Geotechnical Engineering Report

Smokey Point Transit Center
Smokey Point Boulevard & Smokey Point Drive
Arlington, Washington
22 March 2012
Terracon Project No. 81105040

Prepared for:
Perteet, Inc
Everett, Washington

Prepared by:
Terracon Consultants, Inc.
Mountlake Terrace, Washington

Terracon

22 March 2012

Perteet, Inc.
2707 Colby Avenue, Suite 900
Everett, Washington 98201

Attention: Mr. Darrell Smith, PE

Subject: Geotechnical Engineering Report
Smokey Point Transit Center
Smokey Point Boulevard & Smokey Point Drive
Arlington, Washington
Terracon Project Number: 81105040

Dear Mr. Smith:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above-referenced project. This study was performed in general accordance with *Agreement Supplement No. 2*, dated 6 April 2010, under our consulting agreement for Community Transit dated 31 October 2007. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, concrete slabs and surface water infiltration system for the proposed project. This report supplements our draft report dated 15 July 2010.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

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Geotechnical ■ Environmental ■ Construction Materials ■ Facilities

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EXECUTIVE SUMMARY

The geotechnical evaluation has been completed for the proposed Smokey Point Transit Center located at the intersection of Smokey Point Boulevard and Smokey Point Drive in Arlington, Washington. Ten (10) test pit explorations, designated TP-1 through TP-10, were completed to depths ranging from approximately 8.5 to 9 feet below the existing ground surface. Three (3) borings, designated B-1 through B-3, were advanced to a depth of 24 feet.

Based on the information obtained from the subsurface exploration, laboratory testing, and our analysis, construction of the proposed project is feasible from the geotechnical perspective. The following geotechnical considerations were identified:

- **Subsurface Conditions:** The typical native soil profile at the exploration locations includes an 8 to 12-inch thick organic topsoil horizon mantling recessional outwash sand with secondary silt and gravel; up to 2 feet of uncontrolled silty sand fill material with organics was observed as well. Groundwater was encountered at depths of about 5.5 to 7.5 feet below existing grade in the test pits and borings at the time of field exploration and at slightly shallower depths in the monitoring wells on subsequent dates. Native non-organic soils are suitable for use as engineered fill beneath foundations, floor slabs, and pavement areas provided that soil moisture conditions at the time of construction are such that adequate compaction can be achieved.

- **Seismic Site Classification:** The 2009 International Building Code (IBC) Table 1613.5.2 seismic site classification for this site is F based on liquefaction potential. Structures may be designed for ground motions referenced to a Site Class D (see report text).

- **Foundations:** Conventional spread footings will provide adequate support for the proposed comfort station and sound walls provided that the foundation subgrades are properly prepared. Foundation support for the building may be obtained from either the native, non-organic sand or from new engineered fill. The upper 1 foot of all foundation subgrades should be moisture conditioned, as necessary, and compacted to a firm and non-yielding condition and to at least 95 percent of the modified Proctor maximum dry density per ASTM D 1557.

- **Concrete Slabs:** Concrete slabs for the shelters and comfort station may be supported by either the native, non-organic sand and gravelly sand or from new engineered fill. The upper 1 foot of slab subgrades should be moisture conditioned, as necessary, and compacted to a firm and non-yielding condition and to at least 95 percent of the modified Proctor maximum dry density per ASTM D 1557. Slab design should include a 4-inch minimum thickness capillary break if moisture intrusion into the structure should be avoided.

- **Pavement Sections:** Laboratory testing of the shallow silty sand soils yielded a CBR value of 10. Our recommended pavement section for bus traffic areas consists of 9 inches of Portland cement concrete above 6 inches of compacted crushed aggregate base.

- **Surface Water Infiltration:** On-site surface water infiltration is feasible from the geotechnical engineering perspective. The groundwater mounding analysis completed for this evaluation indicates that a groundwater mound that would develop under the proposed infiltration pond would rise only about 1 foot above the seasonal high groundwater elevation during the design inflow event.

- Close monitoring of the construction operations discussed herein will be critical in achieving the design subgrade support. We therefore recommend that the Terracon be retained to monitor this portion of the work.

- This geotechnical executive summary should be used in conjunction with the entire report for design and/or construction purposes. It should be recognized that specific details were not included or fully developed in this summary, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **General Comments** should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
SMOKEY POINT TRANSIT CENTER
SMOKEY POINT BOULEVARD & SMOKEY POINT DRIVE
ARLINGTON, WASHINGTON

Terracon Project No. 81105040

22 March 2012

1.0 INTRODUCTION

The geotechnical engineering exploration and analysis has been completed for the proposed Smokey Point Transit Center in Arlington, Washington. Ten test pits and three borings were completed to depths ranging from approximately 8.5 to 24 feet below the existing ground surface to evaluate subsurface conditions. Logs of the explorations along with the Site and Exploration Plan are included in Appendix A of this report.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- earthwork
- pavement recommendations
- foundation design and construction
- floor slab design and construction
- seismic considerations
- surface water infiltration

2.0 PROJECT INFORMATION

2.1 Project Description

We understand the project will consist of a new park and ride lot including standard Community Transit (CT) shelters with bus loading from a pull-out lane on the south side of Smokey Point Drive. At this time the proposed improvements to the site include concrete pavements, standard Community Transit shelters, an operator comfort station, light standards and possibly sound barrier walls. The project is also expected to employ on-site infiltration of surface water.

ITEM	DESCRIPTION
Site features	See Appendix A, Exhibit A-1: Site and Exploration Plan
Structures	The project is expected to include standard CT shelters and an operator comfort station. Sound walls may be included.
Structure construction	Operator comfort station: slab-on-grade concrete floor and wood framing (Assumed). Sound walls: CMU (Assumed)

ITEM	DESCRIPTION
Finished floor elevation	Comfort station: Within about 1 foot of existing grade (Assumed).
Maximum loads	Comfort station: Columns: No columns (Assumed) Walls: 3 klf (Assumed) Slabs: 150 psf max (Assumed)
Maximum allowable settlement	1 inch (Assumed)
Maximum allowable differential settlement	Less than ¾-inch. (Assumed)
Grading	Grading plans were not available at the time this report was prepared. However, given the relatively level nature of the site, cuts and fills are anticipated to be less than 2 feet.
Cut and fill slopes	3H:1V cut slopes for infiltration facility.
Free-standing retaining walls	No information regarding sound wall height was available at the time this report was prepared.
Below grade areas	Standard service utilities and storm water infiltration system.
Traffic Loading	Light passenger vehicles and loaded transit buses.

2.2 Site Location and Description

The project site is located at the southwest quadrant of the Smokey Point Boulevard and Smokey Point Drive intersection in Arlington, Washington. The site is located immediately south of the existing CT Transit Center, which includes a bus staging area and operator restroom structure. The site is bordered to the east by Smokey Point Boulevard, to the north by Smokey Point Drive, to the west by a Stillaguamish Tribal school/office structure and parking lot and to the south by a restaurant, day-care building and parking lot. The site has approximate dimensions of 86 feet (north-south) by 496 feet (east-west). The site is shown on the Site and Exploration Plan, Exhibit A-1.

2.2.1 Surface Conditions

The site comprises a vacant lot that is relatively level and generally grass covered. According to a preliminary survey prepared by Perteet, Inc., ground surface elevations over most of the site range from 126 to 128 feet. A gravel covered area used for overflow parking for the building to the north is located at the northeast site area. Landscape shrubbery was noted along the east and central areas of the south property perimeter. Chain-link type fencing borders the west, southwest and northwest site area. Several informal pedestrian paths cross the site to the retail area to the south and bus stop at the southeast. Limited surficial debris with asphalt was observed at the northwest site area. We observed minor standing water in isolated low spots during one of our site visits following a substantial rain event.

ITEM	DESCRIPTION
Location	The project is located at the southwest quadrant of the Smokey Point Boulevard and Smokey Point Drive intersection. Refer to Site and Exploration Plan, Exhibit A-1.
Existing site features (site interior)	The site is undeveloped with the exception of a gravel-surfaced parking area at the northeast.
Surrounding developments	North: Smokey Point Drive East: Smokey Point Boulevard South: Commercial West: Commercial
Current ground cover	Primarily scattered grass and brush.
Existing topography	Relatively level with ground surface elevations ranging from 126 to 128 feet.

3.0 SUBSURFACE CONDITIONS

3.1 Site Geology

The publication *Geologic Map of the Marysville Quadrangle, Snohomish County, Washington* (USGS Map MF-1743, 1985) describes that the site is underlain by the Marysville Sand Member of the Recessional Outwash. The publication describes the deposit as well-drained, stratified to massive outwash sand with some fine gravel and some areas of silt and clay. The native soils observed in our explorations are consistent with the mapped geologic unit.

3.2 Subsurface Conditions

The subsurface exploration program completed for this study included advancing three hollow stem auger borings (B-1, B-2, and B-3) and ten backhoe excavated test pits (TP-1 through TP-10). Groundwater observation wells were installed at the three boring locations. Approximate locations of the borings and test pits are shown on Exhibit A-1. All three borings were completed to a depth of about 24 feet below the existing ground surface. The test pits were advanced to 8.5 to 9 feet in depth. Details of the field exploration program completed for this study, along with the exploration logs, are presented in Appendix A. Details of the preliminary laboratory testing program and the results of the laboratory tests are presented in Appendix B and on the logs in Appendix A as appropriate.

The soil descriptions presented below have been generalized for ease of report interpretation. Please refer to the boring and test pit logs for detailed soil descriptions at the exploration locations. Variations in subsurface conditions may exist between the exploration locations and the nature and extent of variations between the explorations may not become evident until construction. If variations then appear, it may be necessary to reevaluate the recommendations of this report.

The subsurface soil conditions disclosed in our explorations were relatively consistent with respect to soil type and density in the upper native soil horizons. Four of the test pits disclosed about 8 to 12 inches of topsoil over native silty sand and sand deposits. The topsoil typically consisted of loose silty sand with organics, some fine roots and trace gravel. Six of the ten test pits encountered loose fill soils underlying the topsoil or mixed with the topsoil to depths up to about 2 feet. The fill consisted of loose silty sand with organics and abundant roots.

The underlying native deposits typically consisted of loose grading to medium dense sand with varying amounts of silt to approximately 5.5 to 6.5 feet in depth. Trace gravel was encountered in the upper 5.5 to 6.5 feet. Coarser sand with gravel was encountered in the test pits below 5.5 to 6.5 feet to the termination depths of 8.5 to 9 feet. Substantial groundwater seepage and sidewall caving prevented excavation to greater depths.

The three exploratory borings encountered soil conditions similar to the test pits with loose to medium dense sand in the upper 5 feet and medium dense gravelly sand below 5 to 9.5 feet in depth. Boring B-1 disclosed medium dense gravelly sand to the termination depth of 24 feet. Boring B-2 encountered medium stiff to very stiff sandy silt at approximately 17 feet in depth to the termination depth of 24 feet. Boring B-3 encountered interbedded loose silty sand and sandy silt at approximately 16 feet in depth atop medium dense to dense sand at approximately 21 feet which was present to the boring's termination depth of 24 feet.

3.3 Groundwater

Groundwater was observed as rapid seepage at depths from 5.5 to 7.5 feet in test pits TP-1 through TP-10 on 29 April 2010. Groundwater was observed at depths ranging from 6 to 7.5 feet below existing adjacent grade while advancing borings B-1, B-2 and B-3 on 10 May 2010, and at shallower depths in the months following drilling. Groundwater conditions should be expected to fluctuate due to changes in seasonal precipitation, site utilization, and other factors.

Terracon monitored groundwater levels in the three on-site wells from May 2010 to May 2011. Our groundwater level measurements were submitted to Perteet, Inc. in monthly memoranda. Seasonal high and low groundwater measurements for the three wells are summarized in the following table.

Groundwater Observation Summary			
Boring / Well Location	**Approximate ground surface elevation (feet)**	**Seasonal high groundwater depth / elevation (feet) / date**	**Seasonal low groundwater depth / elevation (feet)**
B-1	127.5	5.6 / 121.9 / 20 April 2011	9.13 / 118.37 / 20 October 2010
B-2	126	3.98 / 122.02 / 20 April 2011	7.6 / 118.4 / 20 October 2010
B-3	126	3.72 / 122.28 / 20 April 2011	7.7 / 118.7 / 20 October 2010

Ground surface elevations in Table 1 were estimated by interpolating contours on the site survey. We recommend surveying the well monuments if more precise groundwater elevations are required.

3.4 Environmentally Critical Areas

Based on our site observations and field explorations we have summarized geologic hazards regulated by Arlington Municipal Code (AMC) Chapter 20.88. These include erosion hazard areas, landslide hazard areas, slopes, and seismic hazard areas. The AMC also regulates critical aquifer recharge areas.

Erosion Hazard

AMC 20.88.600 defines an erosion hazard using criteria developed by the USDA Soil Conservation Service, USGS, or Washington State Department of Ecology Coastal Zone Atlas. High erosion hazard areas include rapid surface runoff areas, unstable old slides with steep slopes and unstable recent slides. The Lynnwood soils in the site vicinity possess a slight erosion potential and slow runoff potential according to the USDA and do not meet the AMC criteria for an erosion hazard. Please note the entire site is either level or very gently sloping. The risk of erosion and off-site sediment transport is low, in our opinion, provided the contractor employs erosion control BMPs approved by the City of Arlington.

Landslide Hazard

The project site lacks significant slopes (there is only about 2 feet of relief across the entire site). Consequently, it is our opinion that the site slopes do not meet the criteria for a landslide hazard area as described in AMC 20.88.600.

Steep Slopes

AMC 20.88.600 defines a moderate slope as any slope greater than or equal to 15 percent and less than 33 percent. A steep slope hazard is classified as one with a 33 percent or greater inclination. The site lacks moderate or steep slope hazards.

Seismic Hazards

AMC 20.88.600 defines a seismic hazard area as subject to severe risk of earthquake damage as a result of seismic induced settlement, shaking, slope failure or soil liquefaction. Liquefaction is most commonly associated with cohesionless soils of low density usually in association with a shallow groundwater table. Our analysis indicates that the combined soil and groundwater conditions characteristic of the upper soil conditions of the project site would be susceptible to liquefaction during a seismic event. However, given the nature of the proposed site improvements and the degree of total and differential settlement anticipated during the design seismic event (refer to Section 4.4.3 for our liquefaction analysis), it is our opinion that the risk of "severe" damage is relatively low. AMC 20.88.630 discusses standards for development in seismic hazard areas shall be in accordance with the provisions in the IBC as adopted by the City of Arlington.

Aquifer Recharge Considerations

AMC Part IX, 20.88.930 describes hydrogeologic site evaluation requirements in order to protect public aquifer recharge areas. The site is within a critical aquifer recharge area based upon the use of the upper aquifer (Qvr) in the recessional outwash deposits and the lower aquifer (Qva) in the advance outwash deposits. The upper aquifer (Qvr) is defined as unconfined and perched and the lower aquifer (Qva) is defined as mostly unconfined and also the principal aquifer in terms of use.

The site is within the Marysville Trough and the Quilceda Creek drainage basin. To address items in AMC 20.88.930 we referred to the USGS Water Resources Investigation Report 96-4312, *Groundwater System and Groundwater Quality in Western Snohomish County, Washington.*

The site is underlain by the Marysville Sand Member (Qvrm) of the Recessional Outwash (Qvr). The deposit is generally well-drained, stratified to massive outwash sand with some fine gravel and some areas of silt and clay. The typical thickness of the Qvrm deposits range from approximately 60 to 120 feet.

Based on the USDA classification for the Lynnwood Soil Group, permeability is considered rapid with 6 to 20 inches per hour estimated for the loamy sand and sand site soils. We observed groundwater at depths ranging from 5.5 to 7.5 feet below existing grades when the test pits and borings were completed. The median depth to groundwater for the Qvr aquifer is reported as 10 feet. Boring B-2 encountered sandy silt at a depth of approximately 17 feet, and boring B-3 encountered sandy silt interbeds at approximately 16 feet in depth.

The horizontal hydraulic conductivity for the Marysville Trough of the Qvr aquifer has a median value of 210 feet per day, according to the USGS report. Groundwater flow for the Qvr aquifer in the site area of the Marysville Trough flows northward toward Portage Creek and the Stillaguamish River. The relative sensitivity to contamination for the Qvr aquifer is considered moderate to high. However, it should be noted that the proposed site improvements and the intended site use are considered to offer a low risk of aquifer contamination.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on our subsurface exploration program and associated research, we conclude that the proposed development is feasible from the geotechnical perspective contingent on proper design and construction practices. Based on our analyses, conventional spread footings can be used for the comfort station and sound walls, and slabs-on-grade may be used for the comfort station and shelters. Nonetheless, subgrade improvements appear warranted due to the presence of locally loose granular soils at likely subgrade elevations.

Geotechnical engineering recommendations for foundation systems and other earthwork related phases of the project are outlined below. The recommendations contained in this report are based upon the results of and the field exploration, laboratory testing, engineering analyses, and our current understanding of the proposed project. ASTM and WSDOT specification codes cited herein respectively refer to the current manual published by the American Society for Testing & Materials and the current edition of the *Standard Specifications for Road, Bridge, and Municipal Construction* (Publication M41-10). We also reference the Washington State Department of Ecology 2005 *Stormwater Management Manual for Western Washington (SWM)*.

4.2 Earthwork

The following presents recommendations for site preparation, subgrade preparation and placement of engineered fills on the project. The recommendations presented in this report for design and construction of foundations, slabs, and pavements are contingent upon following the recommendations outlined in this section.

Earthwork on the project should be observed and evaluated by a qualified geotechnical engineer, or their representative. Evaluation of earthwork should include observation and testing of engineered fill, subgrade preparation, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project.

4.2.1 Site Preparation

Preparation for site grading and construction should begin with procedures intended to drain ponded water and control surface water runoff. It will be difficult to successfully utilize on-site soils as "engineered fill" if accumulated water is not drained prior to grading or if drainage is not controlled during construction. Attempting to grade the site without adequate drainage control measures will reduce the amount of on-site soil effectively available for use, increase the amount of import fill materials required, and ultimately increase the cost of the earthwork and foundation construction phases of the project.

Following clearing and grubbing, any organic-rich topsoil will need to be stripped from non-landscaped areas, as well as those areas to receive engineered fill. We observed on the order of 8 to 12 inches of organic-rick topsoil mantling the site. However, variation in these depths should be expected, particularly in the locations where trees with large root masses formerly occupied the site. The topsoil should be removed and should not be reused as structural fill. Localized areas of deeper organics, such as root systems, may be encountered within the project site and should likewise be removed. Any excavations that extend below finish grades should be backfilled with engineered fill as outlined subsequently in this report.

Loose fill material with some organics was observed to depths up to 2 feet at six of the test pit locations. The uncontrolled fill material should be removed as well. This material should be wasted from the site or used only in landscaping areas.

Although evidence of underground facilities such as utilities, septic tanks, or basements was not observed during the field explorations, such features could be encountered during construction. Existing undocumented utilities should be removed from the planned development area, properly capped at the site perimeter, and the trenches should be backfilled in accordance with engineered fill recommendations presented in Section 4.2.3 of this report. If unexpected underground facilities are encountered, such features should be removed and the excavation thoroughly cleaned prior to backfill placement and/or construction.

4.2.2 Subgrade Preparation

After stripping of topsoil and uncontrolled fill, and excavation to design grade is completed, the exposed soils will generally consist of sand with secondary silt and gravel. Prior to placement of engineered fill, we recommend proofrolling to a firm and non-yielding condition foundation areas, floor subgrades, pavement areas, and other areas to receive engineered fill. Soils which appear firm after stripping may be proof-rolled with a heavy compactor, loaded double-axle dump truck, or other heavy equipment under the observation of a qualified geotechnical engineer, or their representative. This observer will assess the subgrade conditions prior to filling. Areas where loose or soft surface soils exist due to grubbing and stripping operations should be compacted to a minimum compaction level of 95 percent of the modified Proctor maximum dry density as determined by the ASTM D 1557 test procedure. If the material cannot be adequately compacted, it should either be moisture conditioned, or removed and replaced to the depth of the disturbance as subsequently recommended for engineered fill. Proofrolling and adequate subgrade compaction can only be achieved when the soils are within approximately ± 2 percent of the optimum moisture content.

4.2.3 Engineered Fill Material Requirements

All fill material placed in building, pavement, and non-landscaped areas should be placed in accordance with the recommendations herein for engineered fill. Prior to placement, the surfaces to receive engineered fill should be prepared as previously described. All engineered fill should be free of organic material, debris, or other deleterious material. Individual particle size should be less than 3 inches in maximum dimension.

The suitability of soils for use as engineered fill depends primarily on the gradation and moisture content of the soil when it is placed. As the amount of fines (that soil fraction passing the US No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult, or impossible, to achieve. Generally, soils containing more than about 5 percent fines by weight (based on that soil fraction passing the US No. 4 sieve) cannot be compacted to a firm, non-yielding condition when the moisture content is more than a few percent from optimum. The optimum moisture content is that which yields the greatest soil density under a given compactive effort.

In general, the on-site soils consist of sand with a relatively low fines content. The fines content of shallow soils tested in our laboratory ranged from about 3 to 7 percent. These soils are considered acceptable for use as engineered fill from a compositional perspective. However, it should be understood that while these soils have a low fines content they should be considered somewhat moisture sensitive and strict control of the soil moisture content will be required to achieve adequate compaction. Selective drying of over-optimum moisture soils may be achieved by scarifying or windrowing surficial materials during extended periods of dry weather. Soils which are dry of optimum may be moistened through the application of water and thorough blending to facilitate a uniform moisture distribution in the soil prior to compaction.

Import soils for use as engineered fill material may consist of “common” or “select” granular material, depending on the weather conditions at the time of placement and the anticipated weather conditions until the fill subgrades are protected. “Select” granular fill is recommended for use in wet weather conditions, and for filling in wet site or trench conditions. “Select” engineered fill should meet the general requirements of Section 9-03.14(1), *Gravel Borrow*, as presented in the *Standard Specifications*. The percent passing the US No. 200 sieve should, however, be modified from the WSDOT specification as follows: For “Class A Select” import fill, less than 5 percent by weight should pass the US No. 200 sieve. For “Class B Select” import fill, no more than 10 percent by weight should pass a US No. 200 sieve. Class A select fill reduces the risk of wet weather delays for filling during the winter and spring months. Class B select fill can be placed and compacted in a wider variety of weather conditions than Common import fill, but introduces a risk of weather related delays. Fills constructed with Class B or

"Common" engineered fill could consist of lesser quality, more moisture-sensitive soils that can be compacted to a firm and non-yielding condition if near the optimum moisture content and at the specified compaction levels. "Common" engineered fill should meet the requirements of Section 9-03.14(3), *Common Borrow*, as presented in the *Standard Specifications.*

The use of other fill types should be reviewed and approved by the engineer. Engineered fill should be placed and compacted in horizontal lifts, using equipment and procedures that will produce recommended moisture content and densities throughout the fill. Fill lifts should not exceed 10 inches in loose thickness.

4.2.4 Compaction Requirements

Engineered fill should be placed in lifts no greater than 10 inches in loose thickness and compacted to a firm and non-yielding condition. Recommended compaction and moisture content criteria for engineered fill materials, including trench backfill, are as follows:

Material Type and Location	Per the Modified Proctor Test (ASTM D 1557)		
	Minimum Compaction Requirement (%)	Range of Moisture Contents for Compaction	
		Minimum	Maximum
Beneath foundations	95	-2%	+2%
Beneath floor slabs	95	-2%	+2%
Beneath pavements:			
Upper 2 feet	95	-2%	+2%
2 feet or more below subgrade	90	-2%	+2%
Crushed aggregate base and subbase (beneath slabs and pavements)	95	-2%	+2%

4.2.5 Grading and Drainage

Positive drainage should be provided during construction and maintained throughout the life of the project. Uncontrolled movement of water into utility trenches or foundation excavations during construction should be prevented. In areas where sidewalks or paving do not immediately adjoin the comfort station, we recommend that protective slopes be provided with a minimum grade of approximately five percent for at least 10 feet from perimeter walls. Downspouts, roof drains or scuppers should discharge into splash blocks or extensions when the ground surface beneath such features is not protected by exterior slabs or paving.

4.2.6 Construction Considerations

It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving equipment.

Depending upon depth of excavation and seasonal conditions, groundwater may be encountered in excavations on the site. Pumping from sumps may be utilized to control water within excavations. Well points may be required for significant groundwater flow, or where excavations penetrate groundwater to a significant depth.

Earthwork may be difficult or impossible during periods of elevated soil moisture and wet weather. Excavated site soils may not be reusable as engineered fill depending on the soil moisture content and weather conditions at the time of construction. If soils are stockpiled for future reuse and wet weather is anticipated, the stockpile should be protected with plastic sheeting that is securely anchored. If on-site soils become unusable, it may become necessary to import clean granular soils to complete wet weather site work.

Subgrade soils that become disturbed due to elevated moisture conditions should be overexcavated to expose firm, non-yielding, non-organic soils and backfilled with compacted engineered fill. We recommend that the earthwork portion of this project be completed during extended periods of dry weather if possible. If earthwork is completed during the wet season (typically November through June) it may be necessary to take extra precautionary measures to protect subgrade soils. Wet season earthwork may require additional mitigative measures beyond that which would be expected during the drier summer and fall months. This could include diversion of surface runoff around exposed soils, draining of ponded water on the site, and collection and rerouting of groundwater seepage from upgradient on- and off-site sources. Once subgrades are established, it may be necessary to protect the exposed subgrade soils from construction traffic. Placing quarry spalls, crushed recycled concrete, or clean pit-run sand and gravel over these areas would further protect the soils from construction traffic.

If earthwork takes place during freezing conditions, we recommend allowing the exposed subgrade to thaw and then recompacting the subgrade prior to placing subsequent lifts of engineered fill.

A qualified geotechnical engineer should be retained during the construction phase of the project to observe earthwork operations and to perform necessary tests and observations during subgrade preparation, placement and compaction of structural fill, backfilling of excavations, and just prior to construction of foundations and floor slabs.

4.2.7 Temporary Excavation Slopes

We recommend that utility trenching, installation, and backfilling conform to all applicable Federal, State, and local regulations such as WISHA and OSHA regulations for open excavations. In order to maintain the function of any existing utilities that may be located near excavations, we recommend that temporary excavations not encroach upon the bearing splay of existing utilities. The bearing splay of structures and utilities should be considered to begin 3 feet away from the widest point of the pipe or foundation and extend downward at a 1H:1V slope. If, due to space constraints, an open excavation cannot be completed without encroaching on a utility, we recommend shoring the new utility excavation with a slip box or other suitable means that provide for protection of workers and that maintain excavation sidewall integrity to the depth of the excavation.

Temporary slope stability is a function of many factors, including the following:

1. The presence and abundance of groundwater;
2. The type and density of the various soil strata;
3. The depth of cut;
4. Surcharge loadings adjacent to the excavation;
5. The length of time the excavation remains open.

It is exceedingly difficult under the variable circumstances to pre-establish a safe and "maintenance-free" temporary cut slope angle. Therefore, it should be the responsibility of the contractor to maintain safe slope configurations since the contractor is continuously at the job site, able to observe the nature and condition of the cut slopes, and able to monitor the subsurface materials and groundwater conditions encountered. It may be necessary to drape temporary slopes with plastic or to otherwise protect the slopes from the elements and minimize sloughing and erosion. We do not recommend vertical slopes or cuts deeper than 4 feet if worker access is necessary. The cuts should be adequately sloped or supported to prevent injury to personnel from local sloughing and spalling. The excavation should conform to applicable Federal, State, and local regulations.

Based upon our review of WAC 296-155-66401 (Appendix A – Soil Classification), we have interpreted the existing loose to medium dense fill and native soils disclosed by the explorations to meet the Type C definition. We observed variable caving of the granular soils at the time the test pits were excavated. The contractor should be prepared to adequately shore or slope all excavations.

4.3 Foundations

Based on our analyses, conventional spread footings will provide adequate support for the proposed comfort station and sound walls provided that the foundation subgrades are properly prepared. Foundation support for the proposed structures may be obtained from either the native, non-organic sands or from new engineered fill placed in accordance with the recommendations provided in this report. The upper 1 foot of all foundation subgrades should be moisture conditioned, as necessary, and compacted to a firm and non-yielding condition and to at least 95 percent of the modified Proctor maximum dry density per ASTM D 1557. Design recommendations for foundations for the proposed structures and related structural elements are presented in the following sections.

4.3.1 Shallow Foundation Design Recommendations

Current plans for the comfort station and sound walls were not available at the time this report was written. Preliminary design recommendations for shallow foundations bearing on compacted non-organic on-site silt soils or engineered fill are presented in the following paragraphs. We should be provided the opportunity to review the plans for the comfort station and sound walls once they have been developed in order to assess the applicability of these recommendations to the design.

DESCRIPTION	Column	Wall
Net allowable bearing pressure [1]	2,000 psf	2,000 psf
Minimum dimensions	24 inches	18 inches
Minimum exterior footing embedment below finished grade for frost protection	12 inches	18 inches
Approximate total settlement [2]	1 inch	1 inch
Estimated differential settlement [2]	1/2 inch	½ inch
Allowable passive pressure [3]	215 psf	
Ultimate coefficient of sliding friction	0.40	

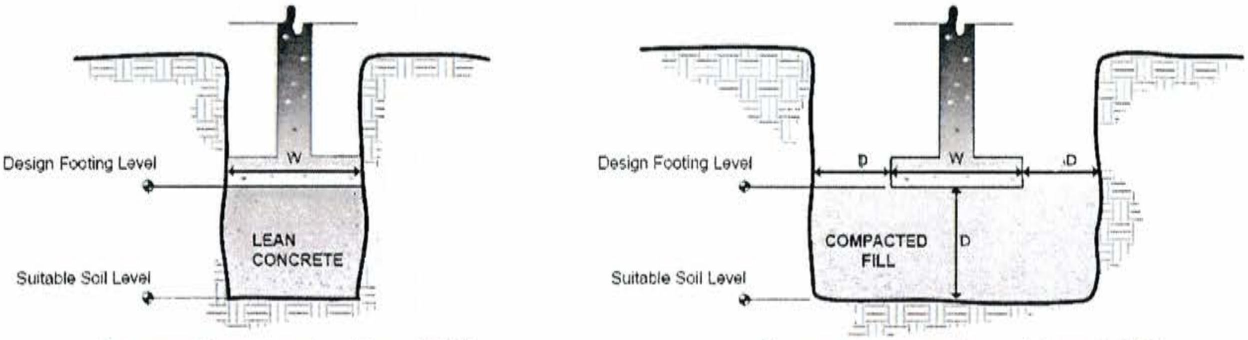
1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. Assumes existing uncontrolled fill, any unsuitable fill or loose native soils, if encountered, will be overexcavated and replaced with engineered fill. Based upon a Factor of Safety of 3.
2. Assumes existing uncontrolled fill, any unsuitable fill or loose native soils, if encountered, will be overexcavated and replaced with engineered fill.
3. Assumed that foundation backfill is compacted in accordance with Section 4.2.4. Based upon a Factor of Safety of 1.5.

The net allowable bearing pressures presented in the table above may be increased by one-third to resist transient, dynamic loads such as wind or seismic forces.

4.3.2 Shallow Foundation Construction Considerations

The base of all foundation excavations should be free of water, loose soil, or debris prior to placing concrete, and should be compacted as recommended in this report. Concrete should be placed soon after excavating and compaction to reduce bearing soil disturbance. Should the soils at bearing level become excessively dry, disturbed, saturated, or frozen, the affected soil should be removed prior to placing concrete. A lean concrete mud-mat should be placed over the bearing soils if the excavations must remain open for an extended period of time. It is recommended that a qualified geotechnical engineer be retained to observe and test the soil foundation bearing materials.

If unsuitable bearing soils are encountered in footing excavations, the excavation should be extended deeper to suitable soils. The footing could bear directly on suitable soils at the lower level or on lean concrete backfill placed in the excavations. As an alternative, the footings could also bear on properly compacted backfill extending down to the suitable soils. Overexcavation for compacted backfill placement below footings should extend laterally beyond all edges of the footings a distance of one foot per foot of overexcavation depth below footing base elevation. The overexcavation should then be backfilled up to the footing base elevation with imported granular material placed in lifts of 10 inches or less in loose thickness and compacted to at least 95 percent of the material's modified Proctor maximum dry density (ASTM D 1557). The overexcavation and backfill procedures are described in the following figure.



Lean Concrete Backfill **Overexcavation / Backfill**

NOTE: Excavations in sketches shown vertical for convenience. Excavations should be sloped as necessary for safety.

4.3.3 Foundation Drains

In our opinion, the comfort station should be provided with permanent drainage system to reduce the risk of future moisture-related problems if moisture-sensitive floor coverings are installed in the building. We offer the following recommendations and comments for drainage design and construction purposes.

We recommend that the building be encircled with a perimeter foundation drain to collect exterior seepage water. The drain should consist of a minimum 4-inch diameter perforated pipe embedded in at least an 12-inch wide envelope of clean, free-draining, washed rock or pea gravel. The free-draining materials should contain less than 5 percent fines, based on that soil fraction passing the US No. 4 sieve. A non-woven filter fabric such as Mirafi 140N, or equivalent, should envelope the free-draining granular material. Ideally, the drain invert should be installed at or slightly below the base of the perimeter footings.

Roof downspouts, parking lot drains, and drains from any other runoff surfaces should not be tied into the perforated piping system of the foundation drains. Instead, the runoff water collected from such sources should be routed through a separate tightline piping system and sent to an appropriate discharge location. Also, final site grades should slope downward away from the building so that runoff water will flow by gravity to suitable collection points, rather than ponding near the foundation walls.

4.4 Seismic Considerations

4.4.1 Tectonic Setting

The tectonic setting of western Washington is dominated by the Cascadia Subduction Zone formed by the Juan de Fuca plate subducting beneath the North American Plate. This setting leads to intraplate, crustal, and interplate earthquake sources. Seismic hazards relate to risks of injury to people and damage to property resulting from these three principle earthquake sources.

4.4.2 Soil Liquefaction

Liquefaction is a phenomenon wherein saturated cohesionless soils build up excess pore water pressures during earthquake loading. Liquefaction typically occurs in loose soils, but may occur in denser soils if the ground shaking is sufficiently strong. We assessed the potential for liquefaction using the simplified procedure originally developed by Seed and Idriss (1971), and updated by Idriss (2004). It is an empirical method based on surficial expressions of soil liquefaction during past earthquakes. The method involves a comparison of earthquake-induced stresses to soil strength at the location and depth of each exploration sample. Soil strength is correlated to the standard penetration resistance blow count, $(N_1)_{60}$, after it has been normalized to an effective overburden pressure of 1 ton per square foot and corrected for drilling/sampling procedures and fines content. Earthquake-induced stresses are estimated with an equation that includes horizontal Peak Ground Acceleration (PGA) at the ground surface and earthquake magnitude as variables.

Our analysis was completed for a design earthquake with a 2,500-year return period, and used a PGA of 0.30g. This PGA value is based on USGS National Seismic Hazard Mapping Project 2006 IBC spectral ordinates and has been factored in accordance with the 2006 International Building Code (IBC) seismic design method. Our analysis used a magnitude of 6.7 based on deaggregated 2002 USGS deaggregated Probabilistic Seismic Hazard Analysis (PSHA) data.

Based on our analyses, zones of liquefied soil are anticipated to develop within some of the looser portions of the sandy site soils during ground shaking from an event with a 2,500-year return period. Based on the conditions encountered in borings B-1 through B-3, it appears that potentially liquefiable zones are laterally and vertically discontinuous due primarily to variations in soil density. Soil liquefaction may be expressed at the ground surface as sand boils, ground cracks, vertical settlements, and lateral displacements. However, given the discontinuous nature of the potentially liquefiable zones and the presence of non-liquefiable soils located above the groundwater table, surficial expression of soil liquefaction such as sand boils and ground cracking may not be observed at the project site.

Ground shaking from an earthquake can result in subsidence of the ground surface and settlement of on-grade supported facilities. Seismic induced settlements tend to be greatest in loose granular soils, and particularly soils which are susceptible to liquefaction. Based on the results of our analyses, we estimate that total vertical settlements on the order of 1 to 3 inches could be experienced at the site during a design earthquake. Differential settlement could approach ½ to 1½ inch over a distance of about 30 feet.

4.4.3 Seismic Design Parameters

As discussed in this report, the site soils are liquefiable; consequently, the 2006 IBC Site Class is F. However, Section 20.3.1 of ASCE 7-05 allows site coefficients F_a and F_v to be determined assuming that liquefaction does not occur for structures with fundamental periods of vibration less than 0.5 second. Based on the results of the field exploration, Site Class D may be used to determine the values of F_a and F_v in accordance with Section 1613.5.2 of the 2006 IBC.

Code Used	Site Classification
2009 International Building Code (IBC) [1]	D [2]
SM_s Spectral Acceleration for a Short Period	1.142 g
SM_1 Spectral Acceleration for a 1-Second Period	0.610 g

1. In general accordance with the *2009 International Building Code,* Table 1613.5.2.
2. The 2009 International Building Code requires a site soil profile determination extending a depth of 100 feet for seismic site classification. The current scope requested does not include the required 100 foot soil profile determination. The borings extended to a maximum depth of approximately 24 feet and this seismic site class definition considers that medium dense alluvial and recessional outwash deposits as noted on the published geologic mapping exist below the maximum depth of the subsurface exploration. Additional exploration to greater depths could be considered to confirm the conditions below the current depth of exploration. Alternatively, a geophysical exploration could be utilized in order to better define the seismic site class.

4.5 Floor and Shelter Slabs

We understand the project will likely include the construction of standard CT shelters and an operator comfort station. Based on our subsurface exploration, the project appears geotechnically feasible using Community Transit standard shelter designs. We reviewed the plans for the comfort stations installed at the Cedar & Grove Park and Ride facility in Marysville. We reviewed the Elevation Drawing No. 5484 for a 12 foot, Non-Ad Low Dome shelter, prepared by Tolar Manufacturing Company, Inc., dated June 20, 2005 and provided by Perteet, Inc. Geotechnical recommendations for the shelter and comfort station slabs are presented below.

Cast-in-place concrete slabs for the proposed comfort station and shelters may be supported on either the native, non-organic sands or on new engineered fill placed in accordance with the recommendations provided in this report. The upper 1 foot of slab subgrades should be moisture conditioned, as necessary, and compacted to a firm and non-yielding condition and to at least 95 percent of the modified Proctor maximum dry density per ASTM D 1557. Design recommendations for slabs are presented in the following sections.

4.5.1 Design Recommendations

ITEM	DESCRIPTION
Floor slab support [1]	Compacted on-site sands or engineered fill prepared in accordance with this report
Modulus of subgrade reaction	250 pounds per square inch per inch (psi/in) for point loading conditions
Capillary break [2]	Minimum of 4 inches of free draining granular material

1. We recommend subgrades be maintained in a relatively moist condition until slabs are constructed. If the subgrade should become desiccated prior to construction of slabs, the affected material should be removed or the materials scarified, moistened, and recompacted. Upon completion of grading operations in the building areas, care should be taken to maintain the recommended subgrade moisture content and density prior to construction of the building floor slabs.
2. The floor slab design should include a capillary break comprised of a compacted clean, free-draining, coarse sand or fine gravel. Alternatively, a clean angular material such as 5/8-inch crushed rock could be used for this purpose. The capillary break material should contain less than 5 percent fines, based on that soil fraction passing the US No. 4 sieve. Other design considerations such as cold temperatures and condensation development could warrant more extensive design provisions.

The use of a vapor retarder should be considered beneath concrete slabs-on-grade that will be covered with moisture-sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. We recommend using a puncture-resistant proprietary product such as RUFCO 3000B, Vapor Block VB 10, Stego Wrap, or an approved equivalent that is classified as a Class A vapor retarder in accordance with ASTM E 1745. The vapor retarder seams and laps should be sealed with a tape product that is approved by the vapor retarder manufacturer. To avoid puncturing of the vapor retarder, construction equipment should not be allowed to drive over any vapor retarder material. The slab designer and slab contractor should refer to ACI 302 for procedures and cautions regarding the use and placement of a vapor retarder.

4.5.2 Construction Considerations

On most project sites, site grading is generally accomplished early in the construction phase. However, as construction proceeds, the subgrade may be disturbed due to utility excavations, construction traffic, desiccation, rainfall, and other factors. As a result, the floor slab subgrades may become unsuitable for placement of capillary break material and concrete and corrective action may be required.

We recommend the area underlying the floor slab be rough graded and then thoroughly proofrolled with a loaded tandem axle dump truck or heavy vibratory compactor prior to final grading and placement of capillary break material. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the affected material with properly compacted engineered fill. All floor slab subgrade areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to placement of the capillary break material and concrete.

4.6 Pavement Recommendations

At the time that this report was prepared, we were of the understanding that Portland cement concrete (rigid) pavement will be used for areas supporting bus traffic. Detailed traffic loading conditions were not available at the time this report was prepared. Consequently, our recommendations for rigid concrete pavement are based upon site conditions, laboratory testing results, and our experience with other Community Transit projects supporting bus traffic. Traffic projects would be required to provide a concrete pavement section tailored to the use of this facility.

4.6.1 Concrete Pavement

Cement concrete pavement (CCP) design recommendations are based on an assumed modulus of rupture of 580 psi and a minimum compressive strength of 4,000 psi for the concrete. It is our opinion that concrete pavements should be reinforced and have relatively closely spaced control joints on the order of 12 feet maximum. We further recommend that, at a minimum, concrete pavement be reinforced with #3 bars on 15-inch centers, each direction. In both cases, the welded wire and rebar should be terminated a minimum of 1.5 inches from all contraction joints. The recommended concrete pavement section is summarized in the table below.

RECOMMENDED CCP SECTION

Pavement Section	Minimum Thickness (in.)
Cement Concrete Pavement	9
Crushed Aggregate Base	6

4.6.2 Pavement Materials and Construction

The following additional recommendations are provided regarding cement concrete pavement materials and construction.

- Subgrade Preparation: Prior to placement of the pavement section materials (base material and concrete), the subgrade should be prepared as recommended in Site Preparation section of this report. We completed a CBR (California Bearing Ratio) test on a composite sample of the native non-organic granular soils and obtained a CBR value of 10 percent. Pavement section subgrade soils, whether native or fill material, should have a CBR value of at least 10.

- Subgrade Compaction: The subgrade should be compacted to a minimum of 95 percent of the Modified proctor maximum dry density and be firm and unyielding when proof-rolled with a loaded dump truck or other suitable heavy equipment.

- Subgrade Stabilization: When the minimum levels of compaction cannot be achieved due to elevated moisture conditions, we recommend the subgrade soils be aerated and allowed to dry back to within -2 to +2 percent of the optimum moisture content. If this is not possible, we recommend the soils be overexcavated and replaced with structural fill. Overexcavation and replacement could include the use of a geotextile or geogrid depending on the severity of the subgrade condition. The type of geotextile or geogrid would need to be determined at the time of construction. The use of stabilization rock consisting of 2 to 4-inch quarry spalls, ballast, or crushed recycled concrete may also be possible.

- Crushed Aggregate Base Course: We recommend that the crushed aggregate base conform to Section 9-03.9(3), Crushed Surfacing Base Course, as presented in the WSDOT Standard Specifications.

- Crushed Aggregate Base Compaction: All base materials should be compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 1557. We recommend that all subgrade and base courses be proofrolled with a loaded dump truck prior to placing the following lift of material.

4.6.3 Construction and Maintenance Considerations

On most project sites, site grading is generally accomplished early in the construction phase. However, as construction proceeds, the subgrade may be disturbed due to utility excavations, construction traffic, desiccation, or rainfall. As a result, the pavement subgrade may not be suitable for pavement construction later in the construction schedule and corrective action may be required.

The pavement section recommended above was determined based on anticipated post-construction bus traffic loading conditions. The pavement section does not account for heavy construction traffic during the early stages of the development. A partially constructed structural section may be subjected to heavy construction traffic that can result in pavement deterioration and premature failure. Our experience indicates that this pavement construction practice can result in pavements that will not perform as intended. Several alternatives are available to mitigate the impact of heavy construction traffic on the pavement construction. These include using thicker sections to account for the construction traffic, using some method of soil stabilization to improve the support characteristics of the pavement subgrade, or by routing heavy construction traffic around paved areas.

Preventive maintenance should be planned and provided for through an ongoing pavement management program. Preventive maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment. Preventive maintenance consists of both localized maintenance (e.g. crack and joint sealing and patching) and global maintenance (e.g. surface sealing). Preventive maintenance is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements. Prior to implementing any maintenance, additional engineering observation is recommended to determine the type and extent of preventive maintenance.

4.7 Surface Water Infiltration Considerations

We understand that surface water management for the project will be addressed in accordance with the design criteria presented in Ecology's 2005 *Stormwater Management Water Manual for Western Washington* (*Manual*). We understand that the surface water management system will include a combination of porous pavement elements as well as an infiltration facility consisting of a rain garden or infiltration pond. The infiltration facility will be located in the southeastern portion of the site in the vicinity of the boring B-1 location.

Based on the findings of the field exploration, laboratory testing, and preliminary analysis, surface water infiltration appears geotechnically feasible. Geotechnical considerations regarding infiltration system design and construction are presented below.

4.7.1 Infiltration Rate

The performance of field infiltration testing was not in our approved scope of services. The Ecology *Manual* describes the use of ASTM mechanical grain size distribution data to evaluate allowable long-term infiltration rates. Table 3.8 *Alternative Recommended Infiltration Rates based on ASTM Gradation Testing* lists allowable long-term infiltration rates based on studies that correlated receptor soil grain size distribution with actual infiltration system performance. The correlative values are based upon the receptor soil D_{10} values. The D_{10} values for six shallow soil samples collected from the borings and test pits are listed in the table below.

Receptor Soil D_{10} Summary

Exploration / Sample	Approximate sample depth / elevation (feet)	D_{10} (mm)	Factored long-term infiltration rate (inches/hour)
B-1, S-3	5 / 122.5	0.15	2.7
B-1, S-4	7.5 / 120	0.1	2

Receptor Soil D_{10} Summary			
Exploration / Sample	**Approximate sample depth / elevation (feet)**	**D_{10} (mm)**	**Factored long-term infiltration rate (inches/hour)**
B-2, S-2	2.5 / 123.5	0.1	2
B-2, S-2	10/ 116	0.4	9
TP-3, S-3	3 / 124	0.12	2
TP-8, S-3	3 / 123	0.1	2

Based upon the results of the grain size analysis, a long-term design infiltration rate of 2 inches/hour would be appropriate per Table 3.8 of the Ecology *Manual*, in our opinion.

We evaluated the saturated hydraulic conductivity of the six samples listed in the table above based on the grain size testing results and the following equation which is described in the Ecology *Manual*:

$$\log_{10}(K_{sat}) = -1.57 + 1.90D_{10} + 0.015D_{60} -0.013D_{90} -2.08F_{ines}$$

D_{10}, D_{60}, and D_{90} are the grain sizes in millimeters for which 10 percent, 60 percent, and 90 percent, respectively, of a sample are finer and F_{ines} is the soil fraction (by weight) passing the US No. 200 sieve. K_{sat} is in centimeters per second (cm/sec). The saturated hydraulic conductivity of the six samples ranged from 2.47×10^{-2} cm/sec to 1.2×10^{-1} cm/sec. These soils may be considered to have a favorable hydraulic conductivity relative to infiltration.

4.7.2 Groundwater Mounding Analysis

A relatively shallow groundwater condition characterizes the site and vicinity. The Ecology *Manual* requires a minimum 3 foot vertical separation between the bottom of an infiltration facility and the seasonal high groundwater condition. The groundwater measurements recorded for one year following completion of the field exploration are presented in Section 3.3.

Perteet, Inc. has indicated that the surface water infiltration system will consist of a pond constructed in the southeastern corner on of the site. Preliminary plans indicate that the pond may occupy an area with bottom of pond plan dimensions of 40 feet by 35 feet with 2 feet of storage. The side slopes of the pond will be set at a 3H:1V (Horizontal:Vertical) inclination. An overflow structure will be located in the southeastern corner of the pond with the overflow elevation equal to the maximum storage elevation.

The use of on-site infiltration depends on sizing the infiltration system such that the receptor soils below the system can accept the water without water backing up into the system to an unacceptable degree. The development of a groundwater mound, or a localized rise in the local groundwater table, can adversely affect an infiltration system if the mound rises too high. A groundwater mounding analysis was completed for the proposed surface water infiltration system since the observed seasonal high groundwater elevation in the southeastern portion of the site is within the 3 foot zone.

The purpose of the mounding analysis was to evaluate if groundwater mounding below the proposed infiltration system would adversely affect performance of the system. We used the MODRET computer software program to model groundwater mounding below the proposed infiltration system.

The simulations incorporated infiltration facility design information and long-term surface water runoff data provided by Perteet, Inc., subsurface conditions as disclosed by the explorations referenced previously, the results of laboratory testing, and estimates of aquifer hydraulic properties based upon data published by USGS (*The Ground-Water System and Ground-Water Quality in Western Snohomish County, Washington* (Water-Resources Investigations Report 96-4312, 1997) and Terracon site observations.

The groundwater mounding analysis included the following parameters:

System dimensions: We modeled an infiltration pond with plan dimensions of 40 feet by 35 feet as per the configuration shown on the Perteet, Inc. preliminary design described as "Alternative 1". We modeled the pond bottom at elevation 124 feet.

Elevation of effective aquifer base: We modeled the bottom of the outwash sand receptor soils at elevation 103.5 feet or 20.5 feet below the finished pond bottom. This is a conservative value and considers the bottom of the nearest exploratory boring as the bottom of the receptor soils even though a low permeability layer or aquiclude was not encountered.

Elevation of seasonal high groundwater table: 122 feet, based on the seasonal high groundwater condition measured in the monitoring well installed at the boring B-1 location in the southeastern portion of the site. We modeled the system with the theoretical high groundwater condition in order to evaluate the effects of high levels of flow into the infiltration system based upon long duration hydrographs developed by Perteet, Inc.

Elevation of starting water level: 122 feet, the elevation of the measured seasonal high water level in the southeastern portion of the site. Modeling the system with a starting groundwater elevation equivalent to the expected seasonal high is a conservative approach.

Design high water level elevation: 126 feet, the elevation of the bottom of the proposed overflow structure. One focus of the analysis was to verify that a groundwater mound would not rise high enough to overwhelm the overflow structure.

Average effective storage coefficient of soil for unsaturated analysis: 0.09 (based upon published correlations as a function of soil type).

Unsaturated vertical hydraulic conductivity (K_v): We incorporated a value of 4 feet/day, which was derived by factoring the saturated vertical hydraulic conductivity developed from grain size analyses completed on representative soil samples collected from our test borings and Table 3.8 of the Ecology *Manual*, as discussed previously.

Factor of safety for K_v : We did not apply a factor of safety to the vertical hydraulic conductivity value as the values recommended in Table 3.8 of the Ecology *Manual* are long-term rates.

Saturated horizontal hydraulic conductivity: Our scope of services did not include conducting field aquifer tests in order to determine a site-specific horizontal hydraulic conductivity. As such, we referred to data published in the USGS report *The Ground-Water System and Ground-Water Quality in Western Snohomish County, Washington.* Testing of numerous wells that were completed in the local recessional outwash deposits (Marysville Sand) over a broad area yielded an average horizontal hydraulic conductivity of 210 feet/day. The report indicates that aquifer testing completed in a well nearest the project site yielded a horizontal hydraulic conductivity of 92 feet/day. Given the lack of site-specific data, we applied a safety factor of 2 to the USGS data; thus, we used a horizontal hydraulic conductivity value of 46 feet/day in our analysis. Based on our experience with other similar projects in the site vicinity, it is our opinion that this is a conservative approach.

Average effective storage coefficient of the sand receptor soil for saturated analysis: 0.08, based upon published correlations between soil type and storage coefficient.

Average effective storage coefficient of the sand receptor soil: 0.9 as per published correlations.

The analysis indicates that the infiltration system will be able to accommodate the anticipated runoff without creating a groundwater mound sufficiently large enough that groundwater would rise significantly into the infiltration facility. The model indicates that a maximum simulated groundwater rise of approximately 1 foot above the expected seasonal high groundwater level may occur; this would place the mound peak approximately 3 feet below the design high water elevation and the overflow structure. The elevation of the mound decreases with distance away from the infiltration system. Based upon our analysis, it is our opinion that the infiltration system will function adequately relative to the groundwater conditions and the design inflow event.

It would be feasible to reduce the size of the infiltration system compared to the dimensions used in our analysis and still have a functioning system. However, this would increase the elevation of the groundwater mound. Given the potential for site variables that could influence the actual performance of the system, we suggest that consideration be given to incorporating the preliminary dimensions into the final design as a means of reducing the likelihood of excessive groundwater mounding.

4.7.3 Infiltration Facility Construction Considerations

Design and construction of the surface water infiltration system should take into consideration the following:

- Variations in subsurface conditions can affect the infiltration rate of the receptor soils. We recommend that Terracon be provided the opportunity to observe conditions at the proposed infiltration facility location at the time of construction in order to verify that actual conditions are consistent with those considered in our analysis.

- The infiltration rate of the receptor soils will be reduced in the event that fine sediment or organic materials are allowed to accumulate on and within the exposed receptor soils. The use of an infiltration facility as a temporary sedimentation control pond during construction has the potential to substantially alter the infiltration rate of the soils. Use of an infiltration facility as a temporary construction phase sedimentation pond is not recommended. If site conditions are such that this cannot be avoided, it will likely be necessary to excavate the soils below the sedimentation pond bottom that have been contaminated with sediment, organic materials, or other deleterious materials that may reduce the permeability of the granular receptor soils prior to operation of the facility for infiltration purposes. Field testing may be necessary as well in order to verify that the restoration activity has been successful and that the infiltration rate of the receptor soils is consistent with that considered in the analysis.

- Operation of heavy equipment may densify the receptor soils below the infiltration facility. The soils exposed in the bottom of the infiltration facility should not be compacted and we recommend that the contractor not operate equipment directly on the infiltration system subgrade. We recommend completing the excavation down to the infiltration facility subgrade with an excavator working “at arm’s length” as a means of reducing the likelihood of compacting the receptor soil subgrade. It may be necessary to scarify the infiltration facility subgrade to facilitate infiltration in the event that compaction of the receptor soils surface occurs.

4.7.4 Water Quality Considerations

Ecology’s *Manual* requires that the soil below an infiltration facility possess a minimum Cation Exchange Capacity (CEC) value of 5 milliequivalents/100 grams (meq/100g) of dry soil determined in accordance with the USEPA Method 9081 in order to provide adequate *in situ* treatment of water exiting the infiltration system. The CEC values of four shallow soil samples from across the site were determined and the test results are presented in the table below. The tested samples do not meet Ecology’s criteria for the minimum CEC value.

Cation Exchange Capacity Testing Summary		
Exploration / Sample	**Approximate sample depth / elevation (feet)**	**CEC value (meq/100g)**
TP-1, S-3	3 / 124	2.8
TP-4, S-2	3 / 123	1.7
TP-5, S-3	4 / 123	4.0
TP-6, S-2	3 / 123	2.2

The CEC value of a sandy soil can be increased by amending it with organic matter, such as peat moss or compost. Should the decision be made to amend on-site soil to meet the standards presented in Ecology's *Manual*, we recommend that pre-mixed amended soil be imported to the site rather than attempting to mix the soil on site.

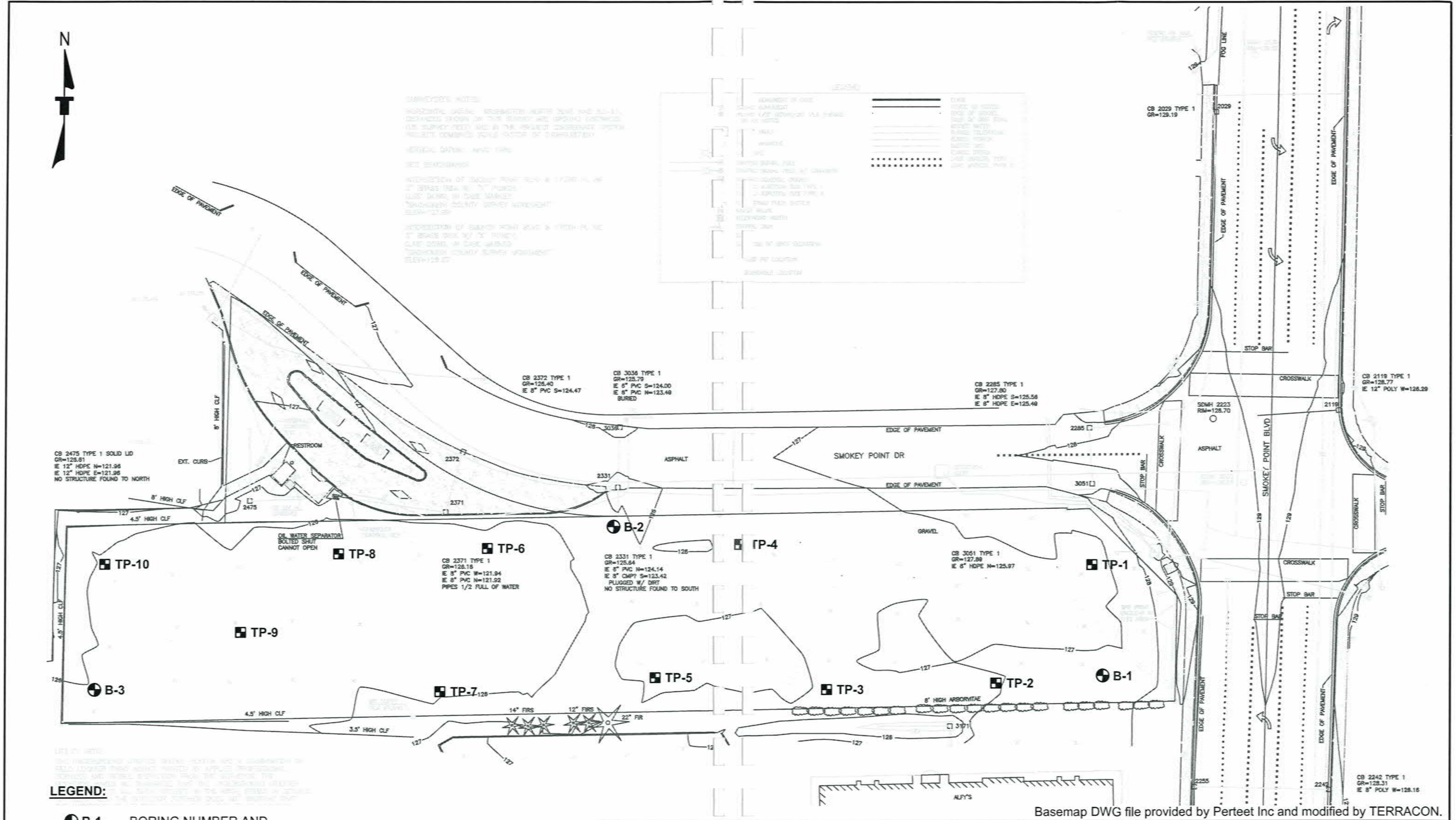
5.0 GENERAL COMMENTS

Terracon should be retained to review the design plans and specifications as they are developed prior to preparation of our final report. A qualified geotechnical engineer should also be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this draft report are based upon the data obtained from the test pits performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between explorations, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This draft report has been prepared for the exclusive use of Perteet, Inc. and Community Transit for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.



Basemap DWG file provided by Perteet Inc and modified by TERRACON.

LEGEND:

◐ B-1	BORING NUMBER AND APPROXIMATE LOCATION
▚ TP-1	TEST PIT NUMBER AND APPROXIMATE LOCATION

40 0 10 20 40
SCALE IN FEET

Project Mngr: DCW	Project No. 81105040	**Terracon** Consulting Engineers and Scientists 21905 64th Avenue W., Ste 100 Mountlake Terrace, WA 98043 PH. (425) 771-3304 FAX. (425) 771-3549	**SITE AND EXPLORATION PLAN**
Drawn By: RMS	Scale: AS S WN		Smokey Point Transit Center Arlington, Washington Prepared For
Checked By: DCW	File No. ExA1.dwg		
Approved By: DCW	Date: Mar 2012		

Ex. No.
A-1

APPENDIX A

FIELD EXPLORATION PROCEDURES AND LOGS

Field Exploration Description

The field exploration included a reconnaissance of surface conditions, completing ten test pits (TP-1 through TP-10), and advancing three borings (B-1 through B-3). Approximate exploration and test pit locations are shown on the Site and Exploration Plan, Exhibit A-1. The locations of the explorations and test pits were determined by measuring distances from existing site features with fiberglass and steel tapes relative to a site plan provided by Perteet, Inc. As such, the exploration locations should be considered accurate to the degree implied by the measurement method. The approximate ground surface elevation at each exploration location was provided by Perteet, Inc. The following sections describe our procedures associated with the exploration. Descriptive logs of the explorations are enclosed in this appendix.

Test Pit Explorations

An independent contractor working under subcontract to Terracon excavated the test pits through the use of a rubber-tired backhoe. An engineering geologist form our firm continuously observed the test pit excavations, logged the subsurface conditions, and obtained representative soil samples. The samples were stored in moisture tight containers and transported to our laboratory for further visual classification and testing.

The enclosed test pit logs indicate the vertical sequence of soils and materials encountered in each test pit, based primarily on our field classifications and supported by our subsequent laboratory testing. Where a soil contact was observed to be gradational or undulating, our logs indicate the average contact depth. We estimated the relative density and consistency of *in situ* soils by means of the excavation characteristics and by the sidewall stability. Our logs also indicate the approximate depths of any sidewall caving or groundwater seepage observed in the test pits, as well as all sample numbers and sampling locations.

Soil Boring Procedures

Exploratory borings B-1 through B-3 were advanced with a hollow stem auger, using a truck-mounted drill rig operated by an independent drilling firm working under subcontract to our firm. An engineering geologist from our firm continuously observed the borings, logged the subsurface conditions encountered, and obtained representative soil samples. All samples were stored in moisture-tight containers and transported to our laboratory for further visual classification and testing.

Throughout the drilling operation, soil samples were obtained at 2.5- to 5-foot depth intervals by means of the Standard Penetration Test (ASTM D 1586). This testing and sampling procedure consists of driving a standard 2-inch outside diameter steel split spoon sampler 18 inches into the soil with a 140-pound hammer free falling 30 inches. The number of blows required to drive the sampler through each 6-inch interval is recorded, and the total number of blows struck during the final 12 inches is recorded as the Standard Penetration Resistance, or "blow count" (N value). If a total of 50 blows is struck within any 6-inch interval, the driving is stopped and the blow count is recorded as 50 blows for the actual penetration distance. The resulting Standard Penetration Resistance values indicate the relative density of granular soils and the relative consistency of cohesive soils.

Groundwater observation wells were installed at each of the boring locations. Each well consisted of a length of slotted 1-inch inside-diameter PVC pipe placed in the bottom of the borehole. A blank PVC riser extended from the lower slotted section to the ground surface. Washed silica sand was utilized to backfill the annular space between the slotted interval and the borehole to allow entry of water into the well, while bentonite clay was used to backfill around the blank riser. A concrete surface seal and metal monument cover were placed at the surface. The groundwater level measured within each observation well subsequent to completion of drilling is discussed in the report text.

The enclosed boring logs describe the vertical sequence of soils and materials encountered in each boring, based primarily upon our field classifications and supported by our subsequent laboratory examination and testing. Where a soil contact was observed to be gradational, our logs indicate the average contact depth. Where a soil type changed between sample intervals, we inferred the contact depth. Our logs also graphically indicate the blow count, sample type, sample number, and approximate depth of each soil sample obtained from the boring, as well as any laboratory tests performed on these soil samples. If any groundwater was encountered in a borehole, the approximate groundwater depth, and date of observation, is depicted on the log. Groundwater depth estimates are typically based on the moisture content of soil samples, the wetted portion of the drilling rods, the water level measured in the borehole after the auger has been extracted, or through the use of an observation well.

BORING LOG NO. B-1

Page 1 of 2

CLIENT
Perteet, Inc.

SITE **Smokey Point Dr. and Smokey Point Blvd.**
Smokey Point, Washington

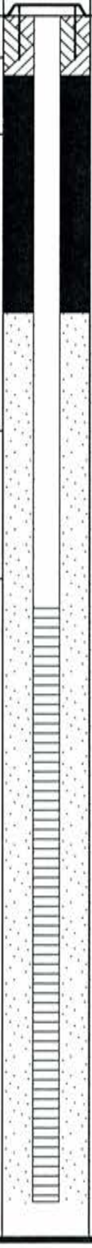
PROJECT
Smokey Point Transit Center

BBA-937
Well Diameter: **1 in**
Approx. Surface Elev.: **127.5 ft**

Depth, ft	DESCRIPTION	Elev., ft
0.7	**SURFACE GRASS AND TOPSOIL**	126.8
2	**SILTY SAND**, with gravel, tan-brown, loose, moist	125.5
7	**SAND**, with silt, brown, loose, moist Grades to trace silt and gravel, brown-gray, medium dense	120.5
9.5	**SAND**, with silt, trace gravel, brown-gray, medium dense, saturated ∇	118
	GRAVELLY SAND, trace silt, gray, medium dense, saturated	

Continued Next Page

WELL DETAIL



USCS SYMBOL	NUMBER	TYPE	RECOVERY, in.	SPT-N BLOWS / ft.	WATER CONTENT, %	UNCONFINED STRENGTH, psf	DRY UNIT WT pcf	
SM	S-1	SS	15	9				
SW	S-2	SS	8	5				
SP	S-3	SS	16	11	7			GSA
SP	S-4	SS	14	16				GSA
SW	S-5	SS	14	25				
SW	S-6	SS	15	30				
SW	S-7	SS	10	15				

DEPTH, ft.: 5, 10, 15, 20

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	∇ 7.5	WD	▼
WL	▼		▼
WL			

Terracon
21905 64th Avenue West, Suite 100
Mountlake Terrace, Washington 98043
T: 425-771-3304 F: 425-771-3549

BORING STARTED			5-10-10
BORING COMPLETED			5-10-10
LOGGED	CRT	CO.	EDI
JOB #	81105040	EXHIBIT	A-4

BORING LOG NO. B-1

Page 2 of 2

CLIENT **Perteet, Inc.**

SITE **Smokey Point Dr. and Smokey Point Blvd.**
Smokey Point, Washington

PROJECT **Smokey Point Transit Center**

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH, ft.	USCS SYMBOL	SAMPLES				TESTS		
					NUMBER	TYPE	RECOVERY, in.	SPT-N BLOWS / ft.	WATER CONTENT, %	UNCONFINED STRENGTH, psf	DRY UNIT WT pcf
⁘	**<u>GRAVELLY SAND</u>**, trace silt, gray, medium dense, saturated	⁘		SW							
⁘		⁘		SW	S-8	SS	14	27			
⁘	24 103.5	⁘									
	End of Exploration at 24 feet. Groundwater observed at 7.5 feet while drilling.										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 7.5	WD	▼
WL	▽		▽
WL			

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BORING STARTED			5-10-10
BORING COMPLETED			5-10-10
LOGGED	CRT	CO.	EDI
JOB #	81105040	EXHIBIT	A-4

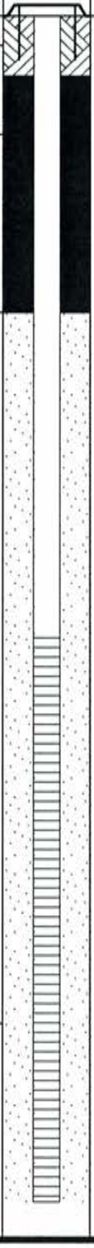
BORING LOG NO. B-2

CLIENT
Perteet, Inc.

SITE **Smokey Point Dr. and Smokey Point Blvd.**
Smokey Point, Washington

PROJECT
Smokey Point Transit Center

BBA-938
Well Diameter: **1 in**
Approx. Surface Elev.: **126 ft**



GRAPHIC LOG	DESCRIPTION	Elev.	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT-N BLOWS / ft.	TESTS WATER CONTENT, %	TESTS UNCONFINED STRENGTH, psf	TESTS DRY UNIT WT pcf	
0.5	**SURFACE GRASS AND TOPSOIL**	125.5		SM	S-1	SS	8	7				
	SILTY SAND, rootlets, gray-brown, loose, moist											
2	**SAND**, with silt, trace gravel, brown, loose to medium dense, moist	124		SW	S-2	SS	13	11	7			GSA
5	**GRAVELLY SAND**, trace silt, brown-gray, medium dense, wet to saturated ▽	121	5	SW	S-3	SS	5	20				
				SW	S-4	SS	13	20				
			10	SW	S-5	SS	12	14				GSA
	Grades to **FINE TO COARSE SAND**, with gravel and trace silt, gray, medium dense, saturated			SW	S-6	SS	12	13				
			15									
17	**SANDY SILT**, gray, medium stiff to very stiff, wet	109		ML	S-7	SS	13	20				
	Continued Next Page		20									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 6.5	WD	▼
WL	▼		▽
WL			

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Mountlake Terrace, Washington 98043
T: 425-771-3304 F: 425-771-3549

BORING STARTED			5-10-10
BORING COMPLETED			5-10-10
LOGGED	CRT	CO.	EDI
JOB #	81105040	EXHIBIT	A-5

BORING LOG NO. B-2

Page 2 of 2

CLIENT
Perteet, Inc.

SITE **Smokey Point Dr. and Smokey Point Blvd.**
Smokey Point, Washington

PROJECT
Smokey Point Transit Center

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH, ft.	USCS SYMBOL	SAMPLES				TESTS		
					NUMBER	TYPE	RECOVERY, in.	SPT-N BLOWS / ft.	WATER CONTENT, %	UNCONFINED STRENGTH, psf	DRY UNIT WT pcf
	SANDY SILT, gray, medium stiff to very stiff, wet										
				ML	S-8	SS	14	8			
24	102										
	End of Exploration at 24 feet. Groundwater observed at 6.5 feet while drilling.										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽ 6.5	WD ▼
WL	▼	▼
WL		

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Mountlake Terrace, Washington 98043
T: 425-771-3304 F: 425-771-3549

BORING STARTED			5-10-10
BORING COMPLETED			5-10-10
LOGGED	CRT	CO.	EDI
JOB #	81105040	EXHIBIT	A-5

TC_WELL_2010 81105040, B-1 TO B-3, WELLS, 5-10-10.GPJ TERRACON.GDT 3/23/12

BORING LOG NO. B-3

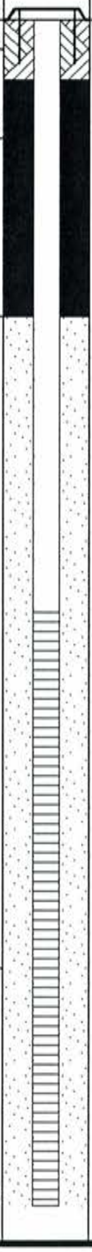
Page 1 of 2

CLIENT
Perteet, Inc.

SITE **Smokey Point Dr. and Smokey Point Blvd.**
Smokey Point, Washington

PROJECT
Smokey Point Transit Center

BBA-939
Well Diameter: **1 in**
Approx. Surface Elev.: **126 ft**



	DESCRIPTION		DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	TYPE	RECOVERY, in.	SPT-N BLOWS / ft.	TESTS WATER CONTENT, %	UNCONFINED STRENGTH, psf	DRY UNIT WT pcf	
0.5	**SURFACE GRASS AND TOPSOIL**	125.5		SM	S-1	SS	12	5				
	SILTY SAND, some organics, roots, orangish brown, loose, moist											
2	**SAND**, with silt, brown, loose, moist	124		SW	S-2	SS	12	9				
5	**SAND**, with gravel, trace silt, brown-gray, medium dense, saturated ▽	121	5	SW	S-3	SS	12	21				
				SW	S-4	SS	13	24				
			10	SW	S-5	SS	13	17				
	Blowcount overstated			SW	S-6	SS	13	53				GSA
			15									
16	**SAND**, trace gravel, with 1/2 inch interbeds of **SILTY SAND, SANDY SILT**, brown-gray, loose, saturated	110										
	Grades to gray			SW	S-7	SS	6	6				
20		106	20									

Continued Next Page

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft	
WL ▽ 6	WD ▼
WL ▼	▼
WL	

Terracon
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Mountlake Terrace, Washington 98043
T: 425-771-3304 F: 425-771-3549

BORING STARTED			5-10-10
BORING COMPLETED			5-10-10
LOGGED	CRT	CO.	EDI
JOB #	81105040	EXHIBIT	A-6

BORING LOG NO. B-3

CLIENT
Perteet, Inc.

SITE **Smokey Point Dr. and Smokey Point Blvd.**
Smokey Point, Washington

PROJECT
Smokey Point Transit Center

GRAPHIC LOG	DESCRIPTION		WELL DETAIL	DEPTH, ft.	USCS SYMBOL	SAMPLES				TESTS			
						NUMBER	TYPE	RECOVERY, in.	SPT-N BLOWS / ft.	WATER CONTENT, %	UNCONFINED STRENGTH, psf	DRY UNIT WT pcf	
21	**SAND**, trace gravel, with 1/2 inch interbeds of **SILTY SAND, SANDY SILT**, gray, loose, saturated	105			SW								
24	**SAND**, trace silt and gravel, gray, medium dense to dense, saturated	102			SW	S-8	SS	12	31				GSA

End of exploration at 24 feet.
Groundwater observed at 6 feet while drilling.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	∇ 6	WD	▼
WL	▼		▼
WL			

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Mountlake Terrace, Washington 98043
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BORING STARTED			5-10-10
BORING COMPLETED			5-10-10
LOGGED	CRT	CO.	EDI
JOB #	81105040	EXHIBIT	A-6

TEST PIT LOG NO. TP-1

Page 1 of 1

CLIENT
Perteet Inc.

SITE **Smokey Point Dr. and Smokey Point Blvd.**
Arlington, Washington

PROJECT
Smokey Point Transit Center

GRAPHIC LOG	DESCRIPTION Approx. Surface Elev.: 127 ft	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES DCP BLOWS / 1.75 in.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, tsf	
	SURFACE GRASS, TOPSOIL 0.7 126.3		SM	S-1	BS						
	SILTY SAND, with rootlets, trace gravel, orangish brown, loose to medium dense, moist 1.5 125.5	1	SM	S-2	BS						
	FINE TO MEDIUM SAND, trace coarse sand, silt, and gravel, brown-gray, loose to medium dense, moist 5.5 121.5	2 3 4 5	SP	S-3	BS						CEC=2.8 meq/100g
	FINE TO MEDIUM SAND, with coarse sand and gravel, trace silt, gray, loose to medium dense, moist ▽	6 7	SP	S-4	BS						
	Grades to **GRAVELLY FINE TO COARSE SAND**, wet to saturated 9 118	8 9	SW	S-5	BS						

Test Pit completed at 9 feet on 4/29/10.
Rapid groundwater seepage at 7.5 feet.
Moderate caving below 5.5 feet.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽ 7.5	WD ▼
WL	▼	▼
WL		

Terracon
21905 64th Avenue West, Suite 100
Mountlake Terrace, Washington 98043
T: 425-771-3304 F: 425-771-3549

TEST PIT STARTED			4-29-10
TEST PIT COMPLETED			4-29-10
LOGGED	CRT	CO. NW Excavating	
JOB #	81105040	EXHIBIT	A-7

TC_HANDAUGER_2010 81105040, TP-1 TO TP-10, 4-29-10.GPJ TERRACON.GDT 3/23/12

TEST PIT LOG NO. TP-2

Page 1 of 1

CLIENT
Perteet Inc.

SITE **Smokey Point Dr. and Smokey Point Blvd.**
Arlington, Washington

PROJECT
Smokey Point Transit Center

GRAPHIC LOG	DESCRIPTION Approx. Surface Elev.: 127 ft	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES DCP BLOWS / 1.75 in.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, tsf	
	SURFACE GRASS, TOPSOIL										
0.7	126.3										
	SILTY SAND, with rootlets, trace gravel, orangish brown, loose to medium dense, moist	1	SM	S-1	BS						
1.8	125.2										
	FINE TO MEDIUM SAND, trace coarse sand, silt, and gravel, brown-gray, loose to medium dense, moist	3	SP	S-2	BS			6			OC=1%
5.5	121.5										
	FINE TO MEDIUM SAND, with coarse sand and gravel, trace silt, gray, loose to medium dense, moist	6	SP	S-3	BS						
	▽ Grades to **GRAVELLY FINE TO COARSE SAND**, wet to saturated	8	SW	S-4	BS						
9	118	9									

Test Pit completed at 9 feet on 4/29/10.
Rapid groundwater seepage at 7.5 feet.
Moderate caving below 4.5 feet.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 7.5	WD	▼
WL	▼		▽
WL			

Terracon
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TEST PIT STARTED			4-29-10
TEST PIT COMPLETED			4-29-10
LOGGED	CRT	CO.	NW Excavating
JOB #	81105040	EXHIBIT	A-8

TEST PIT LOG NO. TP-3

Page 1 of 1

CLIENT **Perteet Inc.**

SITE **Smokey Point Dr. and Smokey Point Blvd.**
Arlington, Washington

PROJECT **Smokey Point Transit Center**

GRAPHIC LOG	DESCRIPTION Approx. Surface Elev.: 127 ft		DEPTH, ft.	USCS SYMBOL	SAMPLES				TESTS			
					NUMBER	TYPE	RECOVERY, in.	DCP BLOWS / 1.75 in.	WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, tsf	
1	**SURFACE GRASS, TOPSOIL** atop **SILTY SAND**, with organics, trace gravel, dark brown, loose, moist (FILL)	126		SM	S-1	BS						
1.8	**SILTY SAND**, with rootlets, trace gravel, orangish brown, loose to medium dense, moist	125.2	1	SM	S-2	BS						
6.5	**FINE TO MEDIUM SAND**, trace coarse sand, silt, and gravel, brown-gray, loose to medium dense, moist	120.5	2 3 4 5 6	SP	S-3	BS			7			OC=1% GSA
9	**FINE TO COARSE SAND**, with gravel, trace silt, gray, loose to medium dense, moist to wet ▽ Grades to **GRAVELLY SAND**, wet to saturated	118	7 8 9	SW	S-4	BS						

Test Pit completed at 9 feet on 4/29/10.
Rapid groundwater seepage at 7.5 feet.
Moderate caving below 5.5 feet.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 7.5	WD	▼
WL	▼		▼
WL			

Terracon
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Mountlake Terrace, Washington 98043
T: 425-771-3304 F: 425-771-3549

TEST PIT STARTED			4-29-10
TEST PIT COMPLETED			4-29-10
LOGGED	CRT	CO.	NW Excavating
JOB #	81105040	EXHIBIT	A-9

TC_HANDAUGER_2010 81105040, TP-1 TO TP-10, 4-29-10.GPJ TERRACON.GDT 3/23/12

TEST PIT LOG NO. TP-4

Page 1 of 1

CLIENT
Perteet Inc.

SITE **Smokey Point Dr. and Smokey Point Blvd.**
Arlington, Washington

PROJECT
Smokey Point Transit Center

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES				TESTS			
				NUMBER	TYPE	RECOVERY, in.	DCP BLOWS / 1.75 in.	WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, tsf	
	Approx. Surface Elev.: 126 ft										
	SURFACE GRASS, TOPSOIL 0.8 125.2										
	SILTY SAND, with rootlets and roots up to 2 inches, trace gravel, orangish brown, loose to medium dense, moist 1.8 124.2	1	SM	S-1	BS						
	FINE TO MEDIUM SAND, trace coarse sand, silt, and gravel, brown-gray, loose to medium dense, moist 6.5 ▽ 119.5	2 3 4 5 6	SP	S-2	BS						CEC=1.7 meq/100g
	FINE TO COARSE SAND, with gravel, trace silt, gray, loose to medium dense, wet to saturated 8.5 117.5	7 8	SW	S-3	BS						
	Test Pit completed at 8.5 feet on 4/29/10. Rapid groundwater seepage at 6.5 feet. Moderate caving below 5 feet.										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 6.5	WD	▼
WL	▼		▼
WL			

Terracon
21905 64th Avenue West, Suite 100
Mountlake Terrace, Washington 98043
T: 425-771-3304 F: 425-771-3549

TEST PIT STARTED			4-29-10
TEST PIT COMPLETED			4-29-10
LOGGED	CRT	CO.	NW Excavating
JOB #	81105040	EXHIBIT	A-10

TC_HANDAUGER_2010 81105040, TP-1 TO TP-10, 4-29-10.GPJ TERRACON.GDT 3/23/12

TEST PIT LOG NO. TP-5

Page 1 of 1

CLIENT
Perteet Inc.

SITE **Smokey Point Dr. and Smokey Point Blvd.**
Arlington, Washington

PROJECT
Smokey Point Transit Center

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	TYPE	RECOVERY, in.	DCP BLOWS / 1.75 in.	TESTS WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, tsf	
	Approx. Surface Elev.: 127 ft										
	SURFACE GRASS, TOPSOIL atop **SILTY SAND**, with organics, trace gravel, dark brown, loose, moist (FILL)	1	SM	S-1	BS						
2											
125											
	SILTY SAND, with rootlets, trace gravel, orangish brown, loose to medium dense, moist	2	SM	S-2	BS						
2.8											
124.2											
	FINE TO MEDIUM SAND, trace coarse sand, silt, and gravel, brown-gray, loose to medium dense, moist	4	SP	S-3	BS						CEC=4.0 meq/100g
6.5	▽										
120.5											
	FINE TO COARSE SAND, with gravel, trace silt, gray, loose to medium dense, wet to saturated	8	SW	S-4	BS						
9											
118											

Test Pit completed at 9 feet on 4/29/10.
Rapid groundwater seepage at 6.5 feet.
Moderate caving below 6 feet.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 6.5	WD	▼
WL	▼		▼
WL			

Terracon
21905 64th Avenue West, Suite 100
Mountlake Terrace, Washington 98043
T: 425-771-3304 F: 425-771-3549

TEST PIT STARTED			4-29-10
TEST PIT COMPLETED			4-29-10
LOGGED	CRT	CO. NW Excavating	
JOB #	81105040	EXHIBIT	A-11

TEST PIT LOG NO. TP-6

Page 1 of 1

CLIENT
Perteet Inc.

SITE **Smokey Point Dr. and Smokey Point Blvd.**
Arlington, Washington

PROJECT
Smokey Point Transit Center

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	 TYPE	 RECOVERY, in.	 DCP BLOWS / 1.75 in.	TESTS WATER CONTENT, %	 DRY UNIT WT pcf	 UNCONFINED STRENGTH, tsf	
	Approx. Surface Elev.: 126 ft										
1	**SURFACE GRASS, TOPSOIL** atop **SILTY SAND**, with organics, trace gravel, dark brown, loose, moist (FILL) 125		SM	S-1	BS						
1.8	**SILTY SAND**, with rootlets, trace gravel, orangish brown, loose to medium dense, moist 124.2										
5.5	**FINE TO MEDIUM SAND**, trace coarse sand, silt, and gravel, brown-gray, loose to medium dense, moist ▽ 120.5	3	SP	S-2	BS						CEC=2.2 meq/100g
8.5	**FINE TO COARSE SAND**, with gravel, trace silt, gray, loose to medium dense, wet to saturated 117.5	7	SW	S-3	BS						

Test Pit completed at 8.5 feet on 4/29/10.
Rapid groundwater seepage at 5.5 feet.
Moderate caving below 5 feet.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 5.5	WD	▼
WL	▼		▽
WL			

Terracon
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Mountlake Terrace, Washington 98043
T: 425-771-3304 F: 425-771-3549

TEST PIT STARTED			4-29-10
TEST PIT COMPLETED			4-29-10
LOGGED	CRT	CO.	NW Excavating
JOB #	81105040	EXHIBIT	A-12

TEST PIT LOG NO. TP-7

Page 1 of 1

CLIENT
Perteet Inc.

SITE **Smokey Point Dr. and Smokey Point Blvd.**
Arlington, Washington

PROJECT
Smokey Point Transit Center

Approx. Surface Elev.: 127 ft

DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES DCP BLOWS / 1.75 in.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, tsf	
SURFACE GRASS, TOPSOIL atop **SILTY SAND**, with organics, trace gravel, dark brown, loose, moist (FILL) — 1 — 126	1									
SILT Y SAND, with rootlets, trace gravel, orangish brown, loose to medium dense, moist — 2 — 125	2	SM	S-1	BS						
FINE TO MEDIUM SAND, trace coarse sand, silt, and gravel, brown-gray, loose to medium dense, moist — 6 — ▽ — 121	3 4 5 6	SP	S-2	BS			8			OC=1%
GRAVELLY FINE TO COARSE SAND, trace silt, gray, loose to medium dense, wet to saturated — 8.5 — 118.5	7 8	SW	S-3	BS						

Test Pit completed at 8.5 feet on 4/29/10.
Rapid groundwater seepage at 6 feet.
Moderate caving below 5.5 feet.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 6.0	WD	▼
WL	▼		▼
WL			

Terracon
21905 64th Avenue West, Suite 100
Mountlake Terrace, Washington 98043
T: 425-771-3304 F: 425-771-3549

TEST PIT STARTED			4-29-10
TEST PIT COMPLETED			4-29-10
LOGGED	CRT	CO. NW Excavating	
JOB #	81105040	EXHIBIT	A-13

TC_HANDAUGER_2010 81105040, TP-1 TO TP-10, 4-29-10.GPJ TERRACON.GDT 3/23/12

TEST PIT LOG NO. TP-8

Page 1 of 1

CLIENT **Perteet Inc.**	
SITE **Smokey Point Dr. and Smokey Point Blvd.** **Arlington, Washington**	PROJECT **Smokey Point Transit Center**

DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES				TESTS			
			NUMBER	TYPE	RECOVERY, in.	DCP BLOWS / 1.75 in.	WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, tsf	
Approx. Surface Elev.: 126 ft										
<u>SURFACE GRASS, TOPSOIL</u>, atop **<u>SILTY SAND</u>**, with organics, trace gravel, dark brown, loose, moist (FILL) 0.9 125.1		SM	S-1	BS						
<u>SILTY SAND</u>, with rootlets, trace gravel, orangish brown, loose to medium dense, moist 2 124	1	SM	S-2	BS						
<u>FINE TO MEDIUM SAND</u>, trace coarse sand, silt, and gravel, brown-gray, loose to medium dense, moist 6 ▽ 120	2 3 4 5 6	SP	S-3	BS			9			OC=1% GSA
<u>GRAVELLY FINE TO COARSE SAND</u>, trace silt, gray, loose to medium dense, wet to saturated 8.5 117.5	7 8	SW								

Test Pit completed at 8.5 feet on 4/29/10.
Rapid groundwater seepage at 6 feet.
Moderate caving below 5 feet.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 6.0	WD	▼
WL	▼		▼
WL			

Terracon

21905 64th Avenue West, Suite 100
Mountlake Terrace, Washington 98043
T: 425-771-3304 F: 425-771-3549

TEST PIT STARTED			4-29-10
TEST PIT COMPLETED			4-29-10
LOGGED	CRT	CO. NW Excavating	
JOB #	81105040	EXHIBIT	A-14

TEST PIT LOG NO. TP-9

Page 1 of 1

CLIENT
Perteet Inc.

SITE **Smokey Point Dr. and Smokey Point Blvd.**
Arlington, Washington

PROJECT
Smokey Point Transit Center

Approx. Surface Elev.: 126 ft

Depth (ft)	DESCRIPTION	Elev.	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES DCP BLOWS / 1.75 in.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, tsf
1	**SURFACE GRASS, TOPSOIL** atop **SILTY SAND**, with organics and charcoal, trace gravel, dark brown, loose, moist (FILL)	125									
1.8	**SILTY SAND**, with rootlets, trace gravel, orangish brown, loose to medium dense, moist	124.2		SM	S-1	BS					
6	**FINE TO MEDIUM SAND**, trace coarse sand, silt, and gravel, brown-gray, loose to medium dense, moist	120		SP	S-2	BS					
8.5	**GRAVELLY FINE TO COARSE SAND**, trace silt, gray, loose to medium dense, wet ▽ to saturated	117.5		SW	S-3	BS					

Test Pit completed at 8.5 feet on 4/29/10.
Rapid groundwater seepage at 6.5 feet.
Moderate caving below 5 feet.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 6.5	WD	▼
WL	▼		▽
WL			

Terracon
21905 64th Avenue West, Suite 100
Mountlake Terrace, Washington 98043
T: 425-771-3304 F: 425-771-3549

TEST PIT STARTED			4-29-10
TEST PIT COMPLETED			4-29-10
LOGGED	CRT	CO. NW Excavating	
JOB #	81105040	EXHIBIT	A-15

TEST PIT LOG NO. TP-10

Page 1 of 1

CLIENT **Perteet Inc.**	
SITE **Smokey Point Dr. and Smokey Point Blvd. Arlington, Washington**	PROJECT **Smokey Point Transit Center**

GRAPHIC LOG	DESCRIPTION Approx. Surface Elev.: 126 ft	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES DCP BLOWS / 1.75 in.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, tsf	
	<u>SURFACE GRASS, TOPSOIL</u> atop **<u>SILTY SAND</u>**, with organics, trace gravel, dark brown, loose, moist (FILL) 1.5 124.5	1	SM	S-1	BS						
	<u>SILTY SAND</u>, with rootlets, trace gravel, orangish brown, loose to medium dense, moist 2.5 123.5	2	SM	S-2	BS						
	<u>FINE TO MEDIUM SAND</u>, trace coarse sand, silt, and gravel, brown-gray, loose to medium dense, moist 6 ▽ 120	3 4 5 6	SP	S-3	BS						
	<u>GRAVELLY FINE TO COARSE SAND</u>, trace silt, gray, loose to medium dense, wet to saturated 8.5 117.5	7 8	SW	S-4	BS						
	Test Pit completed at 8.5 feet on 4/29/10. Rapid groundwater seepage at 6 feet. Moderate caving below 5 feet.										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽ 6.0	WD ▼
WL	▼	▼
WL		

Terracon

21905 64th Avenue West, Suite 100
Mountlake Terrace, Washington 98043
T: 425-771-3304 F: 425-771-3549

TEST PIT STARTED			4-29-10
TEST PIT COMPLETED			4-29-10
LOGGED	CRT	CO. NW Excavating	
JOB #	81105040	EXHIBIT	A-16

APPENDIX B

LABORATORY TESTING

Laboratory Testing

A series of laboratory tests were performed during the course of this study to evaluate the index and geotechnical engineering properties of the subsurface soil samples recovered from the exploratory borings. Descriptions of the types of tests performed are given below.

Visual Classification

Samples recovered from the exploration locations were visually classified in the field during the exploration program. Representative portions of the samples were carefully packaged in moisture tight containers and transported to our laboratory where the field classifications were verified or modified as required. Visual classification was generally done in accordance with the Unified Soil Classification system. Visual soil classification includes evaluation of color, relative moisture content, soil type based upon grain size, and accessory soil types included in the sample. Soil classifications are presented on the exploration logs in Appendix A.

Moisture Content Determinations

Moisture content determinations were performed on representative samples obtained from the explorations in order to aid in identification and correlation of soil types. The determinations were made in general accordance with the test procedures described in ASTM D 2216. The results are shown on the exploration logs in Appendix A or on the grain size curves in this Appendix.

Grain Size Analysis

A grain size analysis indicates the range in diameter of soil particles included in a particular sample. Grain size analyses were performed on representative samples in general accordance with ASTM D 422. The results of the grain size determinations for the samples were used in classification of the soils, and are presented in this appendix.

California Bearing Ratio Test Procedures

A California Bearing Ratio (CBR) test provides a quantitative prediction of the relative quality and support characteristics of a saturated soil when subjected to wheel loads. CBR tests were performed on selected samples in general accordance with ASTM D 1883. Representative portions from each sample are compacted in a mold to obtain a moisture-density relationship curve, a 15-pound surcharge is applied to each sample, and the samples are then immersed in water for at least 96 hours, during which time they are monitored for swell. Next, a vertical load is applied to the surcharged soil with a penetration piston moving at a constant rate of strain, while the associated penetrations are measured and compared with the theoretical strain of crushed rock. The ratio of the measured and theoretical loads (in percent) is defined as the CBR value for the soil at that particular density. The enclosed CBR graphs present our test results as a plot of density and resistance versus moisture content.

CEC Analysis

Cation Exchange Capacity (CEC) tests were completed on representative samples obtained from the explorations in order to evaluate the water quality treatment potential of the soils. The

CEC tests were performed by an analytical testing laboratory (Amtest, Inc.) working under subcontract to Terracon and were completed in accordance with the Environmental Protection Agency (EPA) 9081 test method. CEC test results are presented in this appendix and on the exploration logs.

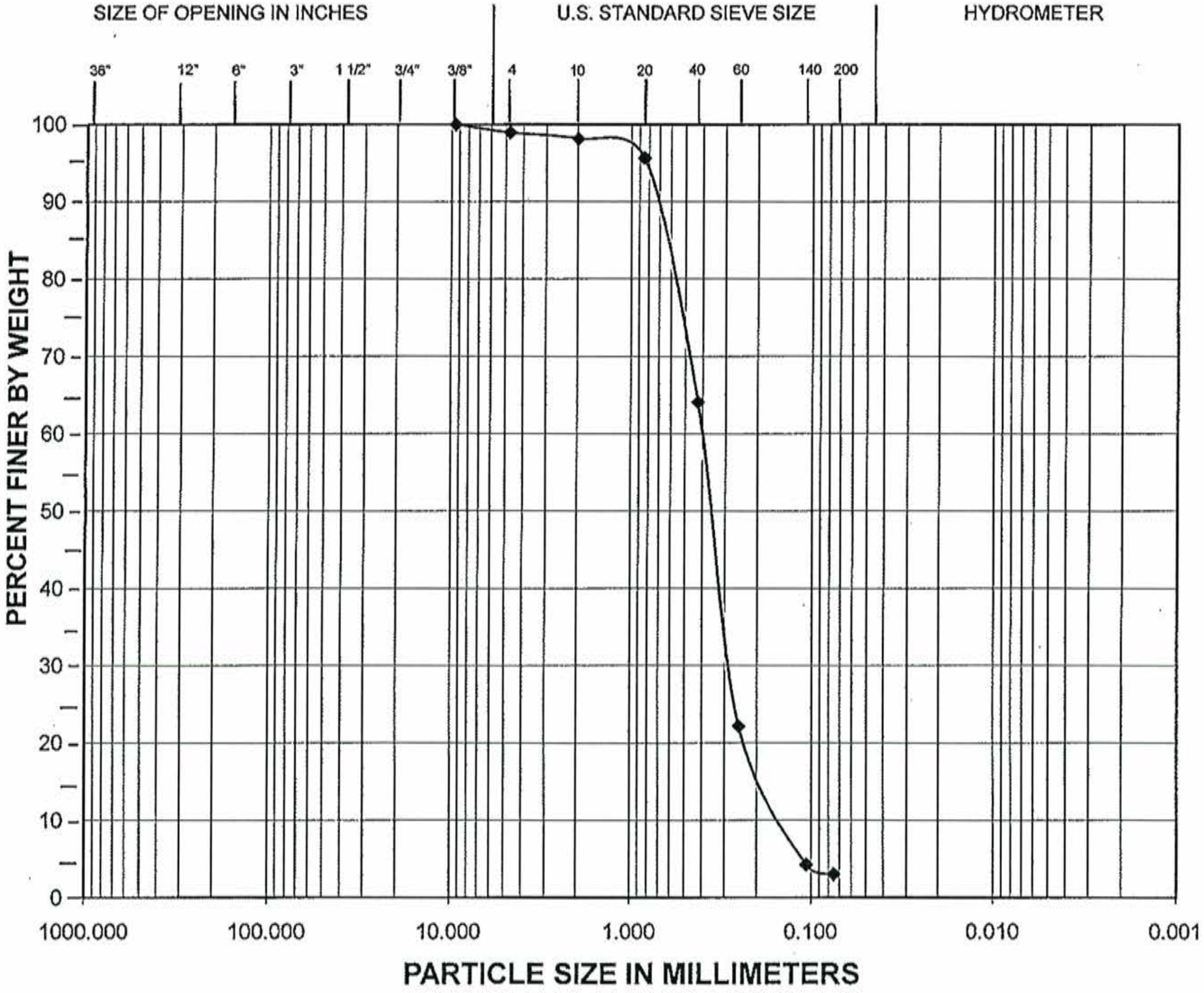
Organic Content Analysis

The organic content of selected samples was determined in general accordance with the ASTM D 2974 testing procedure. The organic content test results, which are expressed as a percent of dry weight, are shown on the logs in Appendix A.

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

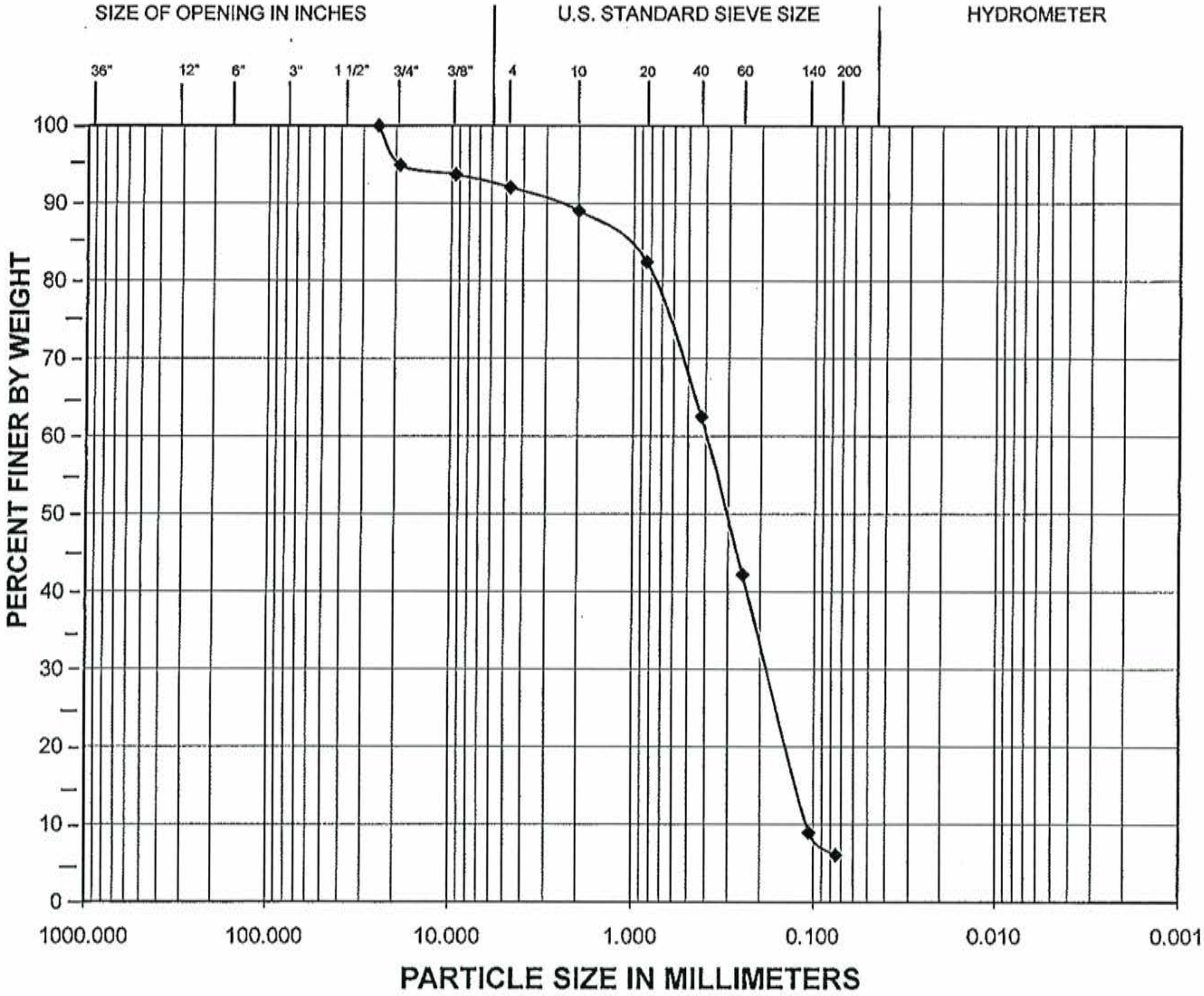
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-1	S-3	5-6.5	7	3.0	SAND, trace silt and gravel

Terracon Geotechnical and Environmental Consulting	JOB NO: 81105040 DATE OF TESTING: 5/18/2010	PROJECT NAME: Smokey Point Transit Center Exhibit B-3

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-1	S-4	7.5-9	20	6.1	SAND, with silt, trace gravel

Terracon
Geotechnical and Environmental Consulting

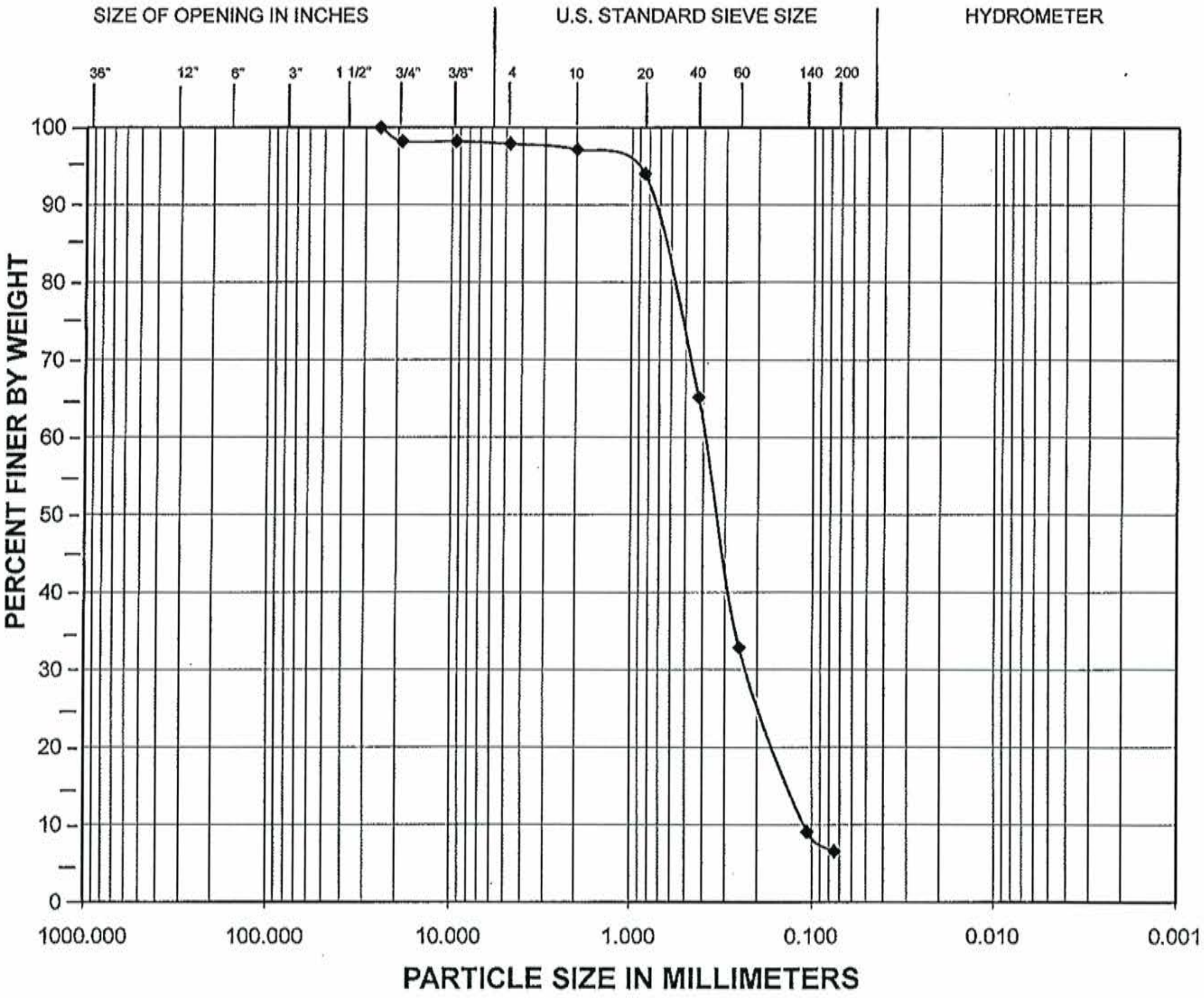
JOB NO: 81105040
DATE OF TESTING: 5/18/2010

PROJECT NAME:
Smokey Point Transit Center Exhibit B-4

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-2	S-2	2.5-4	7	6.6	SAND, with silt, trace gravel

Terracon
Geotechnical and Environmental Consulting

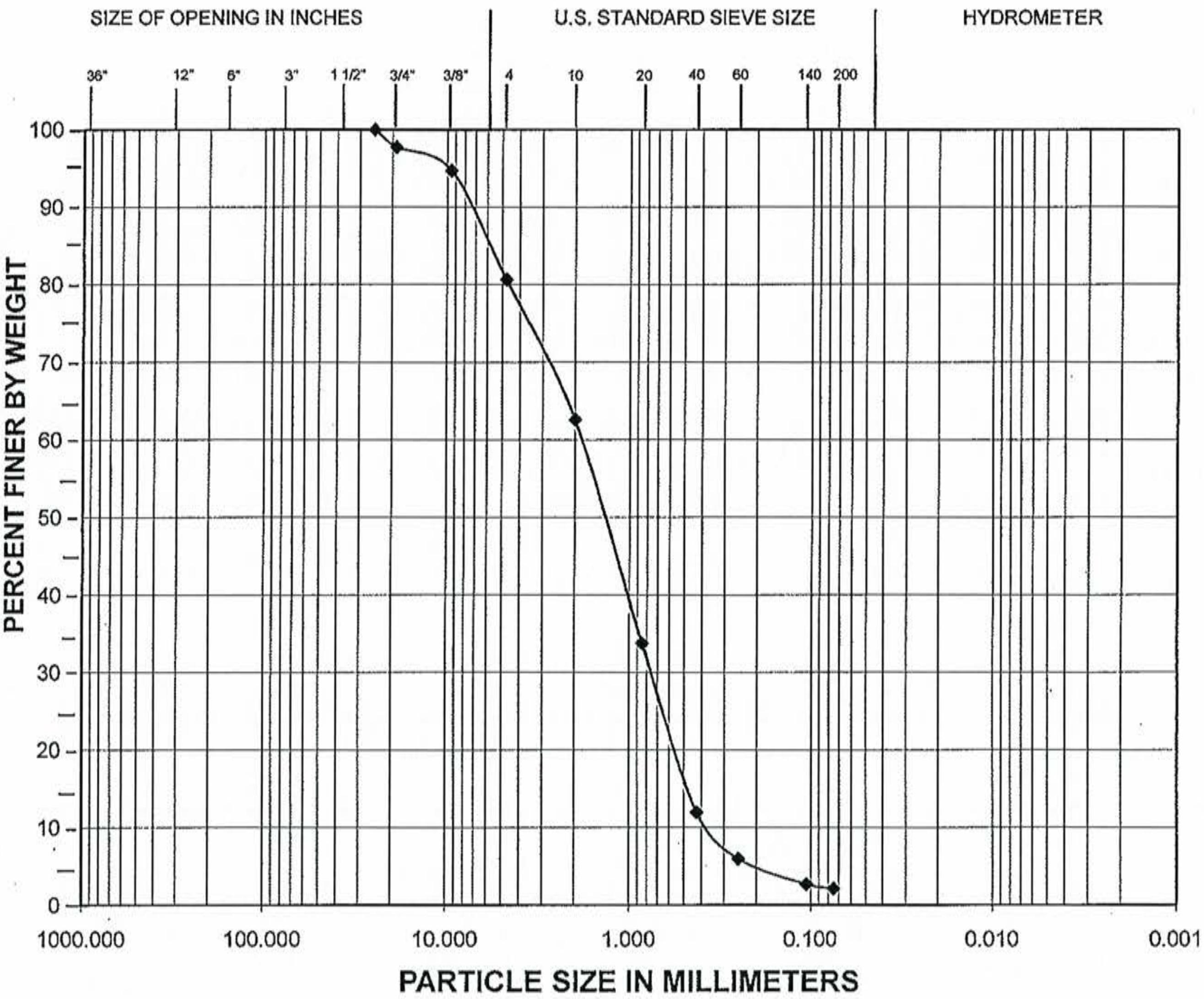
JOB NO: 81105040
DATE OF TESTING: 5/18/2010

PROJECT NAME:
Smokey Point Transit Center Exhibit B-5

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-2	S-5	10-11.5	17	2.1	SAND, with gravel, trace silt

Terracon
Geotechnical and Environmental Consulting

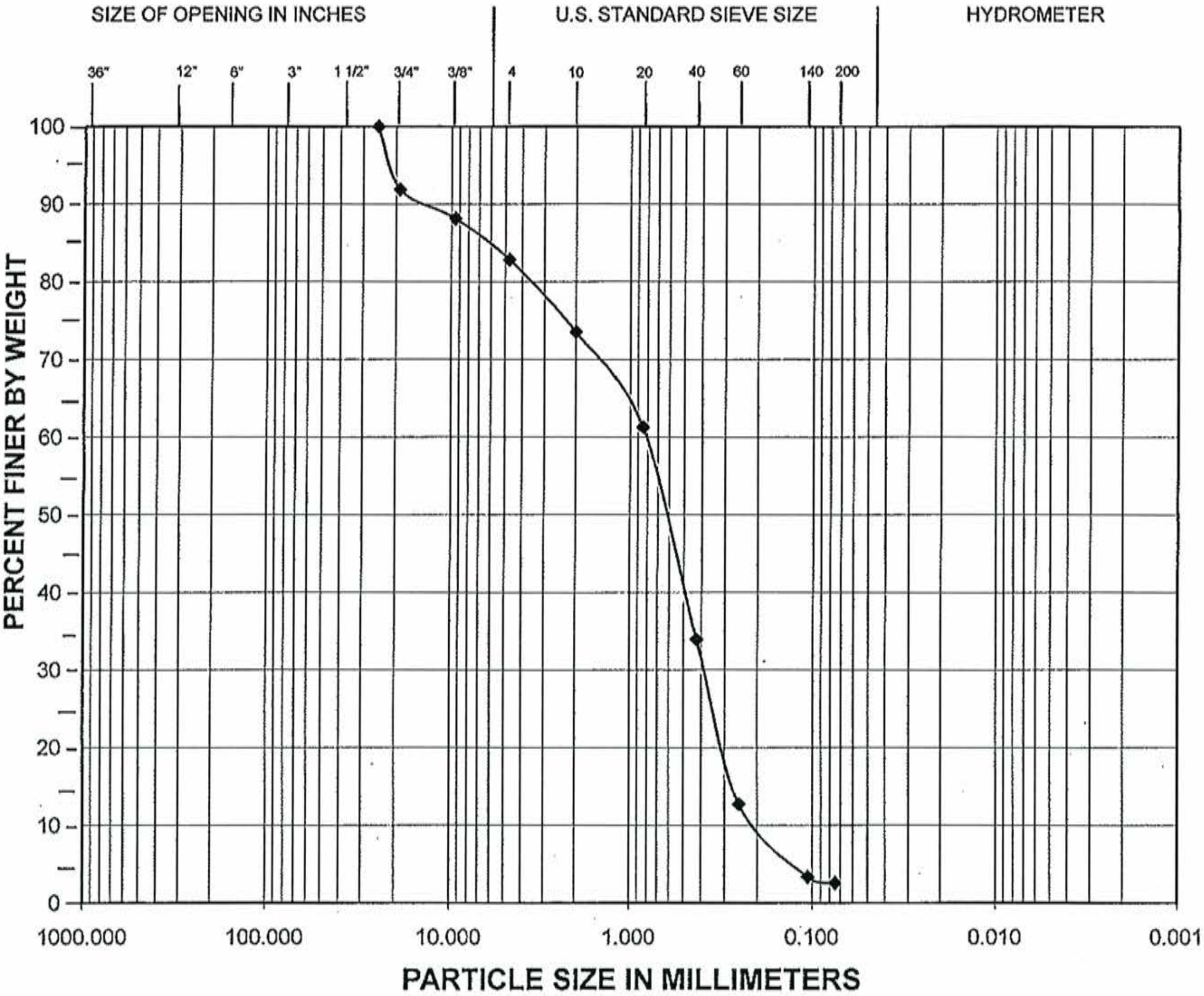
JOB NO: 81105040
DATE OF TESTING: 5/18/2010

PROJECT NAME:
Smokey Point Transit Center Exhibit B-6

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-3	S-6	12.5-14	19	2.6	SAND, with gravel, trace silt

Terracon
Geotechnical and Environmental Consulting

JOB NO: 81105040

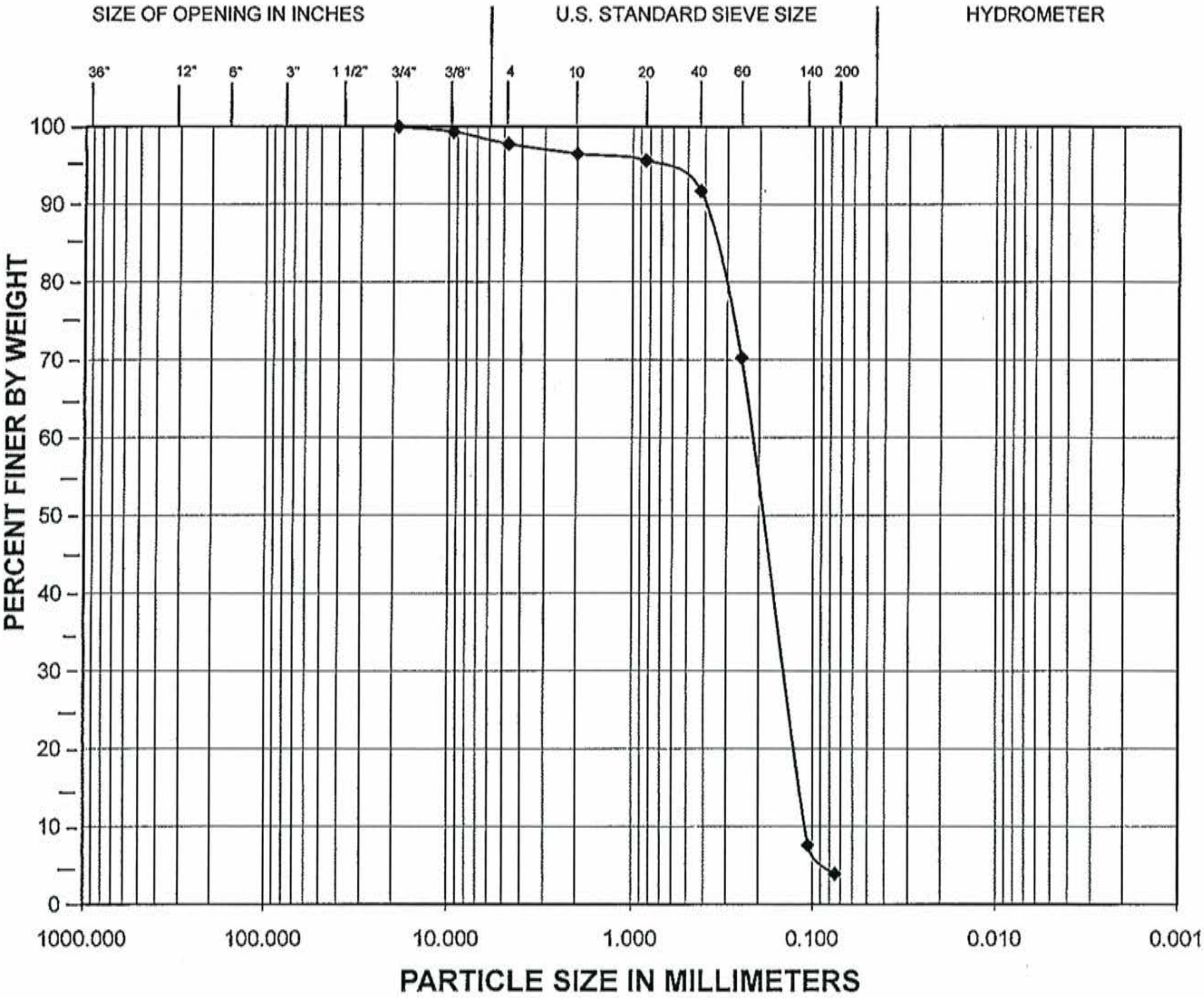
DATE OF TESTING: 5/18/2010

PROJECT NAME: Smokey Point Transit Center Exhibit B-7

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

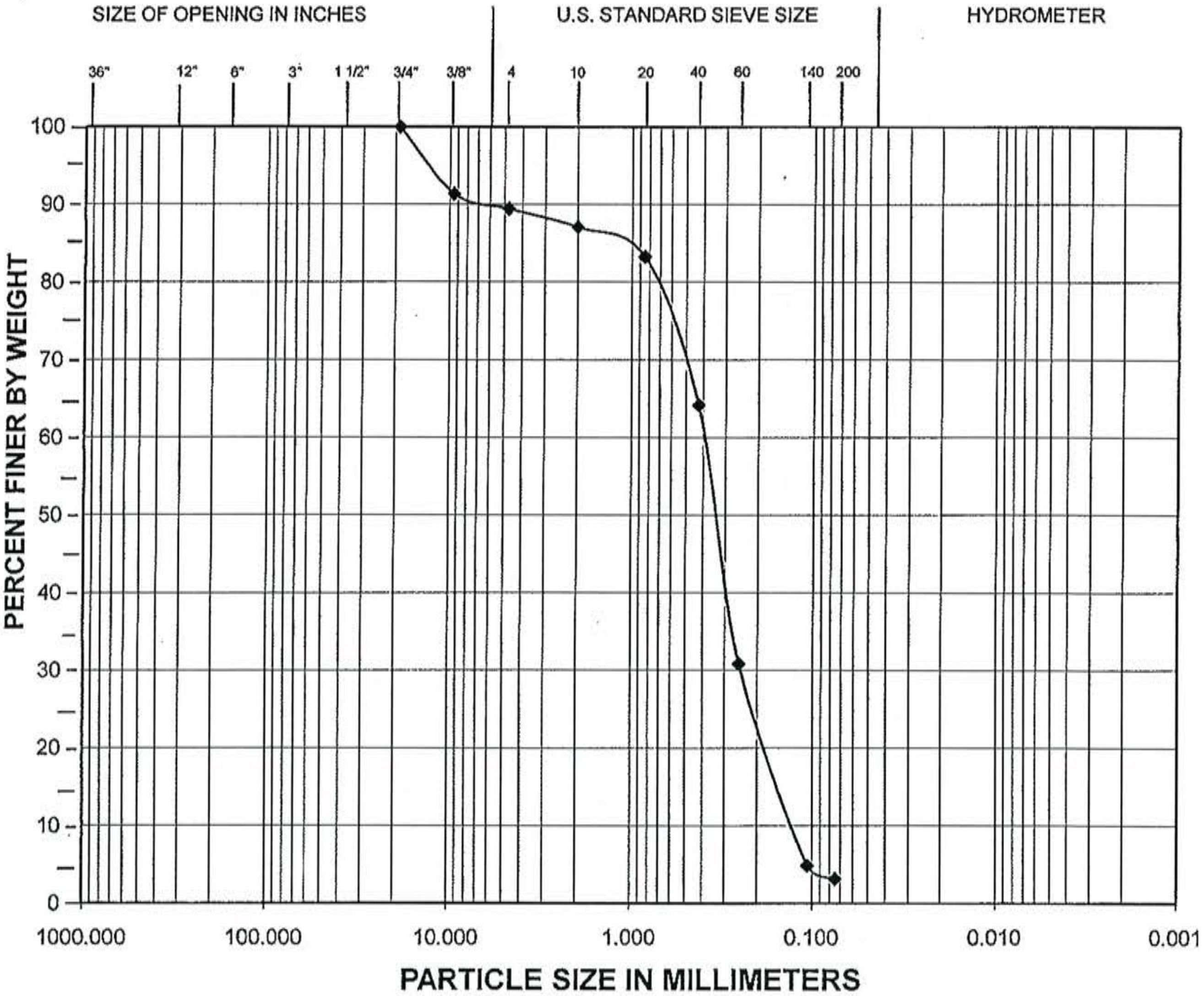
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-3	S-8	22.5-24	29	3.9	SAND, trace silt and gravel

Terracon Geotechnical and Environmental Consulting	JOB NO: 81105040 DATE OF TESTING: 5/18/2010	PROJECT NAME: Smokey Point Transit Center Exhibit B-8

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-3	S-3	3-4	7	3.2	SAND, trace gravel and silt

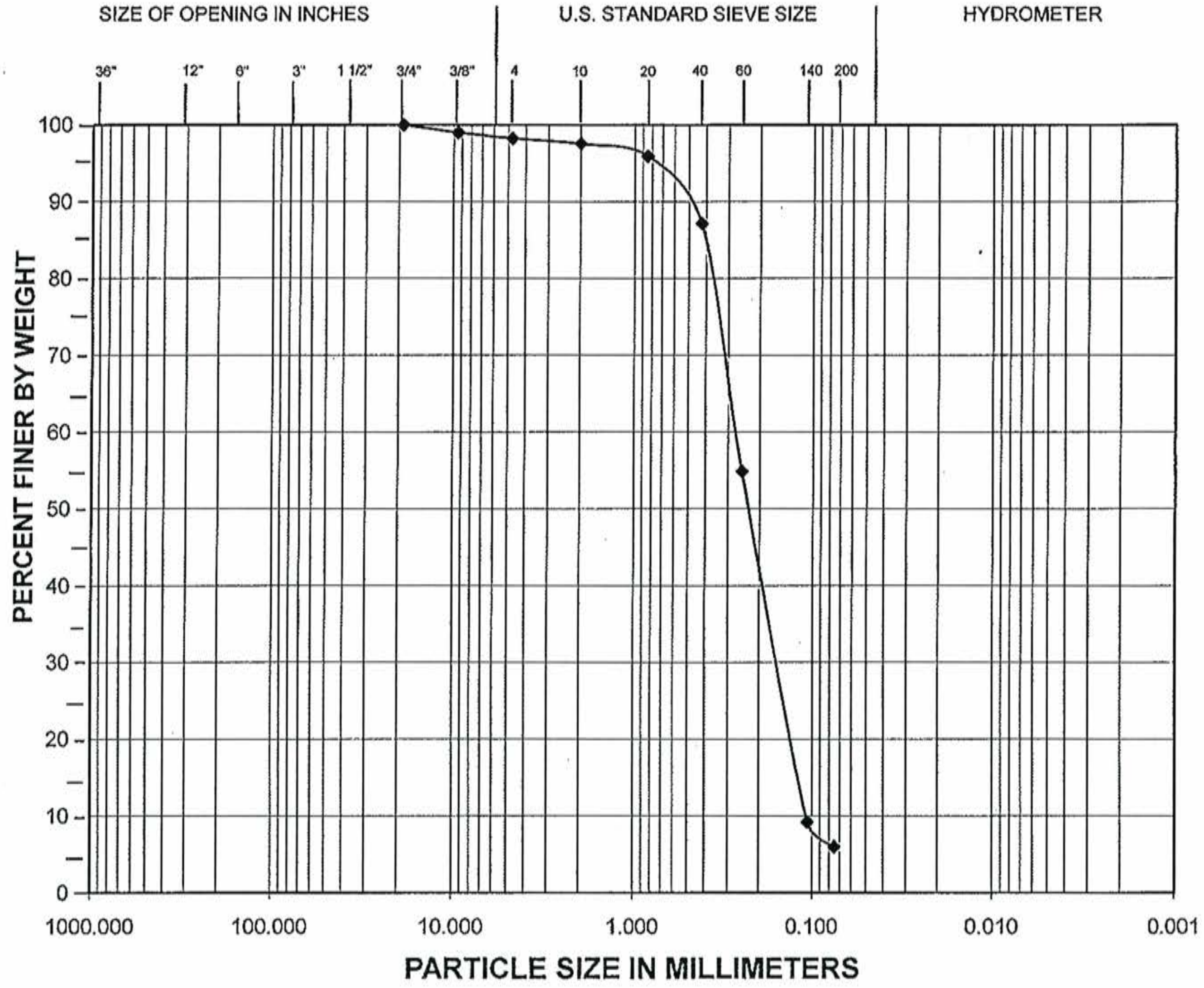
Terracon
Geotechnical and Environmental Consulting

JOB NO:	81105040	PROJECT NAME:
DATE OF TESTING:	5/18/2010	Smokey Point Transit Center Exhibit B-9

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 422



		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
BOULDERS	COBBLES	GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-8	S-3	3-4	9	6.0	SAND, with silt, trace gravel

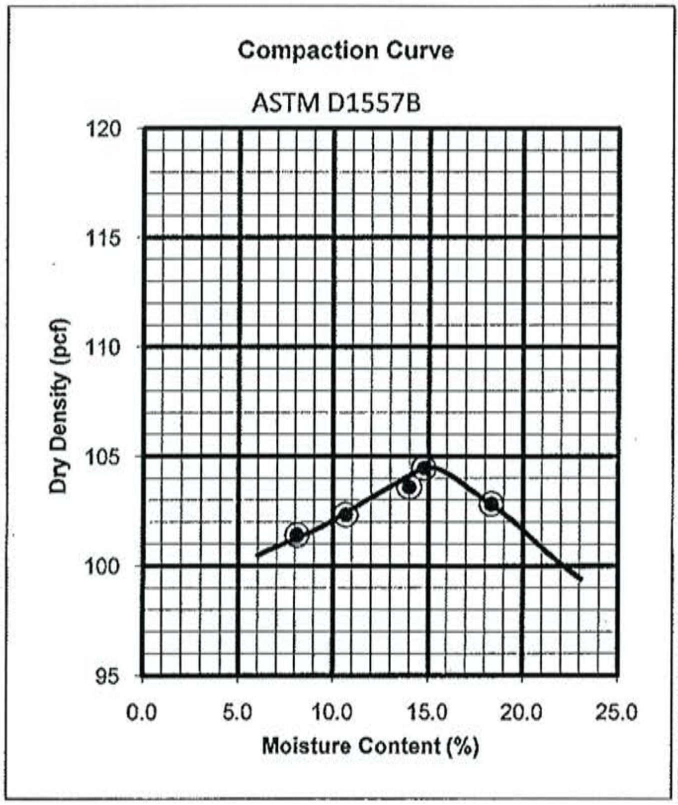
Terracon Geotechnical and Environmental Consulting	JOB NO: 81105040 DATE OF TESTING: 5/18/2010	PROJECT NAME: Smokey Point Transit Center Exhibit B-10

CALIFORNIA BEARING RATIO ASTM D 1883

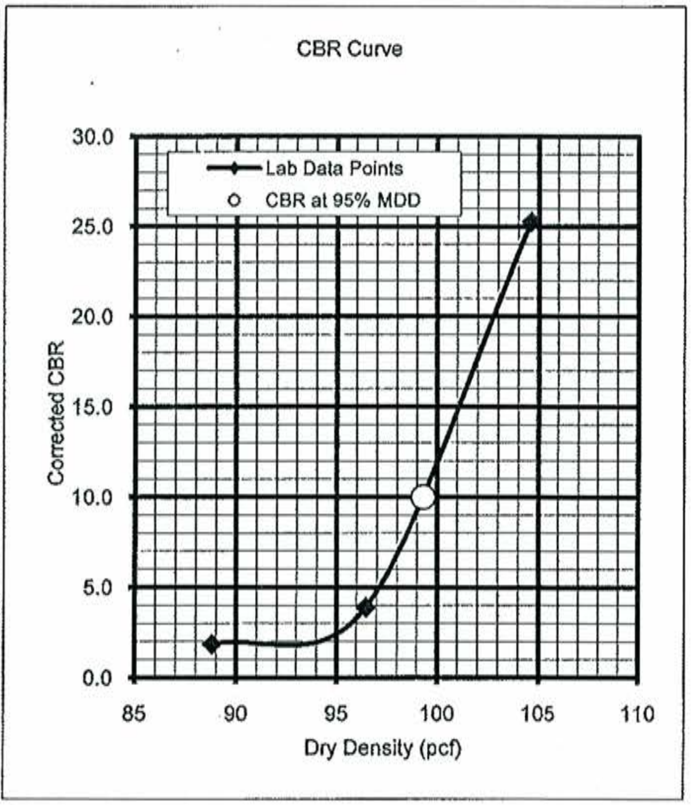
Exploration: TP-4
Sample No.: Grab
Depth: 1 - 2.5 ft

Soil Description: Brown, fine to medium SAND
Tested By: CDF/RMS
Comments:

	10 Blows/Lift		25 Blows/Lift		70 Blows/Lift	
Condition of Sample:	soaked		soaked		soaked	
Dry Density Before Soaking:	89	pcf	96	pcf	105	pcf
Dry Density After Soaking:	91	pcf	97	pcf	106	pcf
Moisture Content:						
Before Compaction:	15.1	%	15.5	%	15.1	%
After Compaction:	15.4	%	15.4	%	15.0	%
Top 1-in Layer After Soaking:	22.0	%	20.6	%	16.9	%
Average After Soaking:	19.9	%				
Swell:	0.1	%	0.0	%	0.0	%
Surcharge Amount:	64.8	psf	64.8	psf	64.8	psf


Compaction Curve

ASTM D1557B


CBR Curve

Max. Dry Density (MDD)* = 104.5 pcf
Optimum Moisture* = 15.0 %
*Rock Corrected Values

95% of MDD = 99.3 pcf
CBR at 95% of MDD = 10

Terracon
Geotechnical and Environmental Consulting

PROJECT NO: 81105040
DATE OF TESTING: 5/19/10

PROJECT NAME:
Community Transit
Exhibit B-11

AMTEST
LABORATORIES

Am Test Inc.
13600 NE 126TH PL
Suite C
Kirkland, WA 98034
(425) 885-1664

Professional Analytical Services

Jun 1 2010
Terracon
21905 64th Ave. West
Suite 100
Mounhtlake Terrace, WA 98043
Attention: Dave Williams

RECEIVED
JUN - 7 2010
BY:

Dear Dave Williams:

Enclosed please find the analytical data for your project.

The following is a cross correlation of client and laboratory identifications for your convenience.

CLIENT ID	MATRIX	AMTEST ID	TEST
TP-1 S-3	Soil	10-A008137	CEC-s
TP-4 S-2	Soil	10-A008138	CEC-s
TP-5 S-3	Soil	10-A008139	CEC-s
TP-6 S-2	Soil	10-A008140	CEC-s

Your samples were received on Friday, May 21, 2010. At the time of receipt, the samples were logged in and properly maintained prior to the subsequent analysis.

The analytical procedures used at AmTest are well documented and are typically derived from the protocols of the EPA, USDA, FDA or the Army Corps of Engineers.

Following the analytical data you will find the Quality Control (QC) results.

Please note that the detection limits that are listed in the body of the report refer to the Method Detection Limits (MDL's), as opposed to Practical Quantitation Limits (PQL's).

If you should have any questions pertaining to the data package, please feel free to contact me.

Sincerely,

Kathy Fugiel
President

PO Number: 81105040

BACT = Bacteriological
CONV = Conventionals
TC=Total Coliforms
MET = Metals
ORG = Organics
NUT=Nutrients
DEM=Demand
MIN=Minerals
APC=Aerobic Plate Count

Am Test Inc.
13600 NE 126TH PL
Suite C
Kirkland, WA 98034
(425) 885-1664
www.amtestlab.com

AMTEST
LABORATORIES

Professional
Analytical
Services

ANALYSIS REPORT

Terracon
21905 64th Ave. West
Mounhtlake Terrace, WA 98043
Attention: Dave Williams
PO Number: 81105040
All results reported on an as received basis.

Date Received: 05/21/10
Date Reported: 6/ 1/10

AMTEST Identification Number **10-A008137**
Client Identification **TP-1 S-3**
Sampling Date **04/29/10**

Miscellaneous

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANLST	DATE
Cation Exchange Capacity	2.8	meq/100g		0.5	SW-846 9081	HL	05/27/10

AMTEST Identification Number **10-A008138**
Client Identification **TP-4 S-2**
Sampling Date **04/29/10**

Miscellaneous

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANLST	DATE
Cation Exchange Capacity	1.7	meq/100g		0.5	SW-846 9081	HL	05/27/10

AMTEST Identification Number **10-A008139**
Client Identification **TP-5 S-3**
Sampling Date **04/29/10**

Miscellaneous

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANLST	DATE
Cation Exchange Capacity	4.0	meq/100g		0.5	SW-846 9081	HL	05/27/10

AMTEST Identification Number 10-A008140
Client Identification TP-6 S-2
Sampling Date 04/29/10

Miscellaneous

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANLST	DATE
Cation Exchange Capacity	2.2	meq/100g		0.5	SW-846 9081	HL	05/27/10

Kathy Fugiel
President

QC Summary for sample numbers: 10-A008137 to 10-A008140

DUPLICATES

SAMPLE #	ANALYTE	UNITS	SAMPLE VALUE	DUP VALUE	RPD
10-A008000	Cation Exchange Capacity	meq/100g	8.0	8.1	1.2

STANDARD REFERENCE MATERIALS

ANALYTE	UNITS	TRUE VALUE	MEASURED VALUE	RECOVERY
Cation Exchange Capacity	meq/100g	20.	17.	85.0 %

BLANKS

ANALYTE	UNITS	RESULT
Cation Exchange Capacity	meq/100g	< 0.5

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS: Split Spoon – 1-$^{3}/_{8}$" I.D., 2" O.D., unless otherwise noted
ST: Thin-Walled Tube - 2" O.D., unless otherwise noted
RS: Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted
DB: Diamond Bit Coring - 4", N, B
BS: Bulk Sample or Auger Sample

HS: Hollow Stem Auger
PA: Power Auger
HA: Hand Auger
RB: Rock Bit
WB: Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL: Water Level
WCI: Wet Cave in
DCI: Dry Cave in
AB: After Boring

WS: While Sampling
WD: While Drilling
BCR: Before Casing Removal
ACR: After Casing Removal

N/E: Not Encountered

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	0 – 1	Very Soft
500 – 1,000	2 – 4	Soft
1,001 – 2,000	4 – 8	Medium Stiff
2,001 – 4,000	8 – 15	Stiff
4,001 – 8,000	15 – 30	Very Stiff
8,000+	> 30	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 49	Dense
> 50	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other Constituents	Percent of Dry Weight
Trace	< 15
With	15 – 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75 mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other Constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifiers	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 – 10
Medium	11 – 30
High	> 30

Exhibit C-1

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines[C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3[E]	GW	Well-graded gravel[F]
			Cu < 4 and/or 1 > Cc > 3[E]	GP	Poorly graded gravel[F]
		Gravels with Fines: More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines[D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3[E]	SW	Well-graded sand[I]
			Cu < 6 and/or 1 > Cc > 3[E]	SP	Poorly graded sand[I]
		Sands with Fines: More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		Organic:	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic clay[K,L,M,N]
					Organic silt[K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic Silt[K,L,M]
		Organic:	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic clay[K,L,M,P]
					Organic silt[K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

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[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.

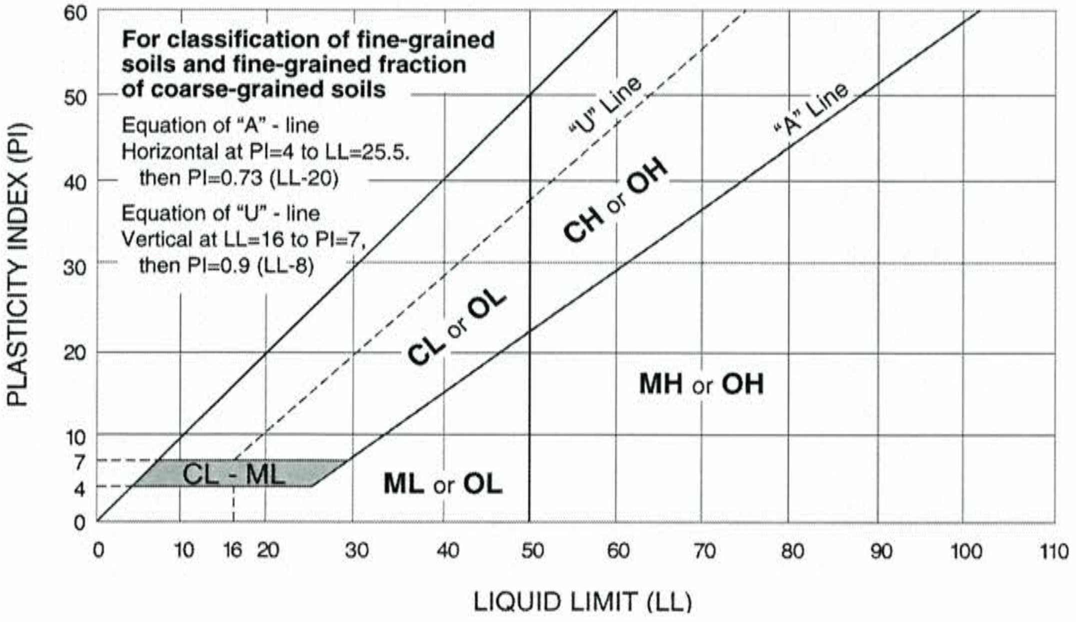

Exhibit C-2