HWA GEOSCIENCES INC.
Geotechnical & Pavement Engineering • Hydrogeology • Geoenvironmental • Inspection & Testing

July 25, 2018
HWA Project No. 2014-177-21

ESA
5309 Shilshole Avenue NW, Suite 200
Seattle, Washington 98107

Attention: Ms. Lisa Adolfson

Subject: **DRAFT GEOTECHNICAL ENGINEERING REPORT**
Cheasty Greenspace Mountain Bike Trail
City of Seattle Parks and Recreation
Seattle, Washington

Dear Lisa,

In accordance with your request, HWA GeoSciences Inc. (HWA) has completed a geotechnical engineering investigation for the proposed Cheasty Greenspace Mountain Bike Trail in Seattle, Washington. The purpose of our investigation was to evaluate the general geologic conditions and provide geotechnical recommendations for design and construction of the proposed trail facilities. Our work included geologic field reconnaissance; review of available geologic literature and geotechnical reports, aerial photos, Lidar imagery, and topographic maps; completion of shallow subsurface explorations; geotechnical engineering analyses; and preparation of this letter report. Deep borings, wells, and inclinometers were not included in the scope of work, as the trails and the loads imposed by users are insignificant such that that level of investigation is not merited. Deep borings were not considered necessary to understand slope stratigraphy, as the available existing geotechnical information in the vicinity largely confirms the geologic conditions shown on the geologic map of the site.

PROJECT UNDERSTANDING

The Seattle Department of Parks and Recreation is implementing a pilot program that will construct two soft surface mountain bike trails within the existing Cheasty Greenspace. The Cheasty Greenspace currently consists of 28.5 acres of wooded slopes and multiple wetlands on the east side of Beacon Hill (see Vicinity Map, Figure 1). The approximate alignments of the proposed trails are indicated on the Site and Exploration Plans, Figures 2A and 2B. We understand that the proposed trail alignments will consist primarily of two loops, with connector trails to streets and walkways. The proposed trail alignments avoid wetland areas as well as areas of known shallow slope instability north of the Parks maintenance yard.
The alignments have been changed from those evaluated in our preliminary geotechnical report (HWA, 2015).

GENERAL GEOLOGIC CONDITIONS

The Geologic Map of Seattle indicates the Cheasty Greenspace is underlain by the typical glacial sequence of the Vashon Stade of the Fraser Glaciation (Troost et al, 2005). During the Vashon Stade, from approximately 20,000 to 13,000 years ago, the Puget lobe of the Cordilleran continental ice sheet advanced south from western British Columbia, filling the Puget Sound lowland. The maximum thickness of ice at the latitude of Seattle was approximately 3,000 feet. During advance of the ice, the sedimentary environment of lakes distant from the ice front transitioned from non-glacial to glacial. The local glaciolacustrine deposits are known as the Lawton clay. As the ice approached, glacial flour (silt and clay) was deposited in areas of slack water. Next, advance outwash consisting mostly of clean sand with pebbles was deposited in broad fans by meltwater emanating from the glacier. As the advancing glacier overrode the advance outwash, a layer of lodgment till was deposited at the base of the ice. The till consists of an unsorted, non-stratified mixture of clay, silt, sand, gravel, and cobbles/boulders. Due to the weight of the ice, the underlying deposits (lodgment till, advance outwash, Lawton clay, and older non-glacial terrestrial deposits) were over-consolidated to a very dense or hard condition. During retreat of the glacier, meltwater deposited sand and gravel in streams, or fine-grained soils in slackwater, depending the on flow velocity. These recessional outwash and recessional lacustrine deposits were not run over by the glacier and are therefore normally consolidated.

Post-glacial geomorphic processes have included mass-wasting of steep slopes, alluvial reworking of sediments, and formation of wetlands in poorly drained areas.

The geologic map indicates the steep hillslopes of the site and vicinity have a core consisting of Lawton clay at the base (including approximately the lower half of the greenspace), with advance outwash above, and capped by till at the very top of the slope. Recessional outwash is mapped in the valley east of the greenspace, with New Rainier Vista largely built upon these deposits. Also, recessional lacustrine deposits are mapped below the north end of the greenspace. Mass wasting deposits were mapped across the entire slope from the southern end of the greenspace to the Parks maintenance yard, and landslide deposits were mapped from that area northward to beyond the north end of the greenspace, including the neighborhood between the Jackson Park golf course and Cheasty Blvd. These deposits consist of colluvium, landslide deposits, and alluvium from small hillside streams.

GEOLOGICALLY HAZARDOUS AREAS

The greenspace has numerous environmentally critical areas, as defined by Seattle Municipal Code 25.09.012. These are shown on the Site and Exploration Plans, Figures 2A and 2B. Potential landslide areas and steep slope areas have been mapped by the City, as documented on the City Department of Construction and Inspections (DCI) GIS web site (Seattle DCI, 2018). Geologically hazardous areas on the site are described below. Wetlands are present in the large drainage swale dividing the site, and a smaller drainage that results from ground water seepage emanating from the slope (at handholes HH-5 and HH-6). Four smaller wetlands are present at scattered locations toward the toe of the overall slope, as shown on Figures 2A and 2B. Specifics associated with wetland critical areas are discussed in other reports.

Steep Slope Hazard Areas

As defined by Seattle DCI, "A 'steep slope' is a slope with an incline of 40 percent or more (10 feet of vertical rise over a horizontal distance of 25 feet or less) with a height of at least 10 feet." Slopes meeting these criteria were mapped by the City using topographic maps (prior to our 2015 study) and Lidar (Seattle 2016 version) along many portions of the site; see the yellow hatching based on the City's 2016 mapping on Figures 2A and 2B. Numerous additions were made to the steep slope hazard areas by the City relative to the prior mapping. The largest concentration of steep slopes is along the northern slope below the City's materials yard and above the main stream. Steep slope areas also qualify as erosion hazard areas. Based on our geotechnical reconnaissance of the proposed trail alignments, only those additional areas which are at existing fill and cut slopes are of concern for trail construction, based on our slope reconnaissance in 2018. These existing fill and cut slopes are discussed in detail in following sections. We recommend that the trail be aligned and constructed to largely avoid steep slope areas, and existing fill and cut slopes as discussed later in this report. The trail alignments as shown in Figures 2A and 2B incorporate our recommendations.

Landslide Hazard Areas

A large portion of the northern half of the site is mapped as a potential slide area as indicated on Figures 2A and 2B, per the DCI critical areas GIS map (Seattle, 2018). The City delineation of the potential landslide area is per the recommendation of the Seattle Landslide Study, Figure D-2 (Shannon & Wilson, 2000 and 2003). Potential slide areas are defined as areas with documented historical landslides; *"areas that have shown significant movement during the last 10,000 years or are underlain by mass wastage debris deposited during this period"; areas described as potential landslide areas in the Seattle Landslide Study (Shannon & Wilson 2000 and 2003); steep slope areas as defined above; or physical or topographic indications of past sliding or "areas with geologic conditions that can promote earth movement."* The contact of granular advance outwash above Lawton clay is one such geologic condition in which ground water seepage at the contact contributes to the likelihood of landsliding. This contact runs through the site and has apparently contributed to slope instability since the last glaciation.

Documented landslides in the greenspace and vicinity are summarized below. Only the New Rainier Vista Slide, which occurred in 2003, is located in close proximity of the proposed trail alignment. The other observed slide areas are located a significant distance from the proposed trail and will not affect the trail, nor will the trail affect the slope stability at those locations. Each of the documented landslides is discussed below.

New Rainer Vista Slide: A known slide area is mapped at the location of a soldier pile and lagging wall with tiebacks on the western edge of the New Rainier Vista housing development (see Figures 2A an 2B). Slide movement was observed starting in September 2003, as documented by Earth Consultants (2004a). A construction drawing for the slide repair (Earth Consultants, 2004b) indicated the presence of several low-relief slide scarps upslope from the proposed wall. The headscarp was mapped ranging from approximately one-third to one-half of the distance from Cheasty Boulevard toward the wall. Boreholes subsequently conducted for design of the wall (Earth Consultants, 2004c) typically encountered surficial loose silty sand over medium stiff to very stiff clays and silts to the full depths explored (up to 55 feet). Some borings encountered water-bearing silty sand layers within or below the clay or silt. Inclinometers were installed in four of the boreholes and monitored prior to wall construction. These instruments indicated slow lateral ground movement that was pronounced in the upper 10 feet at three of the inclinometers. Subtle movement starting above the bottom at 45 to 55 feet to about 10 feet (or the surface) was detected over time as well. The soldier pile and lagging wall was installed to stabilize this landslide. Our observations of this slide area are described in the Site Reconnaissance section. The slide appeared to be stable, as indicated by the degradation of scarps and lack of fresh soil exposures or wall deformation. We do not anticipate future movement of the slide mass due to the presence of the soldier pile and lagging wall. Per our recommendation, the section of proposed trail in this area has been shifted up slope such that the trail alignment stays out of the existing wall's zone of influence. The wall's zone of influence is defined as a 2H:1V line up from the toe of the wall intersects the ground surface. Additionally, we recommend that stormwater generated within the identified slide area be collected and tight lined to a suitable outlet. With the trail alignment out of the wall's zone of influence and assuming stormwater is collected properly through this area, no effect on slope stability is expected to be caused by the trail in this area.

1980s Cheasty Blvd Slide: A slide located near the north end of the greenspace has been documented and shown on the Seattle Department of Construction and Inspection (DCI) critical areas interactive map (City of Seattle, 2018; Shannon & Wilson, 2000 and 2003). This slide occurred in the 1980s, on the slope above Cheasty Blvd, below houses on 25th Ave S. This appears to have occurred in the road cut made for Cheasty Blvd. The slide was evidently a shallow slide rather than a deep-seated rotational slide. No evidence of recent sliding was observed in this area, nor any evidence of rotational failure anywhere along the Cheasty Blvd roadway. This slide area is located a significant distance from the proposed trail alignment and is not expected to be affected by the trail.

Andover Street Slide: A slide was noted as occurring in the 1940s, adjacent to Andover Street at the north end of the greenspace. Another slide occurred in 2014 apparently in this vicinity, as recorded by Stantec (2014). They noted in their Preliminary Geotechnical Evaluation for this project that a slide occurred on a property being redeveloped near S. Andover Street and Martin Luther King Jr. Blvd. They observed that temporary excavations had been made in landslide debris, and left open for a long time. After sliding, the slope was mitigated with a buttress of large quarry rock. Our review of dated aerial photos on Google Earth indicates that the subject redevelopment took place at S. Andover Street and 27th Ave S., and in 2014 the buttress ran south to north upslope of a completed townhouse building at the southwest corner of the lot. The 2015 aerial photo shows a soldier pile wall under construction extending northward from the rock buttress, and later aerial photos show two more townhouse buildings completed below the soldier pile wall. This slide area is located a significant distance from the proposed trail alignment and is not expected to be affected by the construction and operation of the trail.

Seismic Hazards

Seismic hazard areas are defined by the Seattle Municipal Code as lands subject to severe risk of earthquake damage as a result of seismically induced ground shaking, slope failures, settlement or soil liquefaction. The project site is within the Seattle Fault Zone. However, it is located outside of the area of presently known surface rupture which occurred approximately 1,100 years ago. Therefore, we expect the probability of surface rupture at the site to be low.

Liquefaction is a temporary loss of soil shear strength due to earthquake shaking. Loose, saturated cohesionless soils are highly susceptible to earthquake-induced liquefaction; however, recent experience and research has shown that certain silts and low-plasticity clays are also susceptible. Primary factors controlling the development of liquefaction include the intensity and duration of strong ground motions, the characteristics of subsurface soils, in-situ stress conditions and the depth to ground water. The uppermost soils typically consist of seasonally saturated sandy colluvial soils that have a moderate potential of liquefaction during the design earthquake, which could result in localized slope failures. The proposed trails will not affect the onset of liquefaction or the seismic response of the slopes.

EXISTING GEOTECHNICAL INFORMATION

We reviewed existing geotechnical information from the site vicinity, as found in City DCI records. Subsurface conditions as encountered in boreholes and test pits documented in geotechnical reports appeared to be in general agreement with the geologic map. Locations of the existing geotechnical subsurface explorations were determined from site plans included in the geotechnical reports, and are shown on the Site and Exploration Plans, Figures 2A and 2B.

Stantec Consulting Services, Inc. performed a limited preliminary geotechnical investigation of the greenspace (Stantec, 2014). Stantec's investigation was limited to an online and paper study of the geotechnical aspects of building a trail within the greenspace.

Geotechnical reports for projects in locations adjacent to or near the Cheasty Greenspace include several for projects in the valley at and beyond the toe of the overall slope. These reports include borings for Sound Transit's Link Light Rail along Martin Luther King Jr. Way S. (Golder, 2001). Test pits and borings were conducted for the Rainier Vista Redevelopment, as well as for repair of the New Rainier Vista Slide (Earth Consultants, 2000, 2004c).

Other geotechnical investigations had been conducted west of the north end of the greenspace for residential projects, and included borings (Hart Crowser, 1986 and LSI ADAPT, 2001). Test pits were conducted for a residence farther north along 25th Ave S., beyond the area shown on Figures 2A and 2B (Hemphill, 2000).

At the top of the slope, borings were conducted for a Parks maintenance building at the site of the present maintenance yard, which was never built (Seattle Engineering Department, 1973).

Logs of all of the relevant geotechnical explorations associated with each of these reports are included in Appendix C of this report.

GENERAL SITE SURFACE CONDITIONS

Based on available topographic mapping with 5-foot contours (King County iMap) and confirmed with project site surveying, the slope below Cheasty Blvd, dropping down to the east, ranges from approximately 60 feet high at the north end, increasing to 100 feet in the southern portions. The terrain as observed on Lidar imagery shows drainage swales and ridges, and the ground surface is gently hummocky. This imagery reveals the entire slope to be a prehistoric landslide complex, based on the hummocky topography and an apparent compound headscarp forming the hillcrest above Cheasty Boulevard. Steep slope crests indicative of sidecast fill are obvious along Cheasty Blvd, the Parks maintenance yard, and the upper slope below Cheasty Blvd southwest of the yard. The fill character of these steep slopes was confirmed by site observations and handhole explorations. Aerial photos confirm the predominance of Bigleaf Maple trees as observed on site and their similar range of size, and therefore age, indicating forest disturbance of similar age (such as logging, forest fire, or landsliding). An aerial photo from 1936 (as seen on iMap) shows small deciduous trees and brush with some open areas in the greenspace property and adjacent undeveloped properties, indicating disturbance to the forest in the recent past, most likely from logging of the old growth forest.

SITE RECONNAISSANCE

An HWA engineering geologist and a geotechnical engineer evaluated site and surficial soil conditions on January 12, 2015 by performing a geologic reconnaissance of the site on foot along the general alignment of the previously proposed mountain bike trail. The site was traversed clockwise starting at the top of the slope just south of the existing Parks materials yard on Cheasty Blvd. An additional reconnaissance of the proposed trail system was conducted by HWA geologists on April 27, 2018. Trail staking established by the design team surveyors was followed throughout the site.

Slope geomorphology, vegetation patterns, tree growth, and surficial soils were observed during the traverses for signs of slope instability. At intervals the ground surface was probed with a ½-inch diameter, 3-foot or 6-foot long T-handled steel rod to observe density or cohesiveness of surficial soils. General observations and locations of note are discussed below.

The site is mostly wooded, with the vast majority of trees consisting of bigleaf maple from approximately 8 to 24 inches in diameter and 30 to 70 feet high. Cottonwood trees were observed in the southern end of the site on a gentle slope above Columbian Way. Alders, small cedars and Douglas firs were observed as lone trees in various places. Large portions of the wooded area consisted of all bigleaf maple with understory. Understory brush and ground vegetation mainly consisted of sword fern in most areas, with salal, Indian plum, and Oregon grape in various areas. Invasive English ivy was observed in portions of the site, with many areas cleared of ivy and native vegetation replanted. Invasive blackberry canes were observed, mainly along the lower slopes from the northern riparian zone, northward to the slide zone behind the soldier pile wall. Blackberries were observed in scattered places elsewhere, but not as brambles. Salmonberry was observed in the riparian zones and in other low places. The presence of salmonberry is indicative of high soil moisture content through the year.

The steepest observed slopes were inclined at approximately 1H:1V to 2½H:1V (Horizontal:Vertical) along heights of 15 to 25 feet, where fill was pushed out from the top of the slope at the City’s materials yard and lawn areas to the south of the yard. The slopes mapped by the City as exceeding 40 percent (2½H:1V) included some of the fill slopes, as well as areas downslope to the north and east of the materials yard, a section along Cheasty Blvd, and isolated areas elsewhere. Otherwise the slopes were variable in inclination over distances of tens of feet, generally between 3H:1V and 10H:1V.

Surficial soils as observed and probed predominantly consisted of loose grading to medium dense, brown, silty, gravelly sand. Silt and clay soils were observed in the lower slope, particularly north of the large ravine to the north end of the site, which includes the slide area retained by the soldier pile wall. A portion of the fill east of the maintenance yard consisted of clay as well. Rubble consisting of concrete, asphalt paving, and crushed rock were present on and within the granular fill slope to the southeast of the maintenance yard.

Probing depths ranged from 0.5 to 3 feet in the portion of the site south of the yard, 1 to 3.5 feet on slopes elsewhere, and 2 to 3 feet in wetland riparian areas. The soil at the surface in most slope areas (where not consisting of fill) was not a rich topsoil, nor was much duff accumulated. This lack of organic accumulation and topsoil formation is indicative of persistent erosion or slope instability, which may date to logging before the 1930s. The portion of critical (over 40%) slopes just north of the proposed southern loop had surficial soil consisting of gray, plastic silt or clay, as did the plateau at the toe of the fill slope. This material appears to be fill that was spread over the plateau and its edges, spilling downslope to the north and east. Fill slopes in this area were at approximately the angle of repose for granular soils (36 degrees) and higher for cohesive soils (averaging 40 degrees). The fill slopes below the maintenance yard are up to approximately 25 feet high. Signs of surficial creep and sloughing were observed in this area, where there was granular fill apparently sidecast over the slope; handhole HH-8 was advanced at this location.

Soils in the riparian zones consisted of soft or loose, dark brown, organic, silty sand that was saturated from ground water seepage and runoff.

Three areas of recent slope instability were observed during the reconnaissance:

1) **Along the fill slope around the Parks materials yard:** The fill historically spread over the crest of the slope showed signs of sloughing or surficial sliding during the winter of 2014-2015 near the easternmost point. Fresh soil exposures near the top and deposits of sloughed and eroded granular soils down the 15- to 25-foot high slope were evident during our 2015 reconnaissance. In 2018 handhole HH-8 was advanced through this surficial granular fill into underlying clay fill. It is likely that surface runoff and perched seasonal ground water contribute to periodic sloughing in wetter than normal conditions. As the granular fill is at the angle of repose (as noted above), the soil readily sloughs underfoot and has only scattered vegetation. We anticipate that future sloughing will occur within the fill soils, particularly those that are granular. We do not anticipate deep-seated sliding to occur. Per our recommendation the proposed trail has been routed away from these steep slopes.

2) **Above the existing soldier pile wall just west of Dakota St and 24th Ave S. (New Rainier Vista Slide Area):** This curving wall retains the toe of the forested slope within Rainier Vista common space, above a playground and the P-patch. The wall ranges from approximately 6 to 10 feet high and is approximately 300 feet long, with tiebacks along the eastern portion, as well as multiple clean outs in front of the wall, for drainage piping that extends behind the northern portion of the wall to the greenspace property line as shown on construction plans (ECI, 2004b). Two irregular slide scarps were observed in 2015 at approximately 100 and 150 feet upslope from the wall. The scarps were on the order of 1 to 2 feet high and did not appear recent, being sloughed and moss-covered. Horizontal separation appeared to be less than 1½ feet at each scarp. The age of the scarps, based on weathering and vegetation, appeared to fit within the timeline of 2003 sliding, prior to construction of the soldier pile wall (ECI, 2004b). There were fewer and smaller trees in this area, likely due to past instability. However, the trees were not tipped upslope as would occur from deep, rotational sliding, such that in our opinion the most recent slide activity, before the wall was constructed, was relatively shallow and translational. These scarps were not apparent during our 2018 reconnaissance of the currently proposed trail. We do not anticipate future translational sliding in this area due to retention by the soldier pile wall. Recommendations for trail and stormwater modifications in this area are provided below.

3) **The head end of the western riparian area, below hand hole HH-5:** Ground water seepage was observed emanating in a bowl-shaped headwater area extending approximately 40 to 50 feet across. The bowl was gently sloping at the top, and increasing in slope as it transitions to a stream valley. Along the upper edge of the bowl, the slope was over-steepened to approximately 1H:1V to 1½H:1V over a height of 3 to 6 feet, with shallower slopes above. The localized over-steepening of this slope is due to sloughing induced by ground water seepage. The slope incrementally retreats headward over time. This slope was vegetated and in 2015 did not show recent signs of sloughing.

> Probing in the bowl extended only up to 3 feet, in soft, dark brown, organic sandy silt that was saturated. The probe terminated abruptly in dense gravelly sand. Future episodic headward retreat is expected. The currently proposed trails avoid this area. Soil creep appears to be the most prevalent means of current downslope soil movement across this area of the site. Based on the mostly upright nature of the trees on site, slope creep appears to have affected trees primarily early in life, after the site was exposed to runoff and erosion associated with historic logging, burning, and/or landsliding. We expect continued soil creep at this location. As the proposed trail alignment has been shifted away from this area, construction and operation of the trail will not affect future anticipated soil creep.

SUBSURFACE EXPLORATIONS

Manual equipment was used to advance subsurface explorations in two phases – first in 2015 along the previously proposed general trail alignment, and in 2018 along the presently proposed trail system. The 2015 handholes were advanced at areas of proposed wetland crossings and steep slope traverses. Due to the potential critical area impacts, it was decided by Parks to eliminate these areas from the current trail proposal. On January 15, 2015, HWA representatives visited the site and performed a subsurface investigation consisting of six hand borings, designated handholes HH-1 through HH-6. The hand borings were advanced to depths ranging from 2 to 5.75 feet below ground surface (bgs) with a post-hole digger and bucket auger. Dynamic Cone Penetration (DCP) tests were completed at four hand boring locations, to explore the relative density of near-surface soils.

The second phase of explorations was conducted on May 16 and 17, 2018. These handholes, designated HH-7 through HH-13, were advanced until met with gravel refusal at depths ranging from 3.8 to 9.5 feet. DCP tests were completed at each of these handholes except HH-8, in which coarse gravel and rubble precluded its advancement in the upper few feet.

Each handhole and DCP test was advanced and logged by an HWA geologist or geotechnical engineer. Representative soil samples were obtained at selected intervals, and transported to HWA's Bothell laboratory for further examination and testing.

The DCP test equipment consists of a steel extension shaft assembly, with a 60 degree hardened steel cone tip attached to one end, which is driven into the subsoil by means of a sliding drop hammer. The base diameter of the cone is 20 mm (0.79 inches). The diameter of the shaft is 8 mm (0.315 inches) less than the cone, to reduce rod friction at shallow penetration depths. The DCP is driven by repeatedly dropping an 8-kg (17.6-pound) sliding hammer from a fixed height of 575 mm (22.6 inches). The depth of cone penetration is measured after each hammer drop or given number of drops (depending on soil resistance) and the in-situ shear strength of the soil is reported in terms of the DCP Index (DCI). The DCI is based on the average penetration depth resulting from 1 blow of the hammer and is reported as millimeters per blow (mm/blow). The data obtained from the DCP tests was then correlated to Standard Penetration Test (SPT) values, in order to evaluate the strength of the subgrade soils for use in evaluating the allowable bearing capacity of the site soils. The DCP data, converted to SPT, is plotted on the handhole logs in Appendix A.

The approximate locations of the handholes are indicated on the Site and Exploration Plan, Figures 2A and 2B. Exploration logs of the handholes and DCP tests are presented in Appendix A, Figures A-2 through A-14. A legend of the terms and symbols used on the exploration logs is included on Figure A-1.

SUBSURFACE SOIL CONDITIONS

Soil units encountered in our subsurface explorations and in previous geotechnical investigations in the vicinity are described below. Our preliminary subsurface explorations in 2015 were focused on three proposed structures, namely a set of steps and two boardwalks. Such structures are not part of the current proposed trail system due to changes in trail alignments. In 2018 four handholes were advanced on steep existing fill slopes in the southern portion of the site; another was advanced on a steep existing cut slope by Columbian Way; and two were advanced in the northern portion of the site to assess typical soil conditions for the upper and lower slopes of that area. Soils encountered in our explorations and in existing geotechnical explorations are described below.

Fill: Fill soils consisting of very loose to loose, brown, gravelly, silty, sand with woody debris and organics were encountered in handhole HH-1. This fill material appeared to have been placed during grading of the area for the materials yard just to the north. Soil consisting of very loose to loose, brown, gravelly, silty sand with scattered concrete rubble was present on the slope at handhole HH-8. Medium stiff to stiff clay and silt was present on the slope surface in the vicinity of handholes HH-7 and HH-9. The clay was encountered in HH-8 below the granular fill from 4 to 8.5 feet, from the surface to 6.5 feet in HH-7, and to a depth of 1.5 feet in HH-9. Both types of fill appeared to have been graded over the edge of the upper “plateau” upon which is the Parks maintenance yard, within which clay fill was encountered over glacial till in previous borings (Seattle Engineering Department, 1973).

Buried Topsoil: Buried Topsoil consisting of very loose to loose, brown, silty, sand with woody debris and organics. It is differentiated from the fill by odor and presence of abundant organic matter, and by absence of jumbled appearance. This unit was encountered in handhole HH-1 below the fill. Handhole HH-1 was terminated in this unit upon refusal on gravel. It appears that when fill was placed it was simply pushed over the top of a cleared area vegetated with blackberry brambles.

Topsoil: Topsoil very similar in consistency to the buried topsoil in HH-1 was encountered at the surface in HH-2. Handhole HH-2 was dug at the toe of a relatively steep change in grade (due to fill placement). The topsoil was thin – only about six inches thick and supported the growth of blackberry brambles and weeds. This unit is also a fill as indicated by the woven geosynthetic fabric separating it from the unit below. Topsoil was more weakly developed elsewhere on slopes throughout the site, and often there was none with colluvium at the ground surface beneath minor duff.

Organic Silt: Organic silt stream and wetland deposits consisting of very soft sandy silt with abundant organics were encountered at the ground surface in handholes HH-3 and HH-4. The organic silt was so soft that the DCP sank under the weight of the hammer. These organic silt soils were encountered in both wetland areas near the formerly proposed boardwalk locations. This soil unit is very thin – approximately 0.25 feet thick. It is highly compressible, and will undergo consolidation settlement under the application of load. These soils will also undergo biodegradation settlement over time as the organic material within the soil biodegrades. Organic silt deposits are expected to be present anywhere within mapped wetlands.

Coarse-Grained Alluvium: Coarse-grained alluvial deposits were encountered below a depth of 0.25 feet in hand borings HH-3 and HH-4. These soils consisted of very loose grading to dense, gray, silty, fine to coarse sand and gravel. Alluvial soils should be anticipated anywhere along the riparian corridor mapped as a wetland along the large ravine north of the maintenance yard.

Colluvium: Loose to medium soils formed by weathering and downslope movement by physical and biological means were encountered in handholes HH-5 and HH-6, and HH-10 through HH-13. Colluvium was observed at the surface throughout the majority of the greenspace. These soils typically consisted of gravelly, silty sand to sandy silt and was most likely derived from glacial till, advance outwash, and Lawton clay soils. Colluvium was differentiated from topsoil by observing reduced organic content. The upper 4 to 10 feet of the borings within the 2003 slide area consisted of loose, brown silty sand or sandy silt, which we interpret to be colluvium (ECI, 2004c).

Weathered Till: Soils beneath colluvium below a depth of 0.25 feet in hand borings HH-5 and HH-6 appeared to be weathered till, partly based on its presence immediately above glacial till encountered in handhole HH-5. These soils consisted of very loose grading to dense, silty, fine to coarse sand and gravel.

Weathered Advance Outwash: Loose grading to dense, silty sand was encountered in HH-2 under geosynthetic fabric. Color, presence of rust mottling, and density indicate a high degree of weathering near the ground surface with the degree of weathering lessening with depth. Handhole HH-2 was terminated in this unit.

Recessional Lacustrine Deposits: Very soft to soft, laminated to massively bedded silt and clay deposits were encountered in a previous boring east of the greenspace for Sound Transit’s Link Light Rail along Martin Luther King Jr. Blvd (Golder, 2001) at a depth of 12 to 30 feet (the full depth explored). This was interpreted in their report as Vashon recessional lacustrine deposits. Based on our interpretation of borehole logs by others, these deposits were also apparently encountered in test pits and borings for New Rainier Vista (ECI, 2000) and in borings for repair of the 2003 slide (ECI, 2004c).

Recessional Outwash: Medium dense, silty sand was encountered in previous borings within the greenspace for repair of the 2003 slide (ECI, 2004c). Layers up to several feet thick of loose to medium dense or medium stiff, brown silty sand, silt, and clay were encountered to depths of up to 30 to 40 feet.

Glacial Till: Dense, silty sand with gravel that was evidently till-like was documented in borings at the top of the hill in the existing Parks maintenance yard (Seattle Engineering Department, 1973). Very dense, olive gray, silty gravelly sand was encountered in hand hole HH-5 below weathered till. Based on the high density as shown by DCP testing and observations of the soil texture, this was interpreted as glacial till. The transition between weathered and unweathered till is gradual and is interpreted from increase in density and color change with the absence of rust mottling. The location of this apparent glacial till is lower down the hill than would be expected from the geologic map. However, glacial till typically drapes the landscape when deposited, and so till deposits can be present beneath colluvium which was undetected by the geologic mapping published at 1:24,000 scale. Alternatively, the apparent till could be a block within mass wasting deposits on the slope. Glacial till was encountered northeast of the site along 25th Ave S (Hemphill, 2000). The location is beyond the area shown on Figures 2A and 2B, but the logs are included in Appendix C.

Advance Outwash: Very dense, clean sand with scattered gravel was encountered beneath the fill in handholes HH-7, HH-8, and HH-9.

Lawton Clay: Very stiff to hard, gray or bluish gray, clay or silt was encountered at depths below approximately 35 to 40 feet, in some of the boreholes drilled within the greenspace for design of the 2003 slide repair to the full depths of explored of (ECI, 2004c). Other reports indicate the presence of “blue” clay on the slope north of the greenspace (Hart Crowser, 1986), and clayey silt beneath granular fill on a residential lot on 25th Ave S above Cheasty Blvd (LSI ADAPT, 2001). This was also encountered in some of the boreholes downslope of the greenspace, below depths of approximately 10 to 16 feet (ECI, 2000).

GROUND WATER CONDITIONS

Ground water seepage was observed at several locations, most of which were closer to the bottom of the overall slope than the top. The approximate locations in which ground water seepage was observed during our site visits are indicated in Figures 2A and 2B. The exception was ground water seepage below Cheasty Blvd at the head of the large stream valley. These seepages formed the head ends of surface drainages. Based on the geologic mapping and our site soil observations, it is likely that most of the seepage emanates from granular soils just above their contact over hard silts and clays. The presence, specific locations, and flow quantity of ground water seepage should be expected to vary seasonally.

Ground water was observed in three of our subsurface explorations. Handholes HH-3 and HH-4 were dug in a wetland. Water levels observed in each hand hole were at ground surface, and 1 foot below ground surface respectively. Seepage was observed from saturated soils below a depth of 3 feet in HH-6. Ground water monitoring wells were not installed in the 2018 handholes, as seasonal, transient perched ground water is assumed to occur at shallow depths on the slopes.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

Construction of the mountain bike trails within the Cheasty greenspace is feasible from a geotechnical standpoint. If properly designed, in our opinion construction of the proposed trails will not result in increased deep-seated instability of the overall slope, and with proper construction and maintenance of slope retention and drainage facilities, the trails will not result in increased shallow slope instability. It should be noted that future localized areas of shallow slope instability, which could occur virtually anywhere on the site, may affect the trails. We do not anticipate this to be a significant safety issue. Where the trail is affected by future slope instability, sloughed or slid soils would need to be removed from the trail or the trail rerouted around the slide area and drainage re-established where affected. Trail setbacks from certain existing fill and cut slopes as noted below are recommended as buffers to avoid causing or being affected by slope instability. Otherwise, the trails can traverse the potential slide area without the need for buffers.

Specific attention will need to be paid to the trail alignment, grades, drainage and surfacing to limit the amount of maintenance required to maintain a functional and environmentally friendly trail system. We recommend additional drainage measures where the trail crosses the 2003 slide area. Modifications have been made to the trail alignments per our recommendations in order to avoid steep fill and cut slopes. Recommendations to address particular issues are discussed in the following sections. We recommend HWA be included in design review. Furthermore, as we understand trails will be field-fitted during construction around trees and other features as needed, HWA should be engaged to provide geotechnical monitoring during construction.

SEISMIC DESIGN PARAMETERS

Earthquake loading for the slopes along the trail alignment was developed in accordance with Section 3.4 of the *AASHTO Guide Specifications for LRFD Seismic Bridge Design*, 2nd Edition, 2011. For seismic analysis, the Site Class is required to be established and is determined based on the average soil properties in the upper 100 feet below the ground surface. Based on our explorations and understanding of site geology, it is our opinion that the slopes within the proposed trail alignments consist of soils consistent with Site Class D. Therefore, Site Class D should be used with AASHTO seismic evaluations for slope stability of this project. Table 1 presents recommended seismic coefficients for use with the General Procedure described in AASHTO (2011), which is based upon a design event with a 7 percent probability of exceedance in 75 years (equal to a return period of 1,033 years). These seismic parameters were used to evaluate slope stability for the proposed trail alignment and will be used for structural design of structures identified during final design.

The spectral acceleration coefficient at 1-second period (S_{D1}) is greater than 0.5; therefore, the Seismic Design Category D, as given by AASHTO Table 3.5-1 (AASHTO, 2011), should be used.

Table 1.
Seismic Coefficients for Evaluation Using
AASHTO Guide Specifications calculated by USGS 2014 Seismic Hazard Map

Site Class	Peak Ground Acceleration PGA (g)	Spectral Acceleration at 0.2 sec S_S (g)	Spectral Acceleration at 1.0 sec S_1 (g)	Site Coefficients			Acceleration Coefficient A_s (g)
				F_{pga}	F_a	F_v	
D	0.461	1.021	0.342	1.039	1.091	1.716	0.479

Based on the above parameters, the design Acceleration Coefficient (A_S) for Site Class D at the project site is 0.479g. Slope stability was analyzed using a horizontal seismic acceleration coefficient k_h of one-half the peak ground acceleration or 0.24g and a vertical seismic acceleration coefficient k_v of 0.0g. These seismic parameters should also be utilized for design of any structures that may be added to the project.

SLOPE STABILITY

The Cheasty greenspace has and will continue to be an active slope environment. Therefore, future episodes of slope instability may be expected within the greenspace. Based on our experience with similar slope topography and geology, we do not expect that large scale deep-seated slope instability is likely across the greenspace. However, continued shallow slope movements are expected to occur across portions of the greenspace over time.

As the loads associated with the proposed trails are not anticipated to change the stability of the existing slopes from their current condition, slope evaluations have been focused on identifying areas of potential slope instability under current conditions. HWA has evaluated the greenspace to identify areas of potential shallow slope instability through visual assessment of slope characteristics including geomorphology, surficial soils, and vegetation patterns; and review of geologic mapping and existing geotechnical information in the immediate vicinity. Where potential for slope instability was visually evident, the trail alignment has been routed by the design team to avoid these areas. Where previously proposed trail alignments traversed along or at the base of slopes, not showing visual evidence of potential instability, preliminary limit-equilibrium slope stability analysis has been completed. These analyses indicate that most subject locations possess adequate factors of safety under static and pseudo-static loading conditions. However, areas of steep fill south of the Parks maintenance yard and the cut slope adjacent to Columbia Way proved to be areas of potential slope instability. Modifications to the proposed trail alignments are reflected in the alignments shown in Figures 2A and 2B.

TRAIL ALIGNMENT

In addition to trail user criteria, the trail alignment shown in Figures 2A and 2B was chosen by the design team based in part on the following guidelines:

- Avoiding wetlands and their buffers,
- Routing the trail outside of the identified areas of instability,
- Avoiding steep slopes (greater than 40 percent, or 2.5H:1V) where possible,
- Avoiding ground water seepage zones where possible,
- Minimizing cut heights where the trails must traverse steel slopes,
- Minimizing steepness of trail grades, and
- Installing and maintaining suitable drainage features.

In general, the proposed mountain bike trail alignments, shown in Figures 2A and 2B appear to be suitable for the site conditions. Per our recommendation the following revisions were made to the preliminary trail alignments in order to avoid additional areas of potential slope instability.

Parks Maintenance Yard Area: The fill slope below the maintenance yard (southern to eastern slope) shows evidence of sloughing. Site observations and stability analysis suggest that the fill slope is currently standing near the angle of repose of the soil. We recommended the trail alignment be rerouted to avoid the steep fill slope below the maintenance yard. Additionally, to reduce the potential for future instability within this fill, we recommend collecting and dispersing the drainage from the parks maintenance yard to an area below the proposed trails.

Columbia Way Area: We recommended placing the trail outside of the existing road cut which is a mapped steep slope area. Due to the presence of wetlands above, the trail was routed even farther from the roadcut to avoid the wetlands and their buffers.

Top of 2003 Slide Area: At the top of the 2003 slide area, retained by the soldier pile wall, we recommended the upslope portion of trail be rerouted outside of the slide area (closer to Cheasty Blvd).

Bottom of 2003 Slide Area: The trail near the top of the existing soldier pile and lagging wall will be routed at least a minimum distance behind the wall where a 2H:1V line up from the toe of the wall intersects the ground surface. This alignment is shown on Figures 2A and 2B.

All proposed trails should be completed in accordance with the recommendations provided by the International Mountain Bike Association (IMBA). IMBA recommends limiting trail grades to a maximum of 15% with an average grade not to exceed 10% to limit the potential for surface erosion. We recommend that IMBA's recommendations for grade be followed for the design of the Cheasty Mountain bike trails. The IMBA also recommends that trails be designed to follow slope contours to avoid concentrated surface water flows along the trail.

DRAINAGE RECOMMENDATIONS

Soils that become exposed on slopes are prone to erosion from rainfall and runoff. Trail surfaces that are steep with a high proportion of fine-grained soils as found throughout the site at the surface will be especially prone to erosion from bike traffic during both dry and wet conditions. Trail sections should be sloped no more than 15% to minimize the potential of erosion. Per current trail design standards, we recommend against the use of water bars for diversion of runoff from the trail. Water bars typically become plugged with sediment such that runoff is not diverted off the trail, but continues to run down the trail resulting in greater erosion during storm events, and concentrated runoff and erosion where the water ends up diverting from the trail. Concentrated runoff is undesirable in steep slope and potential landslide areas. We recommend the current standard of regularly spaced gentle dips in the trail to break up long sloping runs. Runoff on the trail will naturally divert from the trail at these dips, which are not prone to plugging and thus failure as are water bars, such that regularly spaced runoff diversions will persist and thus prevent concentration of flow such as would result from failure of a number of water bar diversions.

Where the trail will cross the lower portion of the 2003 slide, a short distance above the soldier pile wall, we recommend that surface runoff be collected from the trail and tightlined to the storm system in front of (downslope from) the wall. The purpose of this is to prevent inadvertently concentrating runoff into slide scarps or other ground cracks, which could result in increased pore pressures in the slide plane and thus increased pressure on the soldier pile wall.

Permanent erosion control measures for any side cuts and fills made for the trails will need to be undertaken, and would likely consist of mulching or matting, with native perennial plantings. Ground water seepage zones and resulting surface runoff as observed in 2015 are avoided by the presently proposed trail alignments. Other areas of seepage could become apparent during and after trail construction. The trail should not be constructed with wet crossings of seepage or runoff, as bicycle and foot traffic will cause disturbance of wet soils that will result in rutting and erosion of the trail (requiring higher maintenance) and silty runoff (impacting wetlands and streams down gradient).

At locations where crossing seepage or runoff cannot be avoided, measures to prevent wet crossings include boardwalks, culverts, or rock drainage blankets should be used. Perched ground water seepage may be intercepted by trail cuts where seepage may not have been apparent at the ground surface. Shallow ditching or perforated pipes along the cut side of the trail with tight-lined culverts or other diversions to the opposite side would serve to collect this seepage. Trail surface runoff should be diverted by typical methods for trails in wet, steep forested areas such as inclining the trail outward where possible and, in areas of high runoff, inclining the trail to the upslope side to a ditch and tight-lining runoff beneath the trail.

EARTHWORK

We recommend the trail width be kept to the minimum necessary for a single-track trail, in order to reduce the need for and magnitude of cuts and fills where the trails cross steep slopes. Avoiding the existing fill and cut slopes as noted previously will also reduce this need.

Necessary fills should be benched into the slope, and not placed as a wedge over the slope surface. Organic soils should be stripped where fills will occur, and any loose underlying soils compacted to a firm and unyielding condition. Fill should consist of sand with up to 15% by weight of non-plastic fines. The fill should be placed in horizontal lifts and compacted with hand-operated equipment to a dense condition (at least 90 percent of modified Proctor dry density per ASTM D:1557).

Shallow cuts should be sloped no greater than 2.5H:1V. On slopes greater than 5H:1V, cuts greater than 2 feet high will need to be retained. We recommend the use of treated timber walls laterally supported by driven pin piles. Recommendations for walls are included in the Structures section.

TRAIL SURFACING

The near surface soils along the proposed maintain bike trail alignments are highly variable but generally consist of very loose and highly moisture sensitive soils. The appropriate mountain bike trail surfacing will likely vary along the alignment and will be dependent on the subsurface soils, slope conditions, seepage conditions, trail grade and the anticipated trail usage. IMBA outlines multiple levels of trail surfacing options (in increasing order) to maintain trail functionality through varying conditions. It is likely that some if not all of these options will need to be implemented into the trail design.

- **Microtopography Modification:** Compacted native soil comprises the trail surfacing. This approach uses onsite materials to create raised trail surface, causeways, basins, and mounds with the goal of maximizing drainage. Flatter areas are most suitable for this approach.

- **Foundation Modification:** The trail bed is excavated to place a layer of drain rock that is then overlain by native soil that is placed to form the trail surfacing. If the fines content is high in the native soils, migration of fines into the drainage layer could result in loss of drainage functionality of the rock over time. Wrapping the drainrock in a non-woven geotextile separator fabric adds expense but would add longevity without significantly increasing effort.

- **Surface Modification:** Place imported material for the trail surfacing. Our experience indicates that a well-graded crushed surfacing top course from a ledge rock source with a non-plastic fines content of around 10% works well for supporting wheeled trail uses (e.g. bicycles) without scattering. Gravel deposit sources of Crushed Surfacing Top Course (CSTC) provide the correct gradation but the rounded faces don't provide the interlock between particles necessary to minimize scattering. Proprietary products are available that improve the compatibility and or cohesion of native soils.

- **Extreme Measures:** These include methods familiar to road construction such as ditches and culverts, collection and tight-line, and re-grading. IMBA puts the aforementioned geotextile in this category as well. As noted in the Drainage section we recommend collection and tightlining of runoff from the trail where it crosses the 2003 slide area.

STRUCTURES

Retaining walls may be needed to facilitate construction of switchback turns along some slopes. Each of these structures will require special geotechnical considerations with respect to lateral support. General design recommendations are provided below. Geotechnical design parameters for potential walls will be provided in the final geotechnical report, once the need for and site-specific configurations and heights of walls are determined by the design team.

- **Retaining Walls**
  Pin piles are commonly used for construction of short retaining walls on slopes, such as for trails or landscaping. The pin piles are used to support treated timber or concrete lagging. Pin piles for such walls typically come in the form of 2, 3, or 4-inch diameter schedule 80 steel pipes (round or square). Hammers commonly used for driving consist of hand portable pneumatic jack or breaker hammers, for the smallest pipe sizes, to excavator-mounted pneumatic or hydraulic hammers for the larger sizes. Given the limited access conditions, we recommend assuming the use of hand-portable equipment, which can drive up to 4-inch square pipe.

TRAIL MAINTENANCE

Continued maintenance of the mountain bike trail will be necessary to maintain the functionality of the trail system, protect nearby surface waters from increased sedimentation due to erosion, and to reduce impacts to slope stability. The need for maintenance of the trail surface can be minimized by good alignment selection; suitable trail inclination, earthwork and drainage measures; and regular maintenance of drainage measures. The type and frequency of the required maintenance will depend on several factors including trail use, final trail alignment, and inclinations of the trail sections. Steeper trail sections generally require more frequent maintenance than flatter trail alignments.

LIMITATIONS

We have prepared this report for ESA and the City of Seattle Parks Department and their agents for use in design of a portion of this project. It should be noted that this report is based on site reconnaissance and limited subsurface explorations. The conclusions and interpretations presented in this report should not be construed as a warranty of the subsurface conditions. Experience has shown that soil and ground water conditions can vary significantly over small distances. Inconsistent conditions can occur between explorations and may not be detected by a geotechnical study. We expect that additional geotechnical evaluations will be required as the proposed trail system is taken from preliminary design to final design. If, during future site operations, subsurface conditions are encountered which vary appreciably from those described herein, HWA should be notified for review of the recommendations of this report, and revision of such if necessary.

Within the limitations of scope, schedule and budget, HWA attempted to execute these services in accordance with generally accepted professional principles and practices in the fields of geotechnical engineering and engineering geology in the area at the time the report was prepared. No warranty, express or implied, is made. The scope of our work did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous substances in the soil, surface water, or ground water at this site.

This firm does not practice or consult in the field of safety engineering. We do not direct the contractor’s operations, and cannot be responsible for the safety of personnel other than our own on the site. As such, the safety of others is the responsibility of the contractor. The contractor should notify the owner if he considers any of the recommended actions presented herein unsafe.

We appreciate this opportunity to be of service.

Sincerely,

HWA GEOSCIENCES INC.

Brad W. Thurber, L.G., L.E.G.
Senior Engineering Geologist

Donald J. Huling, P.E.
Geotechnical Engineer, Principal

LIST OF FIGURES (FOLLOWING TEXT)

LIST OF APPENDICES

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0 250 500 750 1000

BASE MAP PROVIDED BY: Google Maps

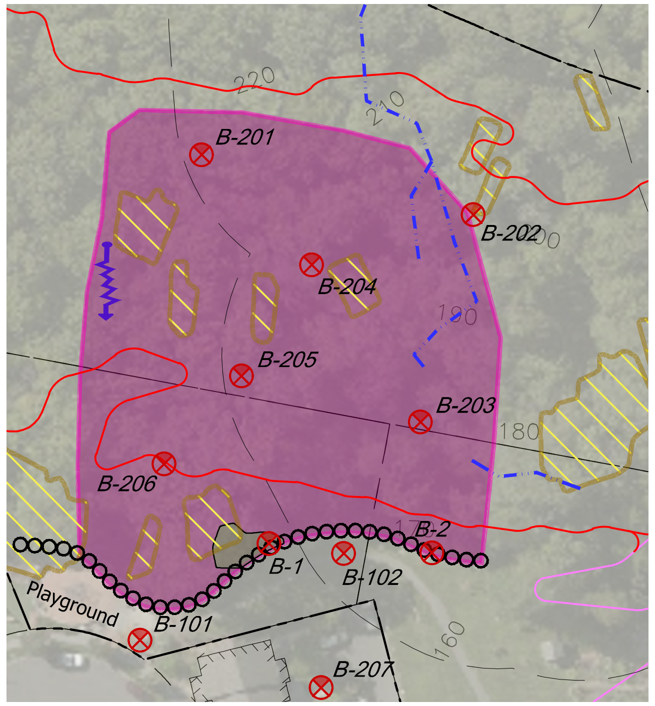
HWA GeoSciences Inc.

Cheasty Greenspace
Mountain Bike Trail
Seattle, Washington

VICINITY
MAP

DRAWN BY BFM	FIGURE # 1
CHECK BY BT	PROJECT # 2014-177-21
DATE: 06.21.2018	

S:\2014 PROJECTS\2014-177-21 CHEASTY GREENSPACE MOUNTAIN BIKE TRAIL\CAD 2014-177\TASK 300 CAD\2014-177-21 CHEASTY GREENSPACE MOUNTAIN BIKE TRAIL.DWG <Fig 1> Plotted: 7/3/2018 9:02 PM



ENLARGED PLAN

Scale: 1" = 100'-0"

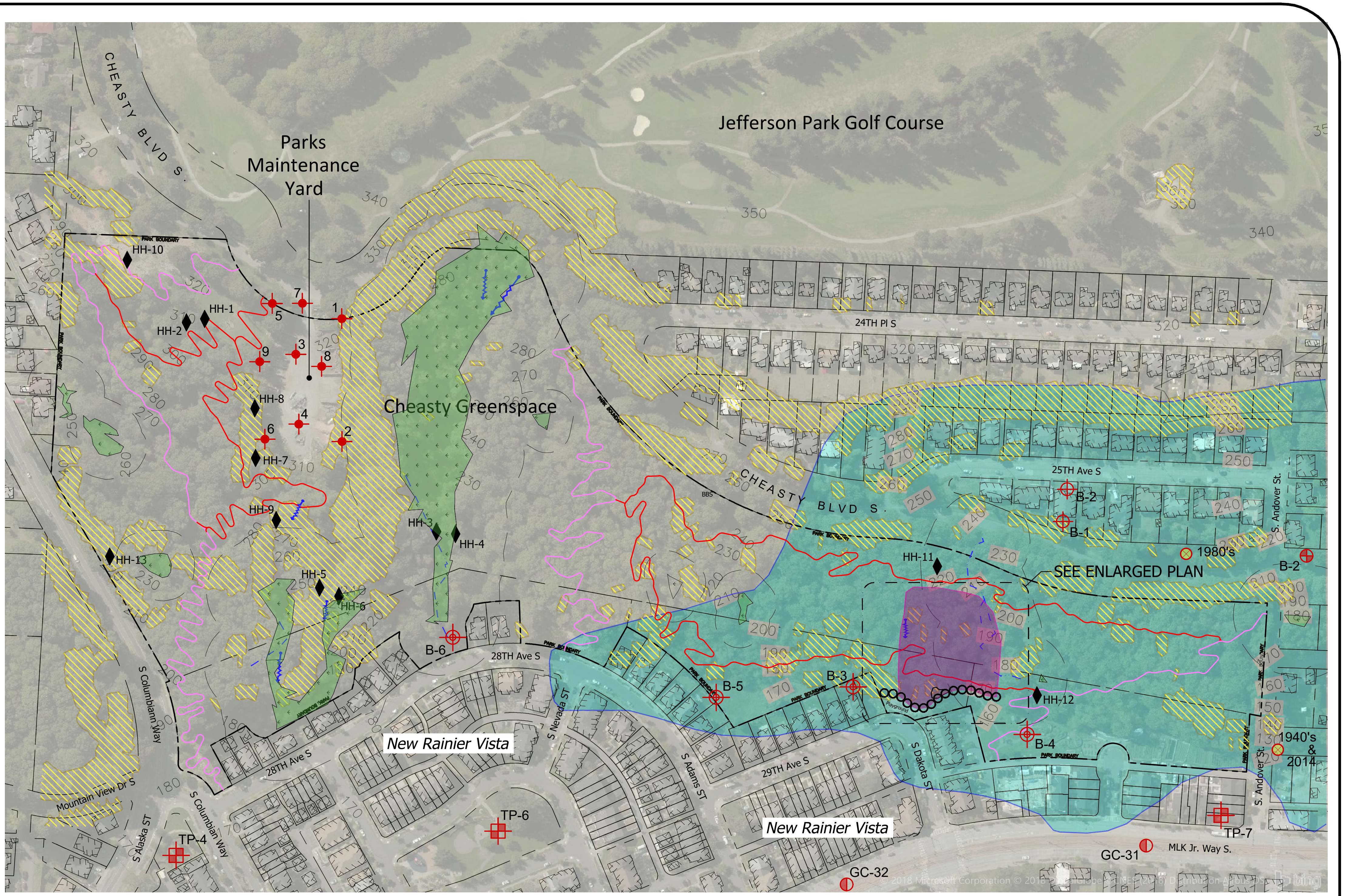
LEGEND

- GROUND WATER SEEPAGE AND RUNOFF (HWA, 2015)
- WATER COURSES
- ▨ MAPPED STEEP SLOPE AREA (SEATTLE GIS; 2016 UPDATE)
- 🟦 MAPPED POTENTIAL SLIDE AREA (SEATTLE GIS; SHANNON & WILSON, 2000)
- 🟩 MAPPED WETLAND AREA (ESA, PRESENT STUDY)
- 🟪 APPROXIMATE AREA OF 2003 LANDSLIDE (ECI, 2004)
- ⊗ APPROXIMATE LOCATION OF DOCUMENTED LANDSLIDES AND ERA (SHANNON & WILSON, 2000)
- ○○○○○ SOLDIER PILE WALL
- PROPOSED MOUNTAIN BIKE TRAILS
- PROPOSED CONNECTOR TRAILS
- PARK BOUNDARY

EXPLORATION LEGEND

HH-13 ◆	HANDHOLE DESIGNATION AND APPROXIMATE LOCATION (HWA 2015, 2018)
B-207 ⊗	BOREHOLE DESIGNATION AND APPROXIMATE LOCATION (ECI, 2003-2004)
B-2 ⊕	BOREHOLE DESIGNATION AND APPROXIMATE LOCATION (LSI ADAPT, 2001)
GC-32 ◐	BOREHOLE DESIGNATION AND APPROXIMATE LOCATION (GOLDER, 2001)
B-6 ⊕	BOREHOLE DESIGNATION AND APPROXIMATE LOCATION (ECI, 2000)
TP-7 ⊞	TEST PITS DESIGNATION AND APPROXIMATE LOCATION (ECI, 2000)
B-2 ⊕	BOREHOLE DESIGNATION AND APPROXIMATE LOCATION (HARTCROWSER, 1986)
9 ✚	BOREHOLE DESIGNATION AND APPROXIMATE LOCATION (SEATTLE ENG. DEPT., 1973)

BASE MAP PROVIDED BY: Google Maps



CHEASTY GREENSPACE MOUNTAIN BIKE TRAIL

Scale: 1" = 250'-0"

0 125 250 375 500

HWA GEOSCIENCES INC.

Cheasty Greenspace
Mountain Bike Trail
Seattle, Washington

SITE AND EXPLORATION PLAN

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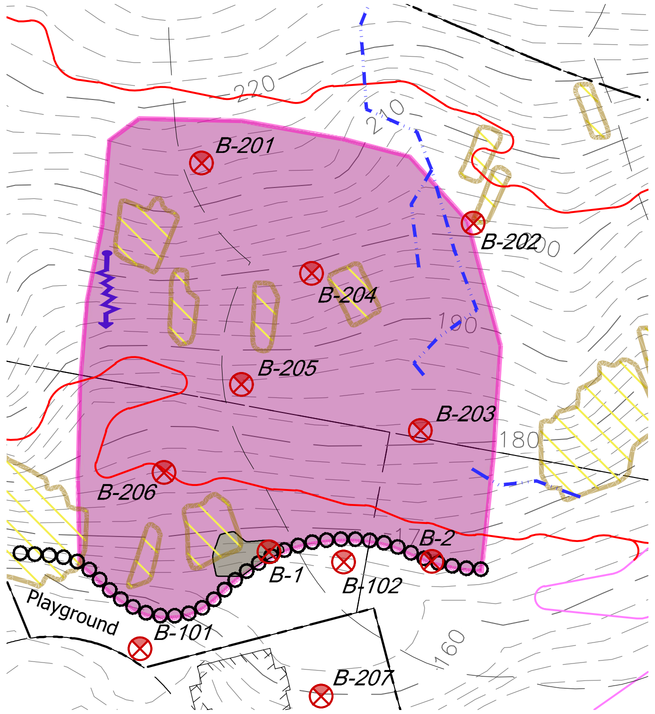
DATE: 06.21.2018
FIGURE #: 2A
PROJECT #: 2014-177-21

H:\HWA GEOTECHNICAL\2014-177-21 CHEASTY GREENSPACE MOUNTAIN BIKE TRAIL\2014-177-21 CHEASTY GREENSPACE MOUNTAIN BIKE TRAIL.DWG <Fig 2a> Plotted: 7/25/2018 4:32 PM



ENLARGED PLAN

Scale: 1" = 100'-0"

LEGEND

- GROUND WATER SEEPAGE AND RUNOFF (HWA, 2015)
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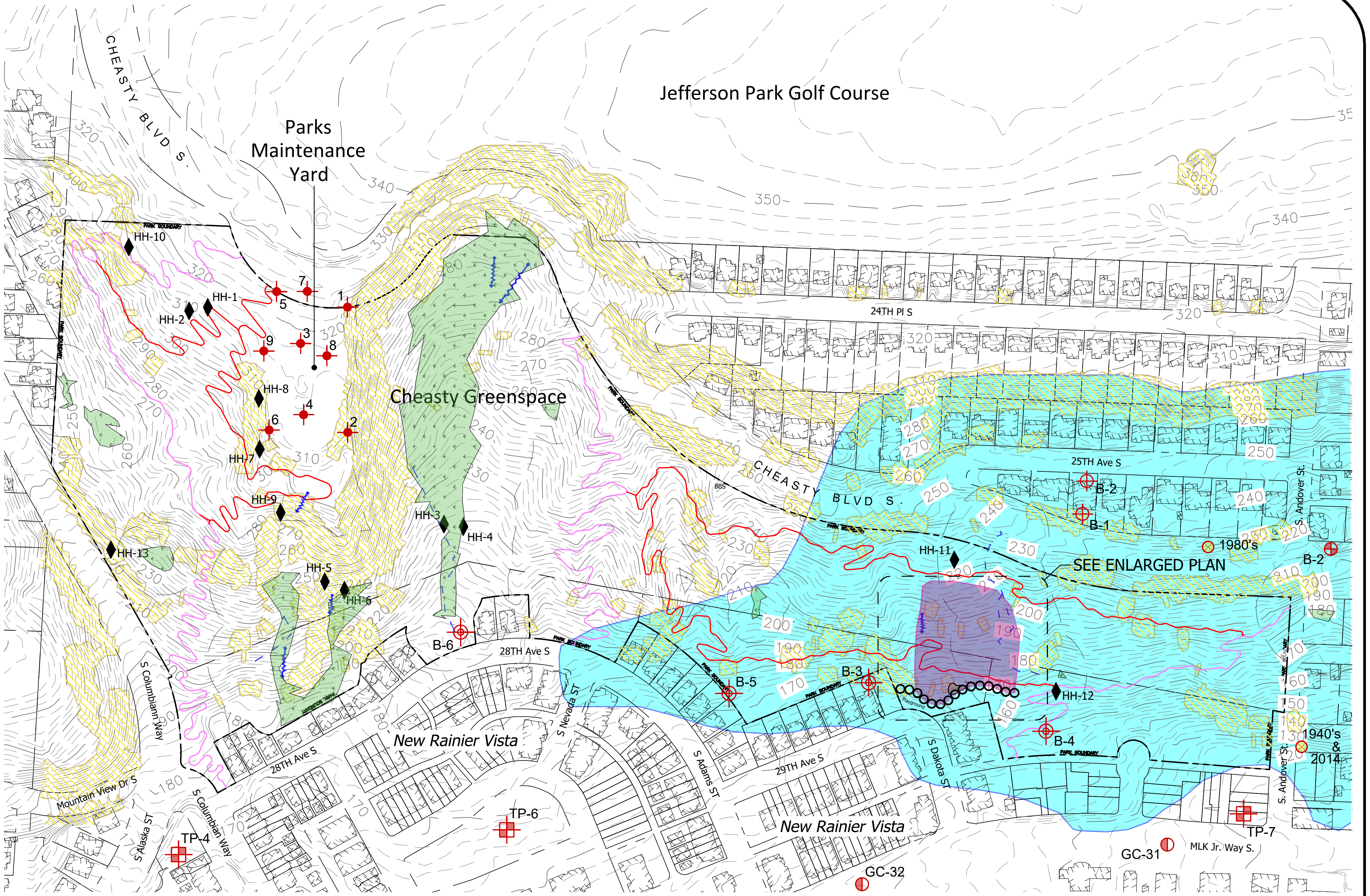
BASE MAP PROVIDED BY: ESA



CHEASTY GREENSPACE MOUNTAIN BIKE TRAIL

Scale: 1" = 250'-0"

0 125 250 375 500

N

HWA GeoSciences Inc.

Cheasty Greenspace
Mountain Bike Trail
Seattle, Washington

SITE AND
EXPLORATION
PLAN

DRAWN BY BFM
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DATE: 06.21.2018
FIGURE # 2B
PROJECT # 2014-177-21

H:\HWA GEOTECHNICAL\2014-177-21 CHEASTY GREENSPACE MOUNTAIN BIKE TRAIL\2014-177-21 CHEASTY GREENSPACE MOUNTAIN BIKE TRAIL.DWG <Fig 2b> Plotted: 7/25/2018 4:31 PM

APPENDIX A

FIELD EXPLORATIONS

RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N-VALUE

COHESIONLESS SOILS			COHESIVE SOILS		
Density	N (blows/ft)	Approximate Relative Density(%)	Consistency	N (blows/ft)	Approximate Undrained Shear Strength (psf)
Very Loose	0 to 4	0 - 15	Very Soft	0 to 2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Medium Dense	10 to 30	35 - 65	Medium Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	over 50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	over 30	>4000

TEST SYMBOLS

%F	Percent Fines
AL	Atterberg Limits: PL = Plastic Limit LL = Liquid Limit
CBR	California Bearing Ratio
CN	Consolidation
DD	Dry Density (pcf)
DS	Direct Shear
GS	Grain Size Distribution
K	Permeability
MD	Moisture/Density Relationship (Proctor)
MR	Resilient Modulus
PID	Photoionization Device Reading
PP	Pocket Penetrometer Approx. Compressive Strength (tsf)
SG	Specific Gravity
TC	Triaxial Compression
TV	Torvane Approx. Shear Strength (tsf)
UC	Unconfined Compression

USCS SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP DESCRIPTIONS	
Coarse Grained Soils More than 50% Retained on No. 200 Sieve Size	Gravel and Gravelly Soils More than 50% of Coarse Fraction Retained on No. 4 Sieve	Clean Gravel (little or no fines)	GW	Well-graded GRAVEL
			GP	Poorly-graded GRAVEL
		Gravel with Fines (appreciable amount of fines)	GM	Silty GRAVEL
			GC	Clayey GRAVEL
	Sand and Sandy Soils 50% or More of Coarse Fraction Passing No. 4 Sieve	Clean Sand (little or no fines)	SW	Well-graded SAND
			SP	Poorly-graded SAND
		Sand with Fines (appreciable amount of fines)	SM	Silty SAND
			SC	Clayey SAND
Fine Grained Soils 50% or More Passing No. 200 Sieve Size	Silt and Clay	Liquid Limit Less than 50%	ML	SILT
			CL	Lean CLAY
			OL	Organic SILT/Organic CLAY
	Silt and Clay	Liquid Limit 50% or More	MH	Elastic SILT
			CH	Fat CLAY
			OH	Organic SILT/Organic CLAY
Highly Organic Soils			PT	PEAT

SAMPLE TYPE SYMBOLS

⊠	2.0" OD Split Spoon (SPT) (140 lb. hammer with 30 in. drop)
⌶	Shelby Tube
▣	3-1/4" OD Split Spoon with Brass Rings
⬯	Small Bag Sample
▚	Large Bag (Bulk) Sample
▮	Core Run
⧄	Non-standard Penetration Test (3.0" OD split spoon)

GROUNDWATER SYMBOLS

▽	Groundwater Level (measured at time of drilling)
▼	Groundwater Level (measured in well or open hole after water level stabilized)

COMPONENT DEFINITIONS

COMPONENT	SIZE RANGE
Boulders	Larger than 12 in
Cobbles	3 in to 12 in
Gravel	3 in to No 4 (4.5mm)
Coarse gravel	3 in to 3/4 in
Fine gravel	3/4 in to No 4 (4.5mm)
Sand	No. 4 (4.5 mm) to No. 200 (0.074 mm)
Coarse sand	No. 4 (4.5 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine sand	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and Clay	Smaller than No. 200 (0.074mm)

COMPONENT PROPORTIONS

PROPORTION RANGE	DESCRIPTIVE TERMS
< 5%	Clean
5 - 12%	Slightly (Clayey, Silty, Sandy)
12 - 30%	Clayey, Silty, Sandy, Gravelly
30 - 50%	Very (Clayey, Silty, Sandy, Gravelly)
Components are arranged in order of increasing quantities.	

NOTES: Soil classifications presented on exploration logs are based on visual and laboratory observation. Soil descriptions are presented in the following general order:

Density/consistency, color, modifier (if any) GROUP NAME, additions to group name (if any), moisture content. Proportion, gradation, and angularity of constituents, additional comments. (GEOLOGIC INTERPRETATION)

Please refer to the discussion in the report text as well as the exploration logs for a more complete description of subsurface conditions.

MOISTURE CONTENT

DRY	Absence of moisture, dusty, dry to the touch.
MOIST	Damp but no visible water.
WET	Visible free water, usually soil is below water table.

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Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

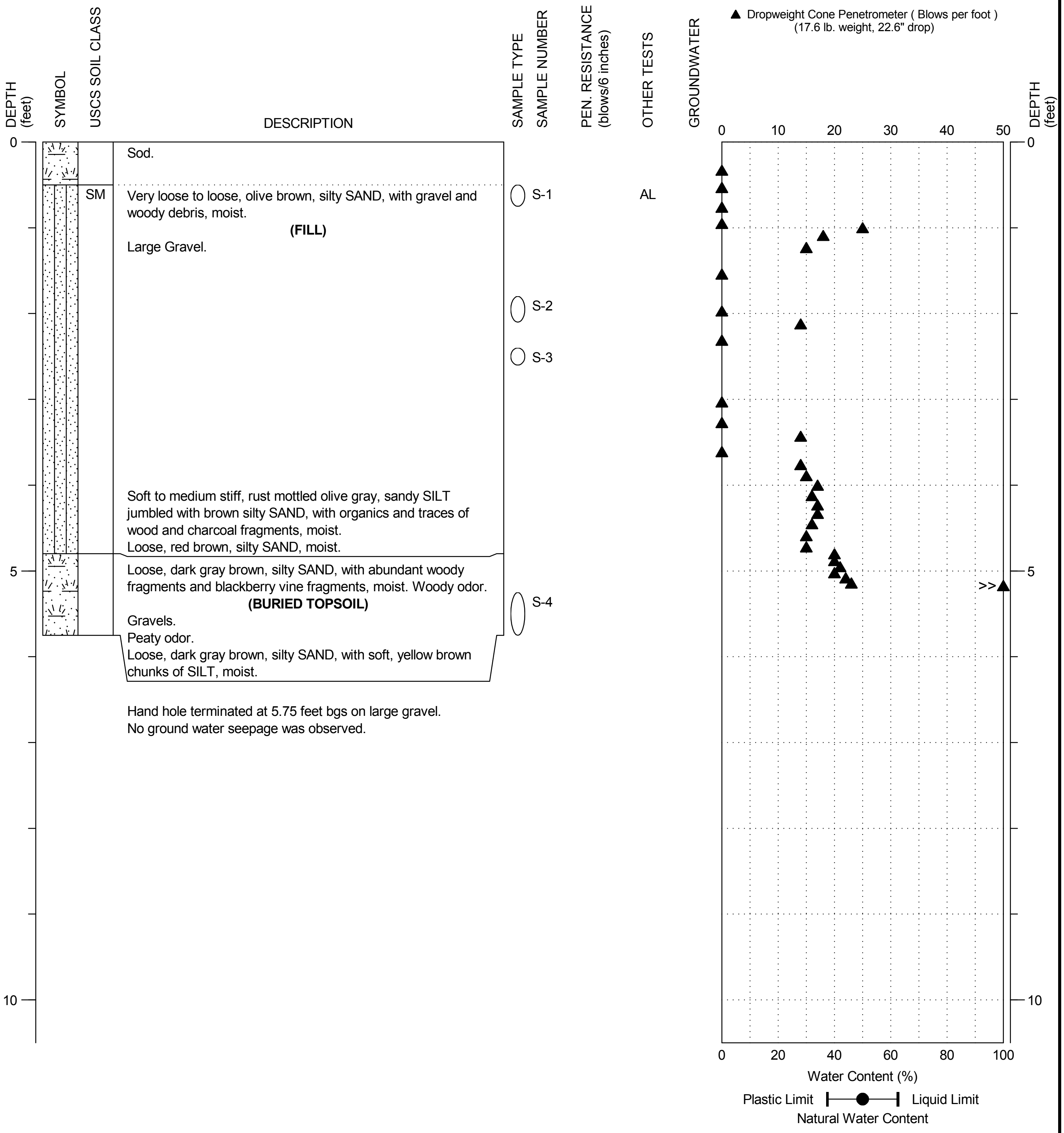
LEGEND OF TERMS AND SYMBOLS USED ON EXPLORATION LOGS

PROJECT NO.: 2014-177-21 FIGURE: A-1

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: 315.00 ± feet
CASING ELEVATION ± feet

DATE STARTED: 1/15/2015
DATE COMPLETED: 1/15/2015
LOGGED BY: T. Hesedahl



Sod.

Very loose to loose, olive brown, silty SAND, with gravel and woody debris, moist.

(FILL)

Large Gravel.

Soft to medium stiff, rust mottled olive gray, sandy SILT jumbled with brown silty SAND, with organics and traces of wood and charcoal fragments, moist.

Loose, red brown, silty SAND, moist.

Loose, dark gray brown, silty SAND, with abundant woody fragments and blackberry vine fragments, moist. Woody odor.

(BURIED TOPSOIL)

Gravels.

Peaty odor.

Loose, dark gray brown, silty SAND, with soft, yellow brown chunks of SILT, moist.

Hand hole terminated at 5.75 feet bgs on large gravel.
No ground water seepage was observed.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

HAND HOLE:
HH- 1

PAGE: 1 of 1

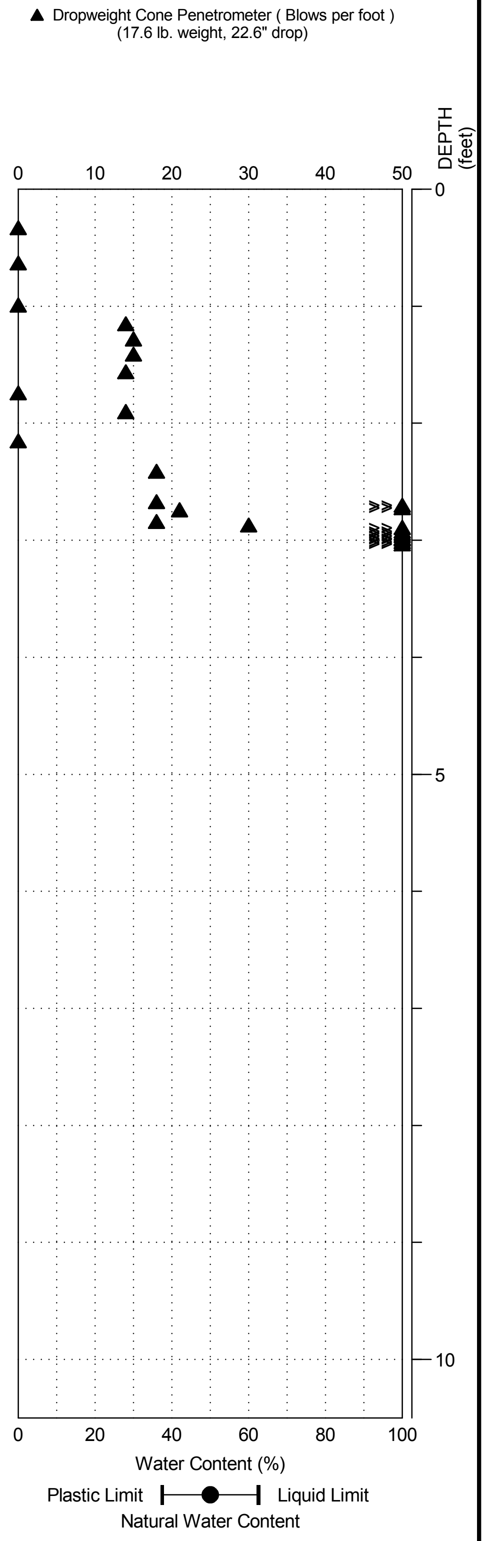
PROJECT NO.: 2014-177-21 FIGURE: A-2

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: 310.00 ± feet
CASING ELEVATION ± feet

DATE STARTED: 1/15/2015
DATE COMPLETED: 1/15/2015
LOGGED BY: T. Hesedahl

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0			Loose, brown, silty, SAND, with gravel and organics, moist. **(TOPSOIL)** **Woven geosynthetic beneath topsoil.**	○	S-1			
		SM	Loose, dark yellow brown, silty SAND, with gravel, moist. **(WEATHERED ADVANCE OUTWASH)**	○	S-2			
			Medium dense to dense, rust mottled yellow brown, silty SAND, with rootlets and gravel, moist. Large gravels.	○	S-3			
		SP SM	Medium dense to dense, olive gray, slightly silty to silty, gravelly, SAND, moist.	○	S-4			
			Hand hole terminated on gravels at 3.25 feet bgs. No ground water seepage was observed.					
5								
10								



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

HAND HOLE:
HH- 2

PAGE: 1 of 1

PROJECT NO.: 2014-177-21 FIGURE: A-3

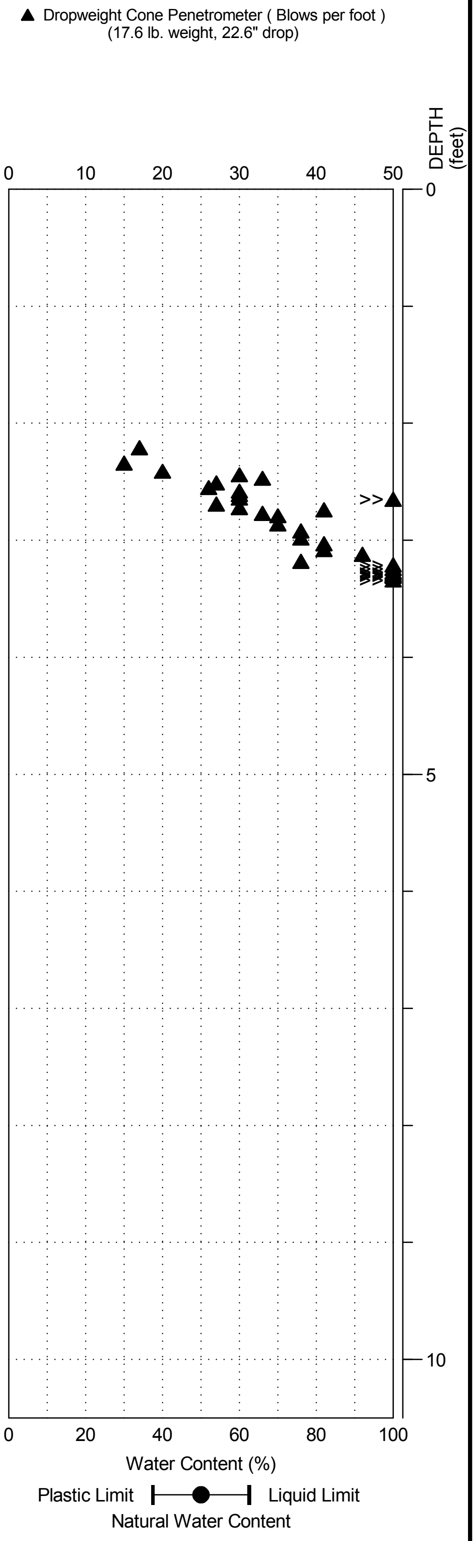
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: 220.00 ± feet
CASING ELEVATION ± feet

DATE STARTED: 1/15/2015
DATE COMPLETED: 1/15/2015
LOGGED BY: T. Hesedahl

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		OL	Very soft, dark brown, ORGANIC SILT, wet. Organic odor. **(ORGANIC SILT)**		S-1			
		SM	Loose, gray, silty SAND, with gravels and dark brown silty pockets, wet. **(COARSE GRAINED ALLUVIUM)** Grades medium dense to dense.		S-2			
5								
10								

Hand hole terminated at 3 feet bgs on gravels.
Ground water at ground surface.



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

HAND HOLE:
HH- 3

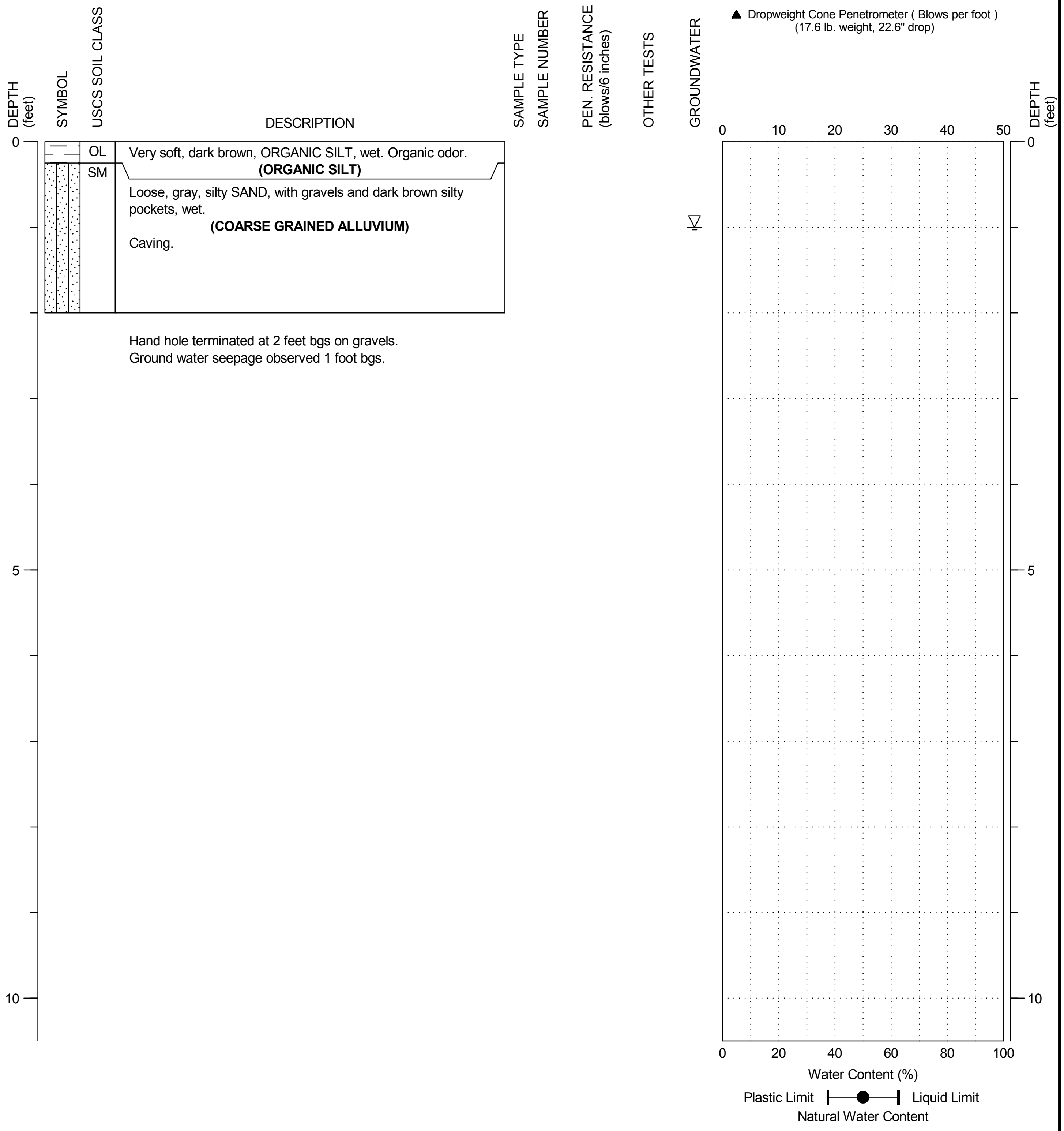
PAGE: 1 of 1

PROJECT NO.: 2014-177-21 FIGURE: A-4

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: 220.00 ± feet
CASING ELEVATION ± feet

DATE STARTED: 1/15/2015
DATE COMPLETED: 1/15/2015
LOGGED BY: T. Hesedahl



OL — Very soft, dark brown, ORGANIC SILT, wet. Organic odor.
(ORGANIC SILT)

SM — Loose, gray, silty SAND, with gravels and dark brown silty pockets, wet.
(COARSE GRAINED ALLUVIUM)
Caving.

Hand hole terminated at 2 feet bgs on gravels.
Ground water seepage observed 1 foot bgs.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

HAND HOLE:
HH- 4

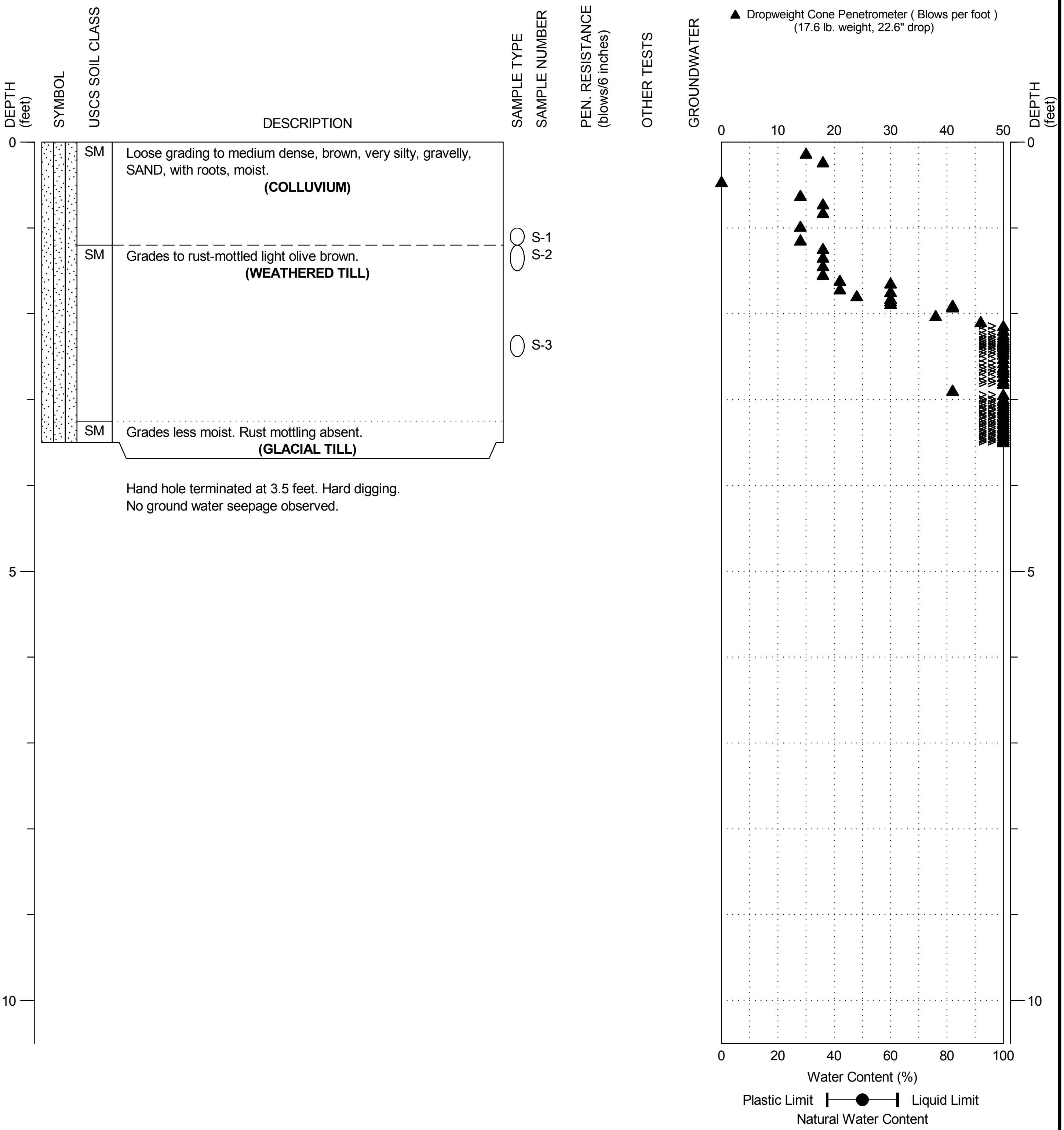
PAGE: 1 of 1

PROJECT NO.: 2014-177-21 FIGURE: A-5

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: 260.00 ± feet
CASING ELEVATION ± feet

DATE STARTED: 1/15/2015
DATE COMPLETED: 1/15/2015
LOGGED BY: T. Hesedahl



SM Loose grading to medium dense, brown, very silty, gravelly, SAND, with roots, moist.
(COLLUVIUM)

SM Grades to rust-mottled light olive brown.
(WEATHERED TILL)

SM Grades less moist. Rust mottling absent.
(GLACIAL TILL)

Hand hole terminated at 3.5 feet. Hard digging.
No ground water seepage observed.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

HAND HOLE:
HH- 5

PAGE: 1 of 1

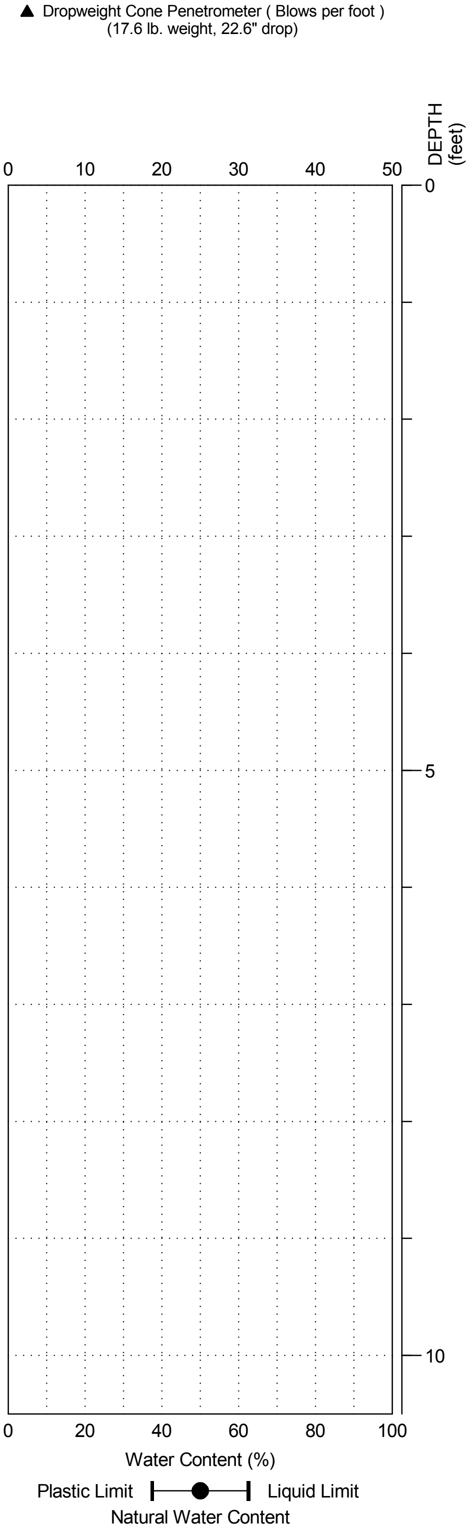
PROJECT NO.: 2014-177-21 FIGURE: A-6

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: 230.00 ± feet
CASING ELEVATION ± feet

DATE STARTED: 1/15/2015
DATE COMPLETED: 1/15/2015
LOGGED BY: T. Hesedahl

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0	▨	SM	Loose, brown, very silty, gravelly, SAND, with roots, moist. **(COLLUVIUM)**					
	▨	SM	Loose, light yellow brown, silty, fine to medium SAND, with scattered gravel, moist. **(WEATHERED TILL)**	○	S-1			
			Grades to medium dense, olive brown, silty, fine to medium SAND, moist.	○	S-2			
			Becomes wet, rust mottled.					
			Hand hole terminated at 4 feet bgs on gravels. Ground water seepage observed at 3 feet bgs.					
5								
10								



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

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Seattle, Washington

HAND HOLE:
HH- 6

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PROJECT NO.: 2014-177-21 FIGURE: A-7

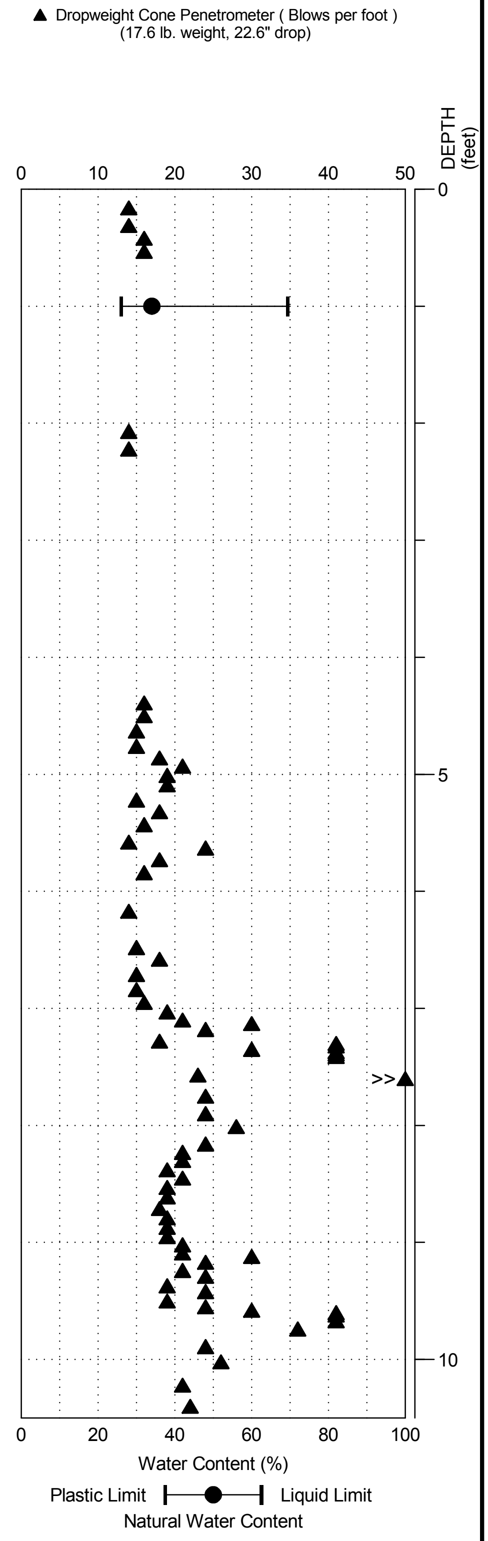
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/16/2018
DATE COMPLETED: 5/16/2018
LOGGED BY: A. York

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0	▨	CH	Very stiff, olive gray, silty CLAY, moist, plastic, with roots and rootlets. **(FILL)**					
				⬯	S-1		AL	
			Becomes gray.	⬯	S-2			
5								
	░	SP SM	Medium dense, brown, slightly silty to clean, fine to medium SAND, moist, with scattered coarse sand and fine gravel. **(ADVANCE OUTWASH)**	⬯	S-3			
			Medium dense, light brown, clean, fine gravelly, fine to medium SAND, moist.	⬯	S-4			
10								

Handhole terminated at 8 feet below ground surface (bgs) due to refusal on gravel.
No ground water seepage encountered.
No caving.



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

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Seattle, Washington

HAND HOLE:
HH- 7

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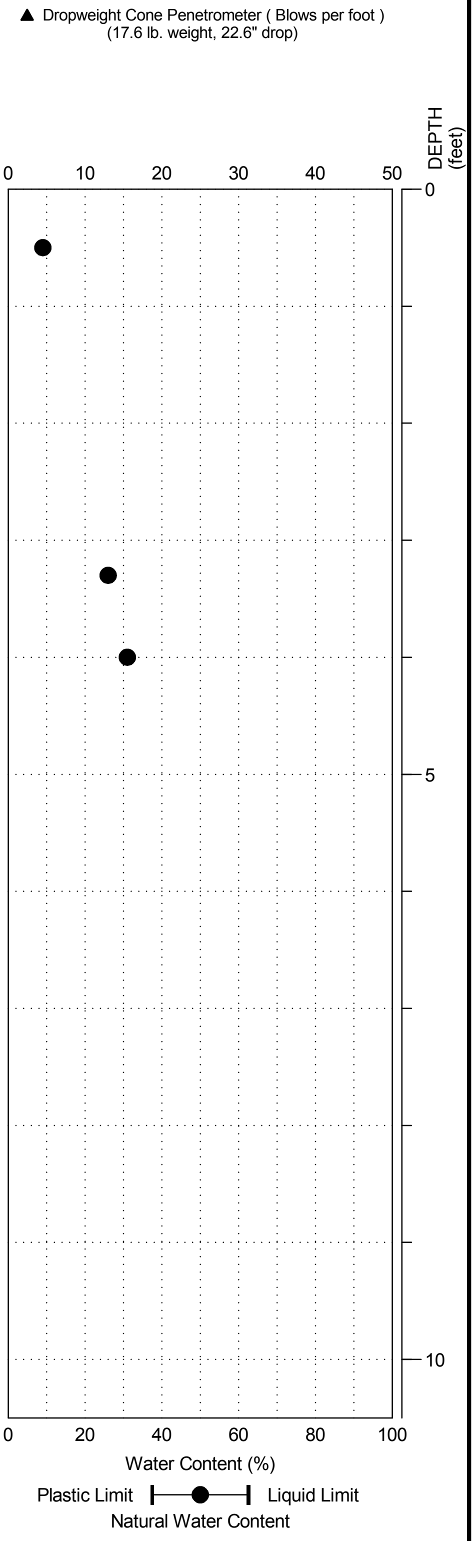
PROJECT NO.: 2014-177-21 FIGURE: A-8

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/16/2018
DATE COMPLETED: 5/16/2018
LOGGED BY: A. York

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		SM	Medium dense, dark brown, slightly silty, fine to coarse gravelly, fine to coarse SAND, moist. Scattered rubble on ground surface and partly buried. **(FILL)**	⬯	S-1		GS	
		SM	Medium dense, brown, silty, fine gravelly, fine to medium SAND, moist	⬯	S-2			
		ML	Medium dense, brown, fine sandy, SILT, moist, with scattered fine gravel.	⬯	S-3			
5		CH	Stiff, gray, silty CLAY, moist, moderately plastic.	⬯	S-4			
		SP	Medium dense, brown, clean, fine gravelly, fine to medium SAND, moist. **(ADVANCE OUTWASH)**	⬯	S-5			
10			Handhole terminated at 9.5 feet below ground surface due to refusal on gravel. No ground water seepage encountered. No caving.					



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

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Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

HAND HOLE:
HH- 8

PAGE: 1 of 1

PROJECT NO.: 2014-177-21 FIGURE: A-9

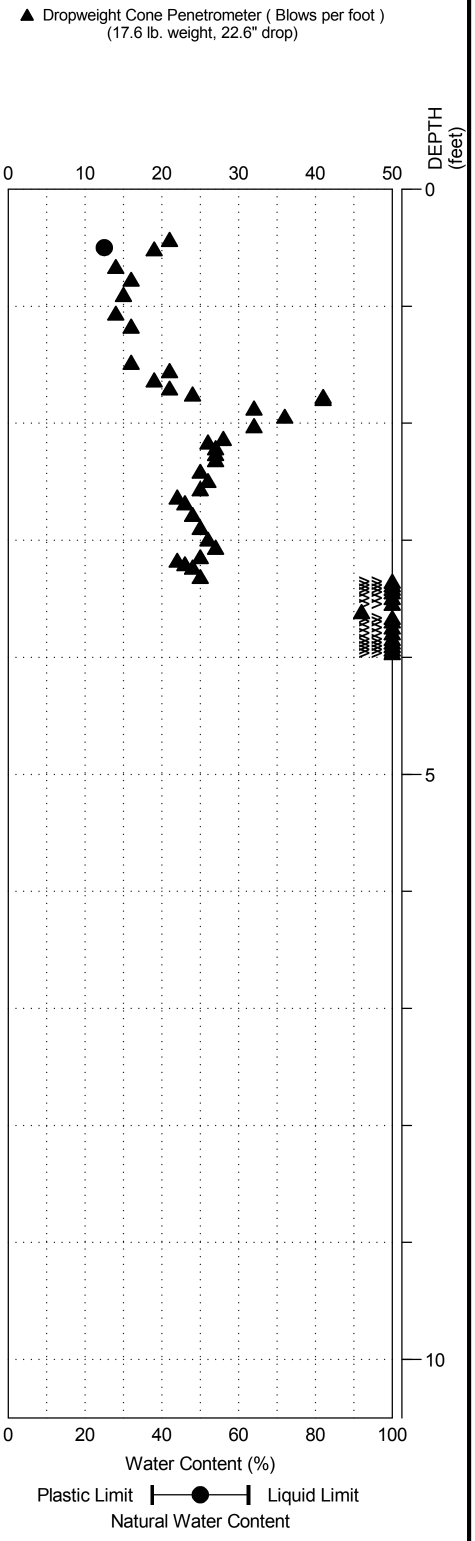
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/16/2018
DATE COMPLETED: 5/16/2018
LOGGED BY: A. York

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		Medium dense, dark brown, fine gravelly, fine sandy, SILT, moist, with roots.					
	CH	Very stiff, grey, silty CLAY, moist, with roots and rootlets. **(FILL)**	⬭	S-1			
	SP	Dense, olive brown, clean, fine gravelly, fine to medium SAND, moist, with scattered coarse gravel. **(ADVANCE OUTWASH)**	⬭	S-2			
			⬭	S-3			

Handhole terminated at 3.8 feet below ground surface (bgs) due to refusal on gravel.
No ground water seepage encountered.
No caving.



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

HAND HOLE:
HH- 9

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PROJECT NO.: 2014-177-21 FIGURE: A-10

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

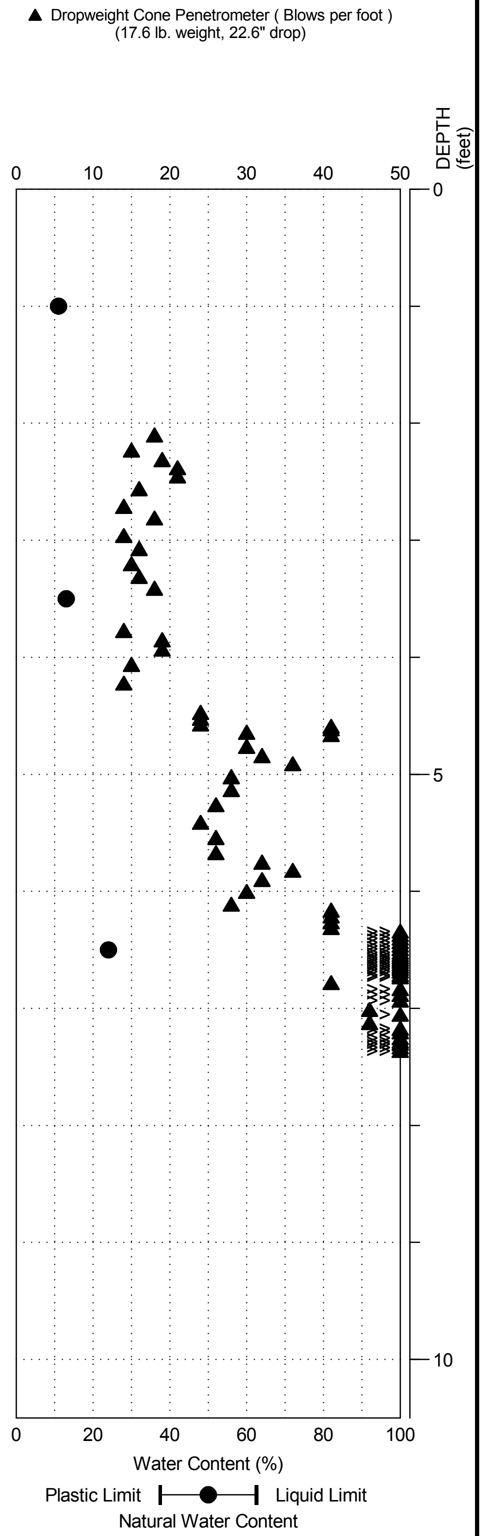
SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/17/2018
DATE COMPLETED: 5/17/2018
LOGGED BY: A. York

USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	OTHER TESTS
SM	Medium dense, brown, silty, gravelly, fine to medium SAND, moist. **(FILL)**	S-1	GS
SM	Medium dense, brown, slightly silty, fine to medium SAND, moist.	S-2	
SM	Medium dense, light olive brown, very silty, fine SAND, moist, with scattered fine gravel and orange mottling. **(COLLUVIUM)**	S-3	
ML	Hard, orangish brown to bluish gray, fine sandy, SILT, moist, with scattered rootlets.	S-4	
SP	Dense, olive brown, clean, fine to medium SAND, moist, with scattered fine gravel. **(ADVANCE OUTWASH)**	S-5	

DEPTH (feet): 0, 5, 10

Handhole terminated at 7.5 feet below ground surface (bgs) due to refusal on gravel.
No ground water seepage encountered.
No caving.



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

HAND HOLE:
HH-10

PAGE: 1 of 1

PROJECT NO.: 2014-177-21 FIGURE: A-11

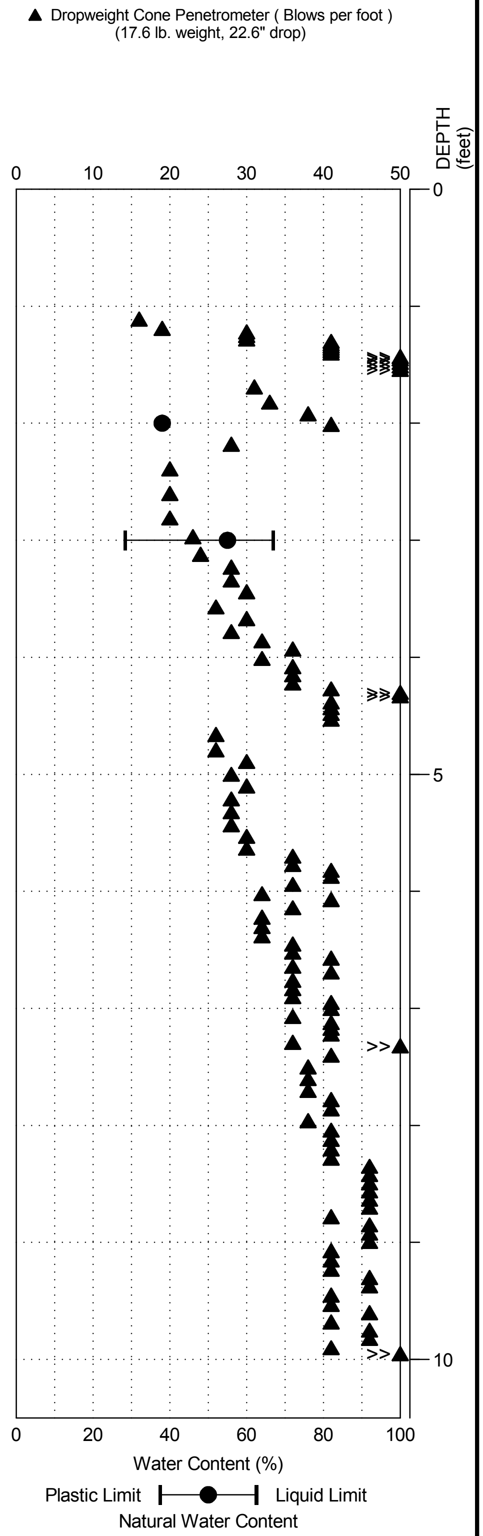
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/17/2018
DATE COMPLETED: 5/17/2018
LOGGED BY: A. York

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	OTHER TESTS	GROUNDWATER
0		Medium dense, dark brown, fine sandy, SILT, moist, with rootlets, large cobble at 1'. **(TOPSOIL)**			
	SM	Medium dense, brown, silty, fine to medium SAND, moist, with scattered fine gravel. **(COLLUVIUM)**	S-1		
	ML	Medium dense, olive gray, fine sandy, SILT, moist, with orange mottling and fine to coarse gravel, sand content decreases at 2.5'.	S-2		
	CH	Hard, light brown, silty CLAY, wet, plastic. **(TRANSITIONAL BEDS)**	S-3	AL	∇
5					
10					

Handhole terminated at 9 feet below ground surface (bgs).
Ground water seepage encountered at 3 feet bgs.
No caving.



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

HAND HOLE:
HH-11

PAGE: 1 of 1

PROJECT NO.: 2014-177-21 FIGURE: A-12

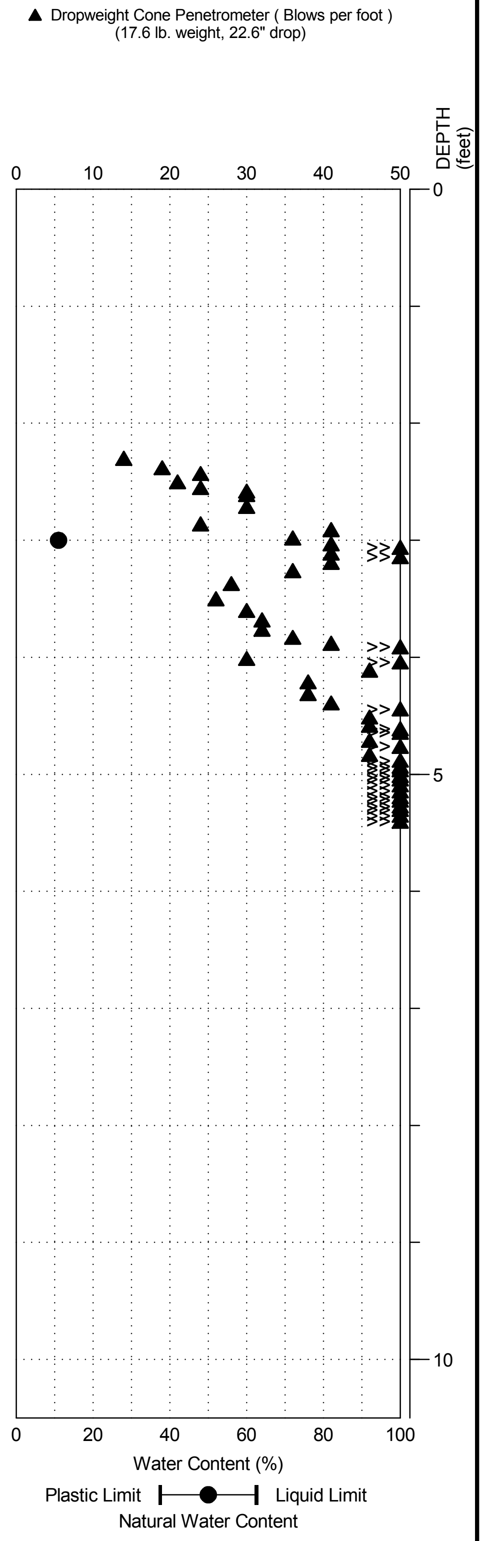
DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/17/2018
DATE COMPLETED: 5/17/2018
LOGGED BY: A. York

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		SM	Medium dense, dark brown, silty, fine SAND, moist, with rootlets and scattered fine to coarse gravel. **(TOPSOIL)**	○	S-1			
		SM	Medium dense to dense, olive brown, silty, gravelly, fine to medium SAND, moist to wet. **(COLLUVIUM)**	○	S-2		GS	
5				○	S-3			
10								

Handhole terminated at 5.3 feet below ground surface (bgs) due to refusal on gravel.
No ground water seepage encountered.
No caving.



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

HAND HOLE:
HH-12

PAGE: 1 of 1

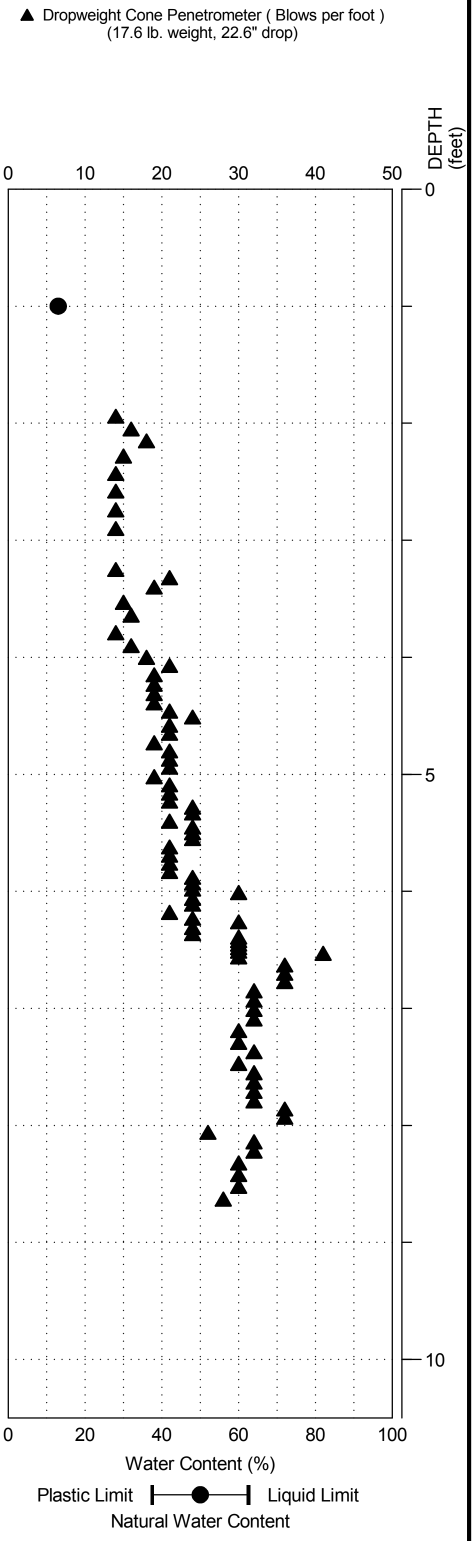
PROJECT NO.: 2014-177-21 FIGURE: A-13

DRILLING COMPANY: HWA GeoSciences Inc.
DRILLING METHOD: Hand Auger
SAMPLING METHOD: Grab
LOCATION: See Figure 2

SURFACE ELEVATION: ± feet
CASING ELEVATION ± feet

DATE STARTED: 5/17/2018
DATE COMPLETED: 5/17/2018
LOGGED BY: A. York

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		Loose, dark brown, silty, fine to medium SAND, moist, with roots and rootlets. **(TOPSOIL)**					
	SM	Loose to medium dense, brown, gravelly, silty, fine to medium SAND, moist, with scattered cobbles and roots. **(COLLUVIUM)**		S-1		GS	
				S-2			
	ML	Medium dense, rust-mottled olive brown, fine sandy, SILT, moist. **(WEATHERED DRIFT)**					
5		Handhole terminated at 4.7 feet below ground surface (bgs) due to refusal on cobbles and roots. No ground water seepage encountered. No caving.					
10							



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

HAND HOLE:
HH-13

PAGE: 1 of 1

PROJECT NO.: 2014-177-21 FIGURE: A-14

APPENDIX B

LABORATORY DATA

EXPLORATION DESIGNATION	TOP DEPTH (feet)	BOTTOM DEPTH (feet)	MOISTURE CONTENT (%)	ORGANIC CONTENT (%)	SPECIFIC GRAVITY	ATTERBERG LIMITS (%)			% GRAVEL	% SAND	% FINES	ASTM SOIL CLASSIFICATION	SAMPLE DESCRIPTION
						LL	PL	PI					
HH- 7,S-1	1.0	1.5	34.1			69	26	43				CH	Gray, fat CLAY
HH- 8,S-1	0.5	1.0	9.4						51.0	43.5	5.5	GP-GM	Very dark brown, poorly graded GRAVEL with silt and sand
HH- 8,S-3	3.3	3.8	26.2									ML	Olive-brown, SILT with sand
HH- 8,S-4	4.0	4.5	30.8									CL	Grayish-brown, lean CLAY
HH- 9,S-1	0.5	1.0	25.5									CL	Grayish-brown, lean CLAY
HH-10,S-1	1.0	1.5	10.8						35.1	46.3	18.6	SM	Yellowish-brown, silty SAND with gravel
HH-10,S-2	3.5	4.0	12.7									SM	Dark yellowish-brown, silty SAND with gravel
HH-10,S-4	6.5	7.0	23.9									ML	Yellowish-brown, sandy SILT
HH-11,S-2	2.0	2.5	37.7									ML	Olive-brown, SILT
HH-11,S-3	3.0	3.5	55.1			67	28	39				CH	Yellowish-brown, fat CLAY with sand
HH-12,S-2	3.0	3.5	11.5						33.7	53.5	12.8	SM	Olive-brown, silty SAND with gravel
HH-13,S-1	1.0	1.5	13.4						13.4	57.1	29.5	SM	Dark yellowish-brown, silty SAND

Notes:
1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report test, other graphs and tables, and the exploration logs.
2. The soil classifications in this table are based on ASTM D2487 and D2488 as applicable.

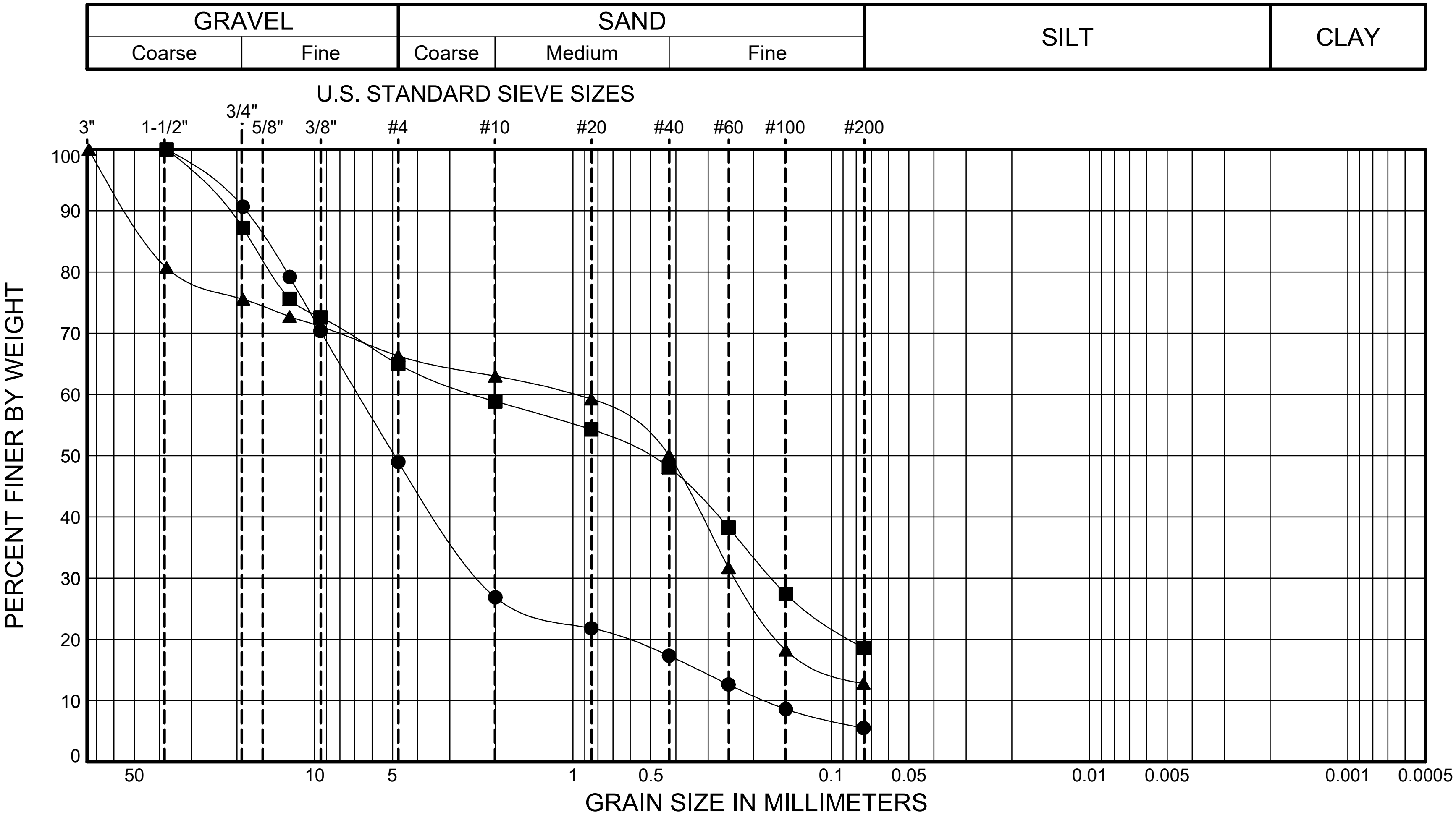
HWA GEOSCIENCES INC.

Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

SUMMARY OF MATERIAL PROPERTIES

PAGE: 1 of 1

PROJECT NO.: 2014-177-21 FIGURE: B-1



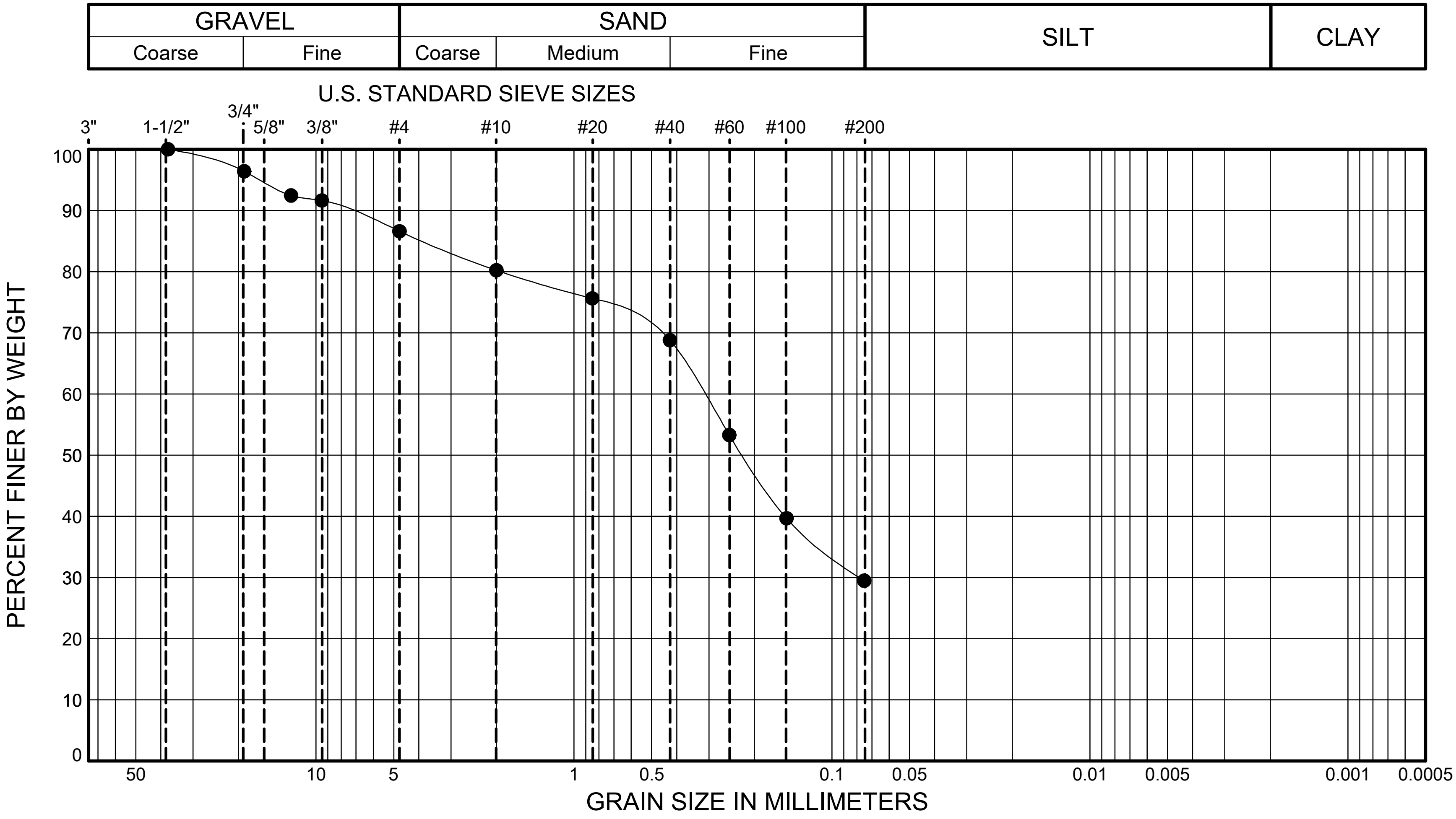
SYMBOL	SAMPLE		DEPTH (ft.)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	HH- 8	S-1	0.5 - 1.0	(GP-GM) Very dark brown, poorly graded GRAVEL with silt and sand	9				51.0	43.5	5.5
■	HH-10	S-1	1.0 - 1.5	(SM) Yellowish-brown, silty SAND with gravel	11				35.1	46.3	18.6
▲	HH-12	S-2	3.0 - 3.5	(SM) Olive-brown, silty SAND with gravel	11				33.7	53.5	12.8

HWA GEOSCIENCES INC.

Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

PARTICLE-SIZE ANALYSIS OF SOILS METHOD ASTM D6913

PROJECT NO.: 2014-177-21 FIGURE: B-2



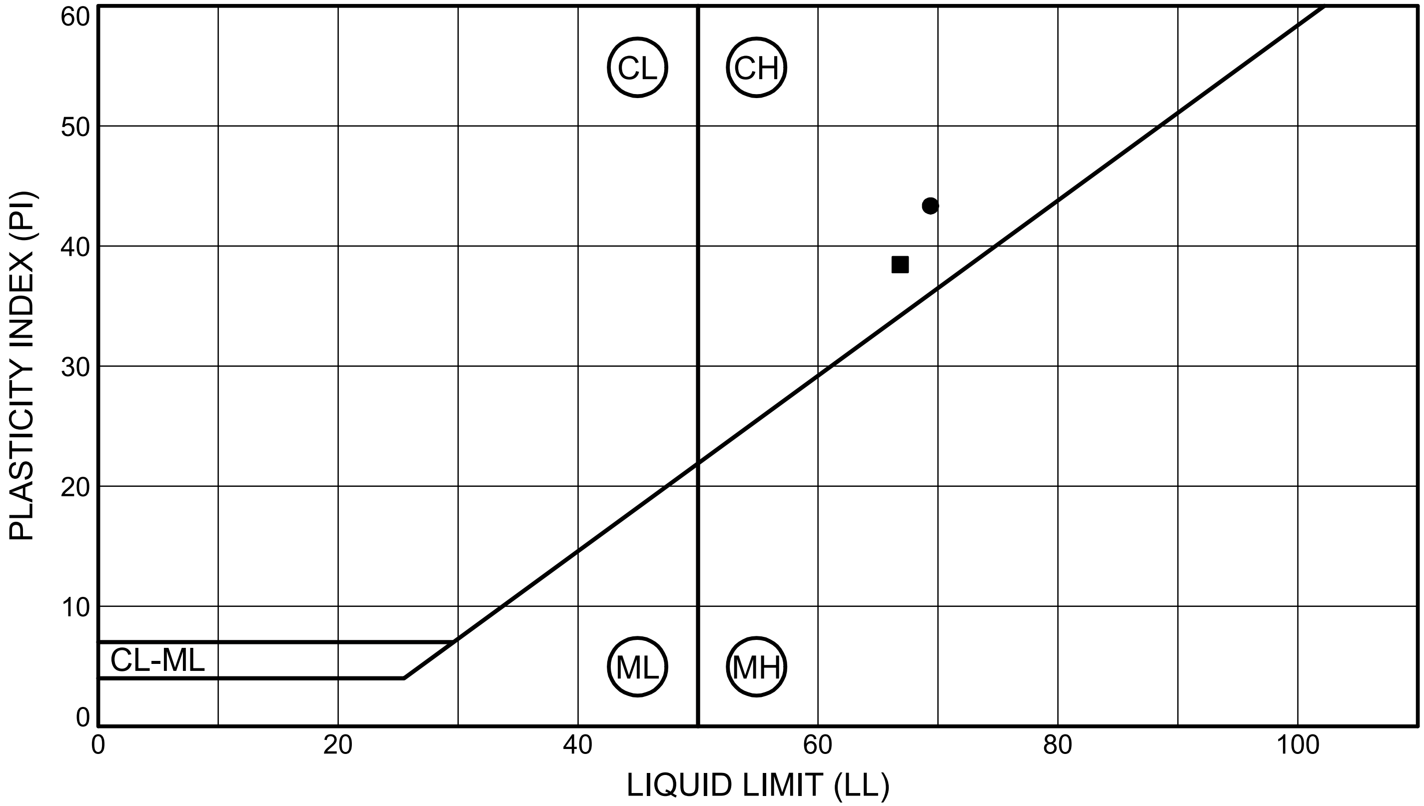
SYMBOL	SAMPLE		DEPTH (ft.)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	LL	PL	PI	Gravel %	Sand %	Fines %
●	HH-13	S-1	1.0 - 1.5	(SM) Dark yellowish-brown, silty SAND	13				13.4	57.1	29.5

HWA GEOSCIENCES INC.

Cheasty Greenspace Mountain Bike Trail
Seattle, Washington

PARTICLE-SIZE ANALYSIS OF SOILS
METHOD ASTM D6913

PROJECT NO.: 2014-177-21 FIGURE: B-3



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION	% MC	LL	PL	PI	% Fines
●	HH- 7	S-1	1.0 - 1.5	(CH) Gray, fat CLAY	34	69	26	43	
■	HH-11	S-3	3.0 - 3.5	(CH) Yellowish-brown, fat CLAY with sand	55	67	28	39	

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS METHOD ASTM D4318

PROJECT NO.: 2014-177-21 FIGURE: B-4