Attachment 13

Sound Transit | Downtown Redmond Link Extension

Design-Build Contract No. RTA/CN 0148-18

Geotechnical Report
Alteration of Geologic Hazard Areas
City of Redmond

April 7, 2020

Prepared for:

SOUNDTRANSIT

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Revision History/Signature Page

Version	Description/Comment		
0	Geotechnical Report – Geologic Hazard Areas, City of Redmond	January 6, 2020	
1	Geotechnical Report – Geologic Hazard Areas, City of Redmond	January 16, 2020	
2	Geotechnical Report – Geologic Hazard Areas, City of Redmond	March 19, 2020	
3	Geotechnical Report – Geologic Hazard Areas, City of Redmond	April 7, 2020	

EXECUTIVE SUMMARY

The Downtown Redmond Link Extension (DRLE) project extends East Link light rail from Redmond Technology Center Station to downtown Redmond and will consist of two parallel lines of track running side by side. The project alignment runs along eastbound State Route 520 (SR 520) through critical landslide hazard areas (geologic hazard areas) between NE 60th Street and the SR 520/West Lake Sammamish Parkway NE interchange. The existing steep slopes in this area of the project are considered a potential landslide hazard by the City of Redmond. The project alignment cannot avoid these potential landslide hazard areas (steep slopes) due to the limited space between SR 520 and the adjacent private properties above the slopes. As a result, landslide hazards along the project are either reduced or not adversely affected through use of earth retaining systems (e.g. retaining walls) in areas of slope cut or by placing fill retention systems at the base of existing steep slopes, i.e. providing new buttressing. Earth retaining systems for the project are designed to meet or exceed the slope stability requirements for the State of Washington, and typically improve the stability compared to the existing slopes. Construction of the project will reduce potential hazard impacts by minimizing grading and slope cuts to the extent practical and adhering to recommended erosion and sediment control practices. Monitoring will take place throughout construction along the steep slopes to actively measure for potential slope movement. If excessive slope movements were to occur during construction, corrective action would be taken to prevent potential damage to nearby properties and structures.

1.0 Introduction

The DRLE project extends East Link light rail 3.4 miles from the Redmond Technology Center Station to downtown Redmond and includes two new stations. Most of the light rail alignment, including both stations, will be within the Redmond city limits. The purpose of this report is to demonstrate project compliance with the City of Redmond's (City) critical areas regulations (Redmond Zoning Code [RZC] Chapter 21.64) in support of the permit application to the City related to Alteration of Geologic Hazard Areas. This report addresses the geotechnical aspects of critical areas regulated under RZC Chapter 21.64.060 regarding geologic hazard areas (GHA).

1.1 Overall Project Background

The DRLE project is a component of the larger East Link Light Rail Transit Project. Sound Transit, Washington State Department of Transportation (WSDOT), and the Federal Transit Administration (FTA) issued the East Link Project Final Environmental Impact Statement (EIS) pursuant to the National Environmental Policy Act (NEPA) and the State Environmental Policy Act (SEPA) in July 2011. The EIS evaluated approximately 18 miles of light rail, and the study area was divided into five segments. Segment E included the City of Redmond portion of the study area from Redmond Technology Station (formerly called the Overlake Transit Center Station) to downtown Redmond. Three build alternatives, in addition to the No Build Alternative, were considered in Segment E.

The Final EIS and Record of Decision (ROD) identified Marymoor Alternative E2 as the Preferred Alternative in Segment E (FTA et al. 2011; FTA 2011; Federal Highway Administration [FHWA] 2011). This alignment was selected by the Sound Transit Board in 2011 as part of the East Link Project, although Segment E was not funded at the time for construction and operation. Both the Final EIS and the ROD noted that the Sound Transit 2 (ST2) Plan does not provide sufficient funding for Segment E; therefore, the Redmond Technology Station was selected as the interim terminus. In 2011, Sound Transit deferred further work on an extension to the downtown Redmond terminus until funding became available.

Preliminary engineering to extend light rail from the Redmond Technology Station to downtown Redmond resumed in 2016, and funding for constructing this extension was approved by voters in the Sound Transit 3 (ST3) Plan. As part of ST3, the Sound Transit Board identified 2024 as the start of operation—one year after East Link begins operating to the interim terminus at the Redmond Technology Station. The portion of the full-length East Link corridor, referred to as Segment E in the Final EIS, was subsequently renamed the Downtown Redmond Link Extension (DRLE) Project.

1.2 Overall Project Description

The current design for the DRLE segment consists of a mix of at-grade and elevated track. The DRLE project alignment begins at the Redmond Technology Center and extends north and east along the eastside of the SR 520 freeway using at-grade track generally supported on retained-cut sections to cut into the hillside and pass under existing overpasses. The alignment then turns east with the freeway and transitions to an elevated structure, crossing the Sammamish River and descending into Marymoor Park. The alignment transitions to retained fill and at-grade sections as it reaches the Southeast (SE) Redmond Station. After the station, the light rail alignment turns to the northwest at grade, crosses under SR 520, transitions to an elevated structure over Bear Creek, and then continues as an elevated structure following the Redmond Central Connector (RCC) alignment into downtown Redmond, terminating at the Downtown Redmond Station located at the north side of Redmond Town Center.

1.3 Report Preparation and Technical Experience

This report has been prepared by Mr. Garry Horvitz, a licensed geotechnical engineer and engineering geologist in the State of Washington, meeting the requirements specified in RZC Appendix 1.E. Garry has 44 years of geotechnical engineering experience including landslide stabilization, slope stability evaluations, and geotechnical engineering design of slopes, embankments, roadways, tunnels, elevated structures, and retaining walls. Additional relevant technical expertise and professional registrations for Garry are shown in the geotechnical engineering resume attached to this report.

2.0 Designated Geologic Hazard Areas of the Project

The remainder of this report focuses on the DRLE alignment along the east side of SR 520 between NE 60th Street and the SR 520/West Lake Sammamish Parkway NE (WLSP)

interchange, hereafter referred to as the Geologic Hazard Areas (GHA) of the project. The project site area, designated by Redmond Zoning Code (RZC) Chapter 21.64.060, as the GHA comprises approximately 2.7 acres and generally consists of currently undeveloped areas of Washington State Department of Transportation (WSDOT) right-of-way along eastbound SR 520. The GHA is bordered by NE 60th Street to the south, SR 520 to the west, private residences and a community center to the east, and the SR 520/WLSP interchange to the north. Historical site grading consisting of cut and fill were completed in the vicinity of the GHA as part of the initial SR 520 construction and subsequent widening. In general, the existing steep slopes in this area appear to be either cuts made during SR 520 construction or existed prior to construction of SR 520. A soldier pile retaining wall was also constructed along the SR 520 roadway just west of the SR 520/WLSP interchange, to retain an apparent cut in this area. Fills were completed for the NE 60th Street abutment just south of the critical areas, and fills were also likely completed in the flatter areas adjacent to the shoulder of SR 520. Guideway Stationing in the project area designated as the GHA runs from approximately East Bound Station 5050+00 to 5072+00.

2.1 Proposed Construction in the Critical Areas

The width of the proposed DRLE project alignment is approximately 35 feet from wall to wall and consists of an eastbound and westbound track running approximately parallel to SR 520. The tracks are planned at-grade through the GHA from approximately Station 5050+00 to 5071+50, and as the track alignment continues northeast past approximately Station 5071+50, it transitions to an elevated segment over the SR 520/WLSP interchange. Along portions of the alignment, the GHA slopes make up nearly all of the area between SR 520 and the private properties above the GHA slopes. Note that the project alignment is already established and cannot avoid the GHA due to the site constraints and will have to be constructed with suitable use of earth retaining system and other measures to not adversely affect the GHA.

For two portions of the alignment, between approximately Station 5050+00 to 5052+00 and 5064+00 to 5067+00, the track will be supported on retained structural fill along the base of existing slopes. The remaining portions of the alignment within the GHA, from approximately Station 5052+00 to 5064+00 and 5067+00 to 5071+50, the site grading for the proposed track alignment will generally consist of retained cuts on the east (uphill) side of the track alignment.

3.0 Site Reconnaissance

We conducted a surface reconnaissance at the project site GHA on November 18 – 19, 2019. During our reconnaissance, we observed the site along the east of SR 520, between NE 60th Street and the SR 520/WLSP interchange.

We noted existing chain-link fencing along the top of the slopes separating WSDOT right-of-way along SR 520 and the private properties above the slopes. We did not note any sections of the fence that appeared to be sagging, leaning, or otherwise indicating previous movement of the existing steep slopes in this area. We did not observe any existing slope failures during our reconnaissance of the steep slopes.

We also did not note any seeps or springs on the slopes during our reconnaissance. We did not observe any rill erosion channels or other surficial erosion indicators during our site reconnaissance.

4.0 Geology and Groundwater

We reviewed the relevant publicly available geologic and hydrogeologic maps and studies of the region (Liesch et. al. 1963; Richardson 1968; Minard 1982; WDNR 2019) to determine geologic conditions around the project site GHA. Project-specific explorations completed along the DRLE track alignment were completed by Golder (2018a, b) and historic borings completed by WSDOT in the vicinity are included in the Golder data report (2018a). Borings DRLE-G012 to DRLE-G015 were completed by Golder along the GHA of the project. Logs of these borings are attached.

As the Sammamish River Valley formed over geological epochs, it is believed to have been filled with fluvial and glacial sediments transported by streams associated with glacial activity. As such, the geological units in the vicinity are identified as alluvium and glacial deposits.

4.1 Major Geologic Units

Golder (2018a, b) identified four geologic units during the subsurface investigations along the project alignment between NE 60th Street and the SR 520/WLSP interchange (from approximately. Station 5050+00 to 5072+00). The geologic units fall into three general groups, based on age: Holocene Units, Quaternary Vashon Units, and Quaternary Pre-Vashon Units. The symbols in parenthesis following the sediment type (e.g. Qvt, Qva, etc.) are the map symbols used on the subsurface cross sections on Figures 3C and 3D.

Holocene units consist of sediments deposited since the last glaciation, within the last 12,000 years. These units include engineered and non-engineered human placed fill and soil deposits resulting from natural processes. These units have not been overridden by glacial ice.

Quaternary glacial units consist of soils deposited during the last glaciation. These units include soil deposits resulting from glacial processes ranging in composition from a mix of till-like diamicton, granular outwash deposits and glaciolacustrine deposits.

We interpret the steep slopes at the site to consist of the Quaternary glacial soil units. It is considered unlikely that WSDOT placed fill on the steep slopes as a part of SR 520 construction.

4.1.1 Fill/Modified Land (af)

Fill soils are a result of human activity and, in this area, include fill associated with the construction of SR 520 as the route descends in the Sammamish River Valley. The fill varies in composition. Along SR 520 in this area, the fill includes medium dense to very dense, silty fine to coarse sand, some gravel with a trace of wood fragments, fine to medium sand with some fines, and trace gravel.

4.1.2 Vashon Till (Qvt)

Till soils are typically dense to very dense and were deposited directly beneath glacial ice. These soils generally consist of a mix of silty sand and sandy silt with varying amounts of gravel and occasional cobbles and boulders.

4.1.3 Vashon Advance Outwash Deposits (Qva)

Advance outwash soils are typically dense to very dense since they have been glacially overridden. These soils are generally composed of sand and silty sand with varying amounts of gravel and cobbles. Outwash soils may contain thin interbeds of lenses of fine-grained soils.

4.1.4 Vashon Glaciolacustrine Deposits (Qvgl)

Glaciolacustrine soils are generally fine-grained deposits with a trace of dropstones and are glacially consolidated. These soils typically consist of hard clay, silty clay, and very dense silt. The fine-grained soils are lower-permeability and will typically perch groundwater in overlying granular soils.

4.1.5 Pre-Vashon Till/Till-Like Deposits (Qvd)

The till-like glacial drift deposits at the site are generally composed of silty sand to sandy silt, clayey gravel, and clay with gravel. These soils are typically very dense to hard and may be transitional regarding the overlying fine-grained Qvgl soils.

4.2 Groundwater

Golder (2018a, b) identified groundwater zones with the Holocene and Quaternary glacial units. Within the glacial units, groundwater occurs as isolated, perched, and regional groundwater.

Groundwater was noted in three of the borings along the GHA portion of the project, at depths varying from about 24 to 32 feet below ground surface (bgs). Groundwater elevations range from approximately +190 feet (NAVD88) at Station 5050+00 to approximately +140 feet at Station 5071+00. Proposed track elevations in this area range from approximately +234 feet at Station 5050+00 to approximately +152 feet at Station 5071+00.

Section 6.2.4.1 of the Geotechnical Baseline Report (Golder 2018b) states that “a layer of gravelly soil, up to 5 feet thick [from Station 5066+00 to 5070+00], should be anticipated within the fine-grained soils (Qvgl/Qvd). The top of the gravelly layer should be anticipated at an elevation of approximately 140 feet (+/- 5 feet). The gravelly layer should be anticipated to produce water”. Based on current plans the track elevations through this section are at an elevation of approximately +158 to +175 feet, and the regional groundwater is at elevation of approximately +140 feet. Therefore, the gravelly layer within the fine-grained soils where groundwater is anticipated will likely not be encountered during construction. It is possible that seasonal surface water and perched groundwater may be encountered. This water can be managed with sump-and-pump systems as needed during construction. There is a low

probability that horizontal drains may be required to capture perched groundwater to reduce the risk of soil loss and instability.

5.0 Geologic Hazard Areas

Geologic Hazard Areas (GHA) are defined as areas susceptible to erosion, sliding, earthquake, or other geologic events (RZC 21.78). The following sections of this report present information on the GHA, our evaluation and analysis of potential hazards, and mitigation measures to reduce, or not adversely affect, the geologic hazards.

5.1 Geologic Hazard Areas in the Project Area

City critical areas mapping (2016) identifies the presence of landslide hazard areas in the project area. City mapping (2016) identifies landslide hazard areas along the east side of SR 520 between NE 60th Street and the SR 520/WLSP interchange (Exhibit GH-01 to GH-03). King County (2016) mapped landslide hazards along river corridors for several types of landslides, and the mapping study area for the Sammamish River corridor includes a portion of the project area near the SR 520/WLSP interchange. The King County (2016) mapped area overlaps a portion of the landslide hazard areas mapped by the City (2016). The King County (2016) mapping does not indicate the presence of landslide hazards in the project area. WDNR (2019) does not indicate the presence of any recent or historic landslide activity in the vicinity of the project. Similarly, USGS (2019) mapping does not indicate the presence of landslide hazards or previous landslides in the area.

5.2 Landslide Hazard Areas

Section 21.64.060.A.1.b. of the RZC defines landslide hazard areas as those “potentially subject to significant or severe risk of landslides based on a combination of geologic, topographic, and hydrogeologic factors. They include areas susceptible because of any combination of bedrock, soil, slope, slope aspect, structure, hydrology, or other factors. They are areas of the landscape that are at a high risk of failure or that presently exhibit downslope movement of soil and/or rocks and that are separated from the underlying stationary part of the slope by a definite plane of separation.” A landslide is a mass of rock, earth, or debris moving down a slope. Landslides may be minor or very large and can move at slow to very high speeds. Landslides can cause damage by the slide mass colliding with or burying structures below the slope, and movement of the slope can cause damage to structures on or adjacent to the slide mass that moves.

RZC Section 21.64.060.A.1.b. lists seven criteria for determining whether an area is a landslide hazard.

- Criteria 1 includes areas of historic slope failures or landslides designated or identified by the United States Geologic Survey (USGS) or the United States Department of Agriculture (USDA).

- Criteria 2 includes areas containing a combination of slopes steeper than 15 percent, springs or groundwater seepage, and hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock.
- Criteria 3 includes areas that have shown movement during the Holocene epoch (from 10,000 years ago to the present) or which are underlain or covered by mass wastage debris of that epoch.
- Criteria 4 includes slopes that are parallel or subparallel to planes of weakness in subsurface materials.
- Criteria 5 includes having gradients steeper than 80 percent subject to rockfall during seismic shaking.
- Criteria 6 includes areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action.
- Criteria 7 includes any areas with a slope 40 percent or steeper with a vertical relief of 10 feet or more.

Topography in this area does indicate a large portion of the project area with slopes 40 percent or steeper and vertical relief up to approximately 40 feet (Exhibit GH-01 to GH-03). We note that the potentially water-producing gravelly layer indicated between Station 5066+00 and 5070+00 occurs in an area already identified as a GHA based on the 40 percent or steeper slope criteria. Based on historical mapping, available subsurface information, and our site reconnaissance, we did not identify any slopes or features that meet the other criteria at this project site.

6.0 Slope Stability Assessment

We have evaluated the overall slope stability of the proposed track alignment and related grading, retaining walls, and other improvements. Slope stability analyses consisting of two-dimensional slope cross sections using Spencer and Morgenstern-Price methods of limit equilibrium analysis were performed on two cross sections, Station 5063+50 (Figures 1A through 1D) and Station 5069+00 (Figures 1E through 1H). We selected cross sections in the GHA of the project to represent the critical slope areas, based on the geometry of the slope, proposed grade changes to the slope, and proposed retaining wall heights.

We analyzed slope stability of the selected sections in their existing configuration and final configuration based on preliminary design expectations. We analyzed the existing and final configurations for both the static and 2,500-year pseudo-static (seismic) conditions.

The slope stability, under the various conditions, was analyzed using effective stress analysis method. Based on existing information for the site, the following drained shear strength parameters were used in our slope stability analyses.

Table 1. Generalized / Assumed Design Soil Parameters

Soil Type	Unit Weight (pcf[a])	Drained Friction Angle (degrees)	Drained Cohesion (psf[b])
Artificial Fill (af)	125	34	0
Till (Qvt)	140	40	0
Advance Outwash (Qva)	135	40	0
Glacial Drift (Qvd)	130	37	0
Glaciolacustrine (Qvgl)	130	35	50

Notes:

a. pcf = pounds per cubic foot

b. psf = pounds per square foot

We used the preliminary ultimate soil nail adhesion values below in Table 2 for our slope stability analyses.

Table 2. Preliminary Nail Bond Adhesion

Soil Type	Ultimate Bond Adhesion (ksf)
Artificial Fill (af)	1.5
Till (Qvt)	5.0
Advance Outwash (Qva)	5.0
Glacial Drift (Qvd)	4.0
Glaciolacustrine (Qvgl)	2.5

Notes:

a. ksf = pounds per cubic foot

We evaluated the slopes for the Maximum Design Earthquake (MDE) (2,500-year return period) earthquake hazard level because it is assumed to govern over the Operating Design Earthquake (ODE) (150-year return period) earthquake hazard level. For this project area, the MDE Peak Ground Acceleration (PGA) is consistently about 0.55g (site class B), and the site coefficient is 1.0 for either site class D or C. AS is calculated using the 2014 USGS uniform hazard model for Vs=760 meters/second and the site coefficients in AASHTO load resistance factored design (LRFD). AASHTO LRFD C3.10.2.1 notes that AASHTO uses the uniform hazard for the 975-year return period. As is therefore assumed to be 0.55g for the GHA of the project. K_h is calculated using a minimum of 0.5*A_S, which assumes some permanent wall deformation after the MDE is acceptable (AASHTO LRFD 11.6.5.2.2). Live load from rails is taken as a 390 psf uniform vertical surcharge, per RFP documents.

The SLIDE 2018 computer program was used in our slope stability analyses. The Morgenstern-Price and Spencer methods of limit equilibrium were used to evaluate the balance of both forces

and moments acting within the slope to determine the Factor of Safety (FS) for the slope. The methods assume a circular slip surface, and divides it into slices, each with finite mass. The results of our slope stability analyses are summarized in Table 3. In addition, graphic presentations of our slope stability analyses are presented in Figures 1 to 8.

Table 3. Slope Stability Analysis Results

Condition	Calculated Factor of Safety	Minimum Requirement
Station 5063+50		
Existing (Static) [Fig 1A]	1.3	NA
Existing (Pseudostatic) [Fig 1B]	0.7	NA
Final (Static) [Fig 1C]	1.8	1.5
Final (Pseudostatic) [Fig 1D]	1.2	1.1
Station 5069+00		
Existing (Static) [Fig 1E]	1.6	NA
Existing (Pseudostatic) [Fig 1F]	0.9	NA
Final (Static) [Fig 1G]	1.8	1.5
Final (Pseudostatic) [Fig 1H]	1.3	1.1

Conclusion: The results of the slope stability analyses indicate that the potential for instability at the site includes BOTH the onsite areas (i.e., within the Sound Transit project right-of-way) and offsite areas. Slope stability analyses indicate that the onsite and offsite slopes are stable under static conditions but that slopes within both areas may be unstable during a design level seismic event. Results of the slope stability analysis indicate the proposed retaining wall systems at both selected locations can be designed to provide an appropriate factor of safety against instability in both the onsite areas and offsite areas after the completion of the project in both static and pseudo-static (i.e., seismic) conditions. ***Our analysis indicates the final overall slope stability at both locations would be improved over the existing condition of the slopes for static and pseudo-static (seismic) conditions.***

6.1 Temporary Conditions

The temporary, during construction, case for the slopes was not analyzed at this time as the construction sequencing is not yet available. We will work with the construction team during planning and construction to limit temporary slope cuts such that they do not degrade overall global stability of the GHAs during construction of the proposed retaining walls and guideway. Potential temporary construction risks include, but are not limited to, the following: temporary slope cuts being too deep, grading over too large an area, and wet weather during construction could cause local (minor) slope instability.

We understand temporary conditions will likely include installing a haul road roughly parallel to SR-520 and some grading to accommodate the temporary haul road. The exact grading required to accommodate the temporary haul road is not yet known. It is not clear at this time what, if

any, temporary earth retaining systems will be needed in the geologic hazard areas. Temporary slope conditions and any temporary retaining systems will be designed for a minimum static factory of safety (FS) of 1.3 in accordance with the WSDOT Geotechnical Design Manual (GDM) 15-7.3.2.

7.0 Monitoring

Section 3.4.2 of the Project Requirements, Geotechnical Instrumentation and Monitoring, includes specifications for the Instrumentation Installation and Monitoring Plan; "The Contractor shall develop an Instrumentation Installation and Monitoring Plan (IIMP) for all existing buildings, structures, utilities, and infrastructure along the Project alignment, as deemed necessary by the Contractor and required by permits, to verify successful completion of the Project without causing damage to existing facilities. The IIMP shall be prepared in accordance with Volume 3-02, 31 09 00 Geotechnical Instrumentation and Monitoring of Earthwork."

In accordance with the Project Requirements, the IIMP will be completed and submitted at least 60 days prior to the start of construction activities. Based on the Project Specifications, Section 31 09 00, we anticipate the IIMP will address the following monitoring in the GHA. Prior to construction baseline readings will be taken of all the monitoring points to establish the existing conditions and provide a basis for comparison.

7.1 Optical Survey

We expect optical survey points will be installed at the top of new soil nail retaining walls at the start of construction at intervals of 25 feet or less along the length of the walls. Optical survey points will be used to measure relative horizontal and vertical movement of the walls during and after construction. Optical survey points on new soil nail walls will be monitored at least once daily during construction/excavation of the wall, and at least once per week after completion of the wall and movements have stabilized. The monitoring will continue for four weeks after completion of each wall. Additional reading intervals may be necessary if sudden changes are measured.

7.2 Inclinometer

We anticipate inclinometers will be installed above the proposed soil nail walls or at the top of the GHA steep slopes to monitor horizontal movement of the slopes. Inclinometers are typically installed in a vertical plastic casing and can indicate relative movement at specific depths in the slope. Inclinometers will be monitored daily during wall excavation on or below the GHA slopes and at least once per week after wall excavation is completed and movements have stabilized. Additional readings may be necessary if sudden changes are measured.

7.3 Vibration Monitoring

Vibration monitoring will occur during all construction activity within 100 feet of existing structures and buried utilities. Vibration monitoring consists of geophones placed between the construction work and the nearby structure or utility, to measure vibrations in the ground. Vibration monitoring will be continuous during construction work within 100 feet of existing structures or utilities, and work will be stopped immediately if the vibration measurements exceed the specified limits.

8.0 Geologic Hazard Mitigation

8.1 Potential Geologic Hazard Impacts

Some temporary construction impacts are discussed in Section 6.1 of this report. This section includes these temporary construction impacts as well as longer-term potential geologic hazard impacts for the project. The onsite and offsite impacts (including adjacent residential parcels) have been identified as having the same potential impacts. In other words, the areas within the Geologic Hazard Areas (i.e., steep slopes) that have the greatest potential for instability straddle both the project right-of-way and adjacent properties, concurrently. Potential geologic hazard impacts are listed below.

Potential Onsite and Offsite Impacts include:

- Temporary slope cuts being too deep could cause local (minor) slope instability.
- Temporary slope cuts or grading over a large area could cause local (minor) slope instability or erosion.
- Temporary open cuts/clearing during construction could cause (minor) sloughing and erosion of the slopes, especially during wet weather.
- Seepage from slope faces during construction could cause local (minor) sloughing and erosion.
- Steepened slopes or large cuts could cause slope instability if not supported with earth retention systems in final configuration.
- Seismic (earthquake) event could cause slope instability if not supported by earth retention systems after construction.

8.2 Recommended Mitigation Measures

As the onsite and offsite (including adjacent affected residential parcels) share the same potential impacts, we recommend the following mitigation measures within the GHAs to reduce

or not adversely affect the existing geologic hazards and address the potential impacts listed above:

- Project design will minimize alterations or reduce steepness of the natural contour of the slopes to the extent practical.
- Clearing of existing vegetation on the GHA slopes will be minimized to the extent practical.
- Design will provide retaining wall systems to support slopes where abrupt grade changes are unavoidable due to the track alignment. Retaining walls and other structures will be designed to maintain or enhance the overall stability of the slopes, in both static and seismic (earthquake) conditions.
- Design and construction methods should minimize the length and steepness of slopes with exposed soils as much as practical.
- Construction sequencing and methods should be selected to improve or not adversely affect overall slope stability during construction.
- Provide temporary erosion and sedimentation controls during construction to prevent sloughing and erosion of the slopes. (Additional erosion control information provided in Section 8.3 below).
- Permanent erosion protection will be provided by reestablishing vegetation using hydroseeding and/or landscape planting. Until the permanent erosion protection is established, site monitoring should be performed by qualified personnel to evaluate the effectiveness of the erosion control measures.
- As mentioned above, a potential seepage layer was noted by Golder (2018b) at an elevation of approximately +140 feet (+/- 5 feet) from Station 5066+00 to 5070+00 [Exhibit GH-03]. Track elevations in this area range from approximately +158 to +175 feet, and construction is not expected to extend to this layer. However, dewatering may be required during construction and possibly permanent horizontal drains, to reduce the risk of soil loss and instability.
- RFP drawings V3-01.05 "SR520 148th Ave to SR901_as-builts_July 1978" indicates horizontal drains and piezometers were installed into the hillside during SR 520 construction from about Station 5055+80 to 5071+80 [Exhibit GH-02 to GH-03]. The as-built plans do not include as-built elevations of these drains. If retaining wall or other construction in the GHA impact the existing drainage system, then the construction team should assume that the drainage system will need to be repaired or replaced in-kind. Coordination with WSDOT will likely be required if existing drains are encountered.

8.3 Erosion and Sedimentation Control

The DRLE project is required to meet all applicable local, State, and Federal regulations to avoid environmental impacts. Potential sources and causes of erosion depend on construction

methods, slope length and gradient, amount of soil exposed and/or disturbed, soil type, construction sequencing, and weather. The impacts on erosion-prone areas, such as steep slopes, will be reduced by implementing an approved erosion and sedimentation control plan.

DRLE project Temporary Erosion and Sedimentation Control (TESC) plans include, but are not limited to, the following items related to GHA on the project:

- Install siltation control fencing around project work areas to protect all adjacent properties from sediment deposition and runoff.
- All exposed soils will be stabilized with an approved TESC method (e.g. seeding, mulching, plastic covering, crushed rock) within two days during wet weather months or seven days during dry months.
- Where straw mulch is required for temporary erosion control, it will be applied at a minimum 2-inch thickness.
- Provide temporary curb or drainage bypass to direct runoff away from exposed soils and slopes.
- Inspect and maintain erosion and sediment control measures frequently. Repair and/or replacement of dysfunctional erosion control elements should be completed as quickly as possible.
- Decreasing runoff velocities with check dams, straw bales, or wattles.

9.0 Conclusions

In summary, our findings and recommendations are as follows:

- The project alignment runs through critical landslide hazard areas which are GHAs along eastbound SR 520 between NE 60th Street and the SR 520/WLSP interchange.
- Landslide hazards along the project are either reduced or not adversely affected through use of earth retaining systems in areas of slope cut (approximate station 5052+00 to 5064+00 [Exhibit GH-01 to GH-02] and 5067+00 to 5071+50 [Exhibit GH-03]) or by placing fill retention systems at the base of existing slopes, providing new buttressing.
- Temporary construction slope cuts will be further analyzed during the final design process to limit cuts so as not to degrade overall stability of the GHA slopes.
- Proposed site activities must follow best management practices (BMPs) and the proposed mitigation measures in Section 8.0 to ensure construction activities will not adversely affect slope stability.
- The proposed work will be designed, constructed, operated, and maintained in conformance with the contract requirements and appropriate construction practices. As such, landslide

hazard areas are unlikely to be degraded by the project, and City requirements for GHA will be satisfied.

10.0 Decision Criteria Analysis and Response

Three decision criteria are identified by the City of Redmond Permitting Framework Attachment H, "DRLE Alteration of Geologic Hazard Areas Checklist" of V2-02.04 of the Contract Requirements. The criteria (A, B, and C) are listed below along with responses to each.

A) There must be no reasonable alternative to locating in a Landslide Hazard Area. Alternative locations which would avoid impact to the Landslide Hazard Area must be shown to be economically or functionally infeasible.

Response: Sound Transit conducted a lengthy evaluation of potential alternate locations and determined this alignment was the most economically and functionally feasible location. Sound Transit's analysis and evaluation are shown in the City of Redmond Alteration of Geologic Hazard Area Permit: Alternative Alignment Location Assessment document included with the Alteration of Geologic Hazard Permit Application for this project.

B) A geotechnical evaluation must be conducted to identify the risks of damage from the proposal, both on-site and off-site, and to identify measures to eliminate or reduce risks. The proposal must not increase the risk of occurrence of the potential geologic hazard.

Response: This report constitutes our geotechnical evaluation of the risks of the proposed construction and identifies measures to eliminate or reduce the risks. Section 6.0 of this report contains our slope stability evaluations and Section 8.0 contains recommended measures to not adversely affect stability of the slopes. In general, the steep slopes altered by this project will be reinforced with earth retaining systems in areas of slope cut, or by placing fill retention systems at the base of existing slopes, providing new buttressing. As indicated in Section 6.0 and elsewhere in this report, the proposed construction is unlikely to increase the risk of occurrence of the geologic hazard.

C) Impacts shall be minimized by limiting the magnitude of the proposed construction to the extent possible, any impacts must be eliminated or mitigated by repairing, rehabilitating, restoring, replacing, or providing substitute resources consistent with the mitigation and performance standards set forth in RZC 21.64.010.L and 21.64.010.M.

Response: Impacts to the affected geologic hazards will be minimized or mitigated to the extent practical in accordance with the recommendations in Section 8.0 of this report. As mentioned previously the proposed construction should not adversely affect the stability of the slopes, and the contractor will provide monitoring during construction to verify. The construction team is obligated by contract to repair potential damage caused by the project to the geologic hazard areas.

11.0 Report Limitations

The conclusions and recommendations provided in this report are based on the conditions encountered by Golder (2018a, b) in their explorations completed for the DRLE project and our review of available geologic information. Extrapolation of subsurface conditions beyond the field explorations is necessary due to the spacing between explorations and infeasibility of exploring the entire site. Variations may exist between or outside the explorations due to the nature of geologic deposition or alterations such as grading and/or filling. The nature and extent of any variations between the field explorations may not be evident until construction. If variations are observed during construction, it may be necessary to revise specific recommendations in this report.

12.0 References

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13.0 Attachments

Geologic Hazard Area Exhibit – GH-01 to GH-03
Boring Location Plan and Subsurface Profile (Golder) – Figures 3C and 3D
Logs for Borings DRLE-G012 to DRLE-G015
Slope Stability Results – Figures 1A to 1H
Geotechnical Engineering Resume related to Geologic Hazards – Garry Horvitz, PE

\\seafs\Projects\Notebooks\1942703_DRLE_R200_Heavy_Civil\Deliverables\Reports\Geologic Hazard Critical Area Report rev0\Geotechnical Report - Alteration of Geologic Hazard Area.docx

Xrefs:
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xR200-L90-CRP100
xR200-L90-KAV100
xR200-L90-KAP100
xR200-L90-SEP100
xR200-L90-SEP110
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xDRLE-L90-VRX
xDRLE-L90-VSF
xDRLE-STREET-NAMES
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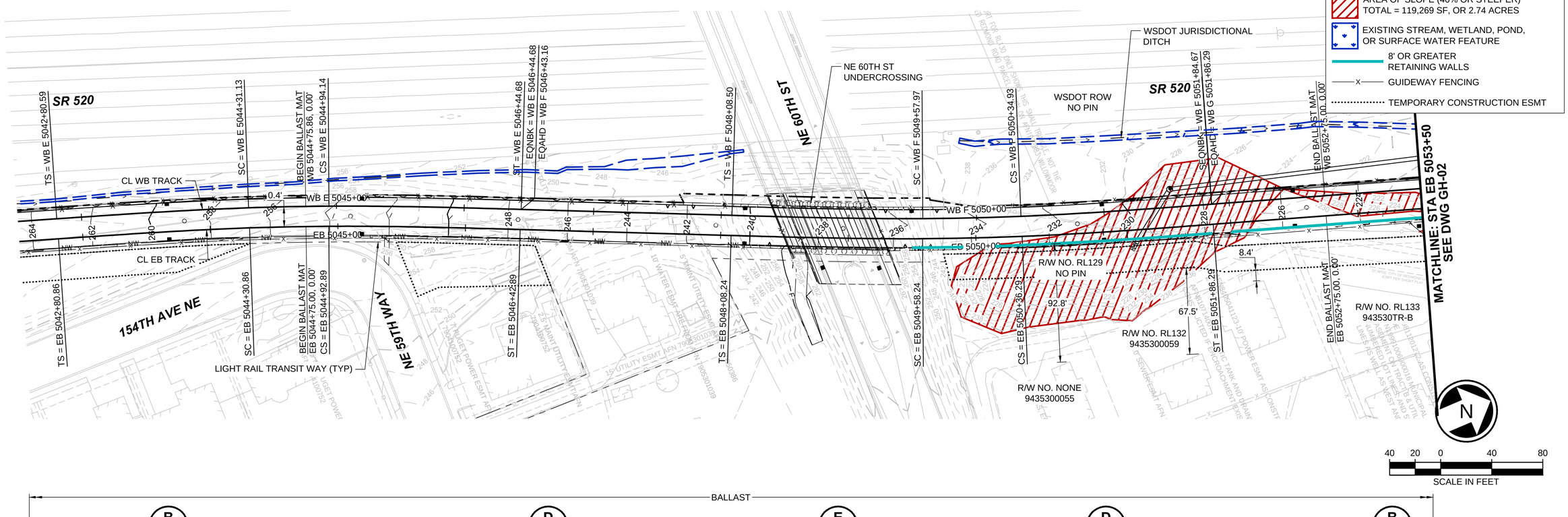
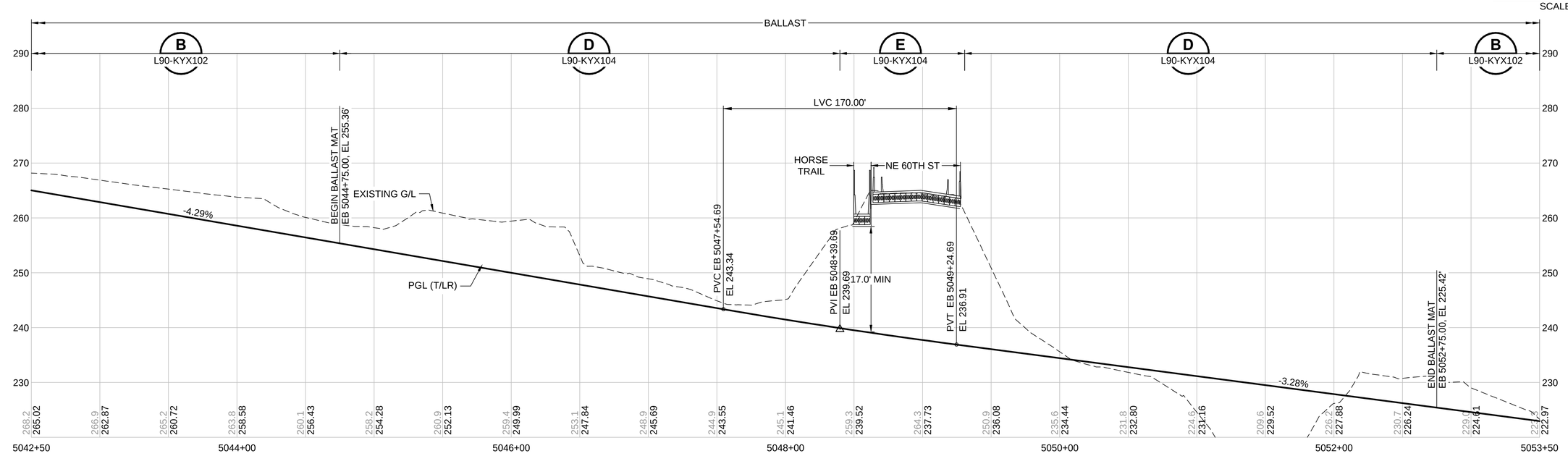
XREF_GH
xR200-L90-RHP100

LEGEND:

- AREA OF SLOPE (40% OR STEEPER) TOTAL = 119,269 SF, OR 2.74 ACRES
- EXISTING STREAM, WETLAND, POND, OR SURFACE WATER FEATURE
- 8' OR GREATER RETAINING WALLS
- GUIDEWAY FENCING
- TEMPORARY CONSTRUCTION ESMT





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						CHECKED BY:					CONTRACT No.:	
						APPROVED BY:		REVIEWED BY: J. SCHETTLER	SUBMITTED BY: A. TISCAREÑO	LINE IS 1" AT FULL SCALE	DATE: 12/20/2019	

GEOLOGIC HAZARD AREA EXHIBIT

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xDRLE-STREET-NAMES
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xR200-L90-RPP100
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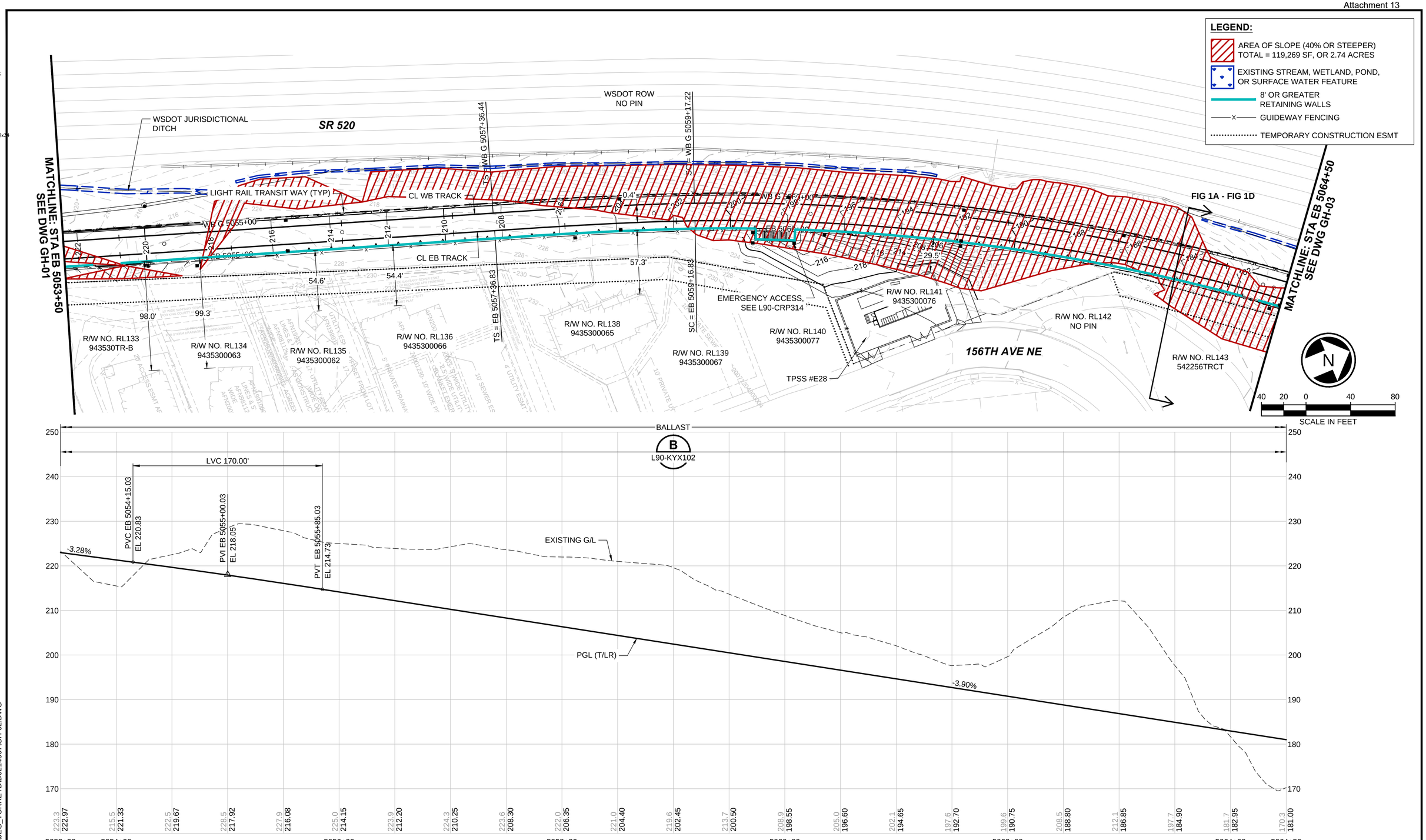

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DRAWN BY:
CHECKED BY:
APPROVED BY:
REVIEWED BY: J. SCHETTLER
SUBMITTED BY: A. TISCAREÑO
SWK Stacy and Witbeck / Kuney
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GEOLOGIC HAZARD AREA EXHIBIT

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xDRLE-STREET-NAMES
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xR200-L90-RPP100
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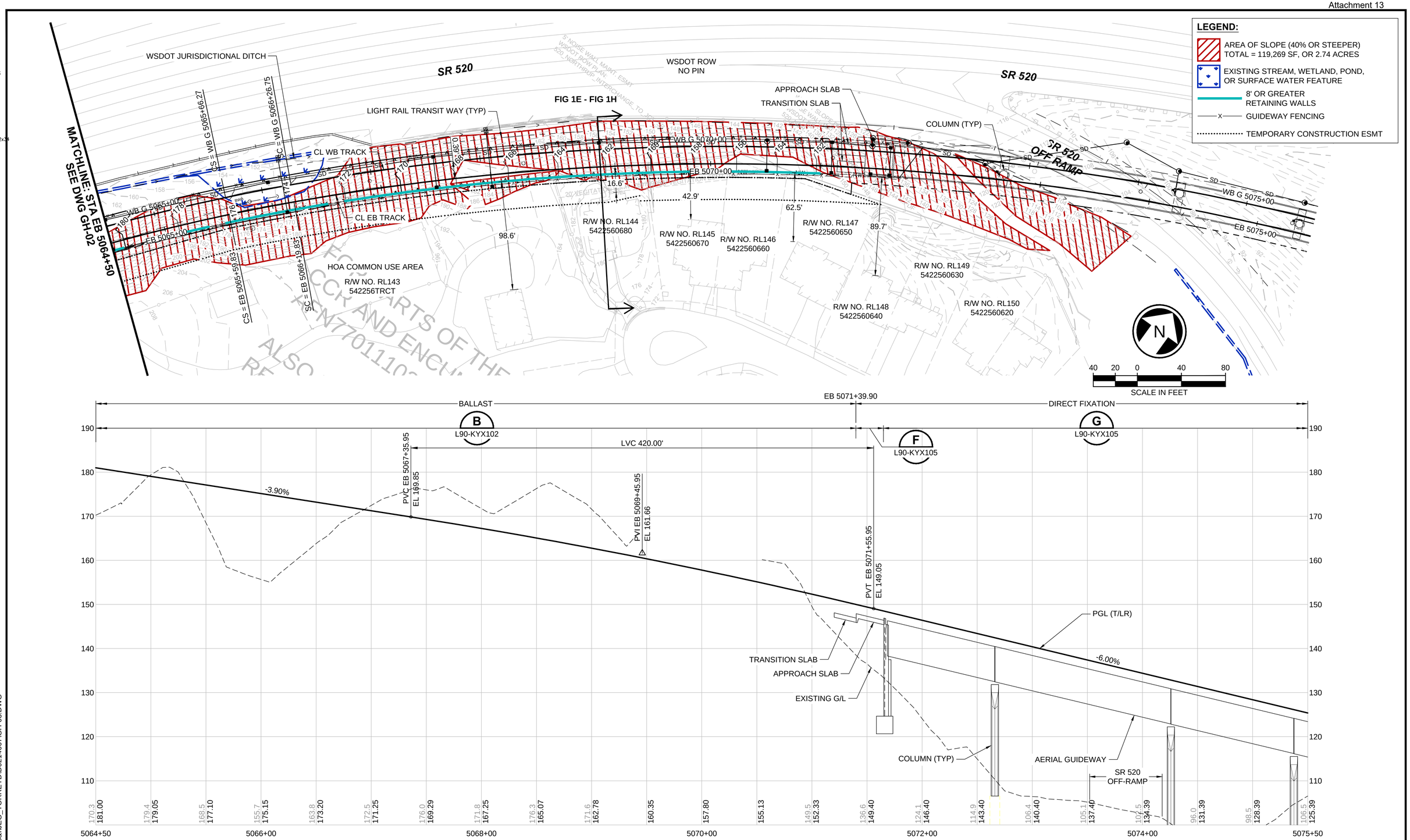

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DRAWN BY:
CHECKED BY:
APPROVED BY:

REVIEWED BY: J. SCHETTLER

SWK Stacy and Witbeck / Kuney

SUBMITTED BY: A. TISCAREÑO

SOUNDTRANSIT

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GEOLOGIC HAZARD AREA EXHIBIT

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EB 5064+50 TO EB 5075+50

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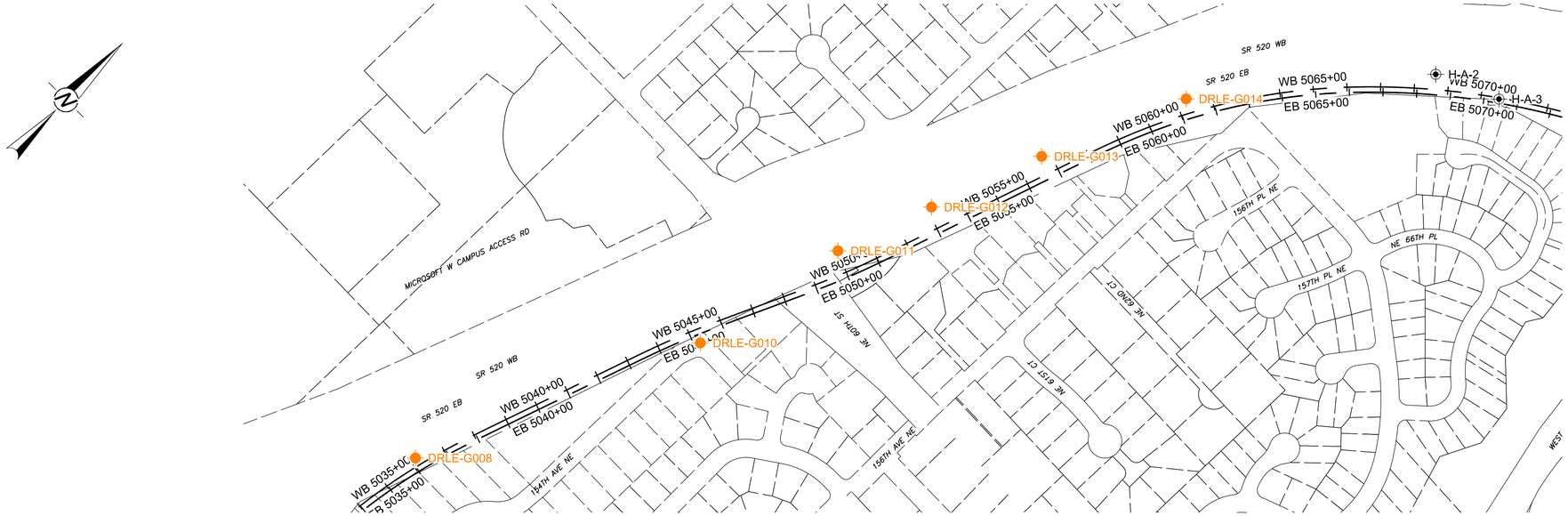

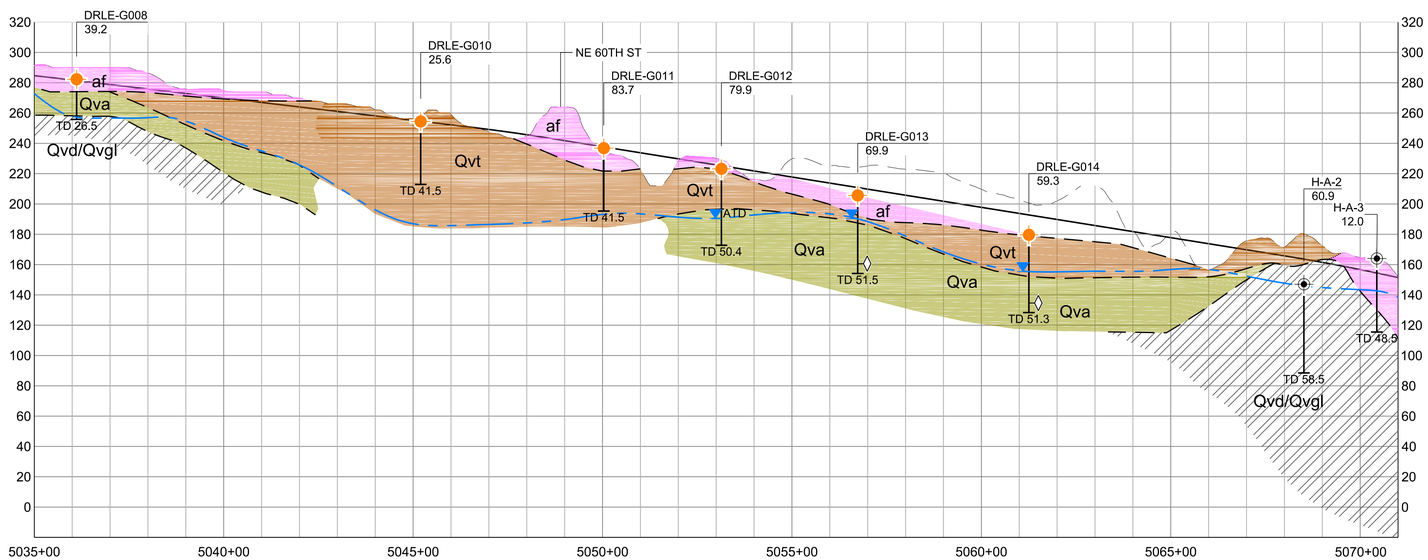

LEGEND

- GOLDER BOREHOLE LOCATION AND ID
- PROPOSED EASTBOUND TRACK ALIGNMENT
- BORING LOCATION AND ID (BY OTHERS)

NOTE(S)

- SEE RECORDS OF BOREHOLES IN GEOTECHNICAL DATA REPORT FOR SUBSURFACE INFORMATION AND DATA AT INDIVIDUAL LOCATIONS.
- CONTACTS BETWEEN SOIL UNITS ARE BASED ON BOREHOLE INFORMATION AND REPRESENT THE INTERPRETATION OF SUBSURFACE CONDITIONS. THE BASELINE ELEVATION OF SOIL UNIT CONTACTS IS PLUS OR MINUS 5 FEET OF THE ELEVATION SHOWN ON THE SOIL PROFILES.
- COMPLETE SOIL UNIT DESCRIPTIONS ARE PROVIDED IN SECTION 5.0 OF THE GEOTECHNICAL BASELINE REPORT (GBR).
- FOR THE PURPOSE OF THIS GBR IN ESTABLISHING SOIL CONDITIONS, THE CONTRACTOR IS RESPONSIBLE FOR SOIL CONDITIONS BEYOND THE DEPTH SHOWN ON THE SOIL PROFILES.

REFERENCE(S)

BASE DRAWINGS, PROVIDED BY SOUND TRANSIT, IN DWG FORMAT.

0 50 100
1" = 50' VERT. FEET
0 200 400
1" = 200' HORIZ. FEET

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DRAWN BY: THR
CHECKED BY: BB
APPROVED BY: RAM

GOLDER

Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES

LINE IS 1" AT FULL SCALE

SOUNDTRANSIT

SUBMITTED BY: GOLDER
DATE: 2018-09-07
REVIEWED BY:
DATE:

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CONTRACT No.: 1657705/200
DATE: 2018-09-07

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KING COUNTY, WASHINGTON

TITLE: PLAN AND PROFILE - STA 5035+00 - 5071+00

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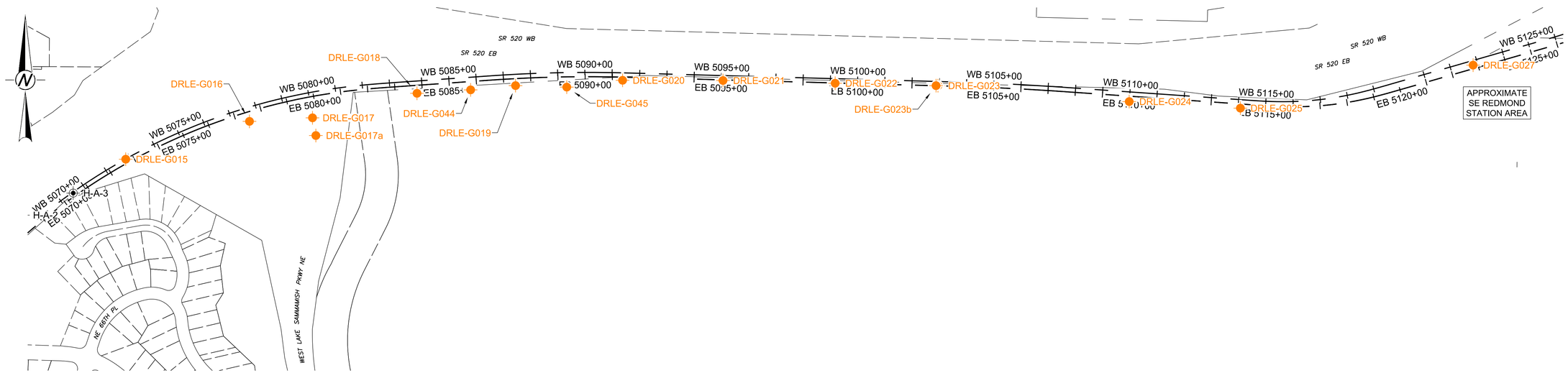

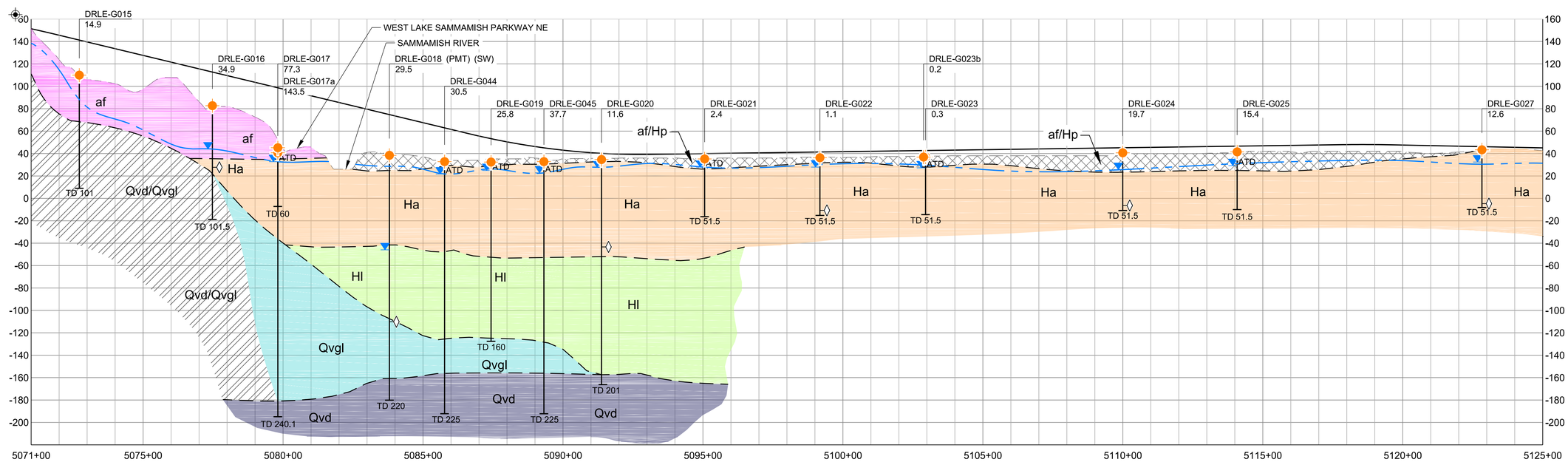

LEGEND

- GOLDER BOREHOLE LOCATION AND ID
- PROPOSED EASTBOUND TRACK ALIGNMENT

NOTE(S)

- SEE RECORDS OF BOREHOLES IN GEOTECHNICAL DATA REPORT FOR SUBSURFACE INFORMATION AND DATA AT INDIVIDUAL LOCATIONS.
- CONTACTS BETWEEN SOIL UNITS ARE BASED ON BOREHOLE INFORMATION AND REPRESENT THE INTERPRETATION OF SUBSURFACE CONDITIONS. THE BASELINE ELEVATION OF SOIL UNIT CONTACTS IS PLUS OR MINUS 5 FEET OF THE ELEVATION SHOWN ON THE SOIL PROFILES.
- COMPLETE SOIL UNIT DESCRIPTIONS ARE PROVIDED IN SECTION 5.0 OF THE GEOTECHNICAL BASELINE REPORT (GBR).
- FOR THE PURPOSE OF THIS GBR IN ESTABLISHING SOIL CONDITIONS, THE CONTRACTOR IS RESPONSIBLE FOR SOIL CONDITIONS BEYOND THE DEPTH SHOWN ON THE SOIL PROFILES.

REFERENCE(S)

BASE DRAWINGS, PROVIDED BY SOUND TRANSIT, IN DWG FORMAT.

0 50 100
1" = 50' VERT. FEET

0 200 400
1" = 200' HORIZ. FEET

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DESIGNED BY: DF
DRAWN BY: THR
CHECKED BY: BB
APPROVED BY: RAM

GOLDER

Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES

LINE IS 1" AT FULL SCALE

SOUNDTRANSIT

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DATE: 2018-09-07
REVIEWED BY:
DATE:

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FILENAME: 1657705_200_GDR_004
CONTRACT No.: 1657705/200
DATE: 2018-09-07

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KING COUNTY, WASHINGTON

TITLE: PLAN AND PROFILE - STA 5071+00 - 5125+00

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RECORD OF BOREHOLE DRLE-G012

PROJECT: Downtown Redmond Link Extension
PROJECT NO.: 1657705
LOCATION: NB SR520 Shoulder

DRILLING START: November 2, 2017 09:43
DRILLING END: November 2, 2017 12:14
COORDINATES: N: 344,115 E: 1,419,864

SHEET: 1 of 2
GS ELEV.: 223.2 feet
TOC ELEV.: na
DATUM: NAVD88/Project Datum

BORING METHOD: Hollow Stem Auger

Depth (ft)	Description	Elev	USCS	Sample Type & Number	Blows per 6 in (Automatic 140 lb Hammer, 30 inch drop)	REC/ATT (in)	Penetration Resistance (Blows / ft)	Notes / Water Levels
0.0	(PT), SANDY PEAT, some fine sand, very dark brown-brown; moist	223.2	PT					
1.8	(SM), SILTY SAND, fine to coarse sand, some nonplastic fines, trace fine to coarse subangular gravel, pale gray-blue; medium dense to very dense, moist, iron staining	221.4	SM	SS S-1	15-14-18 **(32)**	13/18	32	
				SS S-2	3-5-12 **(17)**	12/18	17	5: S-2: % Fines = 37
	Color change to pale tan gray			SS S-3	44-14-27 **(41)**	11/18	41	
				SS S-4	11-30-50/4" **(80/10")**	12/16	>>	
	Trace wood fragments			SS S-5	6-16-16 **(32)**	13/18	32	
	Color change to pale brown			SS S-6	27-30-26 **(56)**	14/18	>>	
				SS S-7	50/4" **(50/4")**	2/4	>>	
24.0	(SP), POORLY GRADED SAND WITH GRAVEL, fine to coarse sand, little fine to coarse subrounded gravel, trace nonplastic fines, pale gray to dark gray; very dense, moist	199.2	SP	SS S-8	26-50/5" **(50/5")**	11/11	>>	
30.5	(SP-SM), POORLY GRADED SAND WITH SILT, fine sand, few nonplastic fines, pale tan-brown; very dense, moist to wet	192.7		SS S-9	13-25-35 **(60)**	18/18	>>	∇ 32.7 ft, ADT
	6-inch thick lense of Sandy Silt		SP-SM	SS S-10	26-28-27 **(55)**	18/18	>>	

Log continued on next page

DRILLING CO.: Holt Services Inc
DRILLER: Todd Knipscheld
DRILL RIG: Mobile B58

LOGGED: Daniel Bida
CHECKED: Margaret Pryor
REVIEWED: Dave Findley

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 6/28/18 08:40
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RECORD OF BOREHOLE DRLE-G012

PROJECT: Downtown Redmond Link Extension
PROJECT NO.: 1657705
LOCATION: NB SR520 Shoulder

DRILLING START: November 2, 2017 09:43
DRILLING END: November 2, 2017 12:14
COORDINATES: N: 344,115 E: 1,419,864

SHEET: 2 of 2
GS ELEV.: 223.2 feet
TOC ELEV.: na
DATUM: NAVD88/Project Datum

DEPTH (ft)	BORING METHOD	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic 140 lb Hammer, 30 inch drop)	REC/ATT (in)	PENETRATION RESISTANCE BLOWS / ft (10 20 30 40) / WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
40		40.0		183.2								
	Hollow Stem Auger		(SP-SM), POORLY GRADED SAND WITH SILT, fine sand, few nonplastic fines, pale tan-brown; very dense, moist to wet *(continued)*		SP-SM		SS S-11	12-18-50/5" **(68/11")**	17/17	>>		
		44.0		179.2								
45			(SP), POORLY GRADED SAND WITH GRAVEL, fine to coarse sand, little fine to coarse subrounded to subangular gravel, pale brown-tan; very dense, wet		SP		SS S-12	50/5" **(50/5")**	5/5	>>		
50		50.4		172.8			SS S-13	50/5" **(50/5")**	5/5	>>		
			Bottom of borehole at 50.4 ft. Backfilled with bentonite chips.									
55												
60												
65												
70												
75												
80												

DRILLING CO.: Holt Services Inc
DRILLER: Todd Knipscheld
DRILL RIG: Mobile B58

LOGGED: Daniel Bida
CHECKED: Margaret Pryor
REVIEWED: Dave Findley

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 6/28/18 08:40
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RECORD OF BOREHOLE DRLE-G013

PROJECT: Downtown Redmond Link Extension
PROJECT NO.: 1657705
LOCATION: EB SR520 Shoulder

DRILLING START: November 3, 2017 09:45
DRILLING END: November 3, 2017 12:14
COORDINATES: N: 344,452 E: 1,419,988

SHEET: 1 of 2
GS ELEV.: 205.6 feet
TOC ELEV.: na
DATUM: NAVD88/Project Datum

BORING METHOD: Hollow Stem Auger

Depth (ft)	Description	Elev	USCS	Sample Type & Number	Blows per 6 in (Automatic 140 lb Hammer, 30 inch drop)	REC/ATT (in)	Penetration Resistance Blows / ft	Notes / Water Levels
0.0	(ML), SANDY SILT, nonplastic fines, some fine to medium sand, very dark brown; moist	205.6	ML					
2.5	(SM), SILTY SAND WITH GRAVEL, fine to coarse sand, some nonplastic fines, little fine to coarse subrounded to subangular gravel, pale gray; medium dense, moist, trace wood fragments	203.1	SM	SS S-1	5-12-18 **(30)**	18/18	30	
				SS S-2	4-5-6 **(11)**	2/18	11	5: S-2: % Fines = 28
7.5	(SP), POORLY GRADED SAND WITH GRAVEL, fine to medium sand, few fine to coarse subrounded to subangular gravel, trace nonplastic fines, light tan-brown; medium dense to very dense, moist to wet	198.1	SP	SS S-3	5-7-12 **(19)**	0/18	19	
				SS S-4	18-16-18 **(34)**	18/18	34	
	Brown, Lean Clay (CL) observed in tip of sampler shoe (S-5)			SS S-5	15-20-16 **(36)**	11/18	36	
				SS S-6	16-21-30 **(51)**	12/18	>>	15.4 ft, 03/04/2018 VWP reading; 15.5 ft, 06/02/2018 VWP reading
17.5	(SP), POORLY GRADED SAND, fine to coarse sand, trace nonplastic fines, pale tan-gray; dense to very dense, wet	188.1	SP	SS S-7	8-12-19 **(31)**	18/18	31	
	6 inch thick lense of Sandy Silt; color change to pale tan			SS S-8	22-34-40 **(74)**	18/18	>>	24.7 ft, ADT
	Increased coarse sand content			SS S-9	20-50/5" **(50/5")**	11/11	>>	30: 6 inches of heave in S-9
	Color change to pale gray brown			SS S-10	19-28-50/4" **(78/10")**	16/16	>>	35: 6 inches of heave in S-10

Log continued on next page

DRILLING CO.: Holt Services Inc.
DRILLER: Todd
DRILL RIG: Mobile B58 Truck

LOGGED: Daniel Bida
CHECKED: Margaret Pryor
REVIEWED: Dave Findley

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 6/28/18 08:40
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RECORD OF BOREHOLE DRLE-G013

PROJECT: Downtown Redmond Link Extension
PROJECT NO.: 1657705
LOCATION: EB SR520 Shoulder

DRILLING START: November 3, 2017 09:45
DRILLING END: November 3, 2017 12:14
COORDINATES: N: 344,452 E: 1,419,988

SHEET: 2 of 2
GS ELEV.: 205.6 feet
TOC ELEV.: na
DATUM: NAVD88/Project Datum

DEPTH (ft)	BORING METHOD	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic 140 lb Hammer, 30 inch drop)	REC/ATT (in)	PENETRATION RESISTANCE BLOWS / ft (10 20 30 40) / WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
40		40.0		165.6								
	Hollow Stem Auger		(SP), POORLY GRADED SAND, fine to coarse sand, trace nonplastic fines, pale tan-gray; dense to very dense, wet *(continued)*		SP		SS S-11	5-18-50 **(68)**	18/18	>>		
45			Color change to dark gray				SS S-12	10-50/5" **(50/5")**	11/11	>>	45: VWP installed	
50		51.5	Color change to pale gray	154.1			SS S-13	10-20-50 **(70)**	18/18	>>		
			Bottom of borehole at 51.5 ft. Installed vibrating wire piezometer									
55												
60												
65												
70												
75												
80												

DRILLING CO.: Holt Services Inc.
DRILLER: Todd
DRILL RIG: Mobile B58 Truck

LOGGED: Daniel Bida
CHECKED: Margaret Pryor
REVIEWED: Dave Findley

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 6/28/18 08:40
C:\USERS\CSCHAEFFER\DESKTOP\DRLE LOGS.GPJ

RECORD OF BOREHOLE DRLE-G014

PROJECT: Downtown Redmond Link Extension
PROJECT NO.: 1657705
LOCATION: EB SR520 shoulder

DRILLING START: November 6, 2017 09:30
DRILLING END: November 6, 2017 12:12
COORDINATES: N: 344,876 E: 1,420,171

SHEET: 1 of 2
GS ELEV.: 179.6 feet
TOC ELEV.: na
DATUM: NAVD88/Project Datum

BORING METHOD: Hollow Stem Auger

Depth (ft)	Description	Elev	USCS	Sample Type & Number	Blows per 6 in (Automatic 140 lb Hammer, 30 inch drop)	REC/ATT (in)	Penetration Resistance Blows / ft	Notes / Water Levels
0.0	(ML), SILT, nonplastic fines, trace fine sand, trace coarse rounded gravel, pale gray; hard, moist to wet	179.6	ML					0 - 28: Difficult drilling
				SS S-1	9-18-30 **(48)**	18/18	48	
				SS S-2	6-18-29 **(47)**	18/18	47	
				SS S-3	16-30-50 **(80)**	18/18	>>	
				SS S-4	20-40-50/5" **(90/11")**	17/17	>>	
				SS S-5	18-30-39 **(69)**	18/18	>>	
				SS S-6	22-30-50 **(80)**	18/18	>>	
				SS S-7	10-30-50 **(80)**	18/18	>>	24.2 ft, ADT
				SS S-8	22-36-50 **(86)**	18/18	>>	
28.0	(SP), POORLY GRADED SAND, fine sand, trace nonplastic fines, pale gray; dense to very dense, wet	151.6	SP	SS S-9	8-8-26 **(34)**	18/18	34	30: S-9: % Fines = 4
				SS S-10	22-28-34 **(62)**	18/18	>>	
39.0		140.6	SM					40: S-11: % Fines = 16

Log continued on next page

DRILLING CO.: Holt Services Inc.
DRILLER: Todd
DRILL RIG: Mobile B58 Truck

LOGGED: Daniel Bida
CHECKED: Margaret Pryor
REVIEWED: Dave Findley

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 6/28/18 08:40
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RECORD OF BOREHOLE DRLE-G014

PROJECT: Downtown Redmond Link Extension
PROJECT NO.: 1657705
LOCATION: EB SR520 shoulder

DRILLING START: November 6, 2017 09:30
DRILLING END: November 6, 2017 12:12
COORDINATES: N: 344,876 E: 1,420,171

SHEET: 2 of 2
GS ELEV.: 179.6 feet
TOC ELEV.: na
DATUM: NAVD88/Project Datum

DEPTH (ft)	BORING METHOD	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic 140 lb Hammer, 30 inch drop)	REC/ATT (in)	PENETRATION RESISTANCE BLOWS / ft (10 20 30 40) / WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES WATER LEVELS	ADDITIONAL LAB TESTING
40		40.0		139.6								
	Hollow Stem Auger		(SM), SILTY SAND, fine sand, little nonplastic fines, pale gray; dense to very dense, wet *(continued)*		SM		SS S-11	6-10-22 **(32)**	18/18	32		
45							SS S-12	22-34-50/5" **(84/11")**	17/17	>>		
50		51.3		128.3			SS S-13	28-40-50/4" **(90/10")**	16/16	>>		
			Bottom of borehole at 51.3 ft. Backfilled with bentonite chips.									
55												
60												
65												
70												
75												
80												

DRILLING CO.: Holt Services Inc.
DRILLER: Todd
DRILL RIG: Mobile B58 Truck

LOGGED: Daniel Bida
CHECKED: Margaret Pryor
REVIEWED: Dave Findley

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 6/28/18 08:40
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RECORD OF BOREHOLE DRLE-G015

PROJECT: Downtown Redmond Link Extension
PROJECT NO.: 1657705
LOCATION: EB SR520 shoulder

DRILLING START: November 7, 2017 10:10
DRILLING END: November 8, 2017 13:36
COORDINATES: N: 345,657 E: 1,421,021

SHEET: 1 of 3
GS ELEV.: 110.0 feet
TOC ELEV.: na
DATUM: NAVD88/Project Datum

DEPTH (ft)	BORING METHOD	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic 140 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (10 20 30 40) / WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
0	Mud rotary	0.0	(SM), FILL: SILTY SAND WITH GRAVEL, fine to coarse sand, some fine to coarse subangular to angular gravel, little nonplastic fines, pale gray-brown; medium dense to very dense, moist, trace wood fragments, glass, and plastic	110.0	SM		SS S-1	50/4" **(50/4")**	4/4	>>	2.5: Possible cobbles	
5							SS S-2	40-46-50/4" **(96/10")**	12/16	>>		
							SS S-3	12-50/5" **(50/5")**	8/11	>>		
10							SS S-4	12-40-22 **(62)**	7/18	>>		
							SS S-5	23-22-27 **(49)**	14/18	49		
15							SS S-6	22-26-30 **(56)**	9/18	>>		
20							SS S-7	11-12-14 **(26)**	12/18	26	20: S-7: % Fines = 28 22: Drilling chatter	
25							SS S-8	7-5-6 **(11)**	13/18	11	25: S-8: % Fines = 23	
30							SS S-9	4-30-50/5" **(80/11")**	13/17	>>	32: Drilling chatter	
35							SS S-10	7-7-7 **(14)**	14/18	14	35: S-10: % Fines = 24	
40												

Log continued on next page

DRILLING CO.: Holt Services Inc.
DRILLER: Todd
DRILL RIG: Mobile B58 Truck

LOGGED: Daniel Bida
CHECKED: Margaret Pryor
REVIEWED: Dave Findley

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 6/28/18 08:40
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RECORD OF BOREHOLE DRLE-G015

PROJECT: Downtown Redmond Link Extension
PROJECT NO.: 1657705
LOCATION: EB SR520 shoulder

DRILLING START: November 7, 2017 10:10
DRILLING END: November 8, 2017 13:36
COORDINATES: N: 345,657 E: 1,421,021

SHEET: 2 of 3
GS ELEV.: 110.0 feet
TOC ELEV.: na
DATUM: NAVD88/Project Datum

DEPTH (ft)	BORING METHOD	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic 140 lb Hammer, 30 inch drop)	REC ATT (in)	PENETRATION RESISTANCE BLOWS / ft (10 20 30 40) / WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
40	Mud rotary	40.0		70.0	SM		SS S-11	7-18-30 **(48)**	10/18	48		
		42.5	(CH), FAT CLAY WITH SAND, high plasticity fines, trace fine to coarse sand, trace fine to coarse subrounded to rounded gravel, pale gray; hard, moist	67.5								
45			Thin seams < 1/4 inch thick of preserved wood fibers observed throughout				SS S-12	9-20-30 **(50)**	18/18	50		
50							SS S-13	19-30-50/5" **(80/11")**	17/17	>>	50: S-13: PI = 37	
55					CH		SS S-14	12-23-50 **(73)**	18/18	>>	55: S-14: % Fines = 91	
60							SS S15	16-21-30 **(51)**	18/18	>>		
65							SS S-16	17-28-37 **(65)**	18/18	>>		
70							SS S-17	21-17-28 **(45)**	18/18	45	70: S-17: PI = 46	
75		74.0	(CH), SANDY FAT CLAY, high plasticity fines, some fine to coarse sand, trace fine to coarse subrounded to rounded gravel, pale gray; hard, moist	36.0	CH		SS S-18	19-28-36 **(64)**	18/18	>>	75: S-18: % Fines = 55	
80												

Log continued on next page

DRILLING CO.: Holt Services Inc.
DRILLER: Todd
DRILL RIG: Mobile B58 Truck

LOGGED: Daniel Bida
CHECKED: Margaret Pryor
REVIEWED: Dave Findley

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 6/28/18 08:40
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RECORD OF BOREHOLE DRLE-G015

PROJECT: Downtown Redmond Link Extension
PROJECT NO.: 1657705
LOCATION: EB SR520 shoulder

DRILLING START: November 7, 2017 10:10
DRILLING END: November 8, 2017 13:36
COORDINATES: N: 345,657 E: 1,421,021

SHEET: 3 of 3
GS ELEV.: 110.0 feet
TOC ELEV.: na
DATUM: NAVD88/Project Datum

DEPTH (ft)	BORING METHOD	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic 140 lb Hammer, 30 inch drop)	REC/ATT (in)	PENETRATION RESISTANCE BLOWS / ft (10 20 30 40) / WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
80	Mud rotary	80.0	(CH), SANDY FAT CLAY, high plasticity fines, some fine to coarse sand, trace fine to coarse subrounded to rounded gravel, pale gray; hard, moist *(continued)*	30.0	CH		SS S-19	36-50/5" **(50/5")**	11/11	>>		
85							SS S-20	50/5" **(50/5")**	5/5	>>		
90							SS S-21	40-50/5" **(50/5")**	11/11	>>		
95							SS S-22	30-29-26 **(55)**	18/18	>>		
100		101.0		9.0			SS S-23	40-50/5" **(50/5")**	11/11	>>		
105			Bottom of borehole at 101.0 ft. Backfilled with bentonite grout. Groundwater not observed during drilling									
110												
115												
120												

DRILLING CO.: Holt Services Inc.
DRILLER: Todd
DRILL RIG: Mobile B58 Truck

LOGGED: Daniel Bida
CHECKED: Margaret Pryor
REVIEWED: Dave Findley

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 6/28/18 08:40
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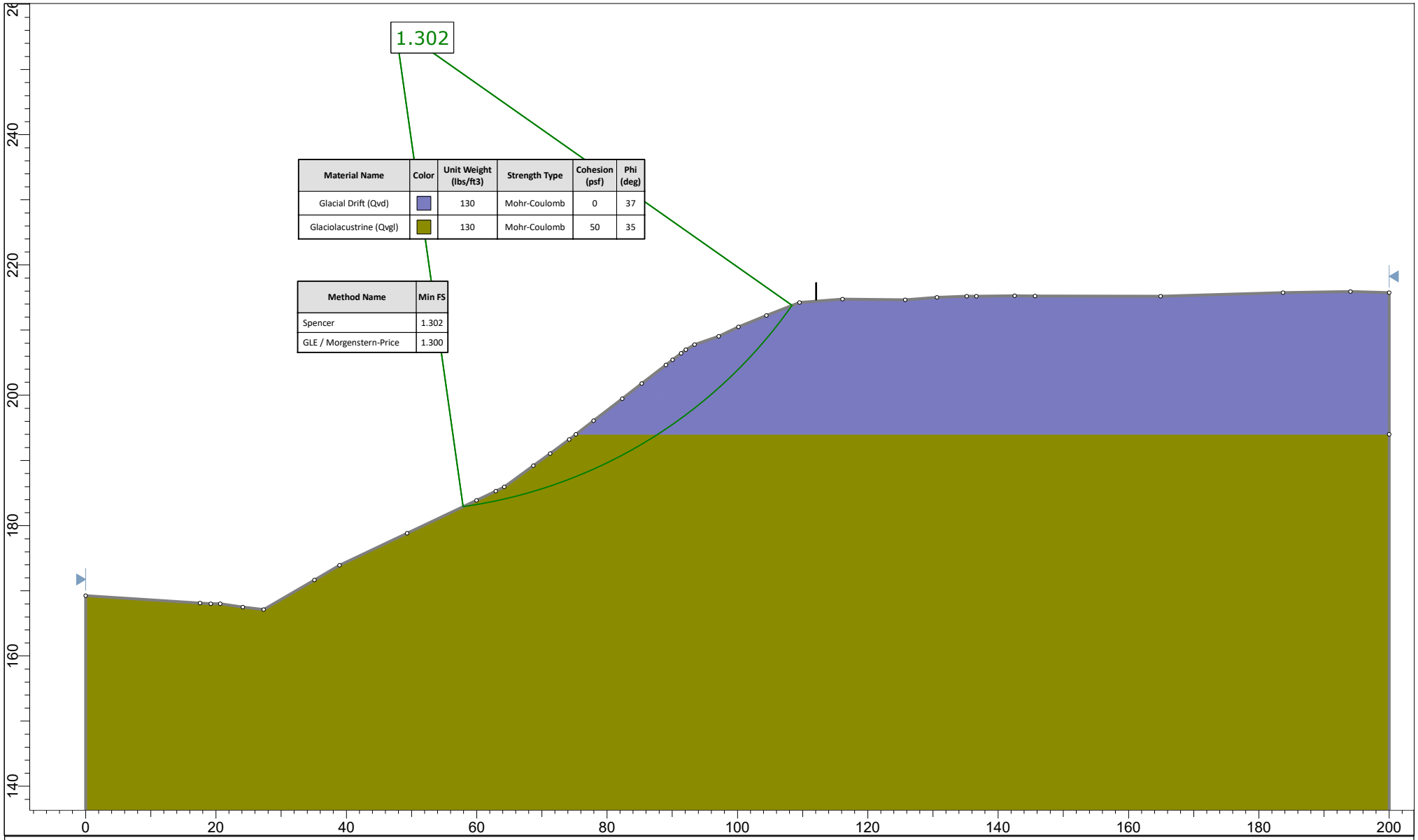


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Glacial Drift (Qvd)		130	Mohr-Coulomb	0	37
Glaciolacustrine (Qvgl)		130	Mohr-Coulomb	50	35

Method Name	Min FS
Spencer	1.302
GLE / Morgenstern-Price	1.300

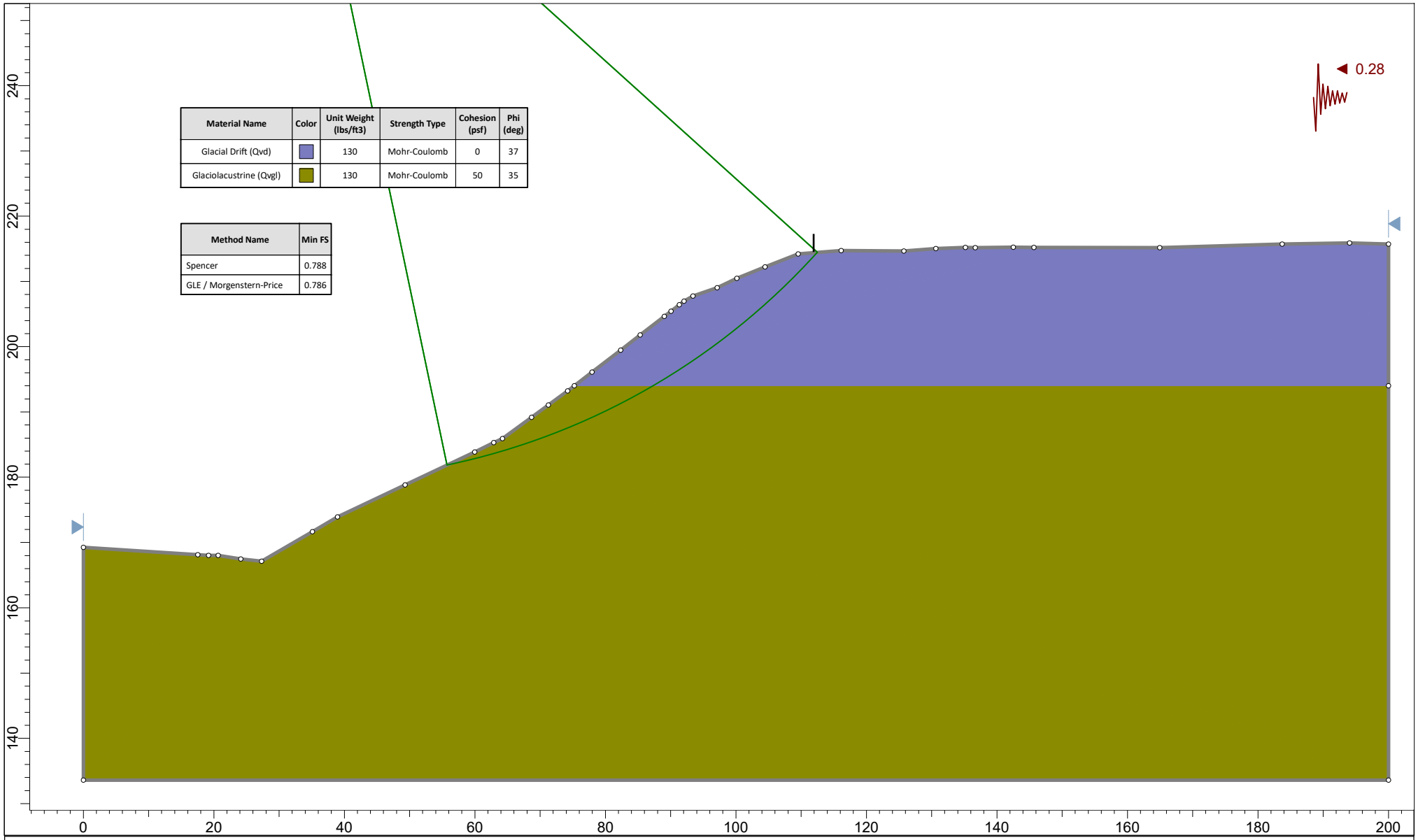
Downtown Redmond Link Extension
Redmond, Washington

Station 5063+50 Existing

19427-03 | Scale 1:247 | 12/19/2019

HARTCROWSER

Figure
1A



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Glacial Drift (Qvd)		130	Mohr-Coulomb	0	37
Glaciolacustrine (Qvgl)		130	Mohr-Coulomb	50	35

Method Name	Min FS
Spencer	0.788
GLE / Morgenstern-Price	0.786

Downtown Redmond Link Extension
Redmond, Washington

Station 5063+50 Existing

19427-03 Scale 1:247 12/19/2019

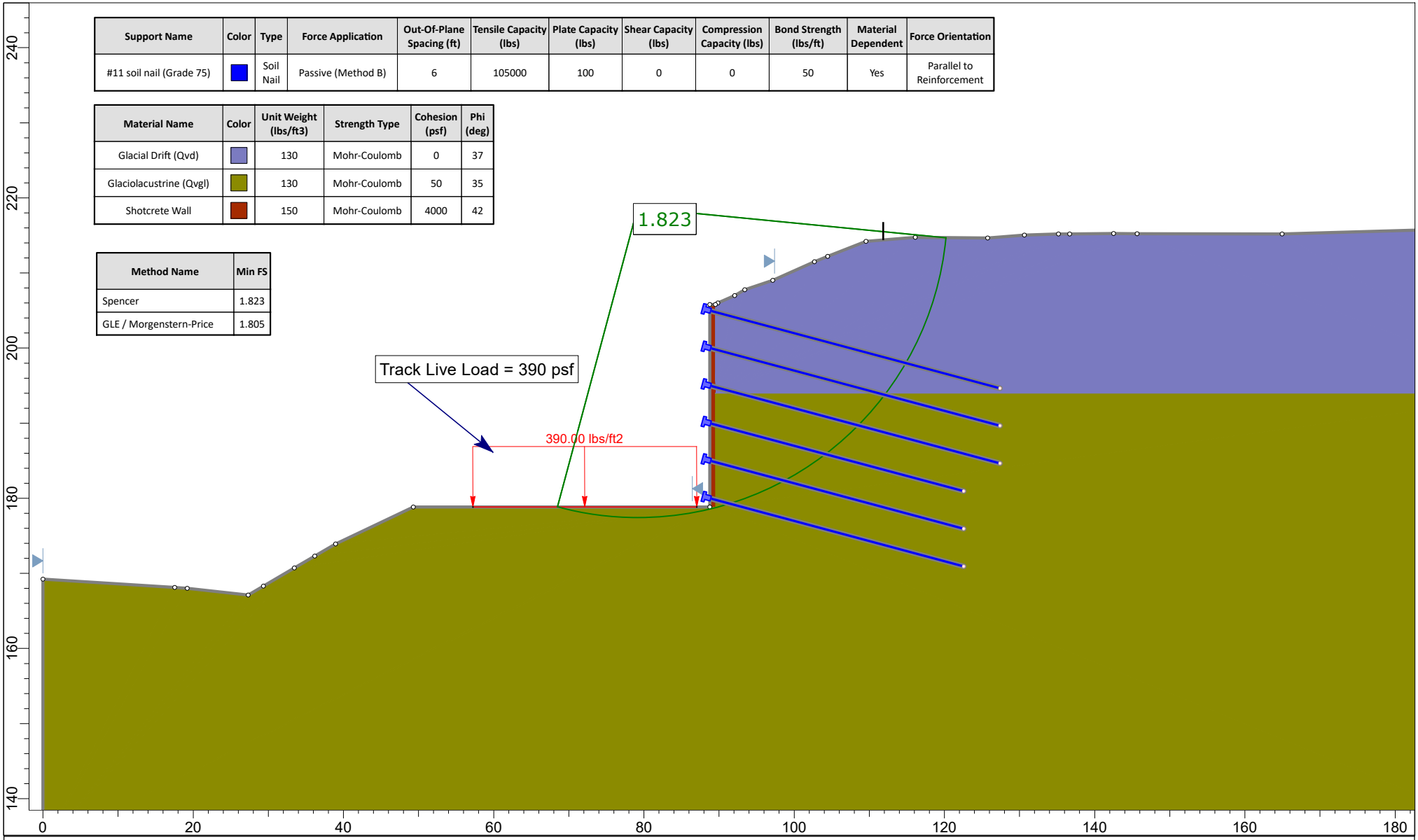
HARTCROWSER

Figure
1B

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Shear Capacity (lbs)	Compression Capacity (lbs)	Bond Strength (lbs/ft)	Material Dependent	Force Orientation
#11 soil nail (Grade 75)		Soil Nail	Passive (Method B)	6	105000	100	0	0	50	Yes	Parallel to Reinforcement

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Glacial Drift (Qvd)		130	Mohr-Coulomb	0	37
Glaciolacustrine (Qvgl)		130	Mohr-Coulomb	50	35
Shotcrete Wall		150	Mohr-Coulomb	4000	42

Method Name	Min FS
Spencer	1.823
GLE / Morgenstern-Price	1.805



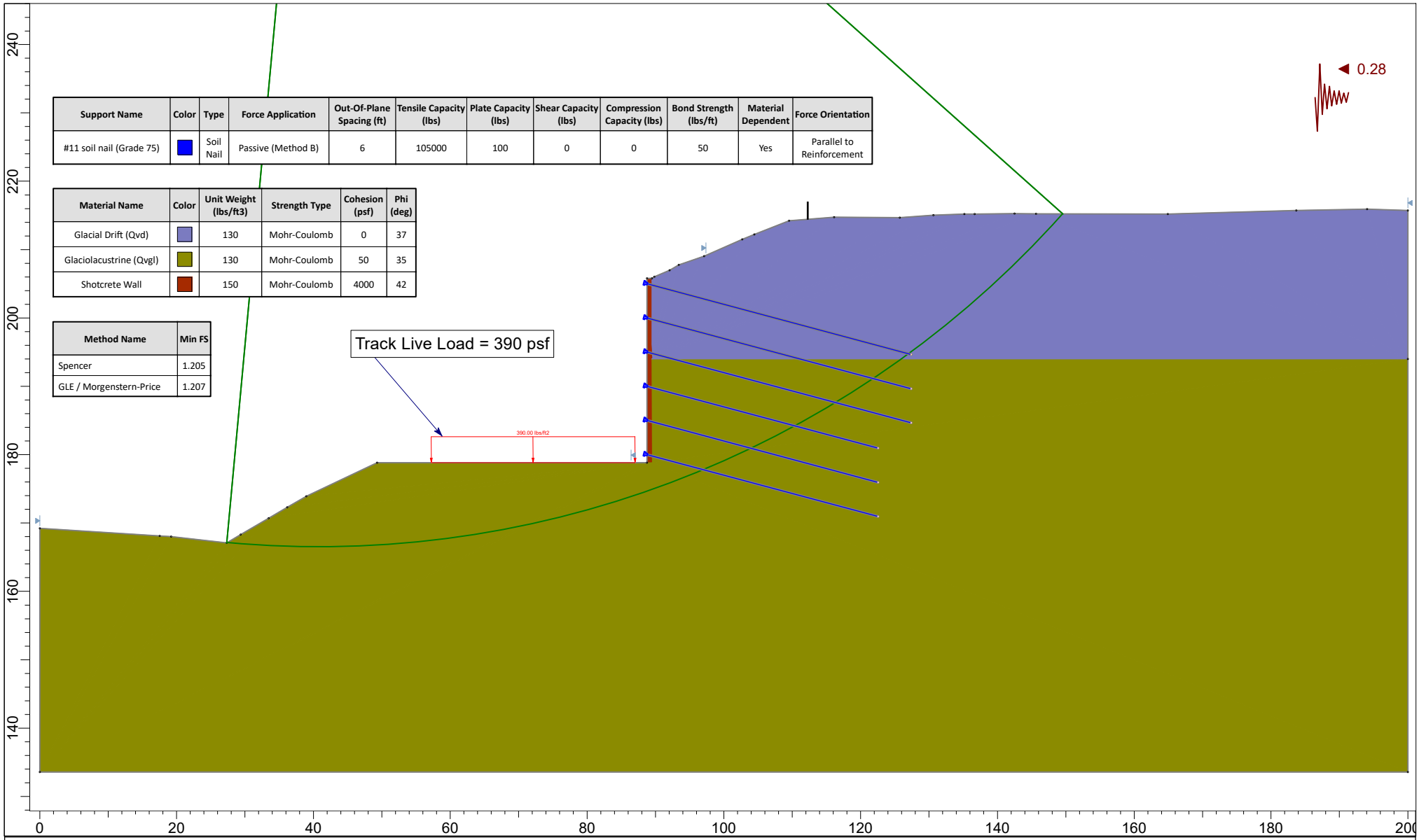
Downtown Redmond Link Extension
Redmond, Washington

Station 5063+50 Final

19427-03 | Scale 1:215 | 12/19/2019

HARTCROWSER

Figure
1C



Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Shear Capacity (lbs)	Compression Capacity (lbs)	Bond Strength (lbs/ft)	Material Dependent	Force Orientation
#11 soil nail (Grade 75)		Soil Nail	Passive (Method B)	6	105000	100	0	0	50	Yes	Parallel to Reinforcement

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Glacial Drift (Qvd)		130	Mohr-Coulomb	0	37
Glaciolacustrine (Qvgl)		130	Mohr-Coulomb	50	35
Shotcrete Wall		150	Mohr-Coulomb	4000	42

Method Name	Min FS
Spencer	1.205
GLE / Morgenstern-Price	1.207

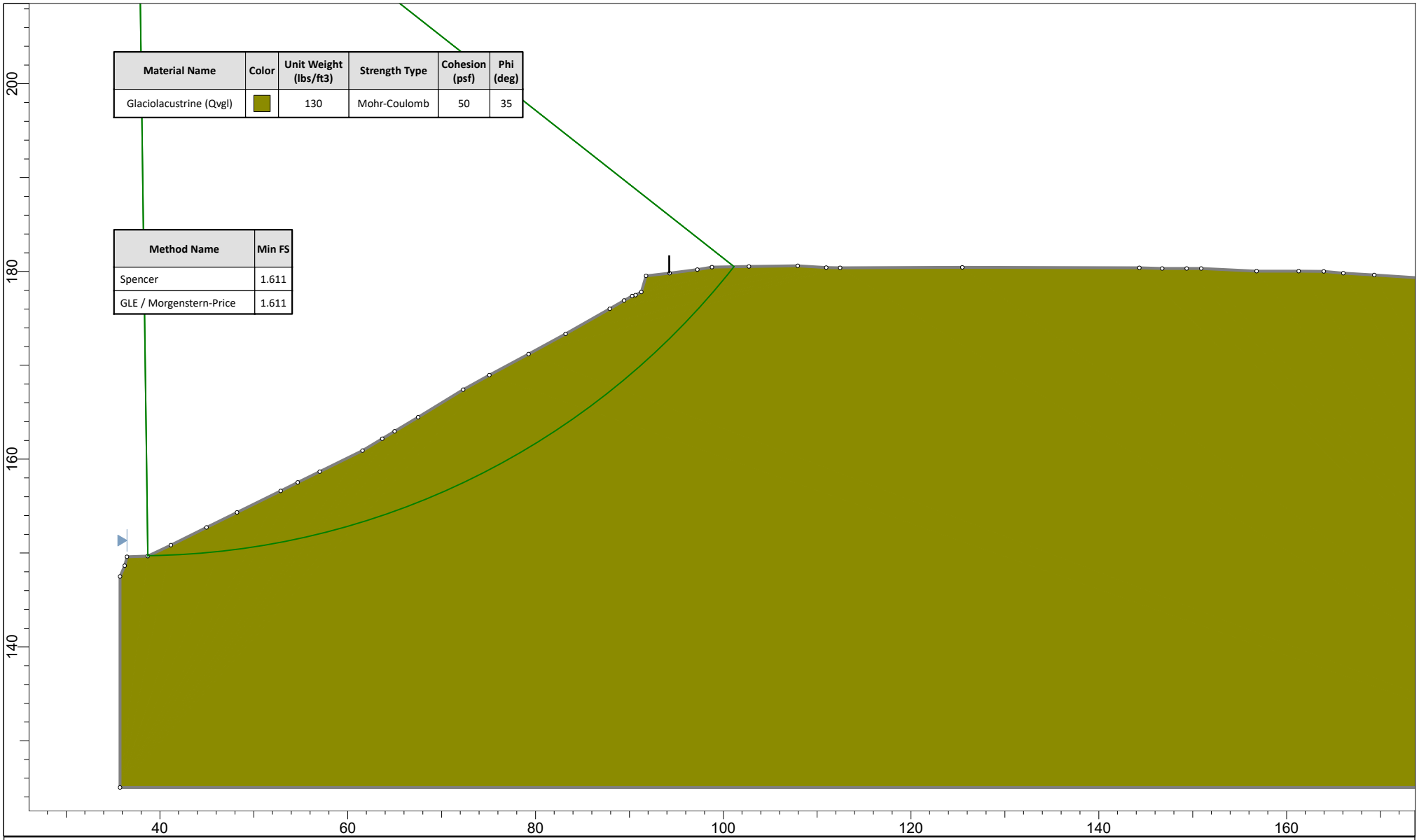
Downtown Redmond Link Extension
Redmond, Washington

Station 5063+50 Final

19427-03 Scale 1:236 12/19/2019

HARTCROWSER

Figure
1D



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Glaciolacustrine (Qvgl)		130	Mohr-Coulomb	50	35

Method Name	Min FS
Spencer	1.611
GLE / Morgenstern-Price	1.611

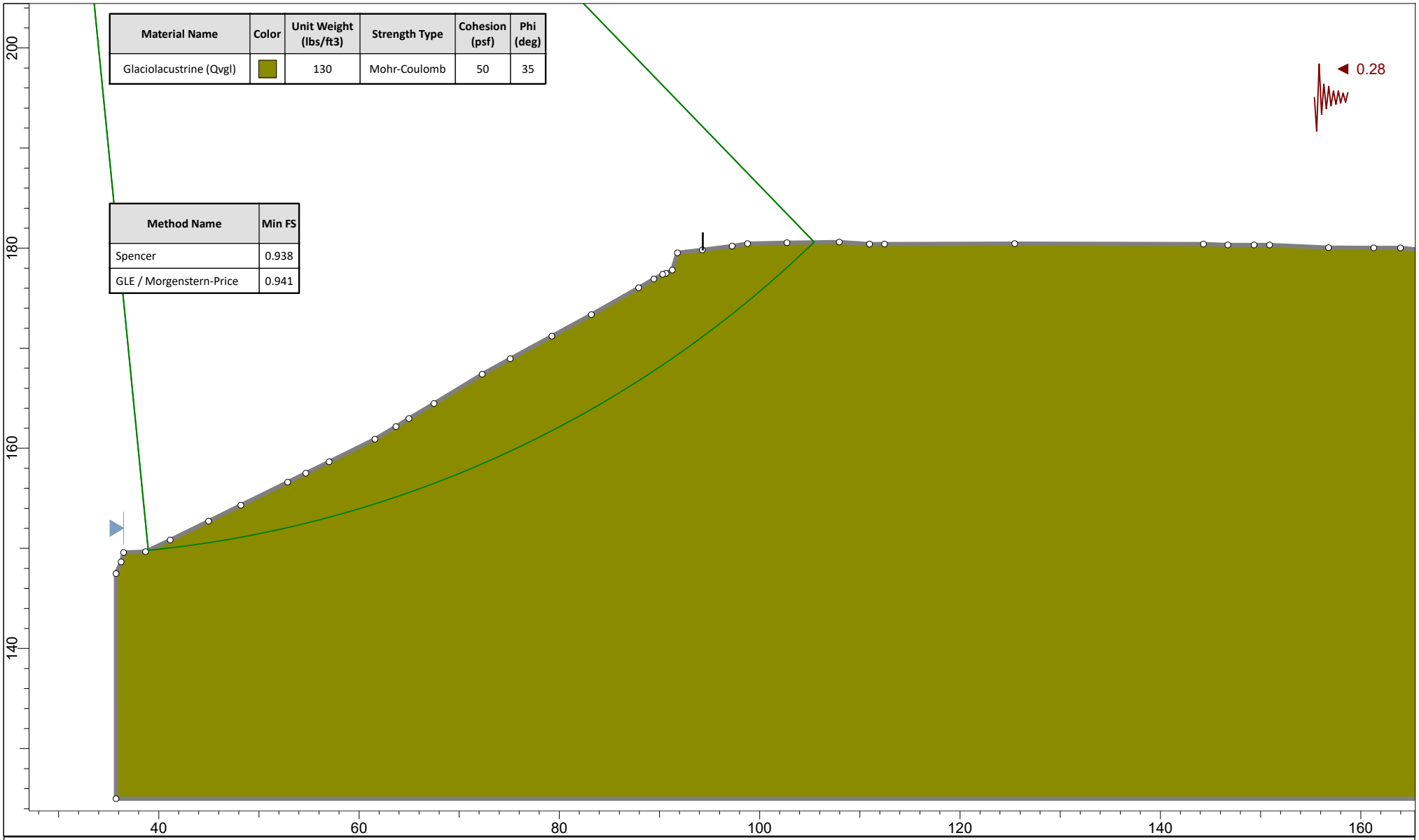
Downtown Redmond Link Extension
Redmond, Washington

Station 5069+00 Existing

19427-03 Scale 1:172 12/19/2019

HARTCROWSER

Figure
1E



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Glaciolacustrine (Qvgl)		130	Mohr-Coulomb	50	35

Method Name	Min FS
Spencer	0.938
GLE / Morgenstern-Price	0.941

Downtown Redmond Link Extension
Redmond, Washington

Station 5069+00 Existing

19427-03 Scale 1:161 12/19/2019

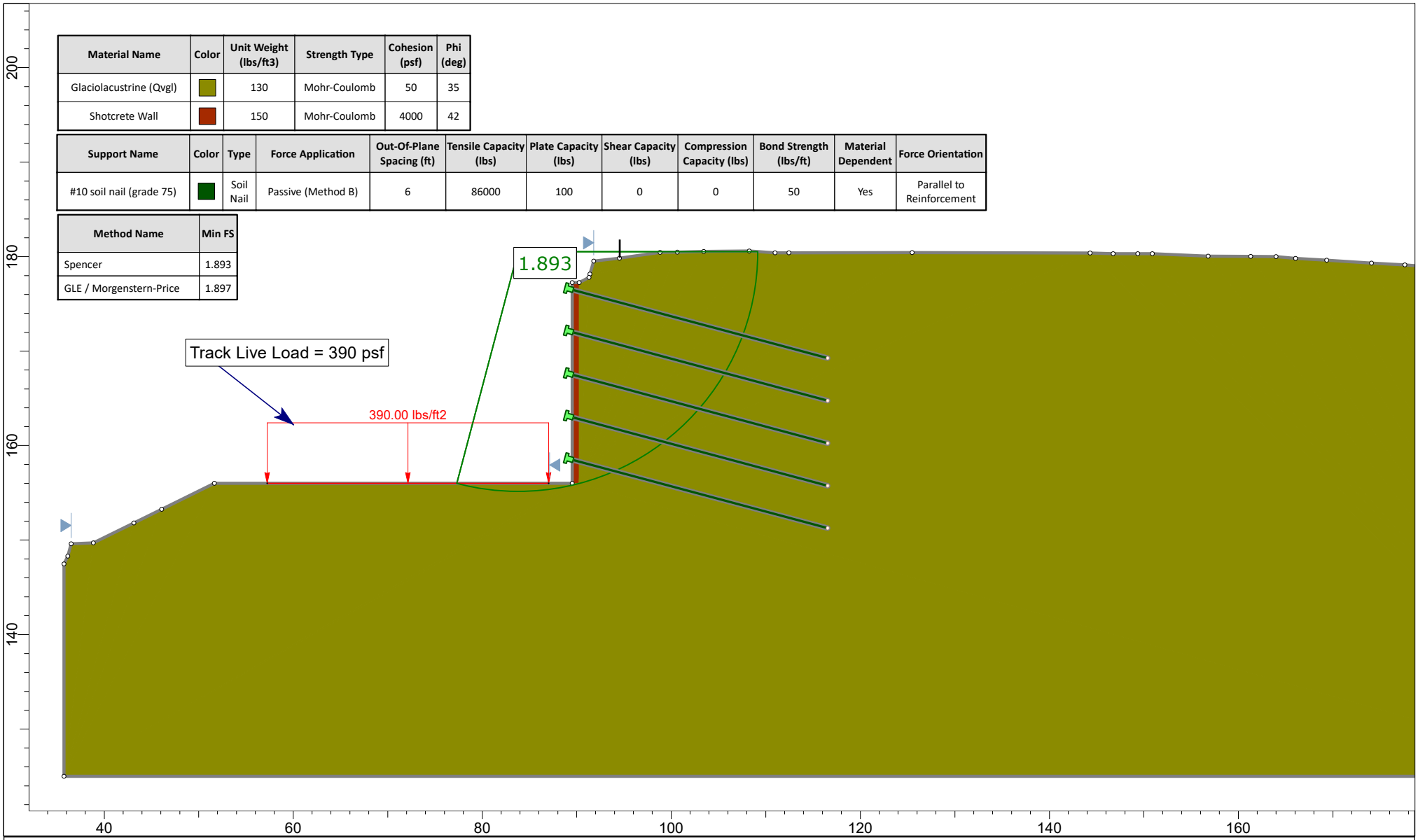
HARTCROWSER

Figure
1F

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Glaciolacustrine (Qvgl)		130	Mohr-Coulomb	50	35
Shotcrete Wall		150	Mohr-Coulomb	4000	42

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Shear Capacity (lbs)	Compression Capacity (lbs)	Bond Strength (lbs/ft)	Material Dependent	Force Orientation
#10 soil nail (grade 75)		Soil Nail	Passive (Method B)	6	86000	100	0	0	50	Yes	Parallel to Reinforcement

Method Name	Min FS
Spencer	1.893
GLE / Morgenstern-Price	1.897



Downtown Redmond Link Extension
Redmond, Washington

Station 5069+00 Final

19427-03 | Scale 1:171 | 12/19/2019

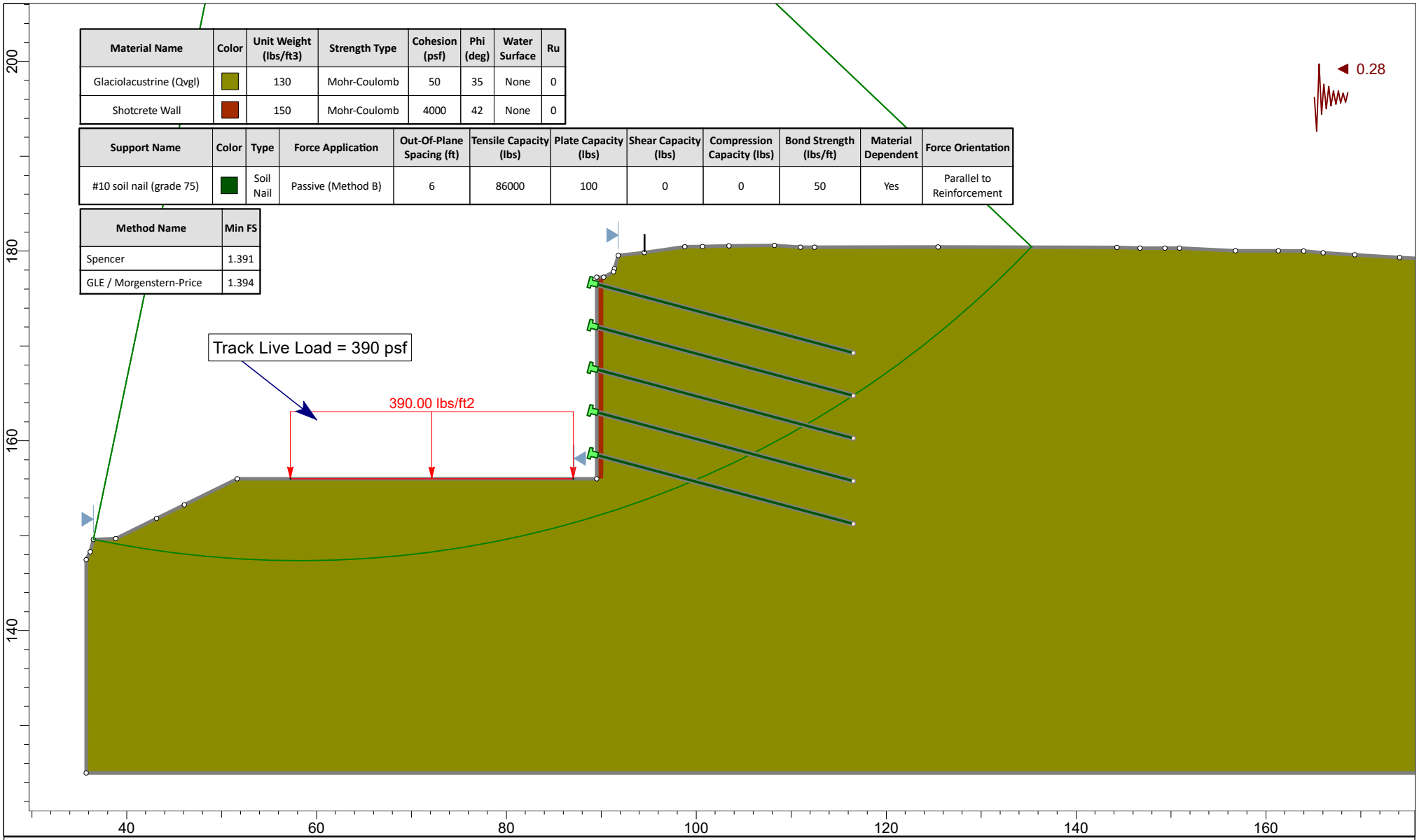
HARTCROWSER

Figure
1G

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Glaciolacustrine (Qvgl)		130	Mohr-Coulomb	50	35	None	0
Shotcrete Wall		150	Mohr-Coulomb	4000	42	None	0

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Shear Capacity (lbs)	Compression Capacity (lbs)	Bond Strength (lbs/ft)	Material Dependent	Force Orientation
#10 soil nail (grade 75)		Soil Nail	Passive (Method B)	6	86000	100	0	0	50	Yes	Parallel to Reinforcement

Method Name	Min FS
Spencer	1.391
GLE / Morgenstern-Price	1.394



Downtown Redmond Link Extension
Redmond, Washington

Station 5069+00 Final

19427-03 | Scale 1:170 | 12/19/2019

HARTCROWSER

Figure
1H

GARRY E. HORVITZ, PE, LEG

Senior Principal Geotechnical Engineer

EDUCATION

MS, Civil (Geotechnical) Engineering, Massachusetts Institute of Technology, 1975

BS, Civil Engineering, State University of New York at Buffalo, 1973

REGISTRATIONS

Professional Engineer, WA, 1981, #19478
HI, 1992, #7705
AK, #AELC-5255

Licensed Engineering Geologist, WA
2002, #2201

Transportation Worker Identification Credential

AFFILIATIONS

American Society of Civil Engineers (ASCE); Coasts, Ocean, Ports, and Rivers Institute (COPRI)

Society of American Military Engineers (SAME)

Garry has 44 years of geotechnical engineering experience including project management and senior-level review for soil and foundation studies and engineering design for hundreds of developments and redevelopments in the Puget Sound area. His expertise includes engineering for landslide stabilization; slope stability evaluations in Environmentally Critical Areas; slope and embankment design; trails, pavement, and roads; and geotechnical engineering design of roadways, utilities, tunnels and elevated structures.

REPRESENTATIVE PROJECT EXPERIENCE

Landslide Evaluation and Mitigation, Issaquah, WA

Garry is Principal in Charge of geotechnical engineering services for evaluation and mitigation/remediation of a 150-foot-high landslide that occurred during interim grading activities. Original pre-landslide design work was performed by other firms; the site owner called on Hart Crowser to evaluate the appropriateness of the proposed solutions and advance the remedial alternatives. Garry's team reviewed the available information, technical analysis, and remedial design plans; conducted a site reconnaissance; discussed likely causes of the failure based on the information developed to date; provided a preliminary evaluation of additional alternatives to be considered; and prepared recommendations for follow on explorations as necessary. Landslide repair alternatives considered subsurface soil and groundwater conditions, loading mechanisms, resistance mechanisms, constructability, and administrative constraints. Garry and his team worked closely with specialty contractors and evaluated a number of landslide repair alternatives. These concepts were considered before selecting the three-tiered slope stabilization system including tie-back anchors, anchor blocks, and drilled shafts analyzed. We discussed these repair concepts with the owner and other design consultants, and the three-tiered system was selected based on our analysis and the discussion.

Helsell Residence Landslide Repair, Greater Seattle (Shoreline), WA

Garry was geotechnical Project Manager for geologic/hydrogeologic assessments and design for repair of a major landslide in the Highlands area of Greater Seattle. The Helsell landslide involved a significant volume of slide debris which ultimately covered a 100-foot span of the BN railroad tracks at an elevation of about 200 feet below the residence. An estimated 10,000 to 15,000 cubic yards of material were involved in the event which involved three separate properties. The escarpment was up to 90 feet high and more than 200 feet long. Garry worked with the design team and owner to assess a wide variety of slope stabilization alternatives, considering not only the technical feasibility, but also constructability issues, relative cost, aesthetics, and logistics. An enhanced

drainage/geosynthetic-reinforced soil slope was selected as the most cost-effective and constructible repair solution to provide stability long-term stability for the residence. Drainage design and surface erosion control were important elements of the repair.

Beach Drive Residence Landslide Repair, Shoreline, WA

Garry was Project Manager for multiple solutions at this residence based on the different site development needs. The work included designing stabilization methods for retention of a high bluff along Puget Sound. In areas where the top of steep slope was close to the new house, Garry designed a structural wall that could be retrofitted with permanent tieback anchors in the event of loss of ground in front of the wall. Based on a thorough review of past slide activity in the area, including aerial photos dating back to 1940, he assessed the rate of loss of the top of bank over time and then developed design parameters for the wall system that were not overly conservative in the assumptions of how much material might be lost in front of the wall over the life of the project. In other areas that were not close to planned structures, he identified the geologic hazard so the owner could plan for future development. In these areas, installation of enhanced subsurface drainage provided the greatest cost benefit to maintain the edge of bluff in its position. The use of structural alternatives was not considered appropriate due to the high cost and low potential for increasing the stability of the bluff.

Bonair Drive SW Slide Stabilization, West Seattle, WA

Garry provided senior-level technical review for fast-track work to stabilize portions of Bonair Drive SW which was experiencing accelerated movement, slipping approximately 1 to 3.5 feet downward, leaving an exposed scarp along 125 feet of Bonair Drive. At the same time, near-surface landsliding or mud flows occurred farther down the slope, causing damage to homes along Alki Avenue. The project included a site reconnaissance and deep borings in the slide area to assess soil and groundwater conditions. A key element was the identification of groundwater seepage zones about half-way down the slope face and saturated sands above hard silts. The project team worked with the contractor to design a trench drainage system to extend through the sand and into the underlying silt, thereby intercepting groundwater that was tending to flow along the top of the hard silt and daylighting about halfway down the slope face, causing the instability. In order to improve the stability for a longer segment of Bonair Drive, the trench drain was extended several hundred feet, toward the northeast. Even during construction, a significant amount of water was being picked up by the drainage system. To handle discharge of the water (another significant challenge), the design used an existing manhole, a new tightline on the face of a steep slope, and a new manhole installed at a critical location on the slope that was connected to the system using directional drilling.

Diablo Lake Barge Facility, North Cascades National Park, WA

A rock slope failed, sending 16,000 cubic yards of rock and soil debris onto barge landing facilities and a road. As Project Manager for geotechnical services, Garry helped Seattle City Light evaluate options for constructing a new barge landing facility and road. Tasks include seismic design, evaluation of slope stability, evaluation of constraints on earth moving operations, assessment of alternatives for foundation design and construction including shallow foundations, structural slabs use of micropiles and/or driven piles, gravity systems, and tieback anchors.

WPYR Cruise Ship Dock Rockfall Hazard Evaluation, White Pass-Yukon Route Railroad, Skagway, AK,
Principal-in-charge providing engineering geology review and analysis related to a rockslide and rockfall hazard evaluation for a busy cruise ship terminal in Skagway, Alaska. Work included developing a remote site safety plan and use of a rock slope climbing crew and rope rappelling geologists to assess rock/site conditions. Geologic site reconnaissance data was collected along distinct traverse lines and analyzed to evaluate rockslide/rockfall stability and risk management options. A complete photographic record and LIDAR evaluation of site conditions was used, along with computer software analysis, to evaluate rockslide stability and historical rockfall occurrence, magnitude, and delivery mechanism. A rockslide/rockfall hazard evaluation report was provided, including a comprehensive slope risk assessment and recommended mitigation/monitoring options. Garry helped develop and implement a long-term instrumentation monitoring program to provide instantaneous rockslide movement data and trigger level alerts if significant movement should occur. Extensometers and inclinometer live internet data is provided via a remote site cellular transmission network. Site evaluation methods also include developing digital elevation model (DEM) for the site using unmanned aerial vehicle (UAV) photogrammetric and LiDAR based methods, and review of potential past site movement using historical InSAR satellite data.