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Geotechnical Engineering Report
Hudson Short Plat
28010 Southeast 258th Street
King County, Washington
PN: 3022079060
Doc ID: H2PropertiesLLC.SE258thSt.RG

INTRODUCTION

This *Geotechnical Engineering Report* summarizes our site observations, subsurface explorations, and provides geotechnical conclusions and recommendations for the construction of a residential short plat in the Ravensdale area of King County, Washington. The general location of the site is shown on the attached Site Location Map, Figure 1.

Our understanding of the project is based on our correspondence with Wayne Nelson of ESM Consulting Engineers, LLC (ESM); the *Site Survey* provided by H2 Properties, our review of the provided *Feasibility Exhibit* prepared by ESM, dated February 2, 2021; our review of the published geologic and soil literature for the site and Ravensdale area; our May 18, 2022 site visit and subsurface explorations; our understanding of the King County Critical Areas [King County Code (KCC) Title 21A.24] and development codes [King County Code Title 17A and the 2018 International Building Code (IBC)]; and our previous experience in King County.

The site is currently developed with an existing workshop, gravel driveway, and associated utilities. According to the provided site plan, you propose to divide the parcel into four lots and a critical areas tract. The proposed lots will be accessed from SE 258th Street. The conceptual site layout is shown on the Site & Exploration Plan, Figure 2.

PURPOSE & SCOPE

Our scope of services was to evaluate the surface and subsurface conditions across the site as a basis for providing geotechnical recommendations and design criteria for the construction of a four-lot residential plat. Specifically, the scope of services for this project included the following:

1. Reviewing the available geologic, hydrogeologic, and geotechnical data for the site area;
2. Exploring surface and subsurface conditions by reconnoitering the site and monitoring the excavation of 10 test pit explorations at select locations across the site;
3. Describing surface and subsurface conditions, including soil type, depth to groundwater, and an estimate of seasonal high groundwater levels;

4. Addressing the KCC Title 21A for Critical Areas including but not limited to erosion hazard, landslide hazard, and steep slope hazard areas;
5. Providing recommendations for seismic design parameters, including 2018 IBC site class;
6. Evaluating the global stability of the site in existing conditions using SLIDE 2 by Rocscience;
7. Providing geotechnical conclusions and recommendations regarding site grading activities including; site preparation, subgrade preparation, fill placement criteria, suitability of on-site soils for use as structural fill, temporary and permanent cut and fill slopes, and drainage and erosion control measures;
8. Providing geotechnical conclusions regarding foundations, including: shallow foundation parameters, floor slab support and design criteria, bearing capacity, and subgrade modulus as appropriate;
9. Providing recommendations for subgrade walls, including lateral earth pressures and applicable seismic surcharges;
10. Providing our opinion about the feasibility of onsite infiltration of stormwater in accordance with the 2021 King County Surface Water Design Manual (KCSWDM) including a preliminary infiltration rate based on grain size analysis, if appropriate;
11. Providing recommendation for erosion and sediment control during wet weather grading and construction; and,
12. Preparing a *Geotechnical Engineering Report* summarizing our site observations and conclusions, and our geotechnical recommendations and design criteria, along with the supporting data.

The above scope of work was summarized in our *Proposal for Geotechnical Engineering* Services dated May 2, 2022. We received written authorization by email to proceed on May 3, 2022.

SITE CONDITIONS

Surface Conditions

The site consists of a single King County tax parcel located at 28010 Southeast 258th Street in the Ravensdale area in King County, Washington. According to the *Feasibility Exhibit*, the site measures about 655 feet wide (north to south) by about 1,325 feet long (east to west) and encompasses about 20 acres. The site is bounded by single-family residences to the east, a tract owned by the City of Seattle Public Utilities operating a hydroelectric dam on the Cedar River to the north, undeveloped land to the west, and by Southeast 258th Street to the south.

The site is situated on the northern margin of the Maple Valley glacial upland area. Based on 2-foot elevation contours shown on the provided *Feasibility Exhibit* and our site observations, the ground surface at the site generally slopes down to a drainage running northeast-southwest through the northwest corner of the parcel. Across most of the parcel, slopes vary between 10 to 25 percent. In the southern portion of the site, in the southwest portion of proposed Lot 2 and southeast portion of proposed Lot 1, the ground surface slopes down to the west at about 40 to 45 percent with about 40 feet of vertical relief. In the northern portion of the site, in the northern portion of proposed Lot 4, the ground surface slopes down to the north at about 40 to 45 percent with about 45 feet of vertical relief. In the northwestern portion of the site, in the eastern portion of the proposed Open Space Tract, the ground surface slopes down to the drainage at about 50 to 60 percent with about 20 to 35 feet of vertical relief. The total vertical relief of the site is on the order of

120 feet. The existing site configuration and topography for the site are shown on the Site Vicinity & Critical Areas Map, Figure 3.

Vegetation across the site consists of moderate stands of mature Douglas fir, hemlock, and western red cedar trees with a sparse to moderate understory of Himalayan blackberries, fern, ivy, and unmaintained grasses. The steep slopes are well vegetated, with no apparent areas of exposed soil. We observed a stream flowing across the northwest portion of the site, which is mapped as joining the Cedar River about 360 feet north of the site.

Site Soils

The USDA Natural Resource Conservation Service (NRCS) *Web Soil Survey of Snoqualmie Pass Area, Parts of King and Pierce Counties, Washington* indicates the site is underlain by Alderwood gravelly loam (1) and Barneston gravelly ashy coarse sandy loam (11) soils. An excerpt of the referenced NRCS Web Soil Survey map for the site and surrounding vicinity is included as Figure 4 and descriptions of the soils are included below.

- *Alderwood gravelly loam (1):* Mapped as underlying the western portion of the site, in the area of the proposed Lot 1 and Open Space Tract, these soils are derived from glacial drift and/or glacial outwash over dense glaciomarine deposits, and are included in hydrologic soils group B. These soils form on slopes of 0 to 15 percent and are considered a "moderate" erosion hazard when exposed. The Soil Survey of King County identifies this soil as type "AgC".
- *Barneston gravelly ashy coarse sandy loam (11):* Mapped as underlying the eastern portion of the site, these soils are derived from volcanic ash mixed with loess over sandy and gravelly glacial outwash, and are included in hydrologic soils group A. These soils form on slopes of 8 to 15 percent and are considered a "slight" erosion hazard when exposed. The Soil Survey of King County identifies this soil as type "3C".

There are localized areas where the slope is greater than those which define the above soil types. Where the Alderwood soils are mapped but slopes are greater than 15 percent, the soil type could more accurately be described as type "AgD", which forms on slopes of 15 to 45 percent. Where the Barneston soils are mapped but slopes are greater than 15 percent, the soil type could more accurately be described as type "3D", which forms on slopes of 15 to 30 percent, or type "3E", which forms on slopes of 30 to 45 percent. In all cases, these potential refinements of the existing soil type mapping would increase the qualitative erosion hazard associated with each soil.

Site Geology

We reviewed the *Geology and Coal Resources of the Cumberland, Hobart, and Maple Valley Quadrangles, King County, Washington* by Vine, J.D. (1969) for the site and surrounding area. The geology of the site is mapped primarily as Terrace gravel and stratified drift (Qt) deposits. Outcrops of undifferentiated Puget Group bedrock (Tp) form local topographic highs, with Vashon glacial till (Qg) mantling slopes in the area above about Elevation 800 feet. The terrace deposits and glacial till were deposited during the Vashon Stade of the Fraser Glaciation, approximately 12,000 to 15,000 years ago. No landslides, mass wasting deposits, or alluvial fans are shown on the map on or within the vicinity of the parcel. An excerpt of the referenced geologic map for the site is included as Figure 5 and detailed descriptions of the geologic units are included below.

- *Terrace gravel and stratified drift (Qt):* Terrace deposits are typically comprised of benches of glacial outwash produced by renewed fluvial downcutting of the valley floor. Glacial outwash deposits generally consist of pebbles, cobbles, and boulders as large as 6 feet across interbedded with sand and silt. These outwash deposits were not overridden by the continental ice mass and are accordingly considered to be normally consolidated, and generally have moderate strength and compressibility characteristics where undisturbed. The infiltration potential of terrace deposits is generally favorable, depending on the grainsize distribution.
- *Vashon glacial till (Qg):* Glacial till typically consists of a heterogeneous mixture of clay, silt, sand, and gravel deposited at the base of the continental ice mass and is subsequently over-ridden. Accordingly, these deposits are considered to be overconsolidated and typically offer high strength and low compressibility characteristics, where undisturbed. The infiltration potential of glacial till is generally limited.
- *Puget Group, undifferentiated (Tp):* The Puget Group is a group of formations that include most prominently the Renton Formation and the Tukwila Formation. In general, the group consists of yellow and fine-grained sandstone and very fine arenaceous shales interbedded with beds of carbonaceous shale and coal. The group extends to occupy a large part of the Puget Sound basin and extends to the western flank of the Cascade Mountain Range. The Puget Group overlies rocks from the Late Cretaceous age. The infiltration potential of bedrock is generally limited.

We reviewed both the WA Department of Natural Resources (WA DNR) 2017 Landslide Compilation and Landslide Inventory datasets for the site vicinity. The Landslide Compilation dataset consists of mapped landslides compiled from a variety of sources including 1:24,000 and 1:100,000-scale surficial geologic maps, landslide hazard zonation studies, watershed analyses, reconnaissance-scale landslide mapping from winter storm landslide events and a lidar-based study of near-shore landforms. The site is situated in an area that has not been analyzed on the post-2017 Landslide Inventory Map.

The Landslide Inventory dataset maps landslide landforms based on criteria provided in the *Protocol for Landslide Mapping from LiDAR Data in Washington State* (Slaughter, et al, 2017) and the Oregon Department of Geology and Mineral Industries (DOGAMI) protocol described in Special Paper 42 (Burns and Madin, 2009). The WA DNR Landslide Compilation maps an alluvial fan of "moderate" confidence about 230 feet north of the site. Based on 5-foot King County GIS Center elevation contours, this alluvial fan appears to be located at the discharge point of a southeast-northwest oriented drainage channel to the east of the site. An excerpt of the landslide compilation map is included in Figure 6.

Subsurface Explorations

On May 18, 2022, we visited the site and monitored the excavation of ten test pits to depths of about 4½ to 7 feet below the existing ground surface. The test pits were excavated by a track-mounted excavator operated by you. A field representative from our office continuously monitored the explorations, maintained logs of the subsurface conditions encountered, obtained representative soil samples, and observed pertinent site features.

Representative soil samples obtained from the explorations were placed in sealed containers and taken to our laboratory for further examination and testing as deemed necessary.

The test pits were backfilled with the excavated soils and bucket tamped, but not otherwise compacted. The densities presented in the test pit logs are based on the difficulty of excavation and our experience. The soils encountered were visually classified in accordance with the Unified Soil Classification System (USCS) and ASTM D2488. The USCS is included in Appendix A as Figure A-1, while descriptive logs of the soils encountered are included as Figures A-2 through A-5.

TABLE 1:
APPROXIMATE LOCATIONS, ELEVATIONS, AND DEPTHS OF EXPLORATIONS

Test Pit Number	Location	Surface Elevation[1] (feet)	Termination Depth (feet)	Termination Elevation[1] (feet)
TP-1	Southwest portion of site	628	7	621
TP-2	Central portion of site	631	7	624
TP-3	Northern portion of site	636	7	629
TP-4	Northeastern portion of site	648	7	641
TP-5	Northeastern portion of site	678	5	673
TP-6	Eastern portion of site	707	5	702
TP-7	Southeastern portion of site	712	5	707
TP-8	Southeastern portion of site	690	5	685
TP-9	Central portion of site	650	4	646
TP-10	Southern portion of site	667	4½	662½

Notes:
1 = Surface elevations estimated by interpolating between contours provided on the *Feasibility Exhibit* prepared by ESM Consulting Engineers, LLC., dated February 2, 2021 (datum: NAVD 88)

Subsurface Conditions

At the locations of our test pits, we encountered uniform subsurface conditions that, in our opinion, generally confirmed the mapped stratigraphy. Our test pits disclosed an approximate 1-foot layer of topsoil in the areas explored. Underlying the topsoil was approximately 1 to 3 feet of loose to medium dense, moist, orange-brown silty poorly graded sand. We interpret these soils to be weathered recessional outwash, or terrace deposits. In test pits TP-2 through TP-7, TP-9, and TP-10, the weathered soils were underlain by a light brown to gray silty sand with gravel in a medium dense, moist condition that we interpret to be unweathered terrace deposits. Directly underlying the weathered terrace deposits in TP-8, and underlying the unweathered terrace deposits, our explorations encountered a light brownish grey sandy gravel with cobbles in a very dense, moist condition. We interpret these soils to be advance outwash. About 2 feet of uncontrolled fill was encountered beneath the topsoil in test pit TP-1. At a depth of 3 feet, we encountered about ½ foot of relict topsoil with underlying advance outwash. Table 2 summarizes the approximate thicknesses, depths, and elevations of selected soil layers.

TABLE 2:
APPROXIMATE THICKNESS, DEPTHS, AND ELEVATION OF SOIL TYPES ENCOUNTERED IN EXPLORATIONS

Test Pit Number	Thickness of:		Depth to Unweathered Advance Outwash (feet)	Elevation of[1] Unweathered Advance Outwash (feet)
	Topsoil/Uncontrolled Fill (feet)	Weathered Terrace Deposits (feet)		
TP-1	3½	NE	3½	624½
TP-2	½	2.5	NE	NE
TP-3	10″	1.2	6½	629½
TP-4	1	2.0	6	642
TP-5	8″	1.3	3	675
TP-6	$^2/_3$	1.2	3½	703½
TP-7	$^2/_3$	1.3	3½	707½
TP-8	1	2.0	3	687
TP-9	1	1.0	3½	647½
TP-10	$^2/_3$	1.3	3½	663½

Notes:
1 = Surface elevations estimated by interpolating between contours provided on the *Feasibility Exhibit* prepared by ESM Consulting Engineers, LLC., dated February 2, 2021 (datum: NAVD 88)
NE = Not Encountered

Laboratory Testing

Geotechnical laboratory tests were performed on select samples retrieved from the test pits to estimate the index engineering properties of the soils encountered. Laboratory testing included visual soil classification per ASTM D2487 and ASTM D2488, moisture content determinations per ASTM D2216, and grain size analyses per ASTM D6913 standard procedures. The results of the laboratory tests are summarized below in Table 3 and graphical outputs are included in Appendix B.

TABLE 3:
LABORATORY TEST RESULTS FOR ON-SITE SOILS

Sample	Soil Type	Lab ID	Gravel Content (percent)	Sand Content (percent)	Silt/Clay Content (percent)	D10 Ratio (mm)
TP-2, S-1, D: 1.5′	SM	103247	15.5	57.1	27.4	<0.075
TP-3, S-1, D: 3.0′	SM	103248	31.2	56.5	12.3	<0.075
TP-3, S-2, D: 7.0′	GW	103249	58.8	37.8	3.4	0.6147

Groundwater Conditions

Groundwater seepage or perched groundwater was not observed at the time of our site visit and subsurface explorations. Orange iron-oxide staining, a form of mottling, was observed in the upper weathered terrace deposits in all test pits. Based on the conditions disclosed by our explorations, it is our opinion the observed mottling is not consistent with shallow groundwater, but rather local variation in saturated hydraulic conductivity. Based on our review of available well logs in the area, we anticipate the first encountered groundwater level would be at least 30 to 40 feet below the existing ground surface at the site.

ENGINEERING CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our data review, site reconnaissance, subsurface explorations, laboratory testing, and our experience in King County; it is our opinion that construction of the proposed short plat is feasible from a geotechnical engineering standpoint.

The site contains potential critical areas (erosion hazard areas and steep slope hazard areas) per King County Code (KCC) Title 21A, and we recommend buffers from erosion, landslide, and steep slope hazard areas onsite based on the performance standards described in KCC Title 21A, the 2018 IBC and our field observations.

Our subsurface explorations within the area of proposed development indicate the surficial soils are sandy gravels and silty sandy gravels in a loose to medium dense and dense to very dense condition (recessional and advance glacial outwash). Provided the recommended buffers and setbacks are maintained, the use of conventional shallow foundations appears feasible. Pertinent conclusions and geotechnical recommendations regarding the design and construction of shallow foundations are presented below.

All development on or near slopes involves risk, only part of which can be mitigated through qualified engineering and construction practices. Favorable performance of structures or slopes in the near term does not imply a certainty of long-term performance, especially under conditions of adverse weather or seismic activity.

Critical Areas per King County Code (KCC) Title 21A

Based on our review, the site is encumbered with critical areas per KCC 21A.24 (steep slope hazard area, erosion hazard area, landslide hazard area). Steep slopes as defined by KCC 21A.24.310 are mapped across the site.

Landslide Hazard Area Per KCC Title 21A.06.680

King County defines a landslide hazard area as an area subject to severe risk of landslide, such as:

A. An area with a combination of:
   1. Slopes steeper than fifteen percent of inclination;
   2. Impermeable soils, such as silt and clay, frequently interbedded with granular soils, such as sand and gravel; and,
   3. Springs or groundwater seepage;
B. An area that has shown movement during the Holocene epoch, which is from ten thousand years ago to the present, or that is underlain by mass wastage debris from that epoch;
C. Any area potentially unstable as a result of rapid stream incision, stream bank erosion or undercutting by wave action;

D. An area that shows evidence of or is at risk from snow avalanches; or
E. An area located on an alluvial fan, presently or potentially subject to inundation by debris flows or deposition of stream-transported sediments.

Slopes steeper than 15 percent are present on the site. However, we do not interpret the geologic and soil conditions mapped and observed at the site as representative of an adverse contact as a result of permeability contrasts. No springs were observed but based on our assessment of groundwater conditions at the site, there appears to be a limited potential for seepage on the steep slopes in the northwestern portion of the site during the wettest portions of the year. An unnamed stream flows southwest to northeast at the toe of the northwestern steep slopes in the proposed Critical Areas Tract, joining the Cedar River to the north of the site. The Cedar River flows east to west about 200 feet beyond the toe of the steep slope north of the site, about 100 vertical feet below the north boundary of the site. Accordingly, we estimate there is limited to moderate potential for rapid stream incision and bank erosion. No landslides are mapped on or in the vicinity of the site. No alluvial fans are mapped on the site.

Based on the above, it appears that the site has two of the indicators of a landslide hazard area (slopes steeper than 15 percent with potential for groundwater seepage; and risk of rapid stream incision or stream bank erosion).

Accordingly, we recommend a buffer and associated building setback be established from the identified landslide hazard areas at the site, as shown on the attached Critical Areas, Buffers, and Setbacks Map, Figure 7. Additional recommendations regarding buffers and setbacks are included in following sections.

Steep Slope Hazard Areas Per KCC Title 21A.06.1230

Steep slope hazard areas are defined as an area on a slope of 40 percent inclination or more within a vertical elevation change of at least 10 feet. For the purpose of this definition, a slope is delineated by establishing its toe and top and is measured by averaging the inclination over at least ten feet of vertical relief.

King County maps steep slope hazard areas across the northern portion of the site within the proposed Critical Areas Tract and Lot 4, as well as in the southern portion of the site, within the southwestern corner of proposed Lot 1 and extending into the southeastern corner of proposed Lot 2. Accordingly, we recommend a buffer and associated building setback be established from the identified steep slope hazard areas at the site, as shown on the attached Critical Areas, Buffers, and Setbacks Map, Figure 7. Additional recommendations regarding buffers and setbacks are included in following sections.

Erosion Hazard Areas Per KCC Title 21A.06.415

Erosion hazard area: an area underlain by soils that is subject to severe erosion when disturbed. These soils include, but are not limited to, those classified as having a severe to very severe erosion hazard according to the United States Department of Agriculture Soil Conservation Service, the 1990 Snoqualmie Pass Area Soil Survey, the 1973 King County Soils Survey or any subsequent revisions or addition by or to these sources such as any occurrence of River Wash ("Rh") or Coastal Beaches ("Cb") and any of the following when they occur on slopes inclined at fifteen percent or more:

A. The Alderwood gravely sandy loam ("AgD");

B. The Alderwood and Kitsap soils ("AkF");
C. The Beausite gravely sandy loam ("BeD" and "BeF");
D. The Kitsap silt loam ("KpD");
E. The Ovall gravely loam ("OvD" and "OvF");
F. The Ragnar fine sandy loam ("RaD"); and
G. The Ragnar-Indianola Association ("RdE"). (Ord. 15051 § 38, 2004: Ord. 10870 § 123, 1993).

The soil mapped to underlie the steeply sloping gully located in the northeast to central portions of the site is Alderwood gravelly loam (AgC) and Barneston gravelly ashy coarse sandy loam (3C) soils, listed by the NRCS as “moderate” and “slight” erosion hazard areas when exposed, respectively. However, localized areas of the site have slopes steeper than those which define the mapped soil types. These steeper slopes could more accurately be mapped as type “AgD” soils, listed by the NRCS as a “moderate to severe” erosion hazard when exposed, which meets the definition of an erosion hazard area per KCC Title 21A.06.415. Therefore, an erosion hazard area buffer should be required by King County for those areas mapped as soils type “AgC” with slopes steeper than 15 percent. These areas are shown on the Critical Areas, Buffers, and Setbacks Map, Figure 7.

Seismic Design

The site is in the Puget Sound region of western Washington, which is seismically active. Seismicity in this region is attributed primarily to the interaction between the Pacific, Juan de Fuca and North American plates. The Juan de Fuca plate is subducting beneath the North American plate at the Cascadia Subduction Zone (CSZ). This produces both intercrustal (between plates) and intracrustal (within a plate) earthquakes. In the following sections we discuss the design criteria and potential hazards associated with the regional seismicity.

Seismic Site Class

Based on our explorations and the subsurface units mapped at the site, we interpret the structural site conditions to correspond to a seismic Site Class “C” in accordance with the 2018 IBC documents and American Society of Civil Engineers (ASCE) standard 7-16 Chapter 20 Table 20.3-1. This is based on the likely SPT blow counts for the soils encountered. These conditions are assumed to be representative for the subsurface across the site.

Design parameters

The U.S. Geological Survey (USGS) completed probabilistic seismic hazard analyses (PSHA) for the entire country in November 1996, which were updated and republished in 2002 and 2008. We used the *ATC Hazard by Location* website to estimate seismic design parameters at the site. Table 4, below, summarizes the recommended design parameters.

TABLE 4:
2018 IBC PARAMETERS FOR DESIGN OF SEISMIC STRUCTURES

Spectral Response Acceleration (SRA) and Site Coefficients	Short Period
Mapped SRA	S_s = 1.171g
Site Coefficients (Site Class C)	F_a = 1.200
Maximum Considered Earthquake SRA	S_{MS} = 1.405g
Design SRA	S_{DS} = 0.937g

Peak Ground Acceleration

The mapped peak ground acceleration (PGA) for this site is 0.497g. To account for site class, the PGA is multiplied by a site amplification factor (F_{PGA}) of 1.2. The resulting site modified peak ground acceleration (PGA_M) is 0.596g. In general, estimating seismic earth pressures (k_h) by the Mononobe-Okabe method are taken as 33 to 50 percent of the PGA_M, or 0.197g to 0.298g.

Slope Stability Analysis

We analyzed the global and internal slope stability of the site for the existing and post site development conditions using subsurface profiles A-A’, B-B’, C-C’, and D-D’. The terrain modeled in the cross sections was based on 5-foot elevation isolines and adjusted based on slope measurements made in the field. The elevation isolines were 2-foot contours as shown on the *Feasibility Exhibit* for the plat development. The location of subsurface profiles A-A’, B-B’, C-C’, and D-D’ were selected as the most critical sections given the height and steepness of the slopes.

We used the computer program SLIDE 2, from RocScience, to perform the slope stability analyses. The computer program SLIDE uses different methods to estimate the factor of safety (FS) of the stability of a slope by analyzing the shear and normal forces acting on a series of vertical “slices” that comprise a failure surface. Each vertical slice is treated as a rigid body; therefore, the forces and/or moments acting on each slice are assumed to satisfy static equilibrium (i.e., a limit equilibrium analysis). The FS is defined as the ratio of the forces available to resist movement to the forces of the driving mass. A FS of 1.0 means that the driving and resisting forces are equal; and a FS less than 1.0 indicates that the driving forces are greater than the resisting forces (indicating failure).

Table 5, below, summarizes the soil properties for various native soil types encountered in the Puget Sound based on *Geotechnical Properties of Geologic Materials* by Koloski, Schwarz, and Tubbs as presented in Volume 1, *Engineering Geology in Washington*, Volume 1 (Washington Division of Geology and Earth Resources Bulletin 78).

TABLE 5:
SOIL PROPERTIES FOR VARIOUS NATIVE SOIL TYPES ENCOUNTERED IN THE PUGET SOUND

Unit	Soil Type	Dry Unit Weight (pcf)	Saturated Unit Weight (pcf)	Cohesion (psf)	Phi (degrees)
Outwash	SM, ML, GW, GP, SW, SP	115 - 130	N/A	0 – 1,000	30 - 40
Notes: N/A = Not available					

GeoResources assigned soil unit weight and strength parameters based on our experience, our subsurface explorations, as well as laboratory testing of representative soils for index properties at the site. The geology of the site's subsurface is based on our subsurface explorations and observations of the site terrain. Table 6 below, summarizes the estimated soil properties of on-site soils used for our slope stability analyses.

TABLE 6:
ESTIMATED SOIL PROPERTIES OF ON-SITE SOILS USED FOR SLOPE STABILITY ANALYSES

Unit	Soil Type	Dry Unit Weight (pcf)	Saturated Unit Weight (pcf)	Cohesion (psf)	Phi (degrees)
Uncontrolled Fill	SM	115	NA	0	28
Terrace Deposits	SM	120	NE	15	36
Advance Outwash	GW	130	NE	40	40

Based on our review, and the table included for your convenience, we conclude the assumed values for the various soil types appear to be within the range of tabulated values in the literature.

We used the Generalized Limit Equilibrium method using the Morgenstern-Price analysis, which satisfies both moment and force equilibrium, to search for the location of the most critical failure surfaces and their corresponding FS. The most critical surfaces are those with the lowest FS for a given loading condition and are therefore the most likely to move. Seismic analyses were completed using 45 percent of the PGA_M for the site, equaling a horizontal acceleration of 0.268g. The PGA_M for the site was referenced from the ATC Hazards website.

The results of our slope stability analysis for subsurface profiles A-A', B-B', C-C', and D-D' indicate factors of safety meeting or exceeding 2.0 in static conditions and 1.2 in pseudo-static conditions. Maximum predicted failure depths range from 5 to 7 feet. The locations of the subsurface profiles A-A', B-B', C-C', and D-D' are labeled on the Site & Exploration Plan, Figure 2. Details of our slope stability analyses for the proposed development are included in Appendix C.

Recommended Buffers and Setbacks

Buffers are typically used to protect critical areas from disturbance while also protecting the proposed development from damage due to the potential hazard. The King County Code Section 21A.06.122 defines a buffer as a "designated area contiguous to a steep slope or landslide hazard area to protect slope stability, attenuation of surface water flows and landslide hazards or a designated area continuous to and intended to protect and be an integral part of an aquatic area or wetland." There are steep slope hazard areas present on the site. The following discussions regarding recommended critical area buffers are based on the King County Code Section 21A.06.122.

Buffers typically consist of an undisturbed area of native vegetation, retained or established, that extends from the edge of the critical area or hazard. The width of the buffer should be a reflection of the potential hazard and associated risks. Buffer widths are generally measured from the edge of the critical area being protected, in this case the crest of steep slopes. Per KCC Sections 21.24A.280 and 21.24A.310, the County requires a minimum buffer of 50 feet from landslide hazard areas and steep slope hazard areas, unless a reduced buffer is recommended by a geotechnical engineer or geologist.

Based on our site reconnaissance, subsurface explorations, laboratory testing, and slope stability analyses, we recommended a critical areas buffer of 20 feet and with an additional 15 foot building setback from the buffer in accordance with the King County Code Title 21A.24.310. The total recommended buffer plus setback distance is 35 feet from the top of slope. Our recommended buffer and setback for the steep slope hazard critical area exceeds the setback that would be required by the 2018 International Building Code (IBC). Recommended buffers and setbacks are shown on the attached Critical Areas, Buffers, and Setbacks Map, Figure 7.

Erosion and Sediment Control

Weathering, erosion and the resulting surficial sloughing and shallow land sliding are natural processes. These processes are common occurrences on the face of steep slopes. The sediment from any surficial sloughing and shallow land sliding may also cog up existing drainage systems and natural drainage paths. To manage and reduce the potential of these natural processes occurring, we recommend temporary erosion protection and sediment control measures be put in place for the steep slopes at the residence during construction activities. Erosion hazards can be mitigated by applying Best Management Practices (BMP's) outlined in the Stormwater Management Manual for Western Washington and the 2016 King County Surface Water Design Manual. To manage and reduce the potential for these natural processes, we recommend the following:

- No drainage of concentrated surface water or significant sheet flow onto or near the steep slope in the northeast portion of the site.
- Any grading should be limited to providing surface grades that promote surface flows away from the site slopes to an appropriate discharge location at the toe.

If any disturbances cause the loss of vegetation on face of the slopes within proximity to the residence, the areas should be re-vegetated with appropriate native plant species as necessary immediately following any construction activities, as applicable. Any erosion and sediment control plan should be in accordance with Appendix D of the 2016 King County Surface Water Design Manual. Guidelines from the Washington State Department of Ecology's Slope Stabilization and Erosion Control Using Vegetation, publication No. 93-30 may also be considered for this project.

Seismic Hazards

Earthquake-induced geologic hazards may include liquefaction, lateral spreading, slope instability, and ground surface fault rupture. Liquefaction is a phenomenon where there is a reduction or complete loss of soil strength due to an increase in pore water pressure in soils. The increase in pore water pressure is induced by seismic vibrations. Liquefaction primarily affects geologically recent deposits of loose, uniformly graded, fine-grained sands and granular silts that are below the groundwater table. The shallow site soils are consistent with dense to very dense glacial till. The glacial till was observed to be generally a silty gravelly sand, and no groundwater was observed during our test pit explorations. *WA DNR Liquefaction Susceptibility Map* classifies the site and surrounding area as a "low" risk of liquefaction during a seismic event. An excerpt of the referenced map is included in Figure 8. Based on our review of the WA DNR Liquefaction Susceptibility map, the density of the observed site soils, and the lack of an observed high groundwater table at the site; it is our opinion the risk of liquefaction induced settlements during a seismic event is "very low".

According to the WA DNR Fault Hazard Map, the Tacoma Fault Zone is mapped about 11½ miles southwest of the proposed site development. The Tacoma Fault Zone is a Class B fault zone, qualitatively listed as "certain". The location of the Tacoma Fault Zone and other faults in relation to the site are shown on the attached WA DNR Fault Hazards, Figure 9. No evidence of ground fault rupture was observed in the subsurface explorations or during site reconnaissance, but evidence of fault rupture may be concealed by the steep topography and vegetation and may also be covered by the younger Vashon glacial sediments and post Vashon sediments. In our opinion, the proposed structures should have no greater risk for ground fault rupture than other structures located in the area.

Shallow Foundation Support

The use of conventional shallow foundation for the proposed residences is feasible from a geotechnical standpoint, provided our recommendations are incorporated into the design. Based on the encountered subsurface conditions, we recommend that any shallow foundation be founded on the medium dense to very dense undisturbed glacial deposits encountered at about 3 to 3½ feet below existing grade or on structural fill that extends to suitable native soils.

The soil at the base of footing excavations should be disturbed as little as possible. All loose, soft or unsuitable material should be removed. If material is over excavated below a design footing bearing elevation it should be replaced with structural fill, controlled density fill (CDF), or structural concrete. Where footings are underlain by structural fill a 1H:1V prism outside the footing down to the glacial till should be maintained; for CDF a 0.5H:1V prism should be maintained. A representative from our firm should observe the foundation excavations to determine if suitable bearing surfaces have been prepared.

We recommend a minimum width of 24 inches for isolated footings and at least 16 inches for continuous wall footings. All footing elements should be embedded at least 18 inches below grade for frost protection. Footings founded on the advance outwash or structural fill can be designed using for an allowable soil bearing capacity of 2,500 psf (pounds per square foot) for combined dead and long-term live loads. The weight of the footing and any overlying backfill may be neglected. The allowable bearing value may be increased by one-third for transient loads such as those induced by seismic events or wind loads.

Lateral loads may be resisted by friction on the base of footings and floor slabs and as passive pressure on the sides of footings. We recommend that an allowable coefficient of friction of 0.35 be used to calculate friction between the concrete and the underlying soil. Passive pressure may be determined using an allowable equivalent fluid density of 350 pcf (pounds per cubic foot). Factors of safety have been applied to these values.

We estimate that settlements of footings designed and constructed as recommended will be less than 1 inch, for the anticipated load conditions, with differential settlements between comparably loaded footings of ½ inch or less. Most of the settlements should occur essentially as loads are being applied. However, disturbance of the foundation bearing surface during construction could result in larger settlements than estimated.

Floor Slab Support

Slab-on-grade floors should be supported on the native terrace deposit soils or on structural fill prepared as described above. Areas of old fill material should be evaluated during grading activity for suitability of structural support. Areas of significant organic debris should be removed.

We recommend that floor slabs be directly underlain by a minimum 4 inch thick pea gravel or washed 5/8 inch crushed rock and should contain less than 2 percent fines. This layer should be placed in a single lift and compacted to an unyielding condition.

A synthetic vapor retarder is recommended to control moisture migration through the slabs. This is of particular importance where moisture migration through the slab is an issue, such as where adhesives are used to anchor carpet or tile to the slab.

A subgrade modulus of 200 pci (pounds per cubic inch) may be used for floor slab design. We estimate that settlement of the floor slabs designed and constructed as recommended, will be 1/2 inch or less over a span of 50 feet.

Subgrade/Basement Walls

The lateral pressures acting on retaining walls (such as basement or grade separation walls) will depend upon the nature and density of the soil behind the wall as well as the presence or absence of hydrostatic pressure. Below we provide recommended design values and drainage recommendations for retaining walls.

Design Values

For walls backfilled with granular well-drained soil such as gravel backfill for walls or permeable ballast, we provided the appropriate active and at-rest equivalent fluid pressures in Table 4 below. If walls taller than 6 feet are required, as seismic surcharge should be included where required by the code. If walls will be constructed with a backslope and will be braced or otherwise restrained against movement, we should be notified so that we can evaluate the anticipated conditions and recommend an appropriate at-rest earth pressure.

TABLE 5:
2018 IBC PARAMETERS FOR DESIGN OF SEISMIC STRUCTURES

Lateral Earth Pressure Condition, equivalent fluid density (PCF)	Backfill Material	
	Gravel Backfill for Walls (WSDOT 9-03.12(2))	Permeable Ballast (WSDOT 9-03.9(2))
At-rest, level backslope	55	45
Active, level backslope	35	27
Active, 3H:11V backslope	48	32
Active, 2H:11V backslope	55	36
Seismic Surcharge	13H	10H

Lateral loads may be resisted by friction on the base of footings and as passive pressure on the sides of footings and the buried portion of the wall, as described in the "**Foundation Support**" section of this report.

Wall Drainage

Adequate drainage behind retaining structures is imperative. Positive drainage which controls the development of hydrostatic pressure can be accomplished by placing a zone of drainage behind the walls. Granular drainage material should contain less than 2 percent fines and at least 30 percent retained on the US No. 4 sieve.

A minimum 4 inch diameter perforated or slotted PVC pipe should be placed in the drainage zone along the base and behind the wall to provide an outlet for accumulated water and direct accumulated water to an appropriate discharge location. We recommend that a nonwoven geotextile filter fabric be placed between the soil drainage material and the remaining wall backfill to reduce silt migration into the drainage zone. The infiltration of silt into the drainage zone can, with time, reduce the permeability of the granular material. The filter fabric should be placed such that it fully separates the drainage material and the backfill, and should be extended over the top of the drainage zone. Typical wall drainage and backfilling details are shown on Figure 10.

A soil drainage zone should extend horizontally at least 18 inches from the back of the wall. The drainage zone should also extend from the base of the wall to within 1 foot of the top of the wall. The soil drainage zone should be compacted to approximately 90 percent of the maximum dry density (MDD), as determined in accordance with ASTM D1557. Over-compaction should be avoided as this can lead to excessive lateral pressures on the wall. A geocomposite drain mat may also be used instead of free draining soils, provided it is installed in accordance with the manufacturer's instructions.

Temporary Excavations

All job site safety issues and precautions are the responsibility of the contractor providing services/work. The following cut/fill slope guidelines are provided for planning purposes only. Temporary cut slopes will likely be necessary during grading operations or utility installation. All excavations at the site associated with confined spaces, such as utility trenches and retaining walls, must be completed in accordance with local, state, or federal requirements including Washington Administrative Code (WAC) and Washington Industrial Safety and Health Administration (WISHA). Excavation, trenching, and shoring is covered under WAC 296-155 Part N.

Based on WAC 296-155-66401, it is our opinion that the terrace deposits at the site would be classified as Type C and the advance glacial outwash soils would be classified as Type B. According to WAC 296-155-66403, for temporary excavations of less than 20 feet in depth, the side slopes in Type C soils should be sloped at a maximum inclination of 1½H:1V or flatter from the toe to top of the slope; Type B soils should be sloped at a maximum inclination of 1H:1V or flatter from the toe to top of the slope. All exposed slope faces should be covered with a durable reinforced plastic membrane during construction to prevent slope raveling and rutting during periods of precipitation. These guidelines assume that all surface loads are kept at a minimum distance of at least one half the depth of the cut away from the top of the slope and that significant seepage is not present on the slope face. Flatter cut slopes will be necessary where significant raveling or seepage occurs, or if construction materials will be stockpiled along the slope crest.

Where it is not feasible to slope the site soils back at these inclinations, a retaining structure should be considered. Retaining structures greater than 4 feet in height (bottom of footing to top of structure) or that have slopes of greater than 15 percent above them, should be engineered per Washington Administrative Code (WAC 51-16-080 item 5). This information is provided solely for the benefit of the owner and other design consultants, and should not be construed to imply that GeoResources assumes responsibility for job site safety. It is understood that job site safety is the sole responsibility of the project contractor.

Drainage Considerations

All ground surfaces, pavements, and sidewalks should be sloped away from the structures. Surface water runoff should be controlled using a system of berms, drainage swales, and/or catch basins, and conveyed to an approved point of controlled discharge. We recommend conventional roof and foundation drains be installed for all structures. The footing drains should be tight lined independent of the roof drains. The roof drain should not be connected to the footing drains unless an adequate gradient will prevent surcharge to the footing drains.

Stormwater Management Recommendations

In the following sections we provide an opinion regarding the feasibility of infiltration, a preliminary design rate as applicable, and setback considerations. King County uses the 2021 King County Surface Water Design Manual (2021 SWDM) for design of stormwater management systems. The following sections discuss the feasibility of on-site infiltration and Limited Impact Development (LID) Infiltration BMPs.

Feasibility of Stormwater Infiltration and Dispersion

The feasibility assessment for infiltration or dispersion of stormwater for the residential development is based on our site observations, review of the infeasibility criteria for infiltration facilities in the 2021 SWDM, our subsurface explorations, and slope observations. Infiltration facilities include infiltration ponds, infiltration tanks, infiltration vaults, infiltration trenches, and small infiltration basins. LID infiltration BMPs include bioretention, permeable pavements, roof downspout controls, and dispersion. It is our opinion that the use of infiltration facilities or dispersion to manage stormwater generated by the new impervious surfaces is likely feasible. The site soils are generally sandy gravel consistent with glacial outwash and are considered to be a permeable soil. The following restrictions apply to infiltration facilities located near a slope steeper than fifteen percent, per Volume 5 Section 5.2.1.:

1. Where infiltration facilities are proposed within 200 feet of a steep slope hazard area or a landslide hazard area, OR closer to the top of slope than the distance equal to the total vertical height of a slope area that is steeper than 15%, a detailed geotechnical evaluation is required. The geotechnical analysis must consider cumulative impacts from the project and surrounding areas under full built-out conditions.
2. Individual lot infiltration and dispersion systems rather than a centralized infiltration facility should be used to the extent feasible, except for lots immediately adjacent to a landslide hazard area. The runoff from such lots should be discharged into a tightline system, if available, or other measures should be implemented as recommended by a geotechnical engineer, engineering geologist, or DLS-Permitting staff geologist.

The bottom of an infiltration facility must be at least 3 feet above the seasonal high groundwater level and must have at least 3 feet of permeable soil beneath the trench bottom. Infiltration facilities are not permitted on slopes greater than 25 percent, and are required by the 2021 SWDM to be a minimum of 200 feet horizontally from the top of a steep slope hazard area or landslide hazard area, or a minimum distance equal to the total vertical height of a slope area that is steeper than 15 percent, whichever is more. It is our opinion a reduced infiltration facility setback of 50 feet from the top of steep slopes will not reduce the stability of adjacent steep slope areas.

Preliminary Design Infiltration Rate

For a preliminary infiltration design rate, we recommend a maximum of 20.0 inches per hour be used in the preliminary design of any infiltration facility for stormwater management. The preliminary design rate is based on the results of our grain size analyses (Massman, 2003). Calculations are included in Appendix D. The above provided infiltration rate should be considered preliminary, and we recommend in-situ infiltration testing be completed prior to or during construction, preferably within enough lead time for the project civil engineer to redesign and/or resize any facility based on the results of our infiltration testing.

Setback Considerations and Geotechnical Concerns

Per the 2021 *King County Surface Water Design Manual* for flow control BMPs, a geotechnical professional (geotechnical engineer, engineering geologist, or DLS-Permitting staff geologist) must evaluate and approve infiltration facilities and flow control BMPs proposed on or near the following. A) slopes steeper than 15 percent B) within a setback from the top of slope equal to the total vertical height of the slope area that is steeper than 15 percent or C) within 200 feet of a steep slope hazard area, erosion hazard area, or landslide hazard area. It is our opinion that the granular soils at the site will allow for the vertical infiltration of stormwater generated by any new impermeable surfaces, and that the surficial soils and slopes on the site will not be at risk of accelerated erosion or instability due to excessive moisture content.

Construction Considerations

Suspended solids could clog the underlying soil and reduce the infiltration rate. To reduce potential clogging of the infiltration systems, the infiltration system should not be connected to the stormwater runoff system until after construction is complete and the site area is landscaped, paved or otherwise protected. Additional measures may also be taken during construction to minimize the potential of fines contamination of the proposed infiltration system, such as utilizing an alternative storm water management location during construction. All contractors working on the site (builders and subcontractors) should divert sediment laden stormwater away from proposed infiltration facilities during construction and landscaping activities. No concrete trucks should be washed or cleaned, and washout areas should not be within the vicinity of the proposed infiltration facilities. After construction activities have been completed, periodic sweeping of the paved areas will help extend the life of the infiltration system.

Water Quality Treatment

Per the 2021 SWDM, a minimum cation exchange capacity (CEC) of 5 milliequivalents per 100 grams of soil and 1 percent organic content is required for soils to provide adequate water quality treatment to the stormwater. Testing was conducted by a third-party laboratory on select samples from our infiltration tests per ASTM D2974 and SW-846 Test Method 9081. Based on the samples tested, the upper weathered soils were determined to have an organic content of 1.49 to 4.23 percent and a CEC of 16.2 to 17.7 milliequivalents per 100 grams of soil. Therefore, the soils do meet the minimum cation exchange capacity.

EARTHWORK RECOMMENDATIONS

Site Preparation

All structural areas on the site to be graded should be stripped of vegetation, organic surface soils, and other deleterious materials including existing structures, foundations or abandoned utility lines. Organic topsoil is not suitable for use as structural fill but may be used for limited depths in non-structural areas. Based on our subsurface explorations we anticipate that stripping depth will likely be about 1 foot in the project area. Areas of thicker topsoil or organic debris may be encountered in areas of heavy vegetation or depressions. Any uncontrolled fill under proposed building or driveway areas should be removed, such as the fill encountered in test pit TP-1.

Soft, loose, or otherwise unsuitable areas delineated during proof-rolling or probing should be recompacted, if practical, or over-excavated and replaced with structural fill. The depth and extent of overexcavation should be evaluated by our field representative at the time of construction. The areas of old fill material should be evaluated during grading operations to determine if they need mitigation, recompaction, or removal.

Structural Fill

All material placed as fill associated with mass grading, as utility trench backfill, or under building areas should be placed as structural fill. The structural fill should be placed in horizontal lifts of appropriate thickness to allow adequate and uniform compaction of each lift. Structural fill should be compacted to at least 95 percent of MDD as determined in accordance with ASTM D1557.

The appropriate lift thickness will depend on the structural fill characteristics, and compaction equipment used, but it is typically limited to 4 to 6 inches for hand operated equipment;

thicker lifts may be appropriate for larger equipment. For planning purposes, we recommend a maximum loose-lift thickness of 12 inches. We recommend that the appropriate lift thickness be evaluated by our field representative during construction. We recommend that our representative be present during site grading activities to observe the work and perform field density tests.

The suitability of material for use as structural fill will depend on the gradation and moisture content of the soil. As the percent of fines (material passing US No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult to achieve. During wet weather, we recommend a material such as well-graded sand and gravel with less than 5 percent (by weight) passing the US No. 200 sieve based on that fraction passing the ¾-inch sieve, such as *Gravel Backfill for Walls* (WSDOT 9-03.12(2)). If prolonged dry weather prevails during the earthwork and foundation installation phase of construction, higher fines content (up to 10 to 12 percent) may be acceptable.

Material placed for structural fill should be free of debris, organic matter, trash, and cobbles greater than 6 inches in diameter. The moisture content of the fill material should be adjusted as necessary for proper compaction.

Suitability of On-Site Materials as Fill

During dry weather construction, the non-organic, granular onsite soil may be considered for use as structural fill, provided it meets the criteria described above in the "**Structural Fill"** section and can be compacted as recommended. If the soil material is over optimum moisture at the time of excavation, it will be necessary to aerate or dry the soil prior to placement as structural fill.

The fines content of the encountered terrace deposits and deeper advance outwash soil likely ranges from 3 to 12 percent, based on our grain size analyses of the glacial outwash soils. The terrace deposits and glacial outwash are consistent with common borrow material (WSDOT 9-03.14(3)) and it is our opinion that these soils are suitable for use as structural fill during periods of extended dry weather. These soils may be difficult or impossible to compact when wet, and we recommend soils containing less than 5 percent fines be used if structural fill is placed during wet weather. The shallow topsoil and uncontrolled fill that contained debris is unsuitable for use as structural fill.

We recommend that completed graded-areas be restricted from traffic or protected prior to wet weather conditions. The graded areas may be protected by paving, placing asphalt-treated base, a layer of free-draining material such as pit run sand and gravel or clean crushed rock material containing less than 5 percent fines, or some combination of the above.

Wet Weather and Wet Condition Considerations

In the Puget Sound area, wet weather generally begins about mid-October and continues through about May, although rainy periods could occur at any time of year. Therefore, it is strongly encouraged that earthwork be scheduled during the dry weather months of June through September. Most of the soil at the site contains sufficient fines to produce an unstable mixture when wet. Such soil is highly susceptible to changes in water content and tends to become unstable and impossible to proof-roll and compact if the moisture content exceeds the optimum.

In addition, during wet weather months, the groundwater levels could increase, resulting in seepage into site excavations. Performing earthwork during dry weather would reduce these problems and costs associated with rainwater, construction traffic, and handling of wet soil.

However, should wet weather/wet condition earthwork be unavoidable, the following recommendations are provided:

- The ground surface in and surrounding the construction area should be sloped as much as possible to promote runoff of precipitation away from work areas and to prevent ponding of water.
- Work areas or slopes should be covered with plastic when not being worked. The use of sloping, ditching, sumps, dewatering, and other measures should be employed as necessary to permit proper completion of the work.
- Earthwork should be accomplished in small sections to minimize exposure to wet conditions. That is, each section should be small enough so that the removal of unsuitable soils and placement and compaction of clean structural fill could be accomplished on the same day. The size of construction equipment may have to be limited to prevent soil disturbance. It may be necessary to excavate soils with a backhoe, or equivalent, and locate them so that equipment does not pass over the excavated area. Thus, subgrade disturbance caused by equipment traffic would be minimized.
- Fill material should consist of clean, well-graded, sand and gravel, of which not more than 5 percent fines by dry weight passes the No. 200 mesh sieve, based on wet-sieving the fraction passing the ¾-inch mesh sieve. The gravel content should range from between 20 and 50 percent retained on a No. 4 mesh sieve. The fines should be non-plastic.
- No exposed soil should be left uncompacted and exposed to moisture. A smooth-drum vibratory roller, or equivalent, should roll the surface to seal out as much water as possible.
- In-place soil or fill soil that becomes wet and unstable and/or too wet to suitably compact should be removed and replaced with clean, granular soil (see gradation requirements above).
- Excavation and placement of structural fill material should be observed on a full-time basis by a geotechnical engineer (or representative) experienced in wet weather/wet condition earthwork to determine that all work is being accomplished in accordance with the project specifications and our recommendations.
- Grading and earthwork should not be accomplished during periods of heavy, continuous rainfall.

We recommend that the above requirements for wet weather/wet condition earthwork be incorporated into the contract specifications.

LIMITATIONS

We have prepared this report for use by H2 Properties, and other members of the design team, for use in the design of a portion of this project. The data used in preparing this report and this report should be provided to prospective contractors for their bidding or estimating purposes only. Our report, conclusions and interpretations are based on our subsurface explorations, data from others and limited site reconnaissance, and should not be construed as a warranty of the subsurface conditions.

Variations in subsurface conditions are possible between the explorations and may also occur with time. A contingency for unanticipated conditions should be included in the budget and schedule.

Sufficient monitoring, testing and consultation should be provided by our firm during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork and foundation installation activities comply with contract plans and specifications.

The scope of our services does not include services related to environmental remediation and construction safety precautions. Our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design.

If there are any changes in the loads, grades, locations, configurations or type of facilities to be constructed, the conclusions and recommendations presented in this report may not be fully applicable. If such changes are made, we should be given the opportunity to review our recommendations and provide written modifications or verifications, as appropriate.

◆ ◆ ◆

We have appreciated the opportunity to be of service to you on this project. If you have any questions or comments, please do not hesitate to call at your earliest convenience.

Respectfully submitted,
GeoResources, LLC

Meryl Evans, GIT
Staff Geologist

State of Washington
Engineering Geologist
3237
Licensed Geologist
7/12/2022
Seth Taylor Mattos

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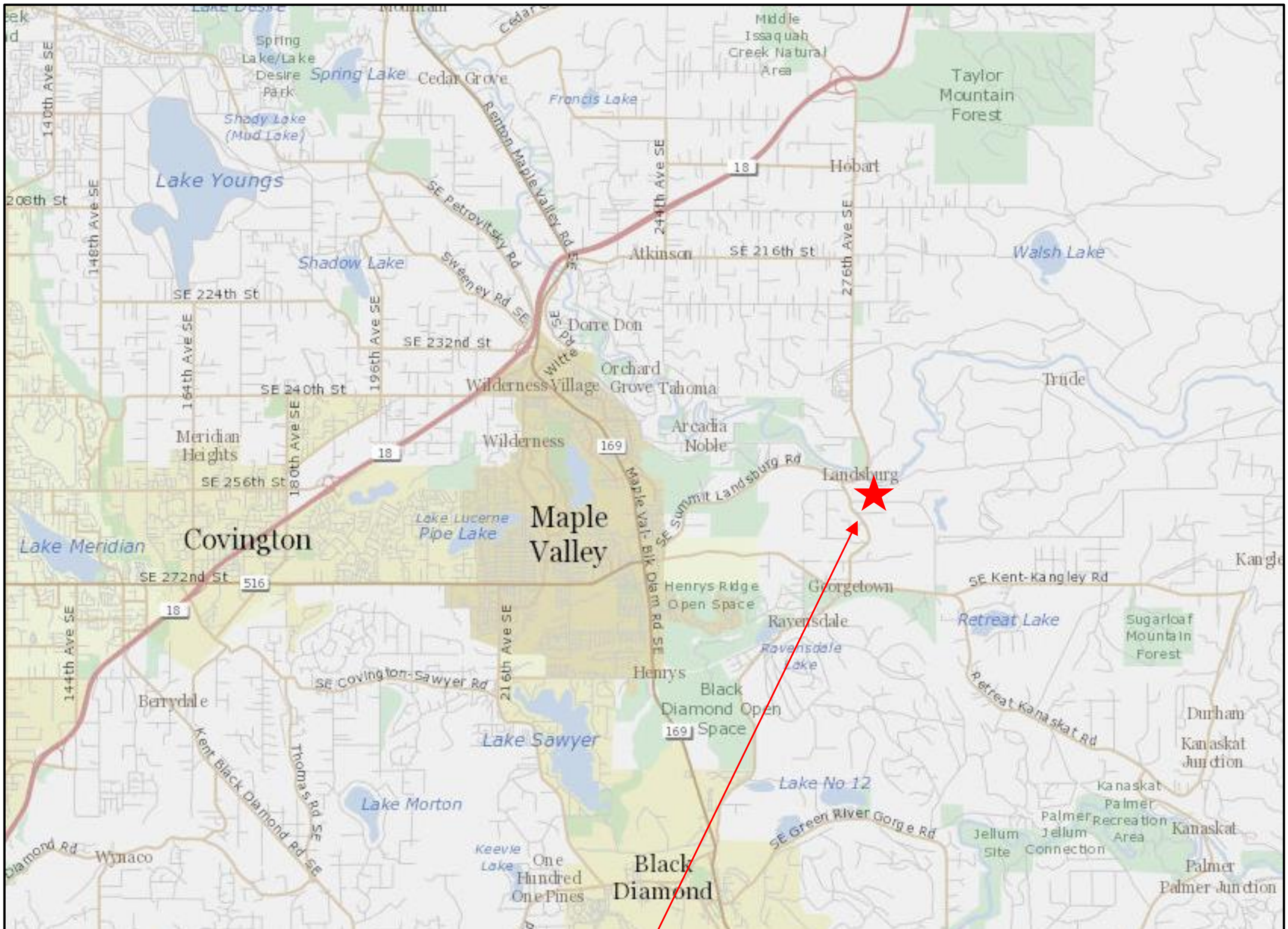
Senior Geotechnical Engineer

MAE:STM:EWH/mae
DocID: H2PropertiesLLC.SE258thSt.RG
Attachments:
Figure 1: Site Location Map
Figure 2: Site & Exploration Plan
Figure 3: Site Vicinity & Critical Areas Map
Figure 4: NRCS Soils Map
Figure 5: Geologic Map
Figure 6: WA DNR Landslide Compilation Map
Figure 7: Critical Areas, Buffers, and Setbacks Map
Figure 8: Liquefaction Susceptibility Map
Figure 9: WA DNR Fault Hazards
Appendix A - Subsurface Explorations
Appendix B - Laboratory Test Results
Appendix C - Slope Stability Results



Approximate Site Location

Figure created from King County public GIS
(https://gismaps.kingcounty.gov/iMap/)

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Not to Scale

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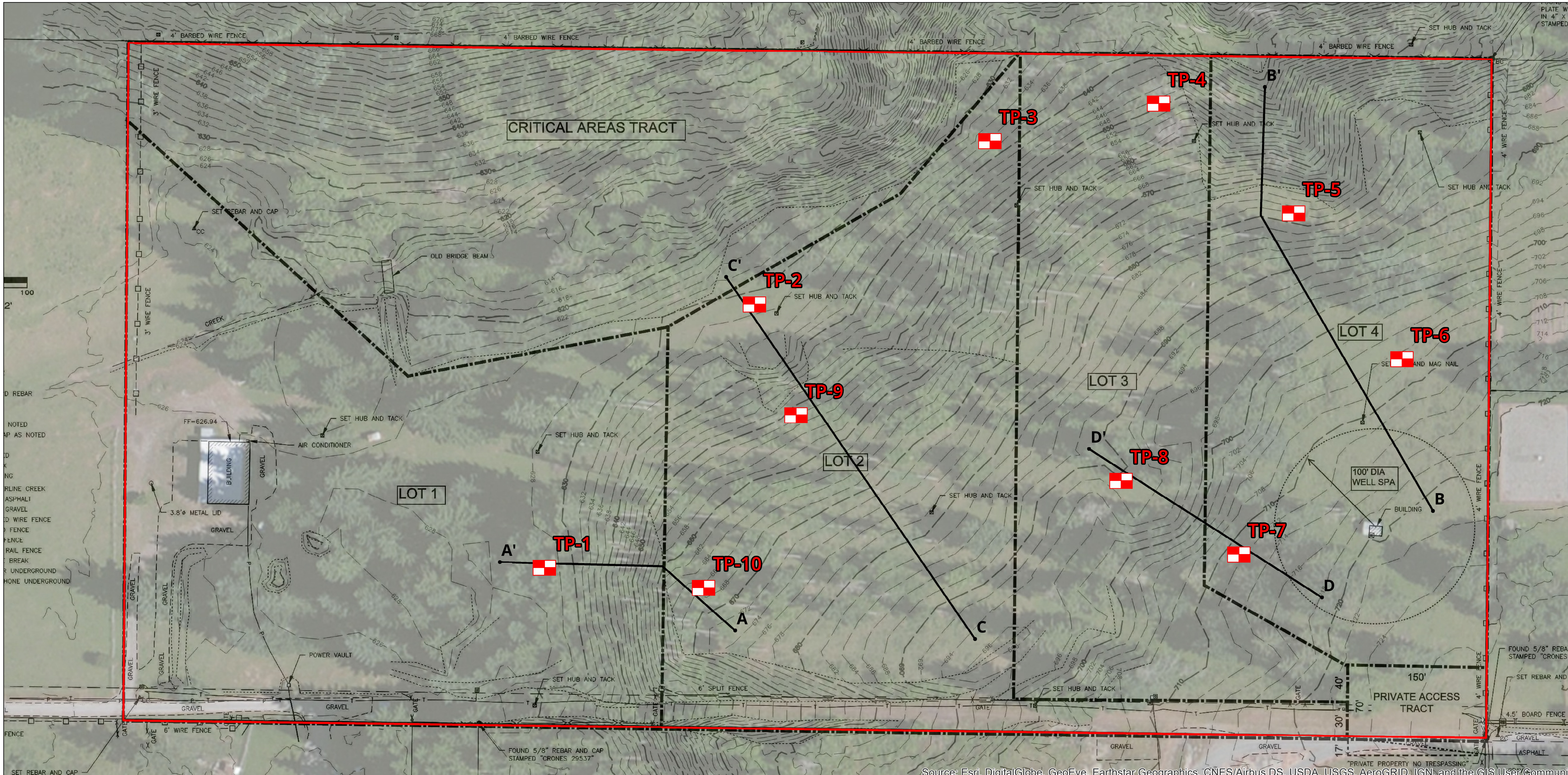
Site Location Map

Hudson Short Plat
28010 Southeast 258th Street
King County, Washington
PN: 3022079060

DocID: H2PropertiesLLC.SE258thSt.F	July 2022	Figure 1



Number and approximate location of test pit(s) (GeoResources, 2022)

Slope Stability Profile

0 50 100 200 Feet

N

Site Survey provided by H2 Properties

Datum: NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet

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Site & Exploration Plan

Hudson Short Plat

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King County, Washington

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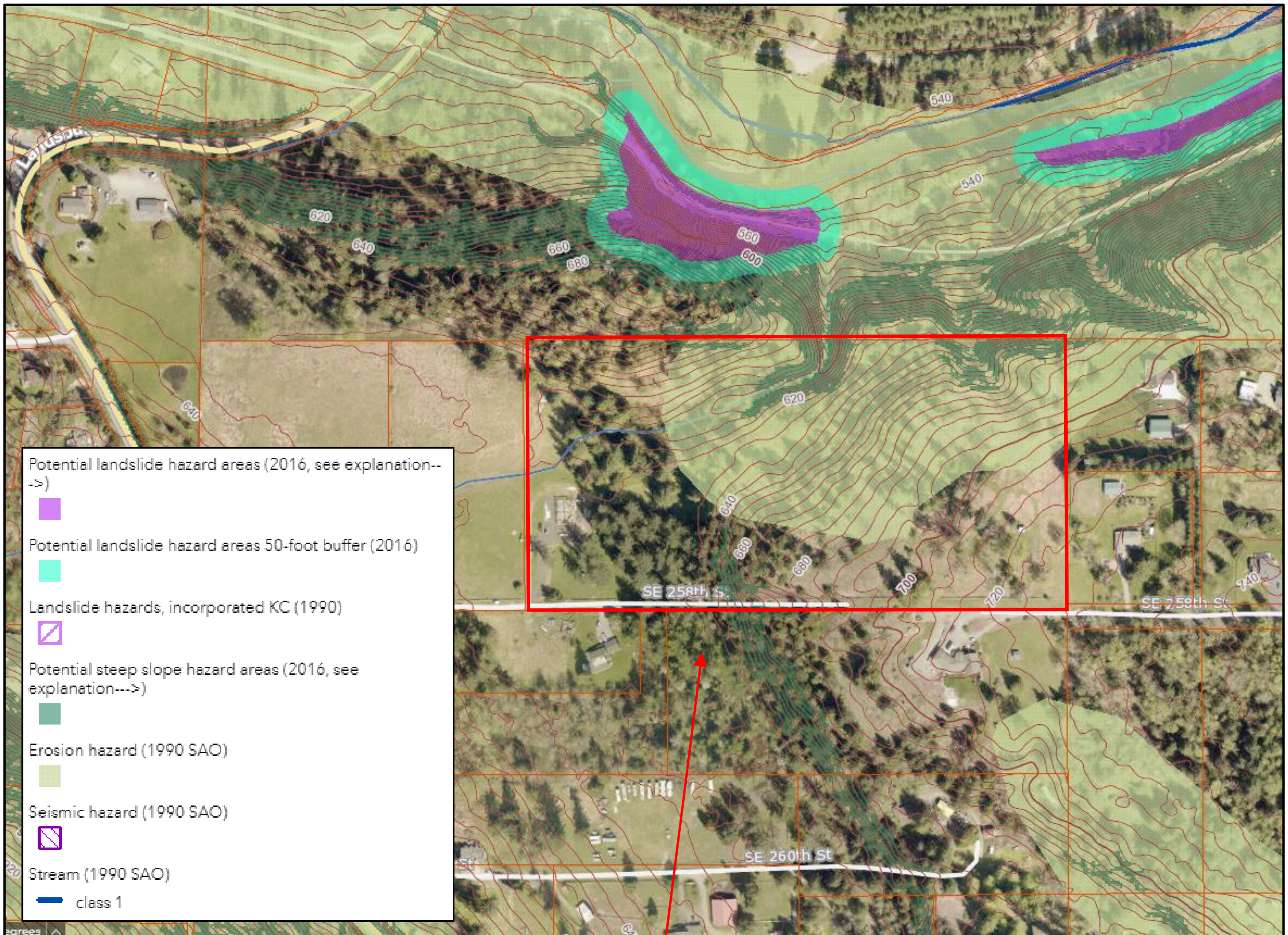
Doc ID: H2PropertiesLLC.SE258thSt.F	July 2022	Figure 2



Approximate Site Location

Figure created from King County public GIS
(https://gismaps.kingcounty.gov/iMap/)

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Site Vicinity & Critical Areas Map

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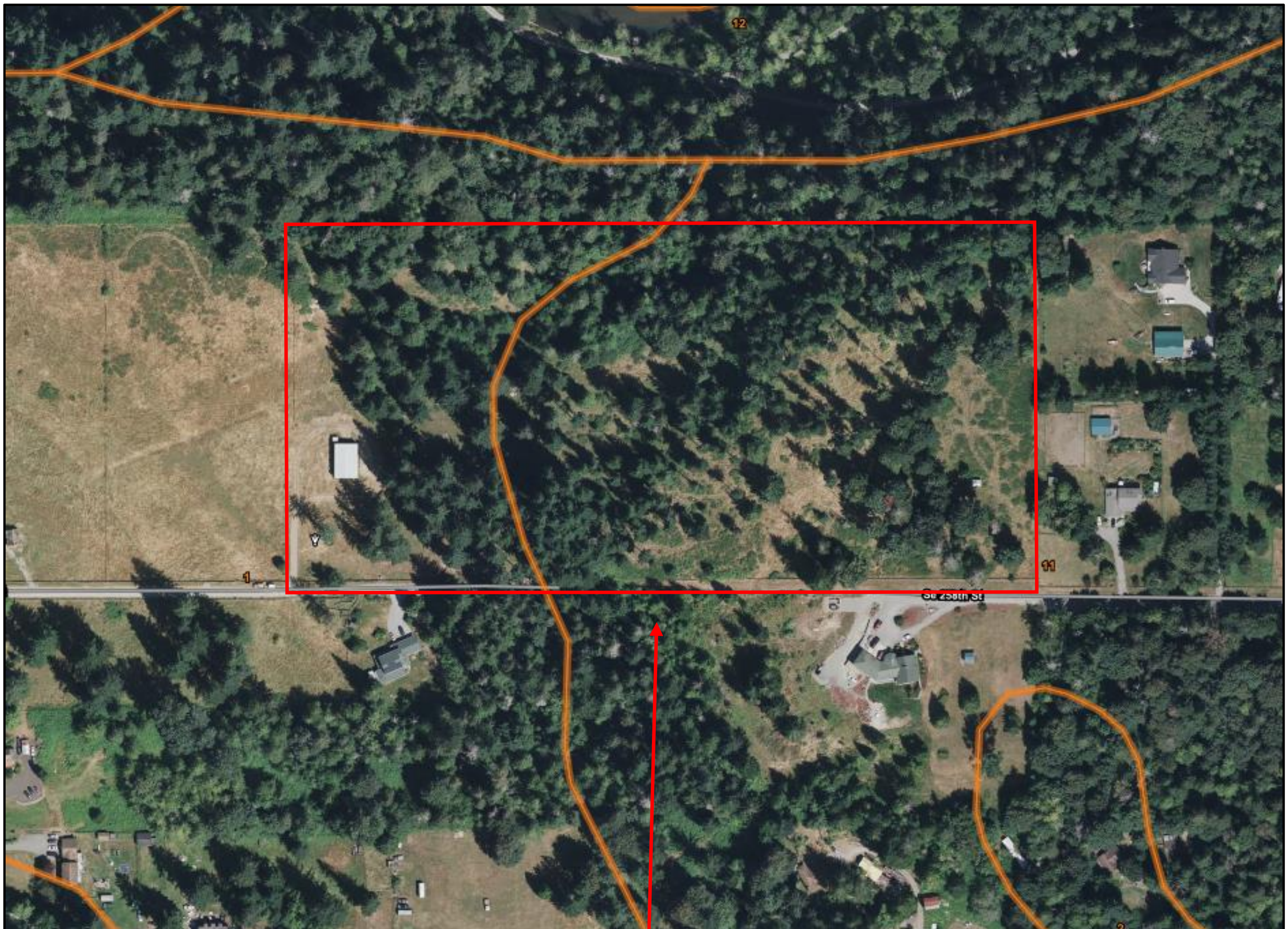
DocID: H2PropertiesLLC.SE258thSt.F	July 2022	Figure 3



Approximate Site Location

Figure created from Washington State NRCS Web Soil Survey
(http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx)

Soil Type	Soil Name	Parent Material	Slopes (%)	Erosion Hazard	Hydrologic Soils Group
1	Alderwood gravelly loam	Glacial drift and/or glacial outwash over dense glaciomarine deposits	0 to 15	Moderate	B
11	Barneston gravelly ashy coarse sandy loam	Volcanic ash mixed with loess over sandy and gravelly glacial outwash	8 to 15	Slight	A

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NRCS Soils Map

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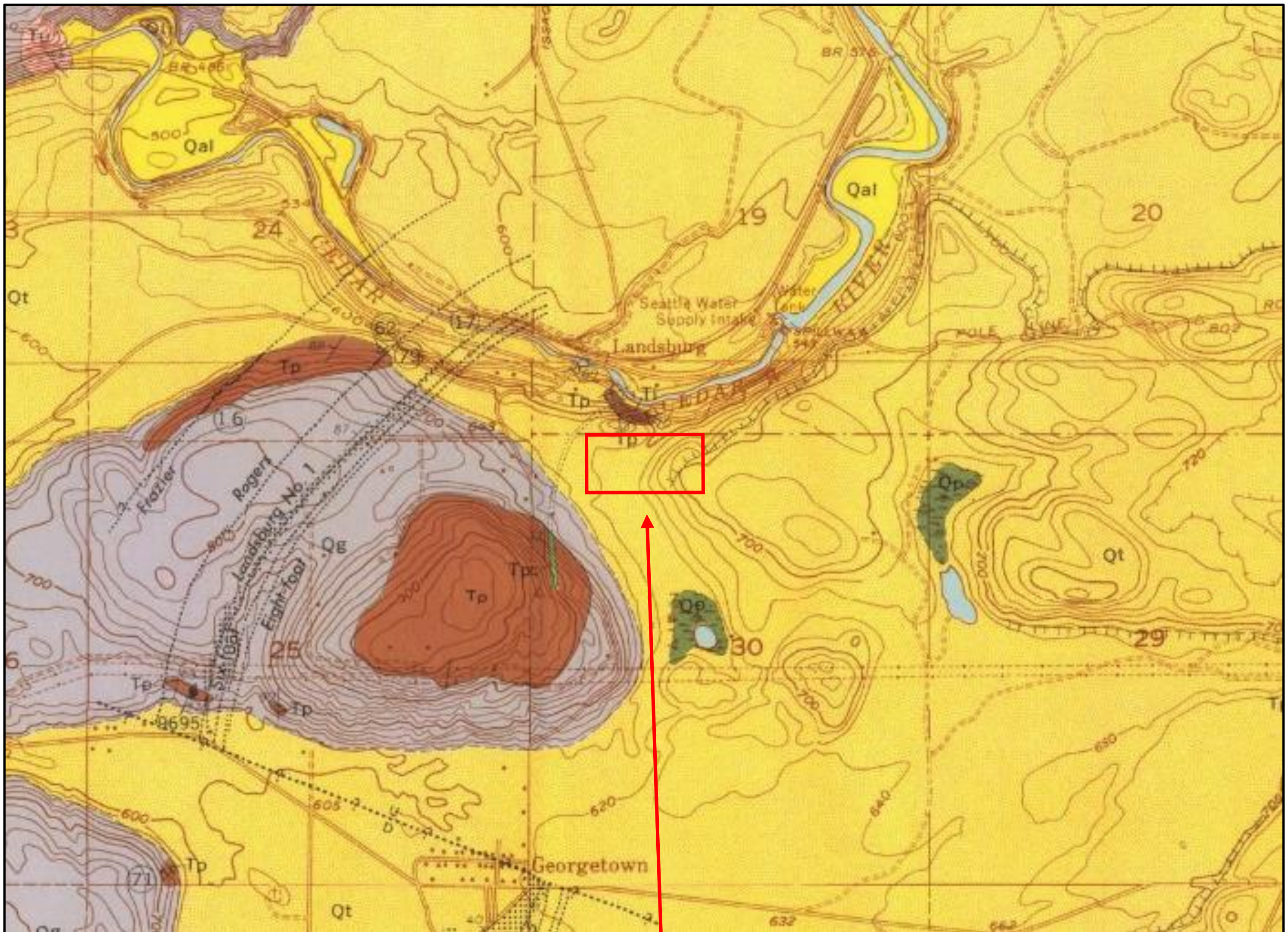
DocID: H2PropertiesLLC.SE258thSt.F	July 2022	Figure 4



Approximate Site Location

An excerpt from *Geology and Coal Resources of the Cumberland, Hobart, and Maple Valley Quadrangles, King County, Washington* by Vine, J.D. (1969)

Qt	Terrace gravel and stratified drift
Qg	Glacial drift
Tp	Puget Group, undifferentiated

N W E S

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Geologic Map

Hudson Short Plat
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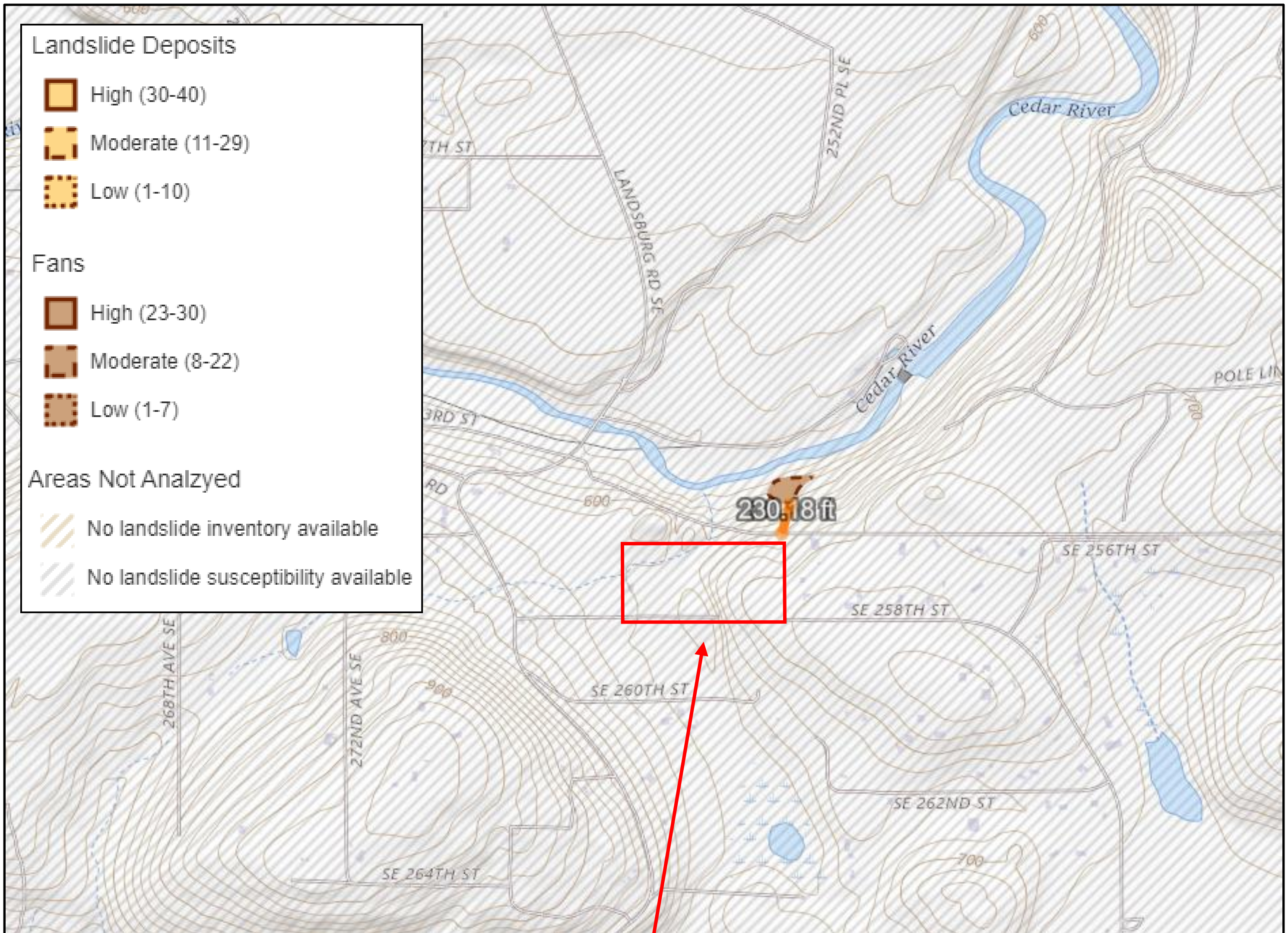
DocID: H2PropertiesLLC.SE258thSt.F	July 2022	Figure 5



Approximate Site Location

Figure created from the Washington Department of Natural Resources Geologic Information Portal (https://geologyportal.dnr.wa.gov/2d-view#wigm?-14056695,-12882622,5737587,6310558)

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WA DNR Landslide Compilation Map

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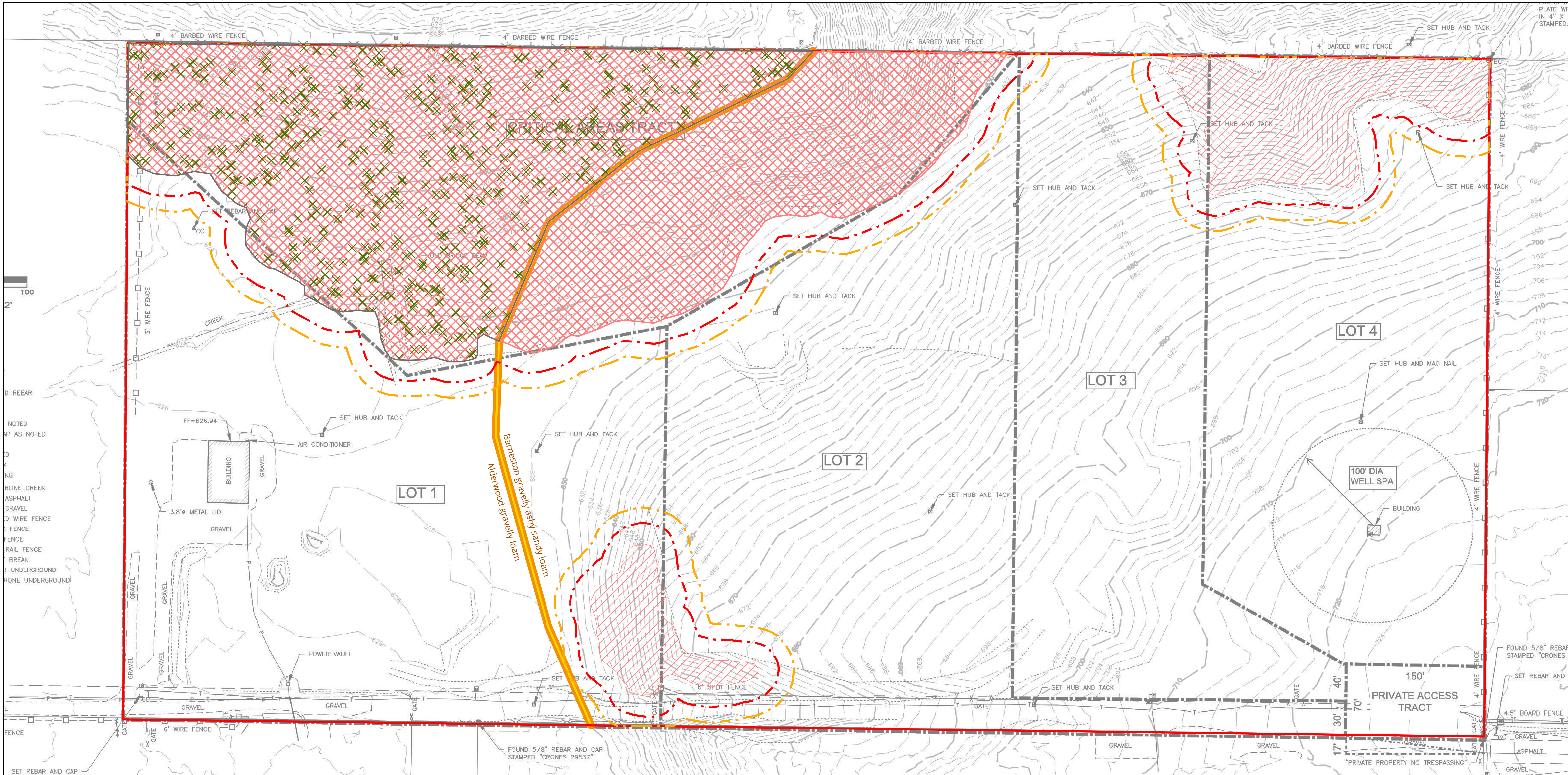
DocID: H2PropertiesLLC.SE258thSt.F	July 2022	Figure 6



Erosion Hazard Area
Steep Slope Hazard Area
Landslide and Steep Slope Hazard Area
20-foot Buffer
15-foot Setback
NRCS Soils

N

0 50 100 200 Feet

Site Survey provided by H2 Properties
NRCS soil data downloaded from USDA Web Soil Survey
Datum: NAD_1983_HARN_StatePlane_Washington_South_FIPS_4602_Feet

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Critical Areas, Buffers, and Setbacks Map

Hudson Short Plat
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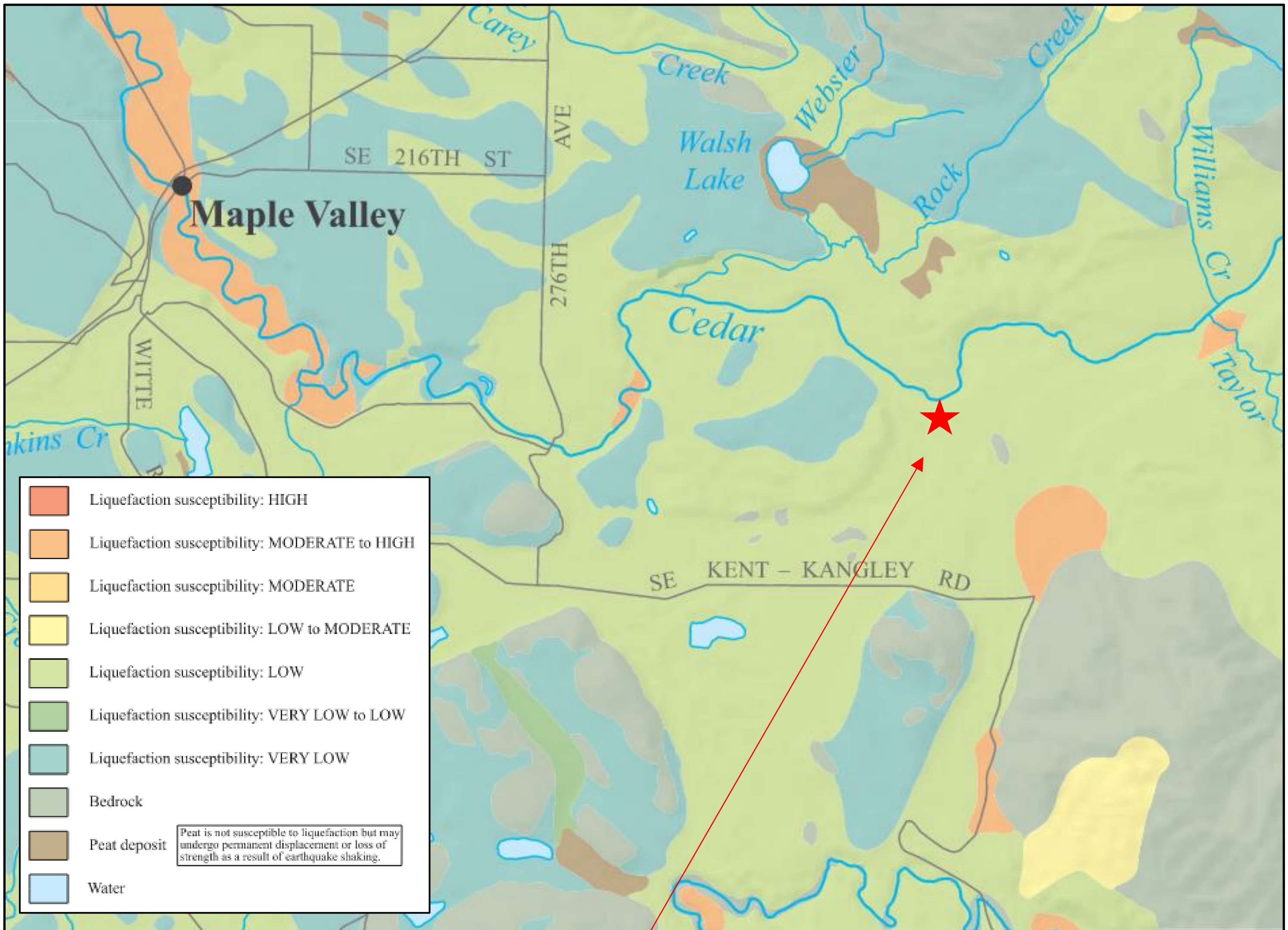
King County, Washington
PN: 3022079060

Doc ID: H2PropertiesLLC.SE258thSt.F	July 2022	Figure 7



Approximate Site Location

An excerpt from the *Liquifaction Susceptibility Map of King County, Washington* by Stephen P. Palmer, Sammantha L. Magsino, Eric L. Bilderback, James L. Poelstra, Derek S. Folger, and Rebecca A. Niggemann (2004)

N W E S

Not to Scale

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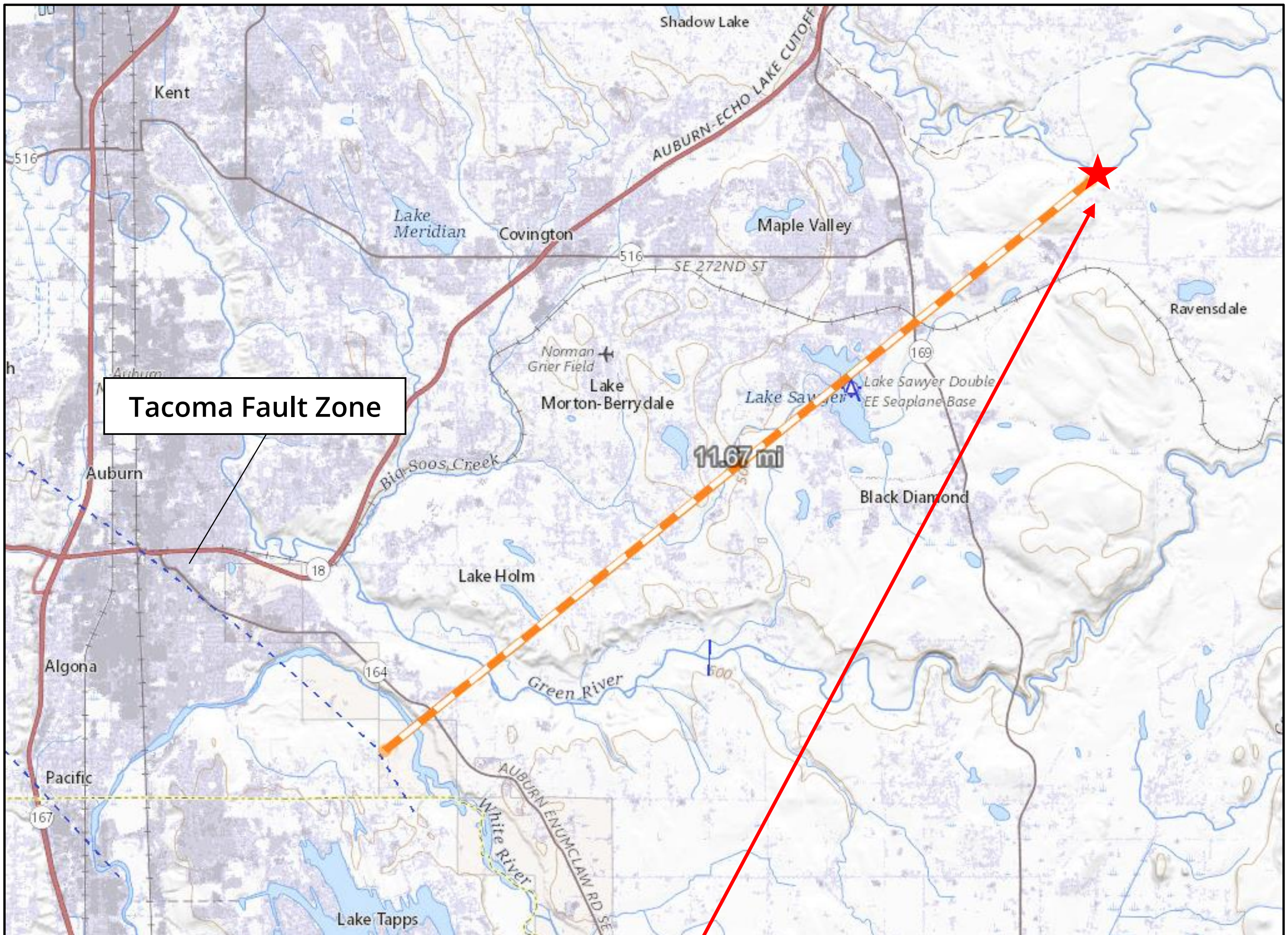
Liquefaction Susceptibility Map

Hudson Short Plat
28010 Southeast 258th Street
King County, Washington
PN: 3022079060

DocID: H2PropertiesLLC.SE258thSt.F	July 2022	Figure 8



Approximate Site Location

Figure created from the Washington Department of Natural Resources Geologic Information Portal
(https://geologyportal.dnr.wa.gov/2d-view#wigm?-14056695,-12882622,5737587,6310558)

N W E S

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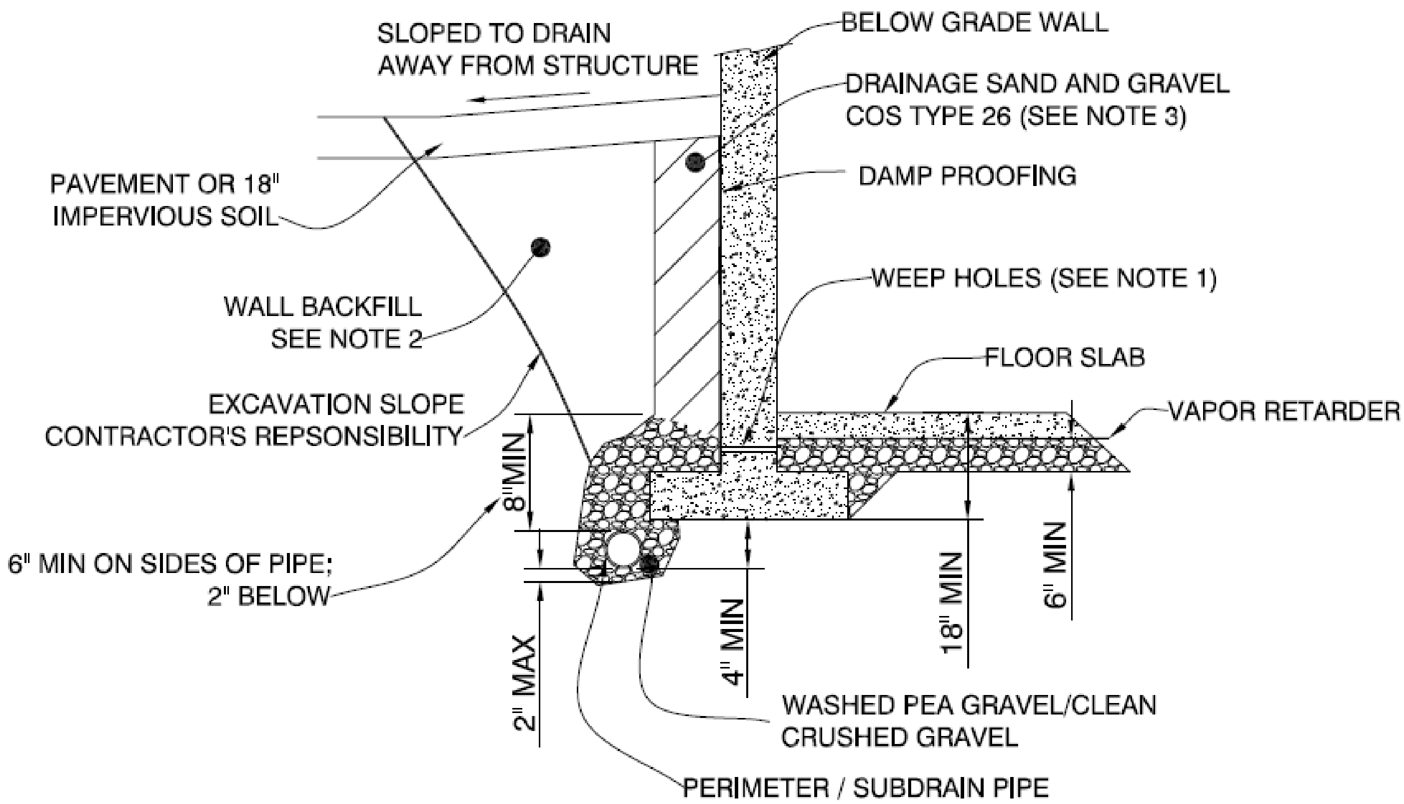
WA DNR Fault Hazards

Hudson Short Plat
28010 Southeast 258th Street
King County, Washington
PN: 3022079060

DocID: H2PropertiesLLC.SE258thSt.F	July 2022	Figure 9



1. Washed pea gravel/crushed rock beneath floor slab could be hydraulically connected to perimeter/subdrain pipe. Use of 1" diameter weep holes as shown is one applicable method. Crushed gravel should consist of 3/4" minus. Washed pea gravel should consist of 3/8" to No. 8 standard sieve.

2. Wall backfill should meet WSDOT Gravel Backfill for walls Specification 9-03-12(2).

3. Drainage sand and gravel backfill within 18" of wall should be compacted with hand-operated equipment. Heavy equipment should not be used for backfill, as such equipment operated near the wall could increase lateral earth pressures and possibly damage the wall. The table below presents the drainage sand and gravel gradation.

4. All wall back fill should be placed in layers not exceeding 4" loose thickness for light equipment and 8" for heavy equipment and should be densely compacted. Beneath paved or sidewalk areas, compact to at least 95% Modified Proctor maximum density (ASTM: 01557-70 Method C). In landscaping areas, compact to 90% minimum.

5. Drainage sand and gravel may be replaced with a geocomposite core sheet drain placed against the wall and connected to the subdrain pipe. The geocomposite core sheet should have a minimum transmissivity of 3.0 gallons/minute/foot when tested under a gradient of 1.0 according to ASTM 04716.

6. The subdrain should consist of 4" diameter (minimum), slotted or perforated plastic pipe meeting the requirements of AASHTO M 304; 1/8-inch maximum slot width; 3/16- to 3/8-inch perforated pipe holes in the lower half of pipe, with lower third segment unperforated for water flow; tight joints; sloped at a minimum of 6"/100' to drain; cleanouts to be provided at regular intervals.

7. Surround subdrain pipe with 8 inches (minimum) of washed pea gravel (2" below pipe" or 5/8" minus clean crushed gravel. Washed pea gravel to be graded from 3/8-inch to No.8 standard sieve.

8. See text for floor slab subgrade preparation.

Materials

Drainage Sand and Gravel

Sieve Size	% Passing by Weight
3/4 "	100
No 4	28-56
No 8	20-50
No 50	3-12
No 100	0-2

3/4" Minus Crushed Gravel

Sieve Size	% Passing by Weight
3/4 "	100
1/2"	75 - 100
1/4"	0 - 25
No 100	0 - 2
(by wet sieving)	(non-plastic)

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Typical Drainage and Backfill Detail

Proposed Foundation Repair
14758 Southwest Spring Beach Road
King County, Washington
PN: 7930000275

DocID: H2PropertiesLLC.SE258thSt.F	July 2022	Figure 10

Appendix A
Subsurface Explorations

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS More than 50% Retained on No. 200 Sieve	GRAVEL More than 50% Of Coarse Fraction Retained on No. 4 Sieve	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND More than 50% Of Coarse Fraction Passes No. 4 Sieve	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% Passes No. 200 Sieve	SILT AND CLAY Liquid Limit Less than 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY Liquid Limit 50 or more	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-90.
2. Soil classification using laboratory tests is based on ASTM D6913.
3. Description of soil density or consistency are based on interpretation of blow count data, visual appearance of soils, and or test data.

SOIL MOISTURE MODIFIERS:

Dry- Absence of moisture, dry to the touch

Moist- Damp, but no visible water

Wet- Visible free water or saturated, usually soil is obtained from below water table

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Unified Soils Classification System

Hudson Short Plat
28010 Southeast 258th Street
King County, Washington
PN: 3022079060

DocID: H2PropertiesLLC.SE258thSt.F	July 2022	Figure A-1

Test Pit TP-1

Location: 47.3711, -121.9691
Approximate Elevation: 628 feet (2ft contour intervals from the *Feasibility Exhibit*)

Depth (ft)	Soil Type	Soil Description
0 - 8″	-	Topsoil
8″ - 3	SM	Heavily iron-oxide stained light brownish grey silty SAND with some gravel, debris (loose to medium dense, moist) (Uncontrolled fill)
3 - 3½	-	Relict topsoil
3½ - 7	SP	Light brownish grey fine to medium SAND with some gravel and cobbles and a trace of silt (medium dense to dense, moist) (Advance outwash)

Terminated at 7 feet below existing grade.
No caving observed at time of excavation.
No groundwater seepage observed at time of excavation.

Test Pit TP-2

Location: 47.3718, -121.9682
Approximate Elevation: 631 feet (2ft contour intervals from the *Feasibility Exhibit*)

Depth (ft)	Soil Type	Soil Description
0 - ½	-	Topsoil
½ - 3	SM	Orange-brown gravelly silty SAND (loose to medium dense, moist) (Weathered terrace deposits)
3 - 7	SM	Light brownish grey silty SAND with angular to round, fine to coarse gravel (dense to very dense, moist) (Advance outwash)

Terminated at 7 feet below existing grade.
No caving observed at the time of excavation.
No groundwater seepage observed at time of excavation.

Test Pit TP-3

Location: 47.3722, -121.9673
Approximate Elevation: 636 feet (2ft contour intervals from the *Feasibility Exhibit*)

Depth (ft)	Soil Type	Soil Description
0 - 10″	-	Topsoil
10″ - 2	SM	Orange-brown silty SAND with gravel (loose to medium dense, moist) (Weathered terrace deposits)
2 - 6½	SM	Light brownish grey gravelly silty SAND (dense, moist) (Terrace deposits)
6½ - 7	GW	Light brownish grey sandy well graded GRAVEL with cobbles (very dense, moist) (Advance outwash)

Terminated at 7 feet below ground surface.
No caving observed at the time of excavation.
No groundwater seepage observed at time of excavation.

Logged By: MAE **Excavated On: May 18, 2022**

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Test Pit Logs
Hudson Short Plat
28010 Southeast 258th Street
King County, Washington
PN: 3022079060

Test Pit TP-4

Location: 47.3724, -121.9667

Approximate Elevation: 648 feet (2ft contour intervals from the *Feasibility Exhibit*)

Depth (ft)	Soil Type	Soil Description
0 - 1	-	Topsoil
1 - 3	SM	Orange-brown silty SAND with gravel (loose to medium dense, moist) (Weathered terrace deposits)
3 - 6	SM	Light brownish grey silty SAND with some gravel (medium dense, moist) (Terrace deposits)
6 - 7	GW	Light brownish grey sandy well graded GRAVEL with cobbles (very dense, moist) (Advance outwash)

Terminated at 7 feet below existing grade.
No caving observed at time of excavation.
No groundwater seepage observed at time of excavation.

Test Pit TP-5

Location: 47.3721, -121.9661

Approximate Elevation: 678 feet (2ft contour intervals from the *Feasibility Exhibit*)

Depth (ft)	Soil Type	Soil Description
0 - 8″	-	Topsoil
8″ - 2	SM	Orange-brown silty SAND with gravel (loose to medium dense, moist) (Weathered terrace deposits)
2 - 3	SM	Light brownish grey silty SAND with gravel (medium dense to dense, moist) (Terrace deposits)
3 - 5	GW	Light brownish grey sandy well graded GRAVEL with cobbles (very dense, moist) (Advance outwash)

Terminated at 5 feet below existing grade.
No caving observed at time of excavation.
No groundwater seepage observed at time of excavation.

Logged By: MAE **Excavated On: May 18, 2022**

Test Pit TP-6

Location: 47.3717, -121.9657

Approximate Elevation: 707 feet (2ft contour intervals from the *Feasibility Exhibit*).

Depth (ft)			Soil Type	Soil Description
0	-	10″	-	Topsoil
10″	-	2	SM	Orange-brown silty SAND with gravel (loose to medium dense, moist) (Weathered terrace deposits)
2	-	3½	SM	Light brownish grey silty SAND with some gravel (medium dense, moist) (Terrace deposits)
3½	-	5	GW	Light brownish grey sandy well graded GRAVEL with cobbles (very dense, moist) (Advance outwash)

Terminated at 5 feet below existing grade.
No caving observed at time of excavation.
No groundwater seepage observed at time of excavation.

Test Pit TP-7

Location: 47.3712, -121.9663

Approximate Elevation: 712 feet (2ft contour intervals from the *Feasibility Exhibit*)

Depth (ft)			Soil Type	Soil Description
0	-	8″	-	Topsoil
8″	-	2	SM	Orange-brown silty SAND with gravel (loose to medium dense, moist) (Weathered terrace deposits)
2	-	3½	SM	Light brownish grey silty SAND with some gravel (medium dense, moist) (Terrace deposits)
3½	-	5	GW	Light brownish grey sandy well graded GRAVEL with cobbles (very dense, moist) (Advance outwash)

Terminated at 5 feet below ground surface.
No caving observed at time of excavation.
No groundwater seepage observed at time of excavation.

Logged By: MAE **Excavated On: May 18, 2022**

Test Pit TP-8

Location: 47.3713, -121.9668

Approximate Elevation: 690 feet (2ft contour intervals from the *Feasibility Exhibit*)

Depth (ft)	Soil Type	Soil Description
0 - 1	-	Light brown topsoil
1 - 3	SM	Orange-brown silty SAND with gravel (loose to medium dense, moist) (Weathered terrace deposits)
3 - 5	GW	Light brownish grey sandy well graded GRAVEL with cobbles (very dense, moist) (Advance outwash)

Terminated at 5 feet below ground surface.
No caving observed at time of excavation.
No groundwater seepage observed at time of excavation.

Test Pit TP-9

Location: 47.3715, -121.9681

Approximate Elevation: 650 feet (2ft contour intervals from the *Feasibility Exhibit*)

Depth (ft)	Soil Type	Soil Description
0 - 1	-	Topsoil
1 - 2	SM	Orange-brown silty SAND with some gravel (loose to medium dense, moist) (Weathered terrace deposits)
2 - 3½	SM	Light brownish grey silty SAND with gravel (medium dense, moist) (Terrace deposits)
3½ - 5	GW	Light brownish grey sandy well graded GRAVEL with cobbles (very dense, moist) (Advance outwash)

Terminated at 5 feet below ground surface.
No caving observed at time of excavation.
No groundwater seepage observed at time of excavation.

Test Pit TP-10

Location: 47.3710, -121.9684

Approximate Elevation: 667 feet (2ft contour intervals from the *Feasibility Exhibit*)

Depth (ft)	Soil Type	Soil Description
0 - 8"	-	Topsoil
8" - 2	SM	Orange-brown silty SAND with gravel (loose to medium dense, moist) (Weathered terrace deposits)
2 - 3½	SM	Light brownish grey silty SAND with some gravel (medium dense, moist) (Terrace deposits)
3½ - 4½	GW	Light brownish grey sandy well graded GRAVEL with cobbles (very dense, moist) (Advance outwash)

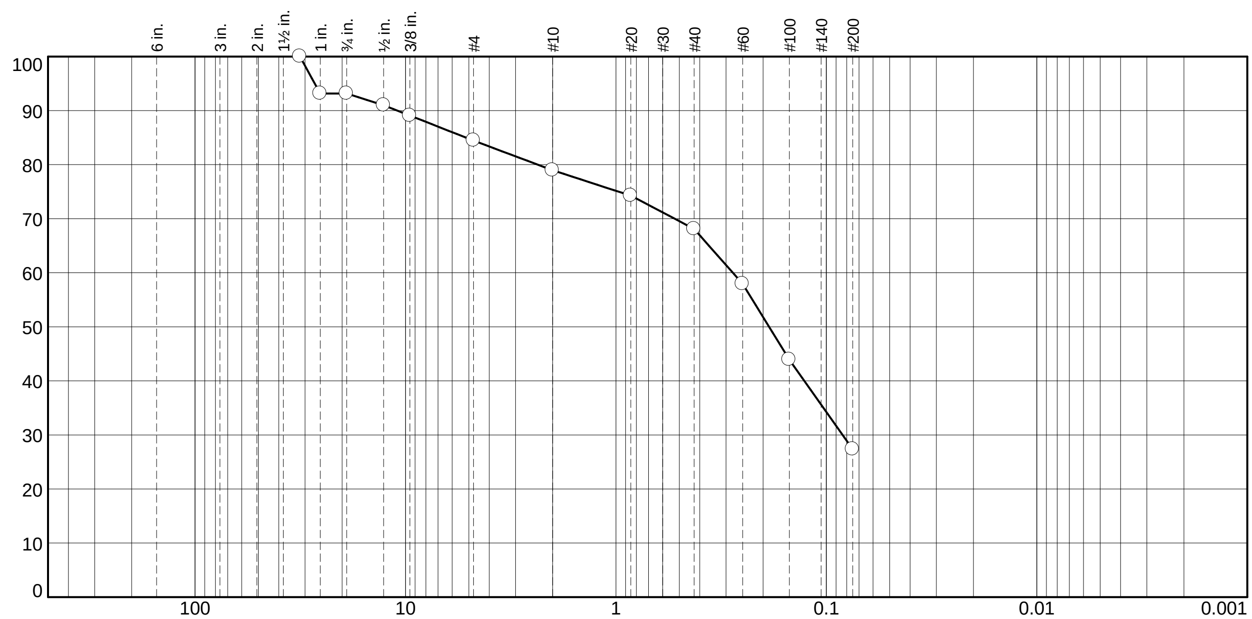
Terminated at 4½ feet below existing grade.
No caving observed at time of excavation.
No groundwater seepage observed at time of excavation.

Logged By: MAE **Excavated On: May 18, 2022**

Appendix B

Laboratory Test Results

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	6.8	8.7	5.5	10.9	40.7	27.4	

Test Results (ASTM D 6913 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.25	100.0		
1	93.2		
.75	93.2		
.5	91.0		
0.375	89.1		
#4	84.5		
#10	79.0		
#20	74.3		
#40	68.1		
#60	57.9		
#100	43.9		
#200	27.4		

* (no specification provided)

Material Description

Gravelly silty SAND (SM)

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 10.9546 D_{85}= 5.1554 D_{60}= 0.2784
D_{50}= 0.1872 D_{30}= 0.0838 D_{15}=
D_{10}= C_u= C_c=

Remarks

Natural Moisture: 23.5%

Date Received: 5/18/22 **Date Tested:** 5/19/22
Tested By: MAW
Checked By: KSS
Title: PM

Location: TP-2, S-1
Sample Number: 103247 **Depth:** 1.5'
Date Sampled: 5/18/22

GeoResources, LLC

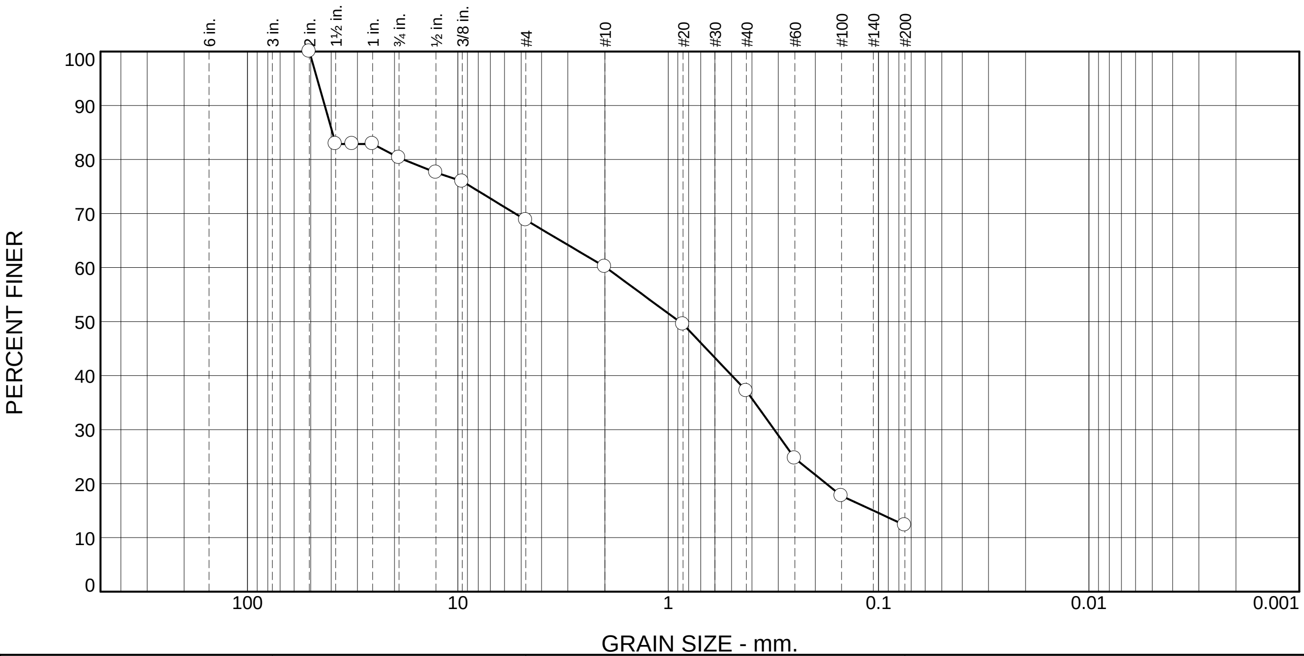
Fife, WA

Client: H2 Properties
Project: Hudson Short Plat
Project No: H2PropertiesLLC.SE258thSt **Figure** B-1

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples.

Tested By: ____________________ **Checked By:** ____________________

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	19.7	11.5	8.7	22.9	24.9	12.3	

Test Results (ASTM D 6913 & ASTM D 1140)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2.0	100.0		
1.5	82.9		
1.25	82.9		
1	82.9		
.75	80.3		
.5	77.6		
0.375	76.0		
#4	68.8		
#10	60.1		
#20	49.5		
#40	37.2		
#60	24.7		
#100	17.7		
#200	12.3		

* (no specification provided)

Material Description

Silty gravelly SAND (SM)

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 42.9435 D_{85}= 39.4834 D_{60}= 1.9771
D_{50}= 0.8841 D_{30}= 0.3134 D_{15}= 0.1058
D_{10}= C_u= C_c=

Remarks

Natural Moisture: 10.3%

Date Received: 5/18/22 **Date Tested:** 5/19/22
Tested By: MAW
Checked By: KSS
Title: PM

Location: TP-3, S-1
Sample Number: 103248 **Depth:** 3'
Date Sampled: 5/18/22

GeoResources, LLC

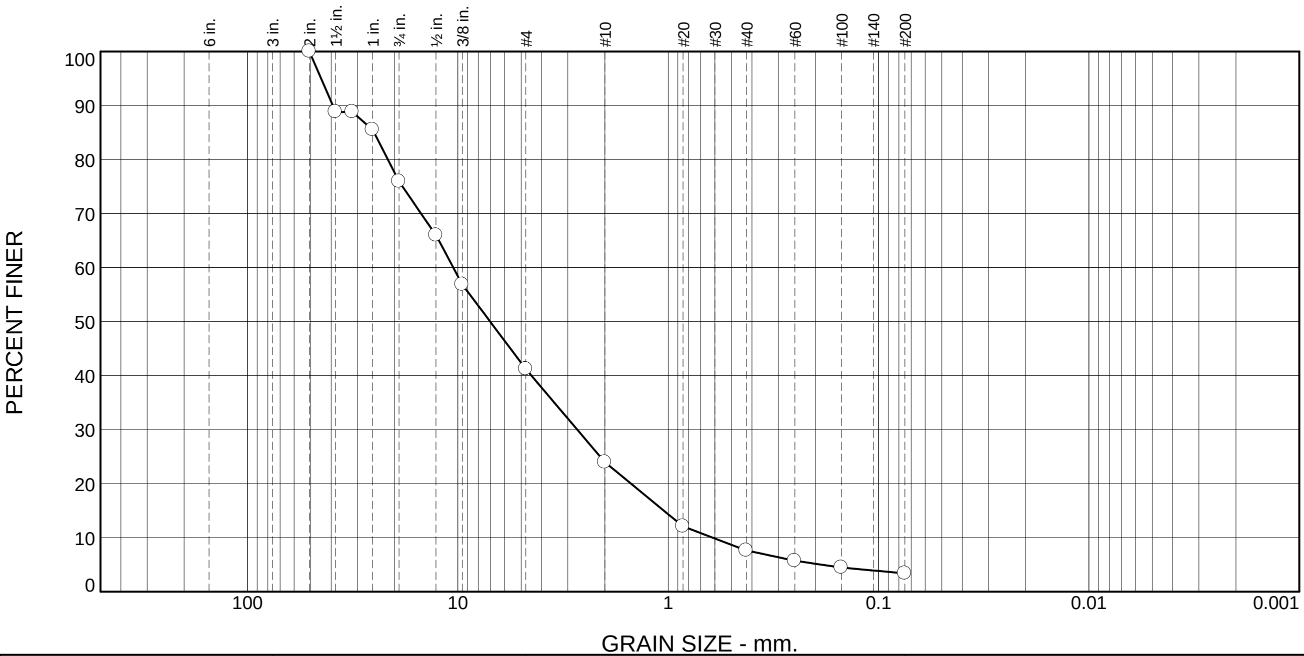
Fife, WA

Client: H2 Properties
Project: Hudson Short Plat
Project No: H2PropertiesLLC.SE258thSt **Figure** B-2

These results are for the exclusive use of the client for whom they were obtained. They apply only to the samples tested and are not indicitive of apparently identical samples.

Tested By: ____________ **Checked By:** ____________

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	24.1	34.7	17.2	16.4	4.2	3.4	

Test Results (ASTM D 6913 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
2.0	100.0		
1.5	88.8		
1.25	88.8		
1	85.5		
.75	75.9		
.5	66.0		
0.375	56.9		
#4	41.2		
#10	24.0		
#20	12.1		
#40	7.6		
#60	5.7		
#100	4.5		
#200	3.4		

* (no specification provided)

Material Description

Sandy well-graded GRAVEL with trace silt (GW)

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= GW **AASHTO (M 145)=** A-1-a

Coefficients

D_{90}= 39.2937 D_{85}= 25.0138 D_{60}= 10.5160
D_{50}= 7.0200 D_{30}= 2.7065 D_{15}= 1.0487
D_{10}= 0.6147 C_u= 17.11 C_c= 1.13

Remarks

Natural Moisture: 7.7%

Date Received: 5/18/22 **Date Tested:** 5/19/22

Tested By: MAW

Checked By: KSS

Title: PM

Location: TP-3, S-2
Sample Number: 103249 **Depth:** 7' **Date Sampled:** 5/18/22

GeoResources, LLC

Fife, WA

Client: H2 Properties
Project: Hudson Short Plat
Project No: H2PropertiesLLC.SE258thSt **Figure** B-3

Tested By: ______________________ **Checked By:** ______________________

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Analytical Report

Geo Resources, LLC
4809 Pacific Hwy E
Fife, WA 98424

Project H2Properties.SE258thSt
PO Number
Date Received 05/24/2022

Client ID: TP-2 S-1 @ 1.5' **Lab No: 302225-01** **Sample Date: 05/18/22 08:30**

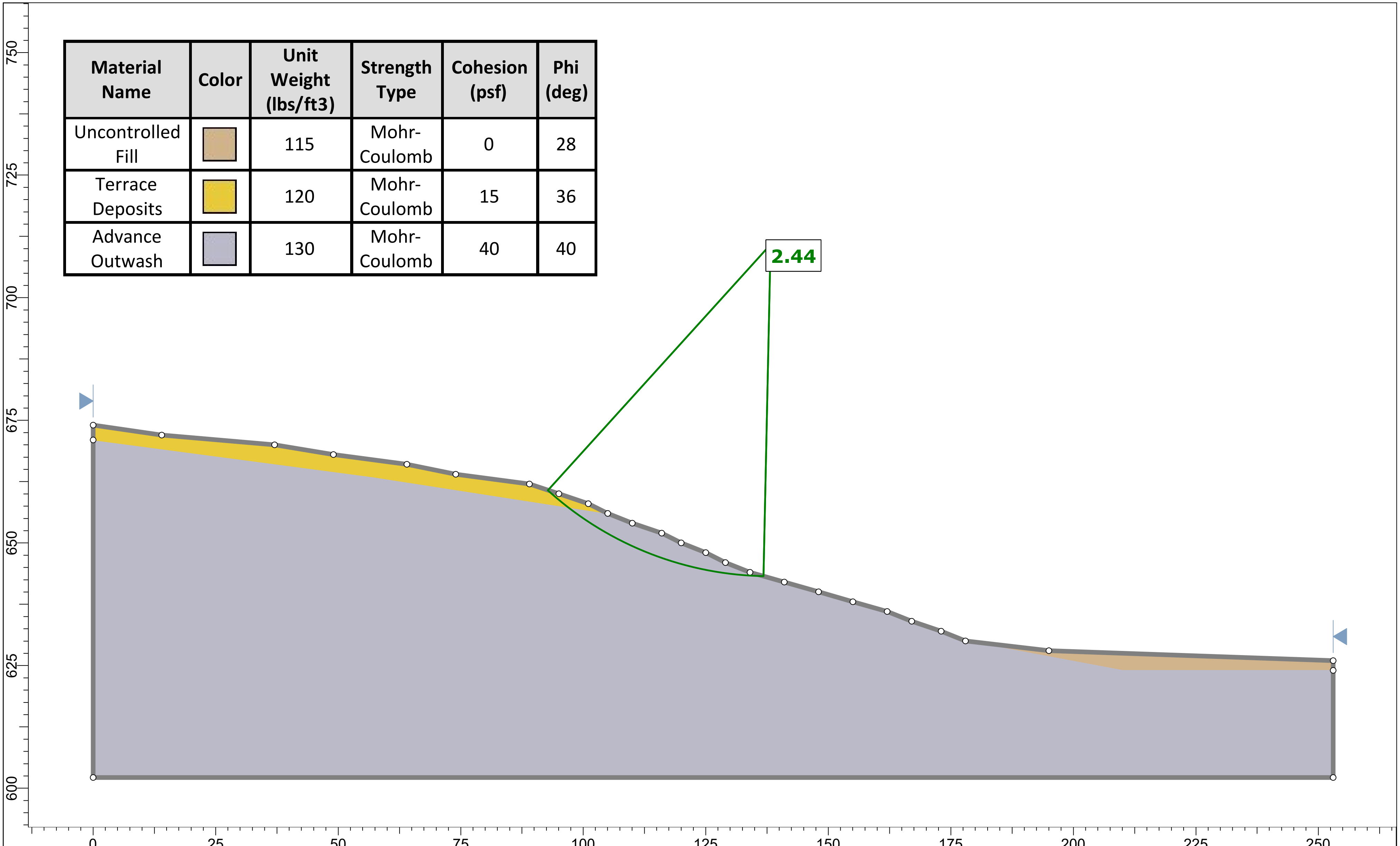
Analyte	Method	Result	Units	PQL	Qualifiers	Analysis Date	Analyst
Organic Matter	ASTM D-2974-13	4.23	wt. % Dry	0.005	---	6/23/2022	KLH
Cation Echange Capcity	SW 9081	17.7	Na, mEq/100g	---	---	6/29/2022	KLH

Client ID: TP-3 S-1 @ 3' **Lab No: 302225-02** **Sample Date: 05/18/22 08:30**

Analyte	Method	Result	Units	PQL	Qualifiers	Analysis Date	Analyst
Organic Matter	ASTM D-2974-13	1.49	wt. % Dry	0.005	---	6/23/2022	KLH
Cation Echange Capcity	SW 9081	16.2	Na, mEq/100g	---	---	6/29/2022	KLH

Lab Qualifiers Comments:

Appendix C
Slope Stability Analyses

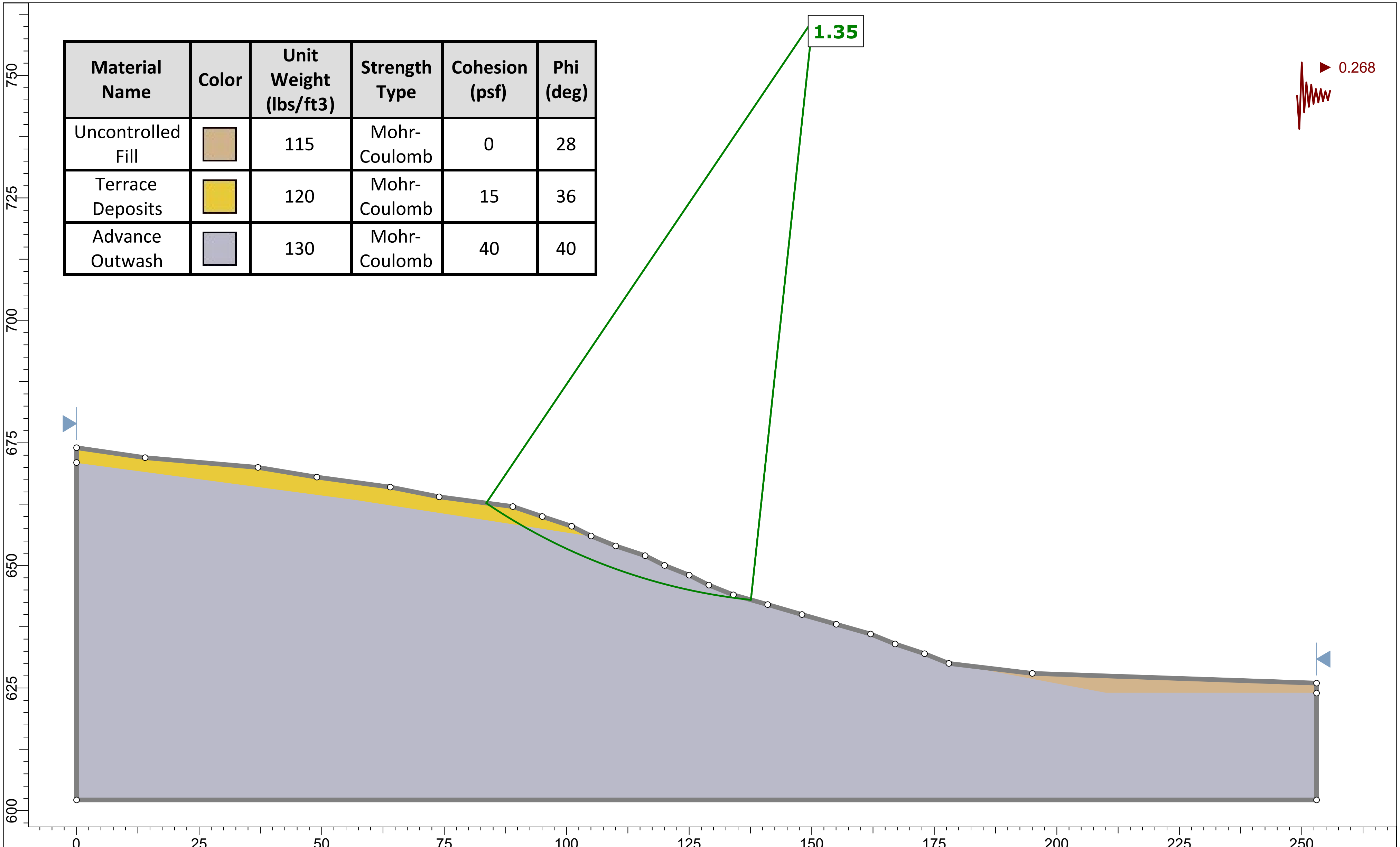


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Uncontrolled Fill		115	Mohr-Coulomb	0	28
Terrace Deposits		120	Mohr-Coulomb	15	36
Advance Outwash		130	Mohr-Coulomb	40	40

rocscience

SLIDEINTERPRET 9.022

Project	Slide2 - An Interactive Slope Stability Program		
Group	Subsurface Profile A-A'	*Scenario*	Static
Drawn By		*Company*	
Date	6/14/2022, 3:21:58 PM	*File Name*	H2PropertiesLLC.258thSt.slmd

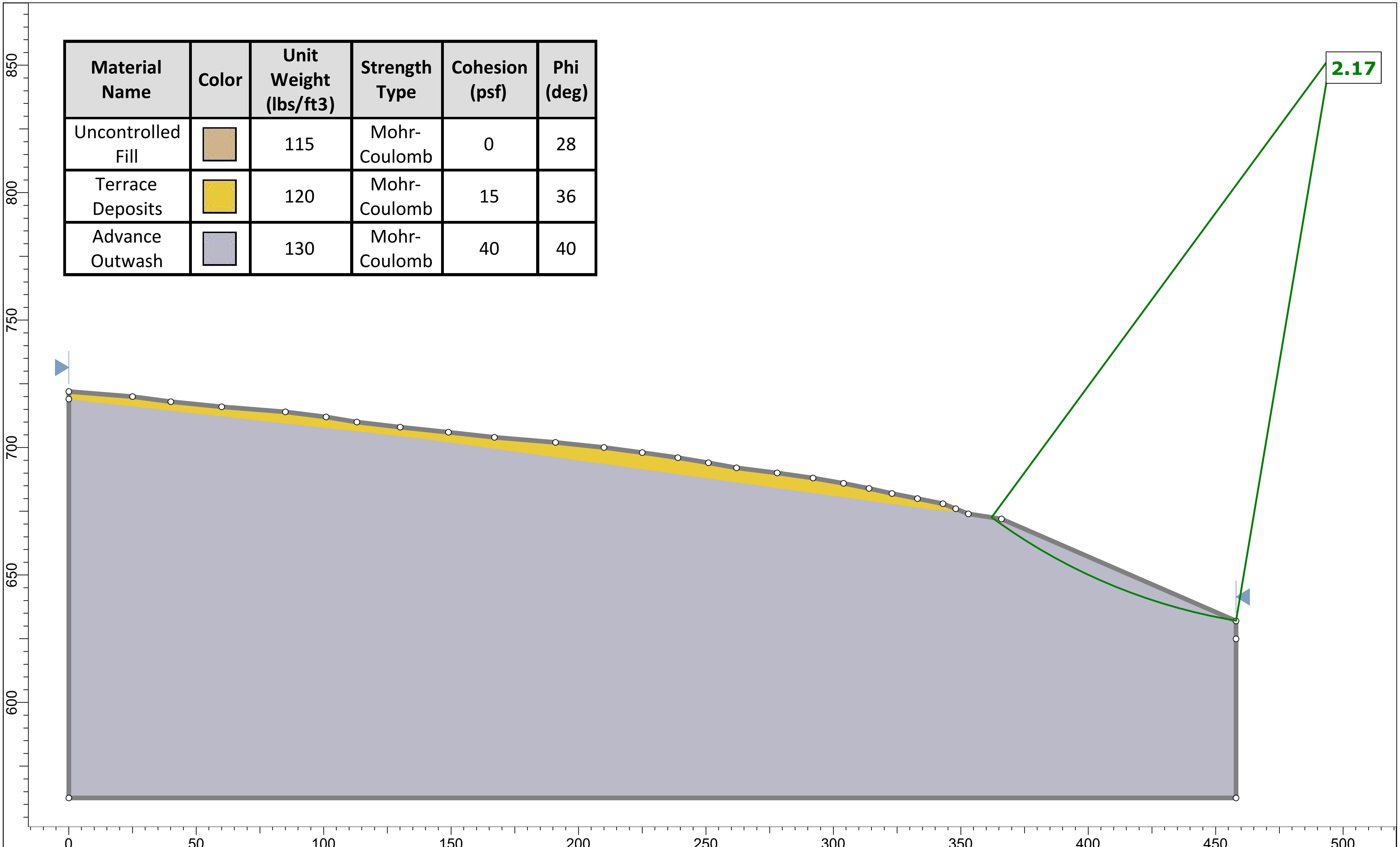


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Uncontrolled Fill		115	Mohr-Coulomb	0	28
Terrace Deposits		120	Mohr-Coulomb	15	36
Advance Outwash		130	Mohr-Coulomb	40	40

rocscience

SLIDEINTERPRET 9.022

Project	Slide2 - An Interactive Slope Stability Program		
Group	Subsurface Profile A-A'	*Scenario*	Pseudo-static (50% PGAm)
Drawn By		*Company*	
Date	6/14/2022, 3:21:58 PM	*File Name*	H2PropertiesLLC.258thSt.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Uncontrolled Fill		115	Mohr-Coulomb	0	28
Terrace Deposits		120	Mohr-Coulomb	15	36
Advance Outwash		130	Mohr-Coulomb	40	40

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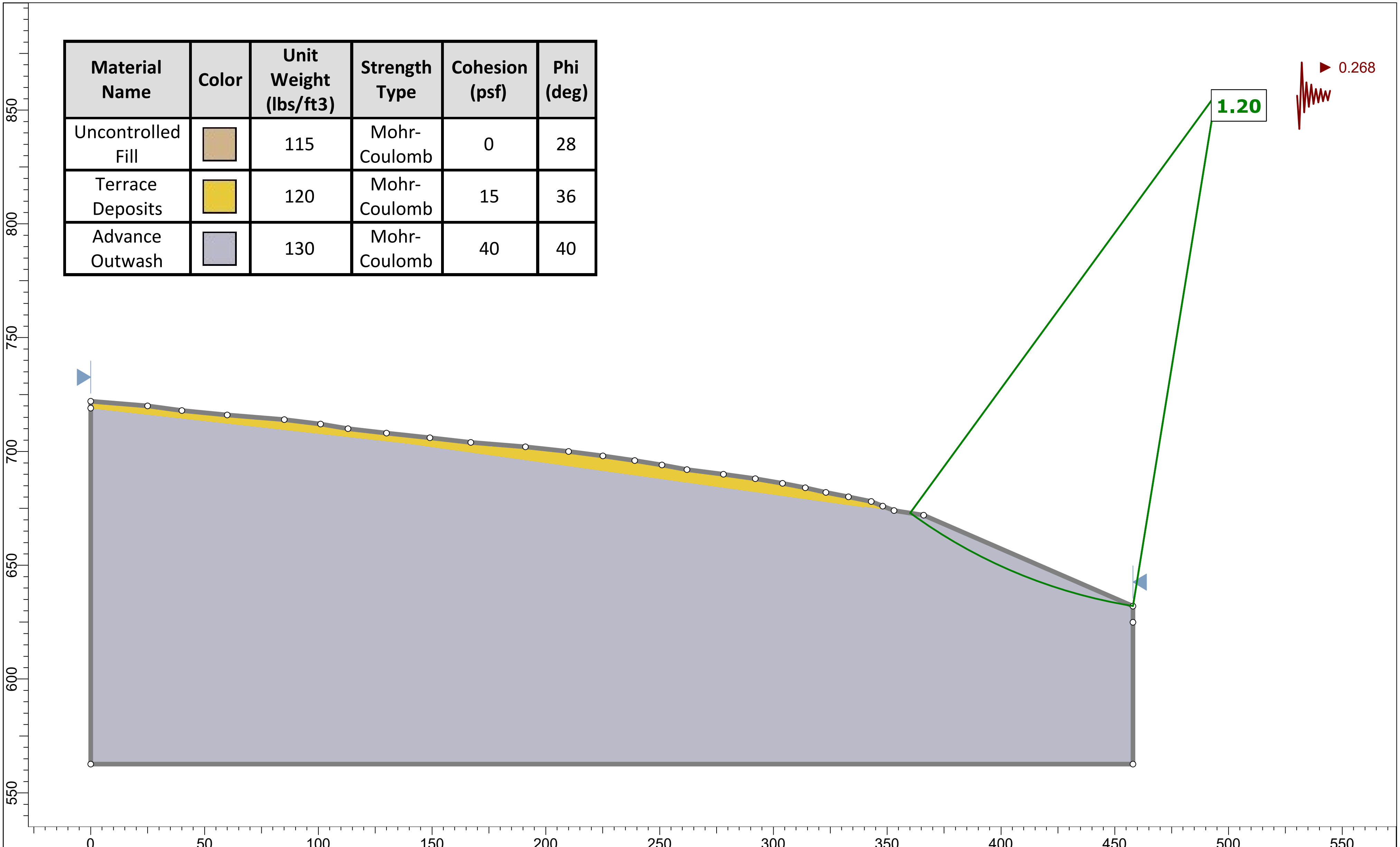
SLIDEINTERPRET 9.022

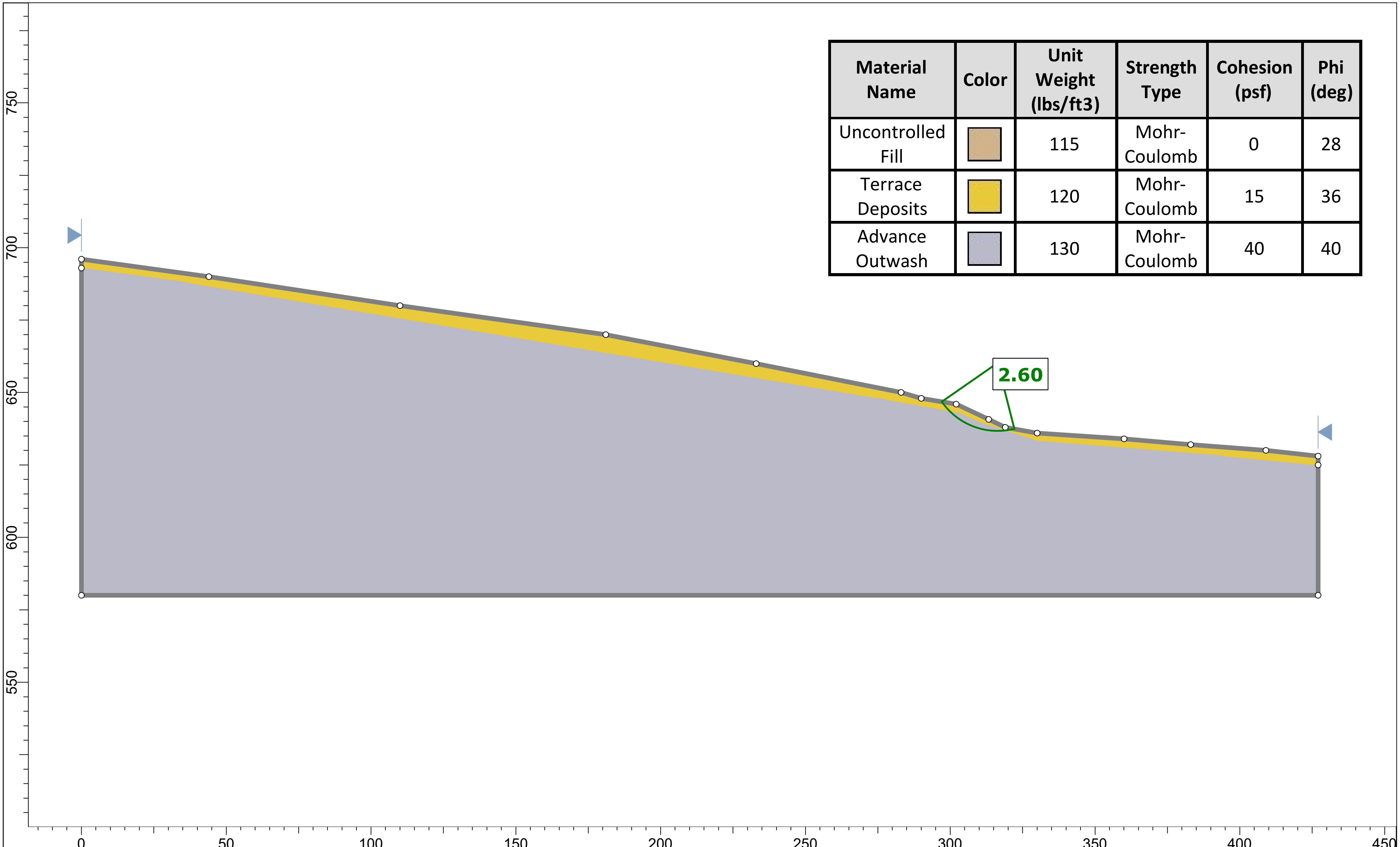
Project	Slide2 - An Interactive Slope Stability Program

Group	Subsurface Profile B-B'	*Scenario*	Static
Drawn By		*Company*	
Date	6/14/2022, 3:21:58 PM	*File Name*	H2PropertiesLLC.258thSt.slmd

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Uncontrolled Fill		115	Mohr-Coulomb	0	28
Terrace Deposits		120	Mohr-Coulomb	15	36
Advance Outwash		130	Mohr-Coulomb	40	40



rocscience	*Project* Slide2 - An Interactive Slope Stability Program		
	Group Subsurface Profile B-B'	*Scenario* Pseudo-static (50% PGAm)	
	Drawn By	*Company*	
SLIDEINTERPRET 9.022	*Date* 6/14/2022, 3:21:58 PM	*File Name* H2PropertiesLLC.258thSt.slmd	



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Uncontrolled Fill		115	Mohr-Coulomb	0	28
Terrace Deposits		120	Mohr-Coulomb	15	36
Advance Outwash		130	Mohr-Coulomb	40	40

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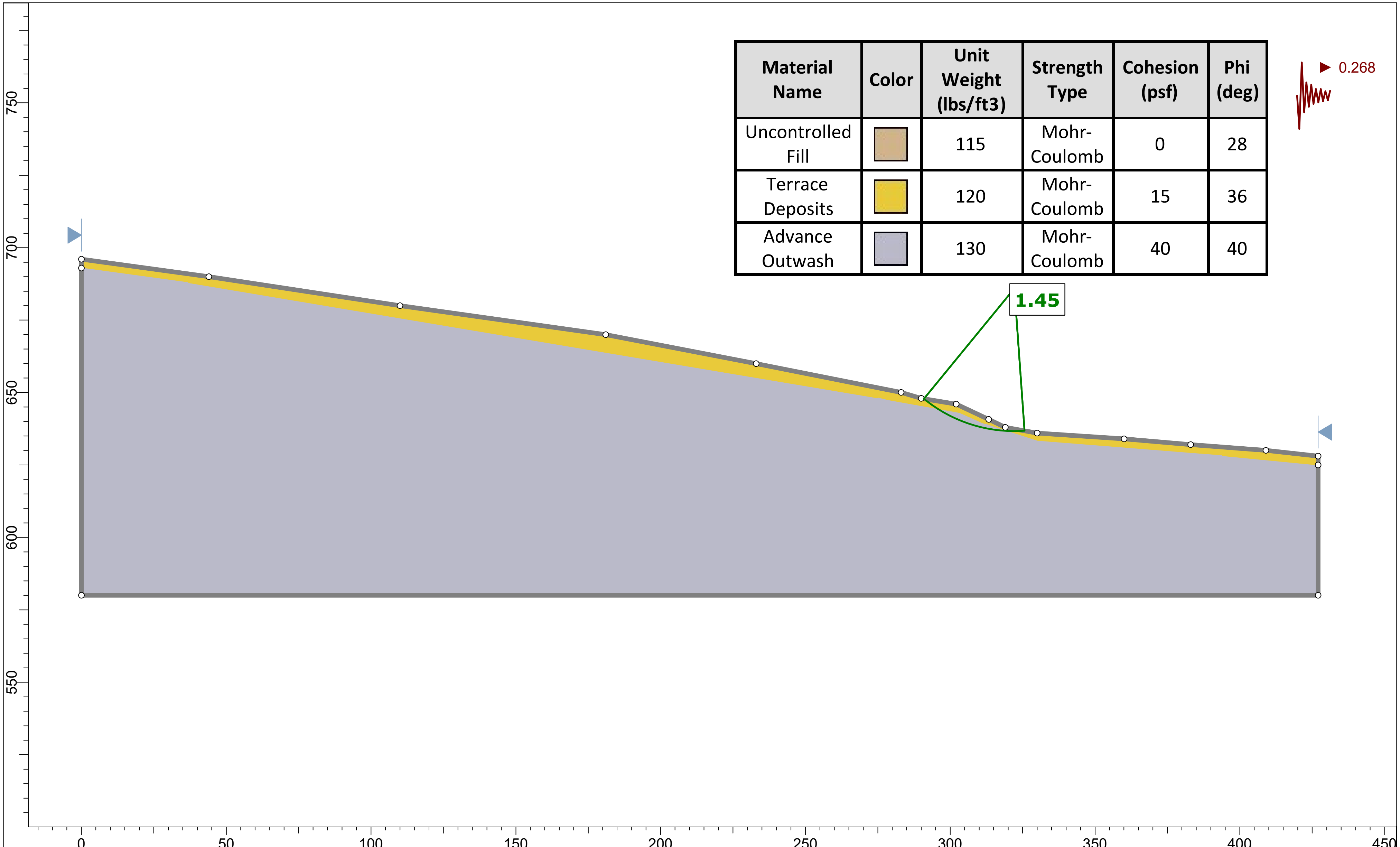
SLIDEINTERPRET 9.022

Project	Slide2 - An Interactive Slope Stability Program		
Group	Subsurface Profile C-C'	*Scenario*	Static
Drawn By		*Company*	
Date	6/14/2022, 3:21:58 PM	*File Name*	H2PropertiesLLC.258thSt.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Uncontrolled Fill		115	Mohr-Coulomb	0	28
Terrace Deposits		120	Mohr-Coulomb	15	36
Advance Outwash		130	Mohr-Coulomb	40	40

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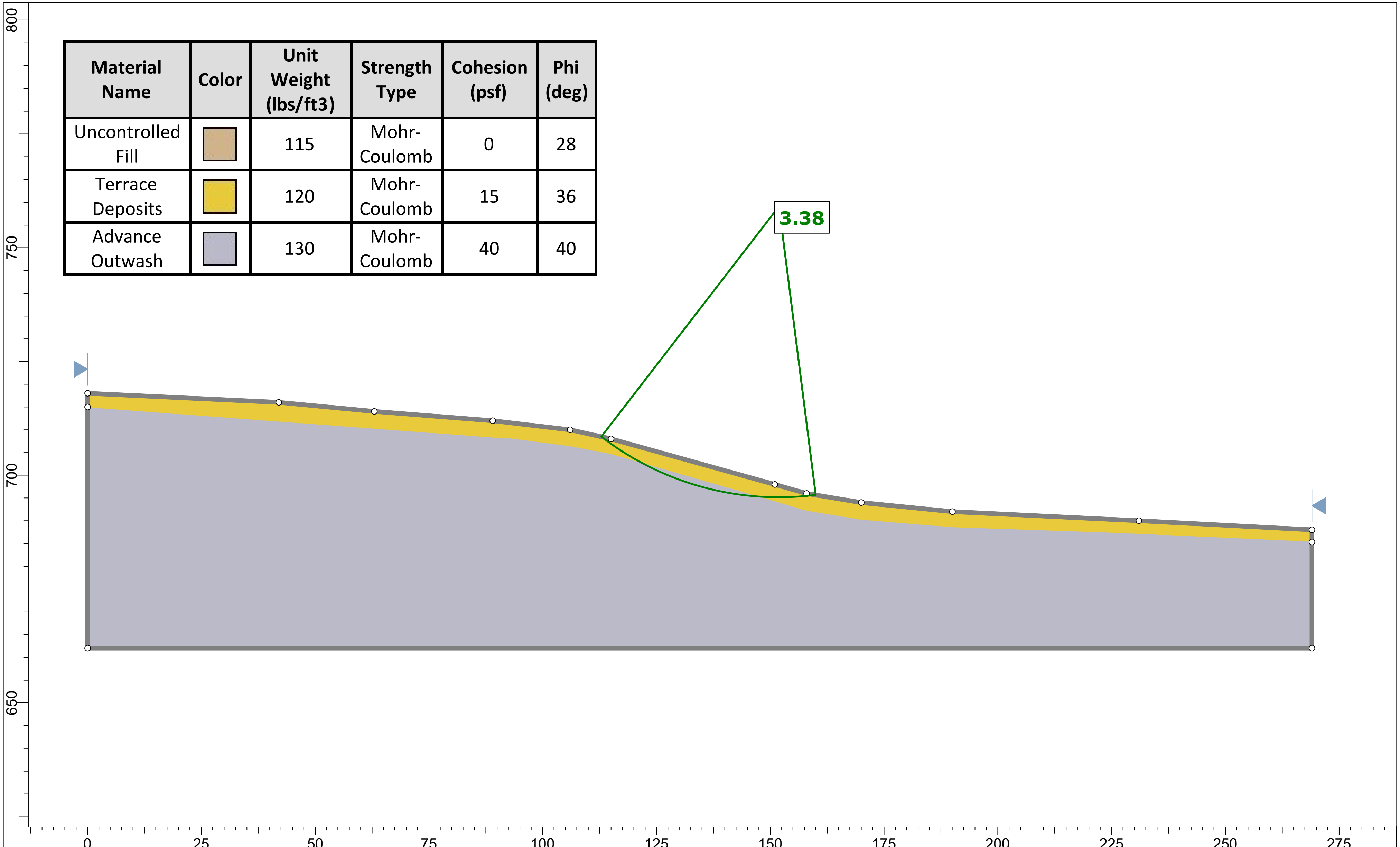
SLIDEINTERPRET 9.022

Project	Slide2 - An Interactive Slope Stability Program		
Group	Subsurface Profile C-C'	Scenario	Pseudo-static (50% PGAm)
Drawn By		Company	
Date	6/14/2022, 3:21:58 PM	File Name	H2PropertiesLLC.258thSt.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Uncontrolled Fill		115	Mohr-Coulomb	0	28
Terrace Deposits		120	Mohr-Coulomb	15	36
Advance Outwash		130	Mohr-Coulomb	40	40

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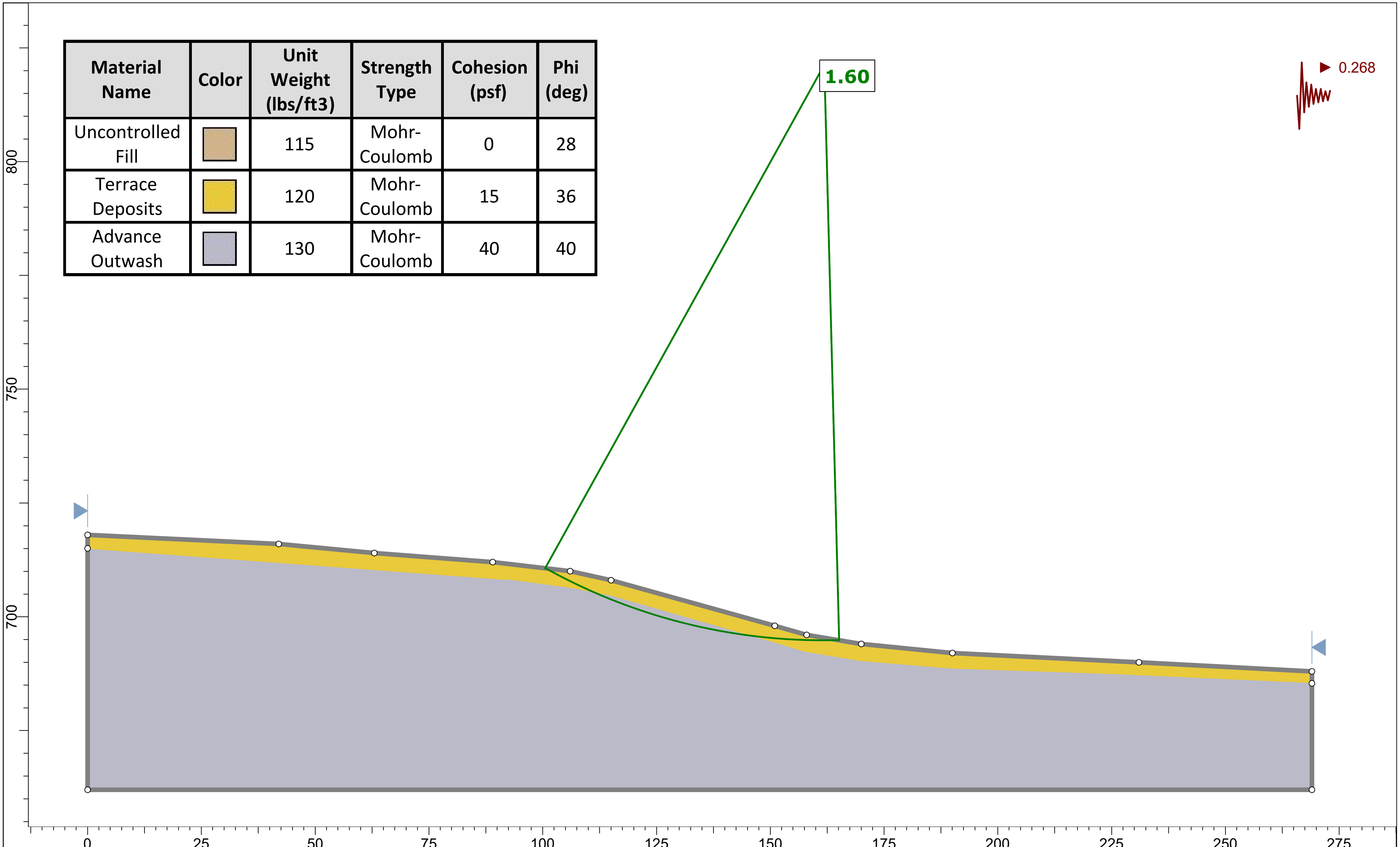
Project	Slide2 - An Interactive Slope Stability Program		
Group	Subsurface Profile D-D'	*Scenario*	Static
Drawn By		*Company*	
Date	6/14/2022, 3:21:58 PM	*File Name*	H2PropertiesLLC.258thSt.slmd

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Uncontrolled Fill		115	Mohr-Coulomb	0	28
Terrace Deposits		120	Mohr-Coulomb	15	36
Advance Outwash		130	Mohr-Coulomb	40	40



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SLIDEINTERPRET 9.022

Project	Slide2 - An Interactive Slope Stability Program		
Group	Subsurface Profile D-D'	*Scenario*	Pseudo-static (50% PGAm)
Drawn By		*Company*	
Date	6/14/2022, 3:21:58 PM	*File Name*	H2PropertiesLLC.258thSt.slmd

Appendix D
Infiltration Rate Calculations

King County - 2021 SWDM

H2Properties.SE258thSt

King County, WA

Infiltration Rate Calculation Sheet

Soil Grain Size Analysis Method

Procudure based on 2021 PCSWMSDM, Appendix III-A

$K_{sat} = 10\text{^}(-1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08F_{fines})$ (provides Ksat in cm/s)

$K_{sat} = [10\text{^}(-1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08F_{fines})]*1417$ (provides Ksat in in/hr)

Sample Information				Sieve Data				Unfactored Rate	
I.D.	Test Pit	Depth (ft)	Layer Thickness (ft)	D_{10}	D_{60}	D_{90}	F_{fines}	Individual K_{sat} (in/hr)	Equivalent K_{sat} (in/hr)
103247	TP-2	1.5	3		0.2784	10.9546	0.274	0.005	7.468
103248	TP-3	3	4		1.98	42.9435	0.123	0.004	6.265
103249	TP-3	7	2+	0.615	10.52	39.2937	0.034	0.149	211.593

Effective Average Hydraulic Conductivity, K_{equiv}

Based on either:

1) Average K_{sat} determined using harmonic mean
2) Lowest conductive layer, if within 5ft of bottom of pond

k_{equiv}=	75.109	Average
	6.265	Lowest
	75.109	To Use

Testing Method ($F_{testing}$)

Grain Size Analysis (Method 3)	0.4

Factor to use for calculations: 0.4

Potential for Plugging ($F_{plugging}$)

Based on USDA Soil Type	1

Loams and Sandy Loams	0.7
Fine Sands and Loamy Sands	0.8
Medium Sands	0.9
Coarse Sands or Cobbles	1

Factor to use for calculations: 1

Facility Geometry ($F_{geometry}$)

between 0.25 and 1.0 using equation: $F_{geometry} = 4\ D/W + 0.05$	

Estimated D: -

Estimated W: -

Factor to use for calculations: 1

$I_{design} = I_{measured} * F_{testing} * F_{geometry} * F_{plugging}$ **30.04** in/hr

Design Value **20.00** in/hr

GEORESOURCES
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Infiltration Analysis

Hudson Short Plat

28010 Southeast 258th Street

King County, WA

PN: 3022079060

DocID: H2Properties.SE258thSt.ksat	July 2022	Figure D-1