Report
Geotechnical Engineering Services
Proposed Residential Development
Kittitas County Parcel No. 138435
Hyak Area, Snoqualmie Pass
Kittitas County, Washington

January 29, 2020
ICE File No. 1329-001

Report
Geotechnical Engineering Services
Proposed Residential Development
Kittitas County Parcel No. 138435
Hyak Area, Snoqualmie Pass
Kittitas County, Washington

January 29, 2020
ICE File No. 1329-001

Prepared For:
Matthew Fuhr

Prepared By:
Icicle Creek Engineers, Inc.

January 29, 2020

Matthew Fuhr
4557 11th Avenue NE, Apartment 308
Seattle, Washington 98105

Report
Geotechnical Engineering Services
Proposed Residential Development
Kittitas County Parcel No. 138435
Hyak Area, Snoqualmie Pass
Kittitas County, Washington
ICE File No. 1329-001

1.0 INTRODUCTION

This report presents the results of Icicle Creek Engineers' (ICE's) geotechnical engineering services regarding the proposed residential development within an approximately 0.2-acre property (Kittitas County Parcel No. 138435 – referred to as the Fuhr Property in this report) located in the Hyak area of Snoqualmie Pass, in Kittitas County, Washington. The Fuhr Property is shown relative to nearby physical features on the Vicinity Map and Site Plan, Figures 1 and 2, respectively.

Our services were provided in general accordance with our Scope of Services and Fee Estimate, dated June 20, 2019, and were authorized in writing by Matthew Fuhr, the property owner, on June 25, 2019.

2.0 PROJECT DESCRIPTION

Our understanding of this project is based on discussions with and information provided by Mr. Fuhr. The information is referenced as follows:

- Direct Surveying, May 25, 2018, *Matthew Fuhr Topographic Survey,* one sheet.
- Terralite Architecture, May 31, 2019, *The Mountainside House,* sheets A.1 through A.13.
- Untitled, undated grading plan (file name "Snoq Grading"), one sheet.

Based on discussions with Mr. Fuhr and review of the information described above, we understand that the project includes construction of an approximately 1,750 square-foot three-story house. We understand that in order to provide space for parking and access, substantial grading will be completed along the west side of the lot adjacent to Snoqualmie Drive. This grading will include placement of fill supported by a three-sided wall (referred to as the "Parking Structure") up to 16-feet high. The outside edges of the Parking Structure will require transition to the existing Snoqualmie Drive fill embankment; the current grading plan shows these proposed fill slopes being inclined at up to 100-percent grade. Cross-sections of the grading plan are provided in the Site Cross-Sections A-A' / B-B', Figure 3.

3.0 SCOPE OF SERVICES

The purpose of our services was to explore subsurface soil and groundwater conditions at the Fuhr Property as a basis for developing geotechnical recommendations for site development. Specifically, our services included the following:

- Review readily available information regarding site conditions, including geologic maps completed by the US Geological Survey (USGS), along with aerial photographs provided by Google Earth and USGS EarthExplorer.
- Complete site reconnaissance of the Fuhr Property and accessible adjacent area to evaluate surface conditions.
- Explore subsurface soil and groundwater conditions by excavating two test pits to depths of about 8 to 9 feet with a trackhoe; the trackhoe and operator were provided by Mr. Fuhr.
- Evaluate pertinent physical and engineering characteristics of the soils based on our observations, test pit explorations and our general knowledge of the property area.
- Provide recommendations for site preparation and earthwork including excavations, foundation subgrade preparation, criteria for Structural Fill placement and wet/cold weather earthwork considerations.
- Provide recommendations for foundation support (allowable bearing pressure), uplift, friction, lateral soil pressures, and estimated postconstruction settlement performance of shallow spread footings.
- Provide design recommendations for the MSE/GBW system supporting the Parking Structure including internal, global (external) and compound stability analyses and evaluation of fill that will be used to transition the wall to the existing Snoqualmie Drive fill embankment.

4.0 SITE CONDITIONS

4.1 GENERAL

Shane Markus, EIT of ICE completed site visits to the Fuhr Property on September 9, 2019 to mark the locations of the test pits, and on September 13, 2019 to complete a field reconnaissance of the area and to observe the excavation of two test pit explorations. We met with Mr. Fuhr, along with Garrett and Ralph with Swiftwater Excavating, LLC at the time of our September 13, 2019 site visit.

Our understanding of the Fuhr Property is based on our review of in-house geological information, geologic map review, historic aerial photograph review (Google Earth and USGS EarthExplorer – https://earthexplorer.usgs.gov/), surface reconnaissance of the site, and observations of subsurface conditions in the two test pit explorations within the Fuhr Property.

4.2 SURFACE CONDITIONS

4.2.1 Fuhr Property Area

The approximately 0.2-acre Fuhr Property occupies an east-facing hillside overlooking the north end of Lake Keechelus. The Fuhr Property is bordered to the west by Snoqualmie Drive and to the north, south and east sides by similar rural residential lots. Within the Fuhr Property, the ground surface slopes moderately (approximately 20-percent grade) down to the east, from about Elevation 2,756 feet along the west property boundary to Elevation 2,729 feet along the east property boundary. The ground surface is generally irregular. Rounded cobbles and boulders (of glacial origin) up to about 4 feet in diameter were observed scattered across the Fuhr Property.

The Fuhr Property area is generally vegetated with vertically-oriented conifer trees up to about 2 feet in diameter with an understory of light to moderately dense brush. We did not observe evidence of surface water or seasonal groundwater seepage in the Fuhr Property area. We did not observe surface evidence of slope instability in the Fuhr Property area.

4.2.2 Fill Embankment Area

Just west of the Fuhr Property boundary, the ground surface rises abruptly and steeply (at about an 80- to 100-percent grade) as a fill embankment for about 15 feet to Snoqualmie Drive. The surface of the fill embankment is generally planar and smooth. Angular gravel and cobbles are visible along the surface of the fill embankment. The fill embankment is generally unvegetated. We did not observe surface evidence of slope instability of the fill embankment. The pavement of Snoqualmie Drive at the top of the fill embankment appeared to be in good condition (no cracks or differential settlement.

4.3 SUBSURFACE CONDITIONS

4.3.1 Geologic Setting

Based on our review of regional geologic mapping by the USGS (2000, *Geologic Map of the Snoqualmie Pass 30x60 Minute Quadrangle, Washington*, Geologic Investigations Series Map I-2538), Pleistocene-age (up to 100,000 years old) Alpine Glacial Drift and late to middle Eocene-age (about 40 million years old) Guye Sedimentary Member bedrock are present in the area of the Fuhr Property. The Alpine Glacial Drift typically consists of silt, sand, gravel, cobbles and boulders. The Guye Sedimentary Member bedrock typically consists of Meta-Sediments (sedimentary rocks such as siltstone and sandstone that have been subject to deformation under high pressure/temperature). We expect that the fill embankment adjacent to Snoqualmie Drive consists of Fill of unknown character, although the angular cobbles and gravel observed at the ground surface, the steep angle of repose, and the overall favorable performance history suggests that the Fill is coarse-grained (sand and gravel) with angular particles and well-compacted.

Regional groundwater is expected to be more than 5-feet deep. However, during the early Spring months, especially following snowmelt or following an extended period of heavy rain with frozen ground, seasonally perched groundwater may occur within the Alpine Glacial Drift.

4.3.2 Subsurface Exploration Program

Subsurface conditions at the Fuhr Property were explored on September 13, 2019 by excavating two test pits (Test Pits TP-1 and TP-2) at the locations shown on Figures 2 and 3 using a Kubota KX04-4 mini-trackhoe provided by Mr. Fuhr and operated by Swiftwater Excavating, LLC.

Mr. Markus observed the completion of the test pits, obtained representative soil samples, classified the soils encountered, observed groundwater conditions and prepared a detailed log of each test pit. Soils were classified in general accordance with the Soil Classification System shown on Attachment A. The logs of the test pits are presented in Attachment B. These logs are based on our interpretation of the field data and indicate the various types of soils encountered. Densities noted on the test pit logs are based on the difficulty of digging, probing with a ½-inch-diameter steel rod, and our experience and judgement. The logs indicate the depths at which the soils or their characteristics change, although the change might be gradual.

4.3.3 Subsurface Conditions

Based on our observations of test pit explorations, the shallow subsurface soil conditions encountered in the test pit explorations are described below. The subsurface conditions encountered in the explorations were generally consistent with the regional geologic mapping (USGS, 2000) of the area.

TP-1 – Test Pit TP-1 encountered approximately 6 inches of Sod and Topsoil, underlain by about 3 feet of Alpine Glacial Drift consisting of medium dense silty fine to medium sand with gravel, cobbles and boulders up to about 3 feet in diameter grading to dense silty fine to medium sand with gravel and cobbles to a depth of about 7 feet. The Alpine Glacial Drift was underlain by Guye Sedimentary Member bedrock consisting of moderately weathered, moderately strong siltstone to the base of the excavation at a depth of about 8 feet.

TP-2 – Test Pit TP-2 encountered approximately 6 inches of Sod and Topsoil, underlain by Alpine Glacial Drift consisting of about 1.5 feet of medium dense silty fine to medium sand with gravel and cobbles grading to dense fine to medium sand with silt, gravel, cobbles and boulders up to about 2 feet in diameter to a depth of about 5 feet, underlain by dense gravel with silt, sand and cobbles, with boulders up to about 3 feet in diameter to the base of the excavation at a depth of about 9 feet.

4.3.4 Groundwater Conditions

No groundwater was observed in Test Pit TP-1. Groundwater seepage was encountered at a depth of about 8.5 feet in Test Pit TP-2. We expect that groundwater level may fluctuate depending on the season; the observed groundwater level in Test Pit TP-2 may be at a seasonal low considering the time of year completed (September). Localized shallow groundwater can occur near the surface during the Spring snowmelt, typically during late March through May.

4.3.5 Other Observations

Excavatability of the site soils/bedrock using a Kubota KX04-4 mini-trackhoe was typically moderately difficult to difficult (Sod and Topsoil, Alpine Glacial Drift without boulders), to very difficult/impossible (Alpine Glacial Drift with boulders and Guye Sedimentary Member bedrock). Large boulders are abundant in the Alpine Glacial Drift in this area and generally preclude excavation with a mini-trackhoe.

Slight caving of the test pit walls was observed between ½ and 2 feet in Test Pit TP-1.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 GENERAL

Based on our field reconnaissance, test pit explorations and analyses, we conclude that the proposed house may be supported on conventional reinforced concrete spread footings extending to medium dense or denser Alpine Glacial Drift or Guye Sedimentary Member bedrock, or on a pad of Structural Fill that extends to these competent soils.

We also conclude that the proposed Parking Structure and fill slopes may be supported on medium dense or denser Alpine Glacial Drift or on a pad of Structural Fill that extends to these competent soils.

Full basement construction is not generally recommended because of the unpredictable occurrence of groundwater in the Hyak area during the spring snowmelt. Daylight basement construction is possible provided that a suitable basement wall drain is installed and flows by gravity to a downgradient surface discharge point.

5.2 SITE PREPARATION

Sod and Topsoil should be stripped and removed from the proposed house, proposed Parking Structure and fill slope areas. We expect that the stripping depth will be at least 1 foot during dry weather conditions. Greater stripping depths may be encountered in the vicinity of tree stumps or during wet weather. Roots larger than about 1-inch diameter should be grubbed to at least 12 inches below the design subgrade. The area of stripping should be limited to those areas that can be effectively developed within a few days at a time to reduce erosion and sedimentation.

Following clearing, stripping, and grubbing, the exposed subgrade should be probed to identify soft, loose or otherwise unsuitable soils. Soft or loose soils identified during probing should be removed and replaced with Structural Fill as described in the subsequent section. The zone of Structural Fill should extend laterally out from the base of the fill slope, Parking Structure or house perimeter a distance equal to the depth of the Structural Fill. Alternatively, footings may be extended deeper to suitable soils rather than replacing with Structural Fill.

5.3 STRUCTURAL FILL

Structural Fill should be free of organic material or other deleterious materials and have a maximum particle size of 4 inches. The material should contain less than five percent fines (soil passing the US Standard No. 200 sieve) by weight relative to the portion finer than the ¾-inch sieve. If earthwork is done during generally dry weather conditions, the fines content may be increased.

As a guideline, Structural Fill should be placed in horizontal lifts which are 10 inches or less in loose thickness. The actual lift thickness depends on the quality of the fill material and the size of the compaction equipment. Structural Fill placed on existing slopes which are steeper than 4H:1V (horizontal to vertical) should be properly keyed into the slope surface; this is typically accomplished by excavating a 4- to 8-foot-wide horizontal bench (or benches, depending on the height of the slope) prior to the placement of Structural Fill.

We recommend that Structural Fill placed in the house, Parking Structure and fill slope areas be uniformly compacted to at least 95 percent of the maximum dry density (MDD) obtained in general accordance with ASTM Test Method D 1557.

5.4 EXCAVATIONS

Alpine Glacial Drift with boulders and Guye Sedimentary Member bedrock will be encountered in excavations. Excavation with a mini-trackhoe was difficult because of dense soil, boulders and bedrock materials during our test pit explorations. Heavier equipment will be required to effectively excavate for footings, the Parking Structure subgrade, fill subgrades and underground utilities.

5.5 FOUNDATION SUPPORT

Based on our observations and soil conditions observed in Test Pits TP-1 and TP-2, it is our opinion that the medium dense or better Alpine Glacial Drift or the Guye Sedimentary Member bedrock are suitable for foundation support.

If bedrock or large boulders are encountered at footing subgrade within parts of the house foundation footprint, we recommend overexcavating the bedrock or boulders by 12 inches, then backfilling with crushed rock compacted to 95 percent of the MDD obtained in general accordance with ASTM Test Method D 1557. The purpose of the overexcavation and backfilling with crushed rock is to provide uniformity in foundation support between soil and subgrades.

Continuous and isolated spread footings should have minimum widths of 16 and 24 inches, respectively. The footings should be a minimum of 24 inches below the adjacent grade for frost protection.

Care should be taken to avoid loosening or softening the bearing surface soils when preparing footing subgrades, particularly during wet weather. During wet weather, foundations should be excavated, formed and poured the same day or be protected by a layer of crushed rock or lean concrete.

For subgrades prepared according to the criteria in section 5.2 of this report, and footings designed and constructed according to the criteria provided in this section, **we recommend an allowable bearing pressure of 2,500 pounds per square foot (psf).** This value applies to the sum of all dead and long-term live loads, exclusive of the weight of the footing and the backfill above the footing. For transient loads, including wind or seismic, a one-third increase in the recommended value may be used. We estimate that settlement of footings founded as described will be less than ½ inch and will occur rapidly as loads are applied.

Resistance to lateral loads can be developed by friction between the base of the foundation and by passive pressures acting on the sides of foundations. **We recommend that resistance to lateral loads be estimated using a coefficient of friction of 0.3 and an equivalent fluid density of 200 pounds per cubic foot (pcf).** These values include a Factor of Safety (FOS) of 1.5.

5.6 PARKING STRUCTURE

5.6.1 General

Permission from Kittitas County should be obtained before any grading of the existing fill embankment for Snoqualmie Drive is completed.

In order to create an elevated driveway and parking area and maintain space for the house, we understand that a grade change of approximately 16 feet is needed. Based on our preliminary review of the existing and proposed contours, in our opinion, a Mechanically Stabilized Earth (MSE) Wall up to 16-feet high is feasible for this application. MSE Walls typically consist of a Reinforced Fill Zone, reinforced with layers of geogrid reinforcing mesh, and a concrete block unit (in this case Ultrablock™ prefabricated modular blocks) facing which is connected to the geogrid reinforcement mesh. The concrete block units are typically supported on a leveling course pad of crushed rock to provide uniform support and to allow for easier installation.

The MSE Wall consists of several components as described below.

Ultrablock™ Prefabricated Modular Units (PMUs) – Full Block measuring 5-feet long, 2.5-feet high and 2.5-feet wide, weighing 4,320 pounds; Cap Blocks can be installed if needed, measuring 5-feet long, 1.25-feet high and 2.5-feet wide, weighing 2,150 pounds.

Drainage Fill – Drainage Fill consists of free-draining aggregate, such as 2020 Washington State Department of Transportation (WSDOT) Standard Specifications Section 9-03.12(2) (Gravel Backfill for Walls), that is placed behind the PMUs. We recommend avoiding drainage composite or fabric as a substitute for drainage fill.

Reinforced Fill – Soil placed within the Reinforced Fill Zone should consist of well-drained aggregate such as 2020 WSDOT Standard Specifications section 9-03.12(2) (Gravel Backfill for Walls) behind the Drainage Fill. See section 5.6.2 of this report for recommendations regarding the Reinforced Fill.

Geogrid Reinforcing Mesh – Mesh placed between the Ultrablock™ units and extending into the Reinforced Fill Zone. Mesh used for this MSE Wall should be Tencate Miragrid 10XT or equivalent. The geogrid reinforcing mesh from the main face blocks and side blocks should not directly overlap. At least 6 inches of compacted Reinforced Fill should be placed between mesh layers. The strong axis of the geogrid should be oriented perpendicular to the wall face.

Leveling Pad / Wall Foundation – A pad of at least 6 inches of compacted and free-draining crushed rock such as the 2020 WSDOT Standard Specifications Section 9-03.9(3) (Top Course) upon which the PMUs are placed.

Embedment – The minimum depth (1.5 feet) to which the base PMU is embedded into the ground.
Foundation Subgrade – Medium dense or better, existing fill or native soil, or Structural Fill that extends to the competent native soils.
Drain Pipe – Perforated 6-inch-diameter, corrugated HDPE pipe or smooth-walled perforated PVC pipe placed full length at the inside base of the wall that discharges by gravity to a suitable location.
Drainage Swale – A small depression adjacent to the top of the walls to collect surface water runoff to the Drainage Fill. Alternatively, a stormwater collection system can be tightlined from pavement areas and carried away from the Parking Structure (see section **5.6.4** of this report).
Backslope – The ground surface slope behind (uphill from) the wall.
Foreslope – The ground surface slope in front of the wall.

5.6.2 Reinforced Fill

Soil used within the Reinforced Fill Zone should meet the requirements for 2020 WSDOT Standard Specifications section 9-03.14(4) Gravel Backfill for Structural Earth Wall modified to limit the silt content (soil particles passing the US Standard No. 200 sieve) to less than five percent.

A minimum 12-inch-thick sand Drainage Fill meeting the requirements of the 2020 WSDOT Standard Specifications section 9-03.12(2) (Gravel Backfill for Walls) should be placed at the back of the PMUs to provide drainage of the Reinforced Fill.

A 6-inch-diameter Drainage Pipe consisting of perforated, corrugated HDPE or smooth-walled PVC should be placed at the inside base of the SEW and run the full length of the wall. The Drainage Pipe should be bedded in washed 3/8 inch to No. 8 size pea gravel with a minimum of 8 inches of cover over the pipe. A nonwoven drainage material, such as Tencate Mirafi 160N should be placed to encapsulate the Drainage Fill and the Drainage Pipe bedding.

Reinforced Fill should be compacted to at least 95 percent of the MDD as determined by ASTM Test Method D 1557. As a guideline, we recommend that the Reinforced Fill be placed in horizontal lifts which are 10 inches or less in loose thickness. The actual lift thickness will be a function of the fill quality and size of the compaction equipment used. Each lift should be compacted to the required specification before placing subsequent layers. Adjacent to the wall facing (within about 3 feet) care should be taken to avoid over-compacting, which can build up excess lateral soil pressures behind the wall facing. Wall backfill can be compacted to 92 percent of the MDD (ASTM Test Method D 1557) in these areas. Lighter compaction equipment may be more suitable adjacent to the wall facing.

5.6.3 Parking Structure Stability Analysis

An evaluation of internal, external and compound stability analyses for the Parking Structure MSE Walls was completed by ICE.

Two cross-sections, one east-west (perpendicular to the existing slope), and one north-south (parallel to the existing slope, resulting in a back-to-back MSE Wall) were analyzed for stability. Analyses were completed using Ultrablock™ Retaining Wall Software (Version 5.0.18138.1010) which is based on the design method outlined in the American Association of State Highway and Transportation Officials (AASHTO) *Standard Specifications for Highway Bridges – 17th Edition,* 2002.

The program has the capability of analyzing stability related to geogrid connection tensile strength, geogrid tensile strength, geogrid pullout strength, and sliding failure, bearing failure and overturning failure of the wall system. The program uses Coulomb theory for determination of active earth pressures.

The program also has the capability of analyzing global stability through or below the face of the wall considering the site topography, soil conditions and block geometry. The program uses Bishop's Method for analysis of global stability.

The following is a summary of the soil strength parameters that were used in our analysis of the Ultrablock™ MSE Wall sections:

Soil Type	Moist Unit Weight (pcf)	Φ (degrees)	C (psf)
Reinforced Fill Soil(1)	130	34	0
Retained Soil (2)	130	34	0
Foundation Subgrade(3)	130	36	0
Leveling Pad(4)	130	40	0

(1) Reinforced Fill soil should be well-drained, clean and granular, consistent with the recommendations in section 5.6.2 of this report.
(2) Retained Soil is expected to be Structural Fill or existing Fill.
(3) The foundation subgrade is expected to be dense Alpine Glacial Drift.
(4) Soil used for the leveling pad and shallow soil in front of the toe of the wall is expected to be Crushed Rock or well compacted Fill.
Φ = angle of internal friction
C = cohesion

The following seismic parameters were used in the analysis:

Parameter	Value
Seismic Site Class	C
Design Peak Ground Acceleration (PGA)(1)	0.29g
Horizontal Seismic Coefficient(1)	0.29g

(1) For seismic evaluation, from ASCE/SEI 7-16 (American Society of Civil Engineers/Structural Engineering Institute, 2017, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures,* version 7-16). The WSDOT Geotechnical Design Manual (July 2019) recommends that the full design-level PGA be used as the Horizontal Seismic Coefficient for back-to-back MSE walls.

The general minimum FOS Safety (static) for MSE Wall structures is 1.5 for sliding and overturning, and 2.0 for bearing. The FOS for seismic conditions is typically acceptable at 75 percent of the static FOS.

A summary of the FOS results is presented below.

Wall Profile	Internal Stability FOS (static/seismic)			External Stability FOS (static/seismic)			Global (static/ seismic)
	Connection Tensile	Geogrid Tensile	Geogrid Pullout	Sliding	Bearing	Overturning	
North-South	3.05 / 7.51	3.48 / 6.03	3.15 / 7.75	3.18 / 1.63	6.28 / 4.33	5.02 / 2.12	1.8 / 1.2
East-West	2.65 / 6.52	2.73 / 6.71	2.49 / 6.12	4.96 / 1.84	3.93 / 2.33	7.11 / 2.04	1.5 / 1.1

Based on our analysis, adding the Parking Structure does not substantially change the deep-seated stability of the existing fill embankment along Snoqualmie Drive. The shallow stability (resistance to raveling or shallow landsliding) is enhanced with the addition of the Parking Structure. Stability analysis files are available upon request.

We understand that an extra row of blocks may be added on the top of the Parking Structure to provide a vehicle barrier. We do not expect this extra row of blocks to impact the stability of the Parking Structure MSE Wall.

5.6.4 Wall Drainage

It is critical that the Parking Structure be properly drained so that excess pore pressures do not build up behind the wall faces. Proper installation of the drainage fill behind the wall faces and the drain pipe at the base of the walls is imperative for proper performance of the wall system.

If excessive stormwater or snowmelt runoff is expected from impervious surfaces behind and upslope of the Parking Structure, the Civil Engineer should consider installing stormwater drains on the top of the Parking Structure to supplement the planned wall drain pipes.

5.6.5 Ultrablock™ MSE Wall Parking Structure Details

Figures 4 and 5, the Ultrablock™ MSE Wall (MSEW) Parking Structure Details show MSE Wall sections for the two critical profiles. The location of the proposed Parking Structure is shown on Figures 2 and 3. MSE Walls must be constructed in accordance with the plans, specifications and installation requirements provided by Ultrablock, Inc., or redesigned and constructed in accordance with the plans, specifications, and installation requirements provided by other manufacturers of gravity block wall systems, as appropriate.

5.6.6 Temporary Cut Slopes

The MSE Walls (and the Structural Fill slopes) will require temporary cut slopes for installation. The Fuhr Property is generally underlain by medium dense or denser Alpine Glacial Drift. The Alpine Glacial Drift is underlain by weathered bedrock (Guye Sedimentary Member). The embankment along the west edge of the property consists of existing Fill. For planning purposes, the following table provides guidance on temporary cut slope inclinations in the vicinity of the Fuhr Property.

Soil Type	Recommended Temporary Cut Slope Inclination (up to 4-feet high)	Recommended Temporary Cut Slope Inclination (over 4-feet high)
Alpine Glacial Drift or Weathered Bedrock	0.75H:1V	1H:1V
Existing Fill	0.75H:1V	1H:1V

Additional evaluation of the actual soil material will be required at the time of earthwork to establish safe temporary cut slopes. Flatter slopes may be necessary to maintain safe working conditions if instability is observed. Some sloughing and raveling of the temporary cut slopes should be expected. Temporary covering, such as heavy plastic sheeting, should be used to protect these slopes during periods of wet weather. Surface water runoff from above cut slopes should be prevented from flowing over the slope face by using berms, drainage ditches, swales or other appropriate methods.

5.7 PROPOSED DRIVEWAY – TRANSITION FILL SLOPE OPTIONS

5.7.1 General

Based on discussions with and documentation provided by Mr. Fuhr, the project includes installation of fill slopes adjacent to Snoqualmie Drive that would support the proposed driveway and would serve as a transition from the proposed Parking Structure to the existing Snoqualmie Drive fill embankment. We understand that the proposed fill slopes may be inclined up to 1H:1V.

Three options for establishing the proposed fill slopes are presented below. As previously mentioned, permission from Kittitas County should be obtained before any grading of the existing fill embankment is completed.

5.7.2 Reinforced Soil Slope (RSS) Option

The intent of this preliminary analysis of the Reinforced Soil Slope (RSS) option is for informational purposes only; this preliminary evaluation is not intended for final design or construction. However, soil and seismic parameters provided in this section can be used by the product manufacturer for design purposes. The final design should be completed by the design team including the product manufacturer.

Based on our preliminary evaluation, a Reinforced Soil Slope (RSS) inclined up to 1H:1V may be a feasible option for the transition fill slope. An RSS includes placement of fill with reinforcement mesh or fabric intermittently placed between lifts of fill. One potential disadvantage of an RSS is the distance behind the finished slope face required to install the reinforcing mesh. Our preliminary evaluation (assuming a maximum geogrid length of about 10 feet) shows that space is available behind the slope face to make an RSS an option to consider but may require grading into the toe of the existing fill embankment within the Fuhr Property boundaries. Another potential disadvantage of the RSS is that the facing materials of the RSS may be subject to corrosion or degradation, potentially leaving the 1H:1V slope vulnerable to surface erosion in the long term.

An RSS steeper than 1.5H:1V should have a wrapped or a welded wire slope face; an RSS flatter than 1.5H:1V may have an exposed face (turf or vegetation facing). Reinforcement mesh should have a minimum length of 6 feet. RSS fill should meet the requirements of Structural Fill outlined in section **5.3** of this report (including requirements for stripping, grubbing and keying, and lift thickness and compaction). Additionally, RSS fill should meet the following requirements for gradation:

US Standard Sieve Size	Percent Passing
4 inch	100
No. 4	20 – 100
No. 40	0 – 60
No. 200	0 – 50

From Federal Highway Administration, November 2009, *Design and Construction of MSE Walls and RSS – Volume 1, Table 3-2.*

It is typical for the RSS vendor to analyze the RSS for internal stability and specify the reinforcing fabric/mesh and reinforcement spacing. ICE can provide critical cross-sections and geotechnical data, or a final design of the RSS, upon request. The following input parameters were used for a preliminary global (external) stability analysis of the critical cross-section, identified as Cross-Section B-B’ on Figure 3.

Soil Type	Moist Unit Weight (pcf)	Φ (degrees)	C (psf)
Non-Reinforced Fill(1)	130	34	0
Native Soil(2)	130	36	0

(1) Existing fill and non-reinforced Structural Fill are assumed to be well-compacted and properly keyed in to place.
(2) Native Soil is expected to be dense Alpine Glacial Drift, or dense weathered bedrock.

Parameter	Value
Seismic Site Class	C
Design Peak Ground Acceleration(1)	0.29g
Horizontal Seismic Coefficient(1)	0.15g
Groundwater Table	Elevation 2,743 feet

(1) For seismic evaluation, from ASCE/SEI 7-16.

A summary of the preliminary FOS results for the global stability analysis for Cross-Section B-B' is presented below. Based on our preliminary analysis, adding an RSS fill does not substantially change the deep-seated stability of the existing fill embankment along Snoqualmie Drive. The shallow stability (resistance to raveling or shallow landsliding) is enhanced with the addition of the RSS. The preliminary stability analysis files are available upon request.

Design Situation	FOS
Static/Permanent	1.5
Seismic	1.1

5.7.3 Quarry Spall Option

Unreinforced Quarry Spall slopes (quarry spalls in accordance with 2020 Washington State Department of Transportation (WSDOT) Standard Specifications 9-13.1(5)) may be inclined at 1.5H:1V or flatter. Quarry spalls placed on existing slopes which are steeper than 4H:1V should be properly keyed into the existing slope surface. This can be accomplished by constructing the Quarry Spall slope in a series of 4-foot-wide horizontal benches cut into the slope. Quarry spalls should be placed in horizontal lifts and bucket-tamped (locked) into place.

5.7.4 Structural Fill Option

Unreinforced Structural Fill slopes may be inclined at 1.75H:1V (about 30 degrees) or flatter, assuming the material comes from local sources (typically, borrow material in the Snoqualmie Pass area is particularly angular and coarse-grained).

Surfaces which will receive Structural Fill should be properly stripped of vegetation and organic material prior to placing Structural Fill. Structural Fill should be placed on firm and unyielding subgrades. Structural Fill placed on existing slopes which are steeper than 4H:1V should be properly keyed into the existing slope surface. This can be accomplished by constructing the Structural Fill slope in a series of 4-foot-wide horizontal benches cut into the existing slope. The Structural Fill should be placed in horizontal lifts. We recommend that Structural Fill be placed on the cut benches as soon as possible following construction of the benches. Structural Fill for slopes should be uniformly compacted to at least 95 percent of the MDD obtained in general accordance with ASTM Test Method D 1557.

6.0 USE OF THIS REPORT

We have prepared this report for Matthew Fuhr. The data and report should be provided to prospective contractors for their bidding or estimating purposes, but our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

Variations in subsurface conditions are possible between the locations of the explorations; variations may also occur with time. Some contingency for unanticipated conditions should be included in the project budget and schedule. Sufficient observation, testing and consultation by our firm should be provided during construction to evaluate that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions observed during construction differ from those anticipated, and to evaluate whether or not earthwork and foundation installation activities comply with contract plans and specifications. We recommend that ICE be contacted if the location or orientation of the house, Parking Structure, or transition fill slope changes.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time the report was prepared. No warranties or other conditions, express or implied, should be understood.

****

We trust this report meets your present needs. Please call if you have any questions.

Yours very truly,
Icicle Creek Engineers, Inc.

Shane J. Markus, EIT
Senior Staff Engineer

Brian R. Beaman, PE, LEG, LHG
Principal Engineer/Geologist/Hydrogeologist

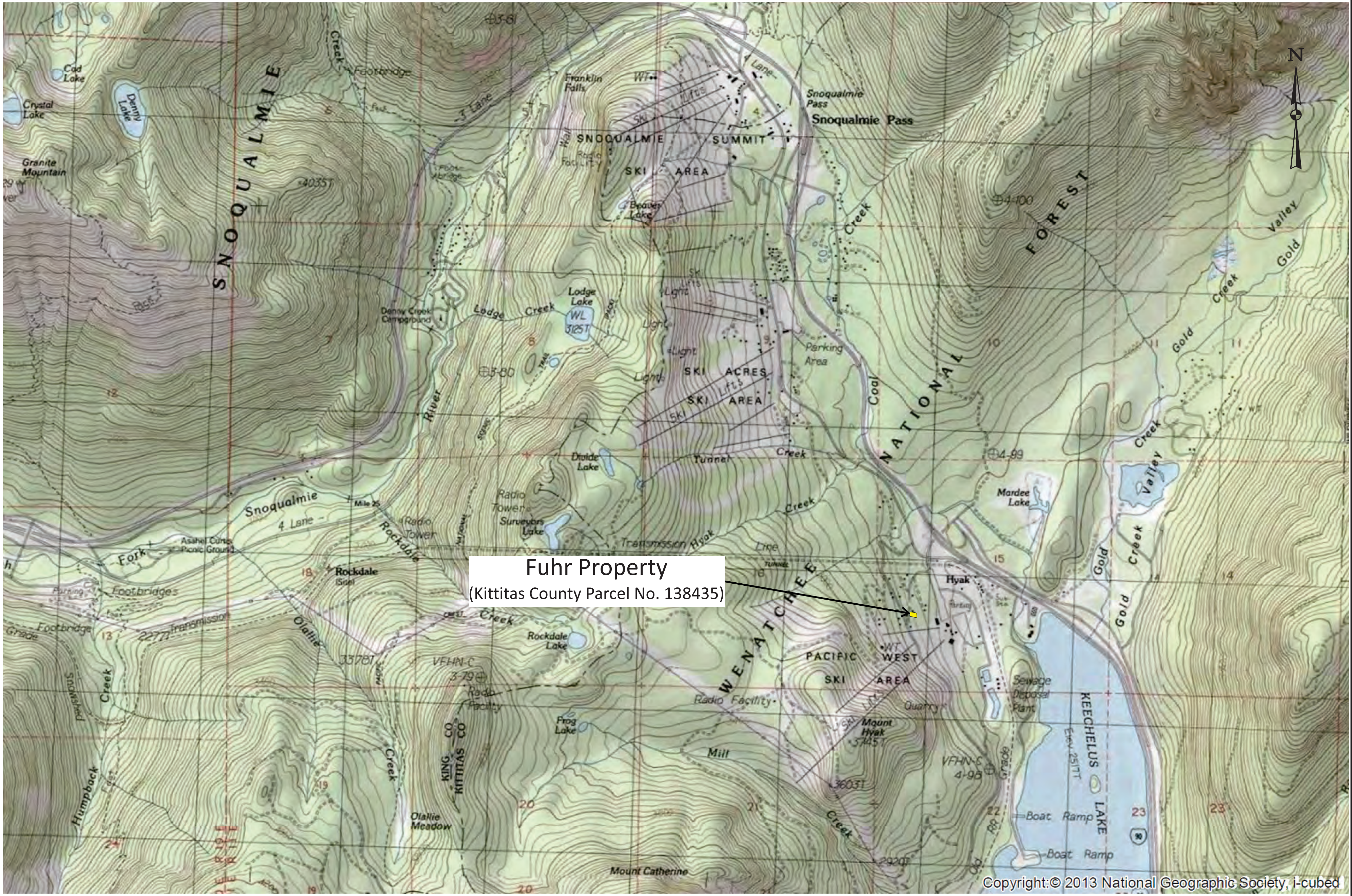
State of Washington Licensed Geologist Engineering Geologist 671 BRIAN R. BEAMAN

BRIAN R. BEAMAN STATE OF WASHINGTON 24010 REGISTERED PROFESSIONAL ENGINEER

Document ID: 1329001.REP
Submitted via email (pdf) and surface mail (one original copy)

Attachments: Vicinity Map – Figure 1
Site Plan – Figure 2
Site Cross-Sections A-A' / B-B' – Figure 3
Ultrablock MSE Wall Parking Structure Diagram – East-West Profile – Figure 4
Ultrablock MSE Wall Parking Structure Diagram – North-South Profile – Figure 5
Soil Classification System – Attachment A
Test Pit Logs – Attachment B

FIGURES AND ATTACHMENTS



Base map obtained from the Washington State Department of Natural Resources, Geologic Information Portal (https://geologyportal.dnr.wa.gov/)

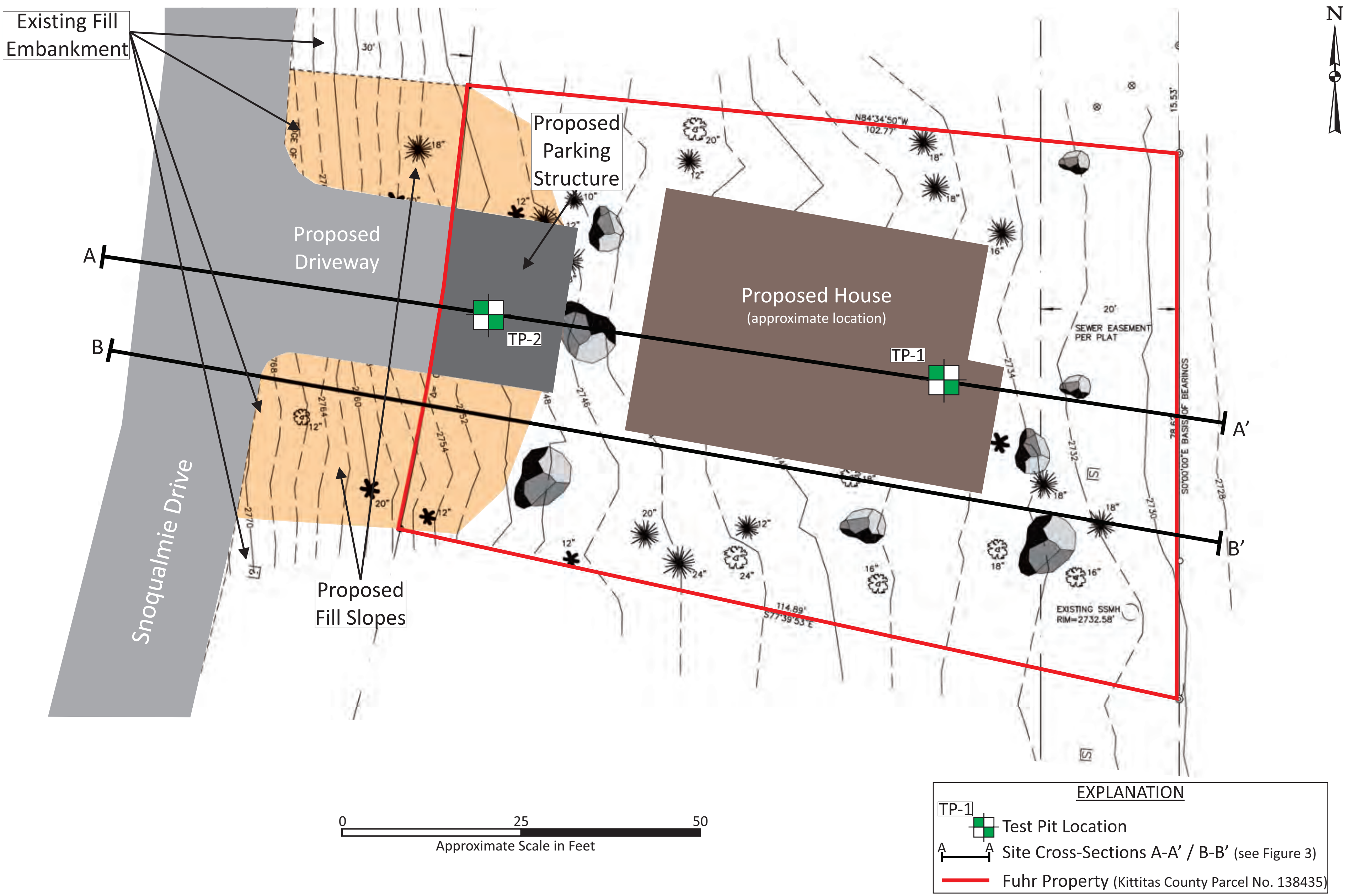
0 ½ 1
Approximate Scale in Miles

VICINITY MAP

PROPOSED RESIDENTIAL DEVELOPMENT
KITTITAS COUNTY PARCEL NO. 138435, HYAK AREA, WASHINGTON

ICICLECREEK ENGINEERS
29335 NE 20th Street
Carnation, Washington 98014
(425) 333-0093

SCALE: As Shown	ICE FILE NO.
DESIGNED: ---	1329-001
DRAWN: SJM	Figure
CHECKED: BRB/KSK	1
DATE: 01/29/20	



Notes: 1) Base map reference: Direct Surveying, May 25, 2018, *Matthew Fuhr Topographic Survey*, one sheet.
2) Proposed House, Proposed Driveway and Proposed Parking Structure locations are based on a conceptual plan set (Terralite Architecture, May 31, 2019, *The Mountainside House,* sheet A-1).

SITE PLAN

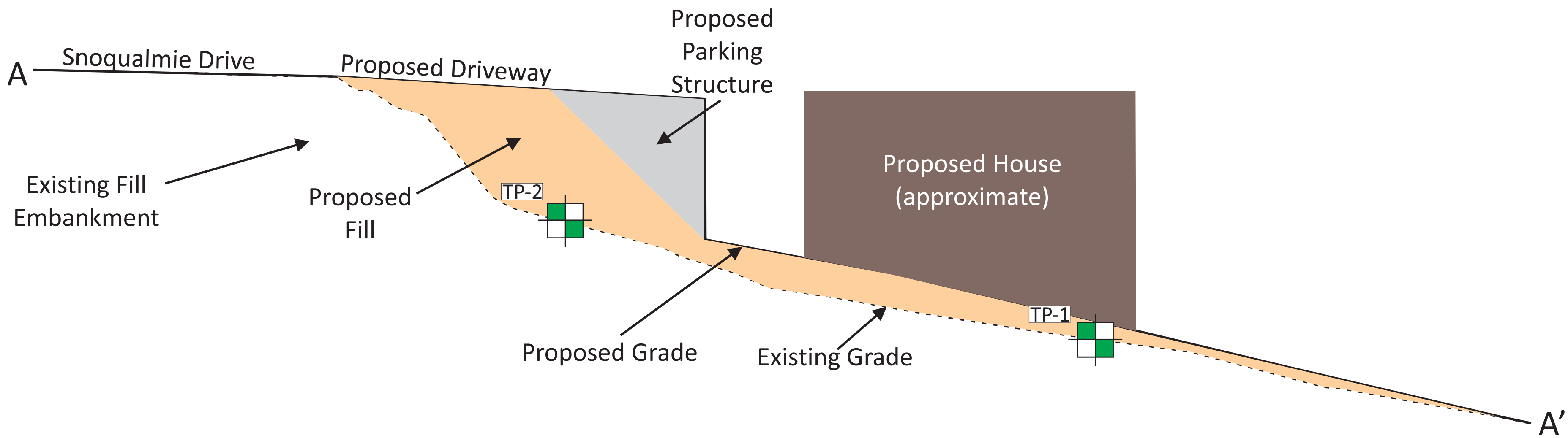
PROPOSED RESIDENTIAL DEVELOPMENT
KITTITAS COUNTY PARCEL NO. 138435, HYAK AREA, WASHINGTON

ICICLECREEK ENGINEERS
29335 NE 20th Street
Carnation, Washington 98014
(425) 333-0093

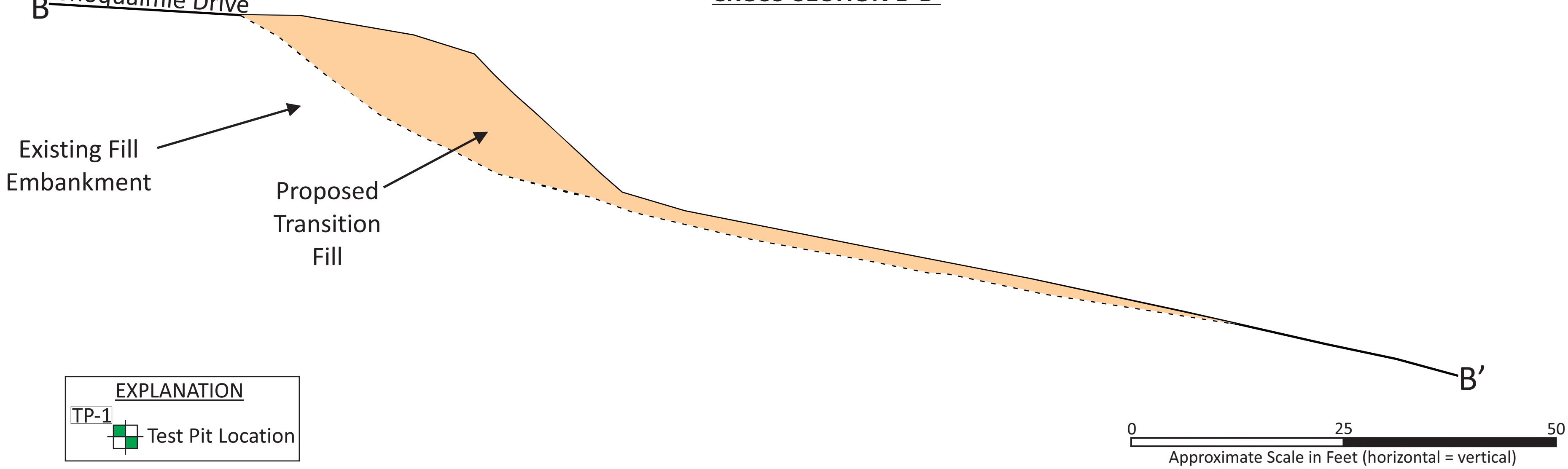
SCALE: As Shown
DESIGNED: ---
DRAWN: SJM
CHECKED: BRB/KSK
DATE: 01/29/20

ICE FILE NO.
1329-001
Figure
2

CROSS-SECTION A-A'



CROSS-SECTION B-B'



Notes: 1) Existing and proposed grades based on the untitled, undated grading plan produced by Encompass Engineering and Surveying, and provided by Matthew Fuhr (File Name: "Snoq Grading", scale 1 inch = 20 feet).
2) Proposed House, Proposed Driveway and Proposed Parking Structure locations are based on a conceptual plan set (Terralite Architecture, May 31, 2019, *The Mountainside House,* sheet A-1).

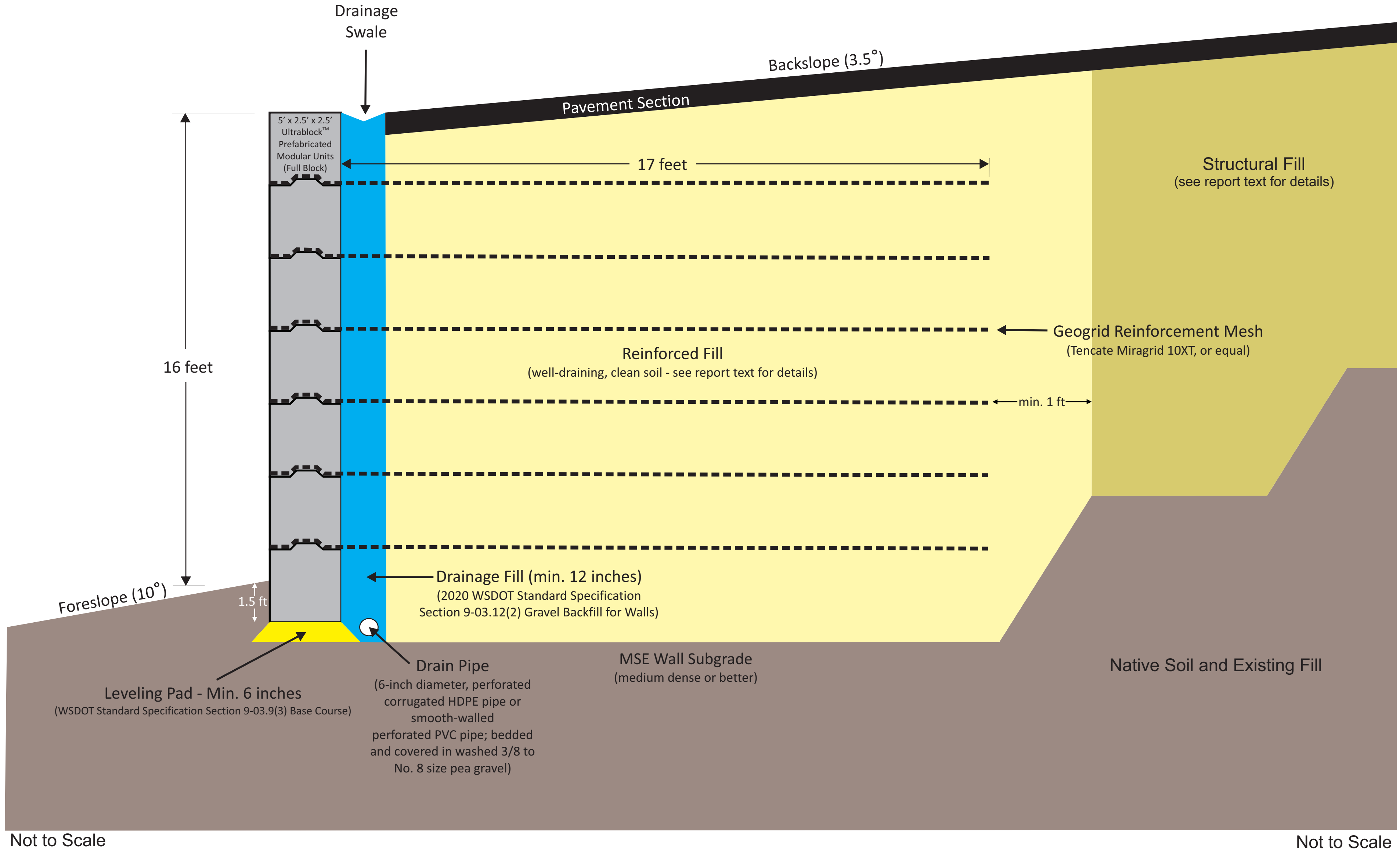
SITE CROSS-SECTIONS A-A' / B-B'

PROPOSED RESIDENTIAL DEVELOPMENT
KITTITAS COUNTY PARCEL NO. 138435, HYAK AREA, WASHINGTON

ICICLECREEK ENGINEERS
29335 NE 20th Street
Carnation, Washington 98014
(425) 333-0093

SCALE: As Shown
DESIGNED: ---
DRAWN: SJM
CHECKED: BRB/KSK
DATE: 01/29/20

ICE FILE NO.
1329-001
Figure
3



Notes: 1) See report text for additional details.
2) Assumed native soil parameters: Φ' = 36°, c' = 0 psf, γ = 130 pcf
3) Assumed Reinforced Fill parameters: Φ' = 34°, c' = 0 psf, γ = 130 pcf
4) Assumed Structural Fill parameters: Φ' = 34°, c' = 0 psf, γ = 130 pcf
5) Design PGA = 0.29g (from IBC 2015)
5) Assumed no groundwater influence.
6) Ultrablock™ walls must be installed in accordance with the design plans, specifications and installation requirements provided by Ultrablock, Inc.

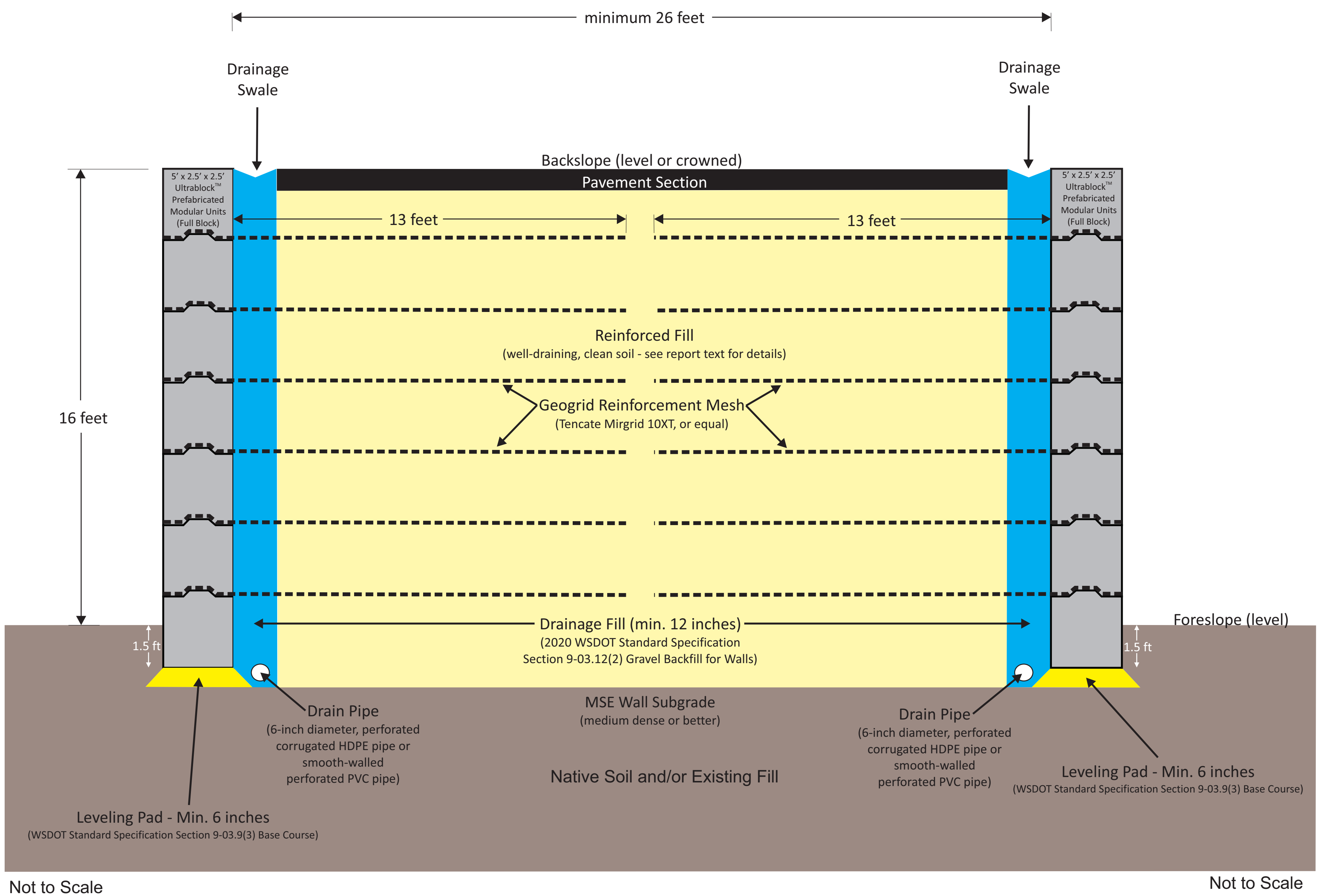
ULTRABLOCK™ MSE WALL PARKING STRUCTURE DIAGRAM – EAST-WEST PROFILE

PROPOSED RESIDENTIAL DEVELOPMENT
KITTITAS COUNTY PARCEL NO. 138435, HYAK AREA, WASHINGTON

ICICLECREEK ENGINEERS
29335 NE 20th Street
Carnation, Washington 98014
(425) 333-0093

SCALE: None
DESIGNED: ---
DRAWN: SJM
CHECKED: BRB/KSK
DATE: 01/29/20

ICE FILE NO.
1329-001
Figure
4



Notes: 1) See report text for additional details.
2) Assumed native soil parameters: Φ' = 36°, c' = 0 psf, γ = 130 pcf
3) Assumed Reinforced Fill parameters: Φ' = 34°, c' = 0 psf, γ = 130 pcf
4) Assumed no groundwater influence.
5) Design PGA = 0.29g (from IBC 2015).
5) Ultrablock™ walls must be installed in accordance with the design plans, specifications and installation requirements provided by Ultrablock, Inc.

ULTRABLOCK™ MSE WALL PARKING STRUCTURE DIAGRAM – NORTH-SOUTH PROFILE

PROPOSED RESIDENTIAL DEVELOPMENT
KITTITAS COUNTY PARCEL NO. 138435, HYAK AREA, WASHINGTON

ICICLECREEK ENGINEERS
29335 NE 20th Street
Carnation, Washington 98014
(425) 333-0093

SCALE: None
DESIGNED: ---
DRAWN: SJM
CHECKED: BRB/KSK
DATE: 01/29/20

ICE FILE NO. 1329-001

Figure 5

Unified Soil Classification System (USCS)

MAJOR DIVISIONS			Soil Group Symbol and Name	
Coarse-Grained Soils More than 50% retained on the No. 200 sieve	GRAVEL More than 50% of coarse fraction retained on the No. 4 sieve	CLEAN GRAVEL	GW	Well-graded gravels
			GP	Poorly-graded gravels
		GRAVEL WITH FINES	GM	Gravel and silt mixtures
			GC	Gravel and clay mixtures
	SAND More than 50% of coarse fraction passes the No. 4 sieve	CLEAN SAND	SW	Well-graded sand
			SP	Poorly-graded sand
		SAND WITH FINES	SM	Sand and silt mixtures
			SC	Sand and clay mixtures
Fine-Grained Soils More than 50% passing the No. 200 sieve	SILT AND CLAY Liquid Limit less than 50	INORGANIC	ML	Low-plasticity silts
			CL	Low-plasticity clays
		ORGANIC	OL	Low plasicity organic silts and organic clays
	SILT AND CLAY Liquid Limit greater than 50	INORGANIC	MH	High-plasticity silts
			CH	High-plasticity clays
		ORGANIC	OH	High-plasticity organic silts and organic clays
Highly Organic Soils	Primarily organic matter with organic odor		PT	Peat

Notes: 1) Soil classification based on visual classification of soil in general accordance with ASTM D2488.
2) Soil classification using laboratory tests is based on ASTM D2487.
3) Description of soil density or consistency is based on interpretation of blow count data and/or test data.

Soil Particle Size Definitions

Component	Size Range
Boulders	Greater than 12 inch
Cobbles	3 inch to 12 inch
Gravel	3 inch to No. 4 (4.78 mm)
Coarse	3 inch to 3/4 inch
Fine	3/4 inch to No. 4 (4.78 mm)
Sand	No. 4 (4.78 mm) to No. 200 (0.074 mm)
Coarse	No. 4 (4.78 mm) to No. 10 (2.0 mm)
Medium	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and Clay	Less than No. 200 (0.074 mm)

Soil Moisture Modifiers

Soil Moisture	Description
Dry	Absence of moisture
Moist	Damp, but no visible water
Wet	Visible water

SOIL CLASSIFICATION SYSTEM	ICICLECREEK ENGINEERS 29335 NE 20th Street Carnation, Washington 98014 (425) 333-0093	SCALE: No Scale	ICE FILE NO.	
		DESIGNED: --	1329-001	
PROPOSED RESIDENTIAL DEVELOPMENT KITTITAS COUNTY PARCEL NO. 138435, HYAK AREA, WASHINGTON		DRAWN: SJM		
		CHECKED: BRB/KSK	Attachment	
		DATE: 01/29/20	A	

Depth [1] (feet)	Soil Group Symbol [2]	Test Pit Description [3]
Test Pit TP-1	Approximate Ground Surface Elevation: 2,737 feet	Latitude 47.39129, Longitude -121.39947
0.0 - 0.5		Sod and Topsoil
0.5 - 3.5	SM	Light brown silty fine to medium SAND with gravel, cobbles and boulders up to about 3 feet in diameter (medium dense, moist) (Alpine Glacial Drift) grades to reddish-brown at about 1.5 feet
3.5 - 7.0	SM	Light grayish-brown silty fine to medium SAND with gravel and cobbles (dense, moist) (Alpine Glacial Drift)
7.0 - 8.0	Rock	Light gray SILTSTONE (moderately weathered, moderately strong bedrock) (Guye Sedimentary Member)
		Test pit completed at about 8.0 feet on 09/13/2019 Difficult excavation below about 3.5 feet with a Kubota KX04-4 mini-trackhoe Slight caving of the test pit walls observed between about 0.5 and 2.0 feet No groundwater seepage observed Disturbed soil samples obtained at about 3.0, 4.0 and 7.5 feet
Test Pit TP-2	Approximate Ground Surface Elevation: 2,751 feet	Latitude 47.39131, Longitude -121.39970
0.0 - 0.5		Sod and Topsoil
0.5-2.0	SM	Reddish-brown silty fine to medium SAND with gravel and cobbles (medium dense, moist) (Alpine Glacial Drift)
2.0 - 5.0	SP-SM	Light grayish-brown fine to medium SAND with silt, gravel, cobbles and boulders up to about 2 feet in diameter (dense, moist) (Alpine Glacial Drift)
5.0 - 9.0	GP-GM	Gray fine to coarse GRAVEL with silt, sand and cobbles (dense, moist) (Alpine Glacial Drift) grades to with boulders up to about 3 feet in diameter at about 7.0 feet
		Test pit completed at about 9.0 feet on 09/13/2019 Very difficult excavation below about 5.0 feet with a Kubota KX04-4 mini-trackhoe No caving of test pit walls observed Groundwater seepage observed between about 8.5 and 9.0 feet Disturbed soil samples obtained at about 2.0 and 5.5 feet

Notes:
(1) The depths on the test pit logs are shown in 0.5 foot increments, however these depths are based on approximate measurements across the length of the test pit and should be considered accurate to 1.0 foot. The depths are relative to the adjacent ground surface.
(2) The soil group symbols are based on the Soil Classification System, Attachment A.
(3) The approximate test pit locations are shown on the Site Plan, Figure 2.