This report summarizes the results of our investigation and provides geotechnical recommendations for the proposed project. This report has been prepared for the exclusive use of the client, Adam Withers, and their design and construction team. We understand the Capital Region District may rely on this report as part of the development permit process and is an authorized user of this report.

2.0 SITE REVIEW

The subject lot is located on the east side of Goldstream Heights Drive in the Malahat area of the Capital Regional District. The property is accessed by a gravel driveway from Goldstream Heights Drive, and is bound to the north, south and east by similar rural properties. The property is a 5.11 acre irregular rectangular parcel, longer from east to west. Based on the available contour mapping from CRD Regional Map the site has slopes of 50 – 60% just east of the proposed building site. Further east within the property, this slope becomes shallower at 20 – 30%. A **Site Location Plan** via CRD Regional Map has been attached following the text of this report.

Coast Geotechnical visited the site on May 9th and met with the client/owner to review the property and discuss the proposed development. The following is a summary of our observations:

- The west side of the property is relatively flat near Goldstream Heights. The site appears to have been levelled with cut and fill during the previous site activities. We expect fill materials were borrowed from roadworks and deposited within the site to create the road and level areas. The fill was noted to be predominantly silty sand with some interspersed coarse angular rock. The existing fill is uncontrolled and of uncertain quality; therefore, it is not suitable for support of new residential foundations. See Photos 1 & 2.
- A natural bedrock exposure can be observed at the west end of the site. The bedrock is mostly covered with thin moss growth. A bedrock cut was observed at the south end of the proposed building area. We

expect this was from previous excavation and blasting and the blastrock was borrowed for site and roadway fills. The cut slope provides an exposure of the natural ground strata which consists of a varying depth of rusty brown silty sand (colluvial soil), overlying weathered and fractured bedrock. Photo 3.

- We understand that design plans are currently under development, however the client indicated plans to adapt the design of the residence to the sloping grade of the site. The new design would incorporate a walkout lower level to manage up to 3 meters of grade change.

Bedrock geology mapping[1] indicates the site is underlain by wark gneiss bedrock. Wark gneiss is a mafic unit of an early Paleozoic metamorphic complex. It is well-foliated to almost massive hornblende-plagioclase rock with green-yellow pleochroic hornblende, commonly saussuritized plagioclase and minor quartz and magnetite. This bedrock consists of massive and gneissic metadiorite, metagabbro, and amphibolite.

3.0 ASSESSMENT

During our site review, we observed that the site is controlled by bedrock. This provides favorable conditions with respect to slope stability and resistance to erosion, landslide, and landslip. We expect that foundation areas can be prepared generally level by rock breaking, excavation, and blasting. Where it is necessary to raise grades to create level building areas, a pad of engineered fill could be constructed. The sloping grade will generally be mitigated by placing foundations directly on bedrock or on properly constructed pad of engineered fill overlying bedrock. Based on our review of the surrounding contours, rockfall hazards are not expected to impact the proposed building site.

We understand the Capital Regional District has adopted a probability of risk tolerance policy for geotechnical failure resulting in property damage of less than 2% in 50 years due to seismic events, including slope stability. Coast Geotechnical has assessed the potential hazards which may impact the safe development of the proposed residence; it is our opinion that the land is safe for the intended use based on a probability of geotechnical failure of less than 2% in 50 years, provided that the recommendations herein are followed during design and construction.

4.0 RECOMMENDATIONS

The following sections summarize our geotechnical recommendations for site preparation and residence construction. This report should be provided to the contractors completing the work and to the structural engineer for the design of foundations. At the time of this report, design plans have not been developed, therefore this report should be considered 'preliminary' until design plans can be reviewed, and recommendations confirmed or revised as necessary.

4.1 Site Preparation

If the proposed building site is to be used, all the existing fill soils must be removed to the depth of native undisturbed soils or bedrock. Subsequently, the building site could be reinstated to the current or proposed elevation with engineered fill. Other building sites could be considered, however they would require removal of trees and blasting or rock breaking to create level areas.

[1] Mueller, J. (1980). *Map 1553A Geology Victoria West of Sixth Meridian British Columbia*

Rock excavation (blasting) may be required to achieve the desired grades shown in the plans provided by the client. If the resultant blastrock is to be used as engineered fill, special care should be given to the stripping process; compressed air or water jetting is recommended to remove loose debris or mud from the surface of the bedrock prior to blasting to mitigate organic soil contamination.

In footing areas proposed to bear on bedrock, all loose rock and debris are to be removed from the intact bedrock surface prior to the construction of footings.

In areas where engineered fill is to be used, the native subgrade/bedrock must be free of all loose soil or rock prior to the placement of the initial layer of engineered fill. Dragging a rubber tire along the bedrock surface is a common practice to remove loose soils from local undulations and crevices.

4.2 Engineered Fill

Engineered fill is expected to be required to create level foundation areas for the proposed single family residence. It will also be required to reinstate grade beneath the slab-on-grade floor systems. Engineered fill may consist of either: typical well-graded 75mm minus sand & gravel, 75 mm minus crushed rock, or 300 mm minus rock fill. Please see the attached *Requirements for Engineered Granular Fill* and *Requirements for Engineered Rock Fill* documents for project requirements.

Appropriate siting of strip and pad footings with respect to slope stability can be assessed once building plans are prepared. For preliminary purposes, the proposed building should be setback from the crest of engineered fill slopes by a distance equivalent to the thickness of the fill.

Geotechnical Engineer to be contacted to review subgrade prior to placement of engineered fill.

4.3 Foundations

We expect that the foundation area will be supported on a pad of engineered fill, overlying bedrock. For foundations placed on engineered fill, the foundations can be designed based on a Serviceability Limit State bearing resistance of 200 kPa, based on a settlement of less than 25 mm, and an Ultimate Limit State bearing resistance of 300 kPa for earthquake and wind loads. A minimum of 0.5 m of ground cover should be provided around all foundation walls to protect from frost impacts, moisture variation, and potential erosion.

For foundations placed on bedrock, an Ultimate Limit State (ULS) bearing pressure of 1000 kPa can be used for the foundation design. The Serviceability Limit State (SLS) bearing resistance is not applicable as the stress required to induce 25 mm of movement is anticipated to exceed the ULS bearing pressure. Where bedrock slopes at an angle greater than 6H:1V, and is not naturally keyed, it should be benched via mechanical breaking or dowelled into rock. As a final step we recommend all footing areas on bedrock be cleaned by water jetting (pressurized hose) to allow for direct bond between concrete and bedrock.

Based on the 2018 British Columbia Building Code site classification for seismic response, the proposed strata conditions of the site can be considered Site Class B for foundations entirely on bedrock, and Site Class C where foundations are placed on a nominal thickness (< 4 m) of engineered fill overlying bedrock.

Geotechnical Engineer to be contacted to review proposed bearing surfaces.

4.4 Slab-On-Grade

We recommend that a layer of clear crushed gravel, a minimum of 150mm thick, be placed directly beneath any crawlspace skimcoat or slab-on-grade to provide a drainage layer for potential seepage zones. The clear crushed gravel layer should be underlain by suitably prepared native subgrade or well-compacted engineered fill, completed as per Section 4.2 and approved by the geotechnical engineer. The gravel drainage layer must have outlets through the low side of any foundation walls and should be properly compacted using a plate tamper. A 6-mil polyethylene vapour barrier must be placed over the clear crushed gravel, prior to placing of concrete, to provide a barrier against the uptick of moisture.

Geotechnical Engineer to be contacted to review compaction of engineered fill beneath slab-on-grade floors.

4.5 Perimeter Drainage

We recommend perimeter drainage be installed around the perimeter of buildings where the lowest floor or slab-on-grade is below the adjacent ground surface. Perimeter drains should consist of perforated 100 mm diameter rigid PVC pipe surrounded by a 300 mm thick layer of clear crushed gravel or drain rock. The gravel should be separated (encapsulated) from backfill and native soil via non-woven geotextile. Perimeter backfill should consist of free-draining material. The drain invert should be a minimum of 200mm below the floor slab elevation and may be daylighted onto exposed bedrock or a rip-rap armoured area downslope of the residence.

4.6 Permanent Slopes & Grading

Where permanent structures are located near sloping ground, due care should be taken to promote long-term stability of the property, including prevention of shallow land slips, and erosion. To provide stable conditions, it is recommended to establish finished grades within the lots at the following maximum slope configurations based on the material type:

- 1.5H:1V or shallower for well compacted blast rock fill.
- 3H:1V or shallower for backfill and general site grading fills.
- 2H:1V or shallower for cut slopes in native soil slopes.
- 1H:4V for permanent rock cuts. All overburden soils to be stripped back within 1.5m of the crest of the rock cut.

Following site disturbance, slopes should be promptly re-vegetated by hydroseeding, seeding, or planting.

For any permanent rock cuts which will exceed 2.0 m in height, we recommend these cuts be blasted using controlled blasting techniques; specifically, a backline pre-shear and buffer row should be used to avoid damage to the face and to minimize backbreak. Pre-shear hole spacing of 0.6 m is expected to be sufficient. Geotechnical Engineer to be contacted to review rock cuts following blasting. Following blasting, we recommend comprehensive machine and hand-scaling to remove loose rock and unstable blocks. Careful scaling will be required near the crests of slopes, where discontinuities will be more closely spaced.

4.7 Retaining Walls

Retaining walls may be desired to manage the change in grades within the lot. Boulders, locally sourced or produced from blasting, could potentially be used in the construction of stacked boulder retaining walls. The Capital Regional District requires building permit and professional design of retaining walls greater than 1.2 m in height. Retaining wall design is outside of the scope of this report.

Coast Geotechnical can complete retaining wall design and drawings upon request.

All other aspects of construction should be in accordance with the 2018 British Columbia Building Code. The client should familiarize themselves with the requirements of Development Permit Area No. 1: Steep Slopes within CRD Bylaw No. 3721.

5.0 FURTHER GEOTECHNICAL REVIEWS

Once design plans have been completed, the plans should be provided to Coast Geotechnical for review to confirm, revise, or provide additional recommendations. Geotechnical field reviews can be provided to satisfy the Letters of Assurance requirements and confirm that the recommendations of the geotechnical report are followed. At minimum, we anticipate that geotechnical engineering and field reviews will be needed to address the following:

- Subgrade — Review of stripped or blasted subgrade prior to any fill placement
- Engineered Fill — Review of engineered fill during placement and compaction.
- Slab-on-Grade — Review of engineered fill beneath slab-on-grade

If you would like further details or require clarification of the above, please do not hesitate to call.

For:
Coast Geotechnical

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
B. W. SCHMIDT
50954
2022-05-27
Permit to Practice #1001639

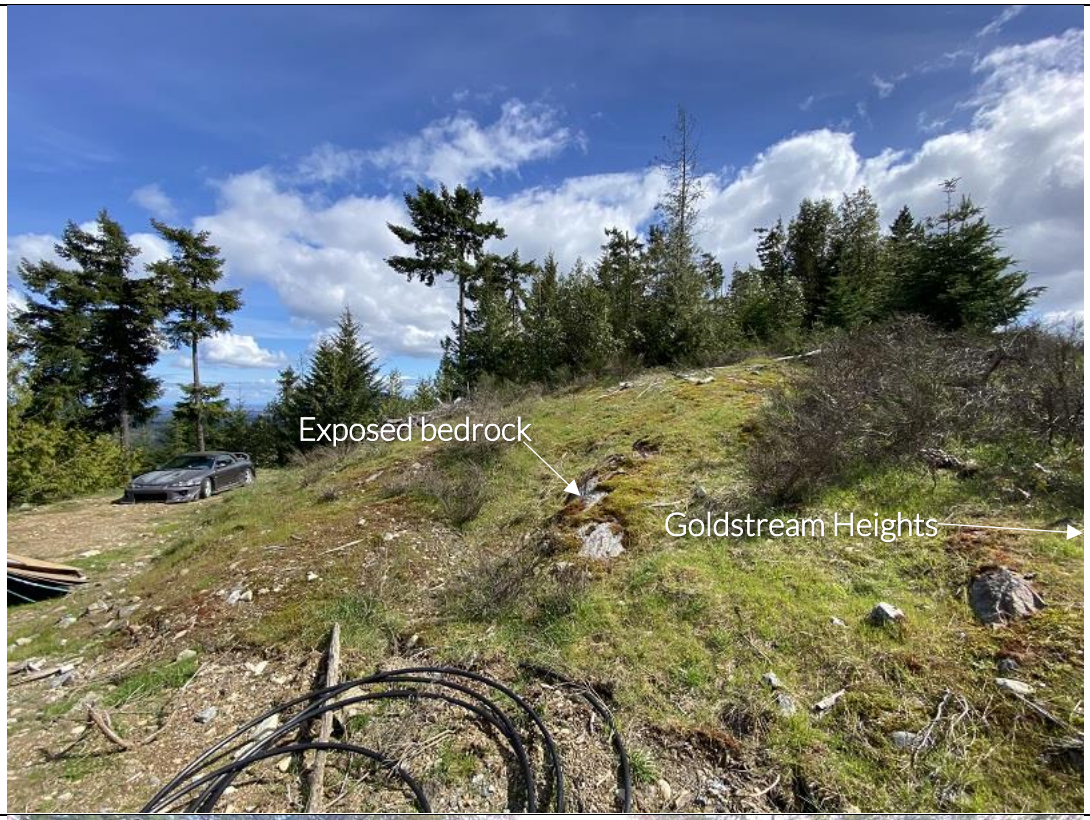
Ben Schmidt, P. Eng.
Principal Geotechnical Engineer

Reviewed By:

Alyse Munro Hindley
Geotechnical EIT

ATTACHMENTS:
Site Photos – May 9th, 2022
Site Location Plan via CRD Regional Map
Requirements for Engineered Fill & Rockfill

Photo 1: View of proposed building area. We expect that this level road area was created using fill. Photo taken facing south.	
Photo 2: View of slope created from previous fill placement within the site. Photo taken facing east	

Photo 3: View of bedrock area at the west end of site. Photo taken facing west.	
Photo 4: View of cut slope which exposed bedrock and overburden soils. Photo taken facing west.	

Making a difference...together

Lot 31 Goldstream Heights

Legend

- Shoreline 1.6m

1m
- Hundred
- Twenty
- Ten
- Five
- Metre

Bathymetry
- 2
- 5
- 10
- 20
- 30
- 50
- 100
- 200

1: 1,000

50.8 0 25.40 50.8 Meters

NAD_1983_UTM_Zone_10N

Notes

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REQUIREMENTS FOR ENGINEERED FILL

In the context of this guide, Engineered Fill is defined as granular soils, free of organic materials, and having a maximum 75mm nominal particle size. For fill materials with a maximum particle size greater than 75mm, refer to *Coast Geotechnical: Requirements for Rockfill as Engineered Fill*.

Table 1: Requirements for Engineered Fill

Compaction Equipment[2]	10–20-ton vibratory roller Backhoe mounted hoe-pac	1000-lb Plate Tamper / < 10 ton roller	Smaller tampers Jumping Jack
Max. Lift Thickness	450mm (1.5ft)	300mm (1ft)	150mm (6in)
Min. # Passes	6 passes	6 passes	6 passes
Density Testing Requirements:	1. During compaction of 1st lift to set minimum pass requirement 2. Every 1 meter of thickness thereafter.		

1. 'Minus' means all particles must be less than the specified size. Material must be clean, free of contaminants or organics, and have less than 8% fines (silt/clay) passing the No. 200 sieve if placed during wet seasons. Generally, fills with more than 10% fines passing the No. 200 sieve are difficult to compact and not appropriate.
2. Commonly used materials are: 19mm minus base gravel, 75mm minus crushed granular sub-base, 75mm minus Pit Run Sand & Gravel.

Recommendations:

Stripping: Prior to placement of any Engineered Fill, all topsoil, fill, weathered, or disturbed soils must be stripped from the proposed building area. We recommend the site be staked or pinned to identify the building extent/width. *Geotechnical Engineer to be contacted to review subgrade prior to placing Engineered Fill*.

Pad Extent: The Engineered Fill pad must be prepared to extend 0.6 m (2 ft) horizontally beyond the outside edge of footings and have a maximum splay of 1H:1V down and away. Larger diameter particles can be used to retain perimeter of fill pad.

Lifts: Engineered Fill to be compacted in lifts appropriate for equipment. Lifts to be prepared level prior to compaction. Track packing will not be accepted as a means of compaction. Track packing may be used as an initial step to grade fill level and eliminate high points.

Compaction: Engineered fill to be compacted to 95% of the materials modified Proctor maximum dry density (MPMDD) and within 2% of optimum moisture content, or as otherwise specified by the Engineer. Density testing is required to confirm compaction. Results to be provided to Engineer for review. We recommend obtaining the Proctor test on the material prior to transport to site. *In lieu of density testing, upon request, Coast Geotechnical can complete full-time review during placement.*

Reviews: Contractor/Client is responsible to contact Geotechnical Engineer to provide density test results and/or schedule the engineering reviews. Final signoff, and/or Schedules will be withheld if Coast Geotechnical is not provided opportunity to review engineered fill.

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REQUIREMENTS FOR ROCKFILL AS ENGINEERED FILL

In the context of this guide, rockfill is defined as coarse rock with particle sizes ranging from sand to coarse cobble. Rockfill is commonly referred to as 'Blastrock' or Shotrock'. For fill materials with a maximum particle size of 75mm, refer to *Coast Geotechnical: Requirements for Engineered Fill.*

Table 1: Requirements for Rockfill

Gradation	200mm (8") Minus[1]	300mm (12") Minus[1]
Min. Compaction Equipment[2]	1000-lb Plate Tamper	10 – 20-ton vibratory steel drum roller
Max. Lift Thickness	300mm (1 ft)	450mm (1.5 ft)
Min. # Passes	6 passes[2]	6 passes[2]
Engineering Reviews Required:	1. During compaction of 1st lift to confirm minimum pass requirement 2. Every 1 meter of thickness thereafter. 3. Upon completion of fill pad to confirm suitable width/extents in relation to foundation layout.	

1. 'Minus' means all particles must be less than the specified size. All fill must be well graded. Material must be clean, free of contaminants or organics, and have less than 8% fines (silt/clay) passing the No. 200 sieve. Rock must also be hard and non-brittle, no shales, no sandstone.
2. A method specification test can be completed which may reduce the number of passes required. Contact Coast Geotechnical to coordinate.

Recommendations:

Stripping: Prior to placement of any Engineered Fill, all topsoil, fill, weathered, or disturbed soils must be stripped from the proposed building area. We recommend the site be staked or pinned to identify the required extent/width. *Geotechnical Engineer to be contacted to review subgrade prior to placing Engineered Fill.*

Pad Extent: The Engineered Fill pad must be prepared to extend 0.6 m (2 ft) horizontally beyond the outside edge of proposed structure or road and have a maximum splay of 1H:1V down and away. Larger diameter particles can be screened and used to retain perimeter of fill pad.

Lifts: Engineered Fill to be compacted in lifts, using appropriate equipment for gradation. Lifts are to be prepared level prior to compaction. Larger particles which protrude must be removed. Track or bucket packing will not be accepted as a means of compaction. Track packing may be used as an initial step to grade fill level and eliminate high points.

Compaction: Rockfill to be compacted with minimum # of passes as specified/confirmed by the Engineer. Seams should no longer visible at the edge of compaction equipment's path or track. For vibrating tampers and rollers, the compaction equipment should begin to bounce when adequate compaction has been achieved.

Reviews: The contractor/client is responsible to contact Geotechnical Engineer to obtain the engineering reviews as noted in Table 1 above. We should be notified a minimum of 24 hours in advance to schedule a review. Final signoff, and/or Schedules will be withheld if Coast Geotechnical is not provided opportunity to review engineered fill.