Geotechnical Engineering Report
Jefferson Transit Authority Maintenance and Administration Facility Project
Jefferson County, Washington

August 23, 2013

Prepared for

Jefferson Transit Authority and
TCF Architecture

Landau Associates
130 2nd Avenue South
Edmonds, WA 98020
(425) 778-0907

TABLE OF CONTENTS

FIGURES

APPENDICES

1.0 INTRODUCTION

This report presents the results of our geotechnical engineering study conducted for the proposed Maintenance and Administration facility near Port Hadlock in Jefferson County, Washington. The facility will be owned and operated by the Jefferson Transit Authority (JTA) and is under design by TCF Architecture (TCF). The purpose of our services was to provide JTA, TCF, and other design team members with information related to subsurface conditions, geotechnical recommendations, and geotechnical design criteria for the proposed maintenance and administration facility (Facility).

1.1 SCOPE OF SERVICES

Our scope of services was outlined in our proposal letter dated March 1, 2013 to TCF. Our services for this project consisted of preparing:

- a site plan showing pertinent site features and the approximate locations of the explorations accomplished for this study
- descriptive logs of the explorations and the results of the geotechnical laboratory testing
- a summary of surface and subsurface soil and groundwater conditions observed at the project site during our field exploration program
- an evaluation of the moisture sensitivity of the soil at the project site
- recommendations for site preparation and earthwork, including reuse of site soil, and criteria for selection, placement, and compaction of structural fill
- recommendations for temporary and permanent fill and cut slopes up to 5 ft in height, and geotechnical recommendations for gravity-block retaining walls
- recommendations for installation and backfilling of buried utilities
- recommendations for shallow foundation support for the proposed maintenance and administration building, including subgrade preparation, allowable soil bearing pressures, estimates of settlement, and soil parameters for lateral load resistance
- recommendations for interior concrete slab-on-grade subgrade preparation
- recommendations for seismic design criteria (including soil type) for use in seismic design under the 2009 International Building Code
- recommendations for rigid and flexible pavement sections for the access driveway, the visitor/employee parking area, and the fleet parking and staging areas
- recommendations for design of stormwater infiltration facilities, including grain-size based infiltration rates, estimated upper elevation of the seasonal groundwater table, and the potential for in-situ treatment of stormwater from -roofs and vehicle pavements

- recommendations for design of an on-site septic system, including a description of soils encountered and their USDA and Department of Ecology classifications, and identification of limiting layers
- recommendations for monitoring and testing during construction.

1.2 PROJECT DESCRIPTION

Jefferson Transit Authority plans to construct a new fleet administration and maintenance facility on a currently undeveloped 10-acre (approximate) property located at the intersection of State Highway 20 and Four Corners Road, about ½-mile southwest of the Jefferson County Airport and 2¼ miles west of Port Hadlock. The location of the proposed facility is shown on the Vicinity Map (Figure 1).

The proposed facility will include an administration and maintenance building, fueling and washing stations, a Park-n-Ride (PnR) bus loop and shelter, parking for visitors, employees, and PnR customers, and staging and parking areas for the JTA fleet of vehicles. The proposed administration and maintenance building will have a footprint of about 100 ft by 170 ft and will consist of a one- or two-story pre-fabricated steel building served by an on-site septic system. The visitor, employee, and PnR parking area will include about 107 spaces. A paved area approximately 320 ft by 260 ft will encompass the fleet parking/staging areas plus the fueling and washing facilities. Stormwater from paved areas, building roofs, and other impervious surfaces will be directed to constructed ponds, rain gardens, or similar features for on-site infiltration. A conceptual layout of the Facility is presented on the Site and Exploration Plan (Figure 2).

2.0 SITE CONDITIONS

This section discusses the general surface and subsurface conditions observed at the project site at the time of our field investigation. Interpretations of the site conditions are based on the results of our review of available information, site reconnaissance, subsurface explorations, and laboratory testing.

2.1 GENERAL GEOLOGIC CONDITIONS

Geologic information for the project site was obtained from *Geologic Map of the Port Townsend South and Part of the Port Townsend North 7.5-minute Quadrangles, Jefferson County, Washington* (Schasse and Slaughter 2005). According to this geologic map, near-surface deposits in the vicinity of the project site are mapped as Pleistocene Age glaciomarine outwash consisting of a capping layer of silt and clay overlying a thick sequence of sand with occasional gravelly layers. This soil unit is similar to glacial recessional outwash, but instead of being river deposited, it was emplaced primarily by strong sub-tidal currents near the active glacial terminus during retreat of the most recent glaciaction. The mapped geology is consistent with the conditions observed during subsurface exploration, as described below.

2.2 EXISTING SURFACE CONDITIONS

The site is currently undeveloped and consists of generally flat terrain vegetated by sparse to dense, second-growth conifers and open areas of field grass and blackberry brambles. Along the Four Corners Road parcel boundary, project site is about 4 to 5 feet below the road grade. Existing features and site topography are shown on Figure 2.

2.3 SUBSURFACE SOIL CONDITIONS

Subsurface conditions were explored by excavating twelve test pits up to 16 feet below existing grades at locations throughout the project parcel. The locations of the test pits are shown on Figure 2. Test pit logs, along with a description of the field exploration procedures, are presented in Appendix A. We performed geotechnical laboratory testing on representative soil samples to determine the natural moisture content, grain size distribution, and Atterberg limits of selected soil specimens. Results of the laboratory testing that was performed are presented in Appendix B.

Our recent explorations revealed subsurface conditions consistent with the surficial geology mapped by Schasse and Slaughter 2005. The typical soil profile consists of about 1 to 3½ ft of silty to sandy, low-plasticity clay (with a poorly-developed, root-bearing soil horizon in the upper 3 to 6 inches) underlain by fine to medium sand to the bottom of the explorations (11 to 16 ft below ground surface [BGS]). The fines content (soil particles finer than the U.S. Standard No. 200 sieve) was typically 5 to 15 percent below the surficial clay layer. Occasional gravel pockets or gravelly zones were encountered in the sand layer, becoming more frequent with increasing depth. At a few test pit locations (TP-5, TP-7, and TP-8), very gravelly sand or sandy gravel was encountered below the surficial clay layer and is much coarser than sands encountered at other exploration locations.

The soil descriptions presented above are based upon the Unified Soil Classification System (USCS), which is most typically used for geotechnical reporting. However, other systems, such as the U.S. Department of Agriculture system is used for certain applications such as infiltration. Based upon the USDA classification system, which differs somewhat from the USCS, the surficial clay (USCS) layer classifies as a silt loam (USDA). A third system – the Washington Department of Health (DOH) scheme (used for design of on-site septic systems) – would typify the surficial clay later as Type 6 at most test pit locations. Beneath the surficial clay/silt loam/Type 6 soil, the sand unit would classify as "sand" with variable modifiers (coarse, medium, gravelly, etc.) according to the USDA. The underlying sand would classify as DOH Type 2A or 2B at most locations, although with increased gravel content (such as at TP-5, -7, and -8, and elsewhere at depth), the soils classify as Type 1B or 1A. The USCS, USDA, and DOH designations are included in the descriptive text for each test pit log presented in Appendix A. Throughout this report, soil descriptions are in accordance with the USCS descriptors unless noted otherwise.

2.4 GROUNDWATER CONDITIONS

Groundwater was not encountered during exploration except for one isolated seep exposed at a depth of 7 to 8 ft BGS at test pit TP-12. This observation indicates that perched zones of water could be encountered during excavation, but would likely be of limited extent. Zones of perched groundwater are more likely to be encountered during the wet season.

According to water well records within about ¼ mile of the project site, the depth to the regional aquifer is about 90 to 100 ft BGS.

3.0 CONCLUSIONS AND RECOMMENDATIONS

Construction of the proposed Jefferson Transit Authority Facility at the project site is considered to be feasible from a geotechnical perspective. The soil on the site is capable of providing adequate foundation support with moderate bearing pressures and tolerable settlement for shallow footings supporting the relatively lightweight structure. Slab-on-grade floor construction is also feasible at the site with adequate subgrade preparation. Infiltration of stormwater runoff can be accomplished through the use of dispersion, infiltration ponds, bioswales, or other methods.

From a practical construction standpoint, the upper 1 to 3½ ft of soil at the project site is moisture-sensitive and susceptible to softening and disturbance by construction equipment, especially when wet. Consequently, it would be preferable to schedule site grading operations and subgrade preparation for the dry summer and early fall months. With careful site preparation, protection of subgrade from additional moisture, and the use of selected imported structural fill, site grading could be performed during other periods of the year. Conclusions and recommendations regarding site preparation and earthwork, seismic design, foundation support and settlement, concrete slabs-on-grade, pavement design, site and foundation drainage considerations, and infiltration and septic design inputs are presented in the following report sections.

3.1 SITE PREPARATION AND EARTHWORK

Site preparation will include stripping vegetation and topsoil beneath the proposed building footprint and in the fleet, PnR, and other paved areas, excavation and subgrade preparation for footings, preparation of subgrade for floor slabs and pavements, and subgrade preparation for the access road embankment near the southern property boundary. Based on the soil conditions observed in our explorations and typical construction experience, we anticipate that the onsite soil can be excavated using conventional construction equipment.

3.1.1 STRIPPING AND EXCAVATION

All deleterious material such as grass, roots, organic soil or topsoil, debris, fill, and soft or loose native soil should be stripped from areas to be occupied by footings and slabs, and in any areas to receive new pavements or walkways. Tree roots and stumps that extend below the planned subgrade of footings and floors should be completely removed; overexcavation may be necessary. Backfilling of over-excavated areas should be performed as described in the following section. Topsoil is not suitable for reuse as structural fill and should be removed from the site or stockpiled for reuse in landscaping areas.

After stripping and prior to any fill placement, the exposed soil should be compacted in place to a dense and unyielding condition.

Footing excavations could encounter perched groundwater. Our test pits did not encounter groundwater in the vicinity of the proposed development, but shallow groundwater may exist in perched wet zones. The presence and extent of perched groundwater is likely limited and seasonally variable. Dewatering, if required, can typically be performed by grading of excavations and use of small sump pumps.

3.1.2 SUBGRADE PREPARATION AND FILL COMPACTION

Prior to placement of any fill, all subgrade within the building footprint or paved areas must be compacted to a suitably dense condition. Subgrade in areas where walkways will be constructed must also be suitably compacted. Preparation of footing subgrades requires additional considerations and is discussed in a following section. Subgrade should be moisture conditioned, if necessary, and bladed to a uniform surface. Clumps, cobbles, and other large particles should be removed from the surface in order to allow even, uniform compaction of the subgrade.

Subgrade should be compacted to a dense, unyielding condition, with a density of at least 95 percent of the maximum dry density, as determined from ASTM International (ASTM) test method D 1557. Following compaction, the entire subgrade should be proof-rolled in order to demonstrate adequate compaction and to identify subgrade trouble spots. Proof-rolling consists of slowly driving a 10-ton, vibratory roller or a fully loaded, ten-wheel dump truck over the subgrade and observing the subgrade response. We recommend that a representative of the geotechnical engineer be present at the time of proof-rolling in order to observe the subgrade performance. Any areas exhibiting significant deflection, pumping, weaving, or other distress that cannot be adequately reworked and/or compacted should be over-excavated and backfilled with material compacted to at least 95 percent of the maximum density (ASTM D 1557). Following proof-rolling, fill operations may proceed as described below.

Structural fill may be used, if necessary, for subgrade support of soil-supported floor slabs, provided that the fill is properly placed and compacted. In general, any suitable, nonorganic, predominantly granular soil may be used for fill material, including onsite excavation spoils, provided the material is properly moisture conditioned prior to placement and compaction, and the specified degree of compaction is obtained. However, the silty and sandy clay encountered in the upper 1 to 3½ ft in the exploration test pits would not be suitable for re-use as structural backfill. Because most excavations would be shallow, we expect that relatively little on-site soil could be re-used as structural fill. However, this clayey soil could be re-used as common borrow for filling beneath exterior pavements, including the access road embankment, provided that all organic matter is removed, it is properly moisture conditioned, placed in loose horizontal lifts not exceeding 8 inches, adequately compacted to 95 percent of ASTM D 1557, and then proof-rolled.

Imported structural fill should consist of aggregate meeting the requirements for Aggregate for Gravel Base, Class A or B [Section 9-03.12(1)] of the Washington State Department of Transportation *Standard Specifications* (WSDOT 2012). Structural fill should be placed in loose, horizontal lifts less than 8 to 10 inches in thickness and compacted to at least 95 percent of the maximum dry density determined by ASTM D 1557. For plumbing and utility trenches, trench backfill within 12 inches above pipes should be compacted to no more than 90 percent of the maximum dry density (ASTM D 1557) and should be completed with small, hand-operated compaction equipment such as plate compactors or "jumping jacks." For trench backfill greater than 12 inches above the pipe, backfill should be compacted to 95 percent of maximum dry density (ASTM D 1557), and use of larger compaction equipment is acceptable. Fill placed within landscaped areas should be compacted to a minimum of 85 percent of its maximum dry density to reduce the potential for excessive settlement. Backfill placed within the zone immediately behind foundation stem walls or other earth retention structures (if any) should be compacted to approximately 90 percent of the maximum dry density (ASTM D 1557). Care must be exercised to avoid overcompaction of wall backfill, which could potentially damage the walls and result in the development of excess lateral pressure against the walls.

3.1.3 RETAINING WALLS

Site preparation may include grade-raising up to about 5 feet around the site access road near Four Corners Road. While most or all of the grade raising along the access road and elsewhere could be accomplished using conventional soil embankment and the earthwork operations described in previous sections, retaining walls may be necessary in areas of limited space or where the footprint of the embankment needs to be reduced. Gravity block walls, rock gabion baskets, crib walls, cast-in-place concrete walls, and other conventional retention systems would be appropriate for retention of up to 5 feet at the project site. Some of these systems are proprietary, with the vendors providing selection guidance and preliminary design services.

Provided that the retaining wall is free to rotate a small amount during construction, the wall can be designed assuming active lateral earth pressures. Deflections of 0.1 to 0.2 percent of the wall height are sufficient to reduce lateral earth pressures to the active state. Soils in the active wedge may be assumed to have an equivalent fluid density of 36 pounds per cubic foot (pcf). This density assumes a level grade at the top and toe of the wall. This density also assumes that backfill behind the wall consists of structural fill selected, placed, and compacted as described in the previous section, and that the wall is well-drained to prevent the build-up of hydrostatic pressure behind the wall. Site-derived soils will generally be unsuitable for reuse as wall backfill, as discussed previously but may be used in the embankment “core” away from the back of walls. We recommend that structural fill extend a distance H behind the back of the wall, where H is the vertical distance between the wall foundation subgrade elevation and the adjacent finish grade of the embankment area. Additional lateral pressures on the wall, such as construction or traffic loads, or additional embankment height above the top of the wall, may be computed as a uniformly distributed lateral pressure equal to 28 percent of the applied vertical pressure. For embankment soils extending above the top of wall, the unit weight of the compacted embankment soil may be assumed to be 130 pcf.

Active earth loads on the wall may be resisted by a combination of passive lateral pressure and friction resistance on the wall foundation. For cast-in-place wall foundations, the guidance provided in Section 3.3 may be used for lateral support. If precast concrete wall elements such as Ultra Blocks or eco-blocks will be used, the sliding coefficient should be reduced to 0.35.

3.1.4 WET WEATHER EARTHWORK

The onsite soil near the ground surface includes silty clay and sandy clay and should be considered moisture sensitive. When exposed to excess moisture, these soils will likely become difficult to work with, impractical to compact to a suitably dense condition, and will tend to soften and pump under construction traffic. These soils will be difficult to work with during periods of wet weather. Conversely, minor amounts of water may need to be added prior to compaction during hot, dry weather. If fill is to be placed or earthwork is to be performed in wet weather or under wet conditions, the contractor will need to reduce soil disturbance by:

- Performing earthwork in small sections
- Limiting construction traffic over unprotected soil
- Sloping excavated surfaces to promote runoff
- Limiting the size and type of construction equipment used
- Providing gravel “working mats” over areas of prepared subgrade
- Removing wet surficial soil prior to commencing fill placement each day
- Sealing the exposed ground surface by rolling with a smooth drum compactor or rubber-tire roller at the end of each working day
- Providing upgradient perimeter ditches or low earthen berms and using temporary sumps to collect runoff and prevent water from ponding and damaging exposed subgrades.

If construction is conducted during wet weather, we recommend that structural fill consist of an imported, clean, well-graded sand, or sand and gravel, containing less than 5 percent passing the U.S. Standard No. 200 sieve, based on a wet sieve analysis of that portion passing the ¾-inch sieve. An alternative to the use of clean, imported sand and gravel would be to use stabilizing agents, such as lime or cement kiln dust mixed with the nonorganic, onsite soil.

3.1.5 TEMPORARY SLOPES AND EXCAVATIONS

Temporary slope and trench configurations and the maintenance of safe working conditions should be the responsibility of the contractor, who is able to monitor the construction activities and has direct control over the means and methods of construction. All applicable local, state, and federal safety codes pertaining to temporary excavation safety should be followed. If instability is detected, the contractor should flatten the side slopes, install temporary shoring, or temporary earth berms. Temporary excavations, such as short-term construction slopes and utility trenches, in excess of 4 ft should be sloped in accordance with *Safety Standards for Construction Work Part N*, Washington Administrative Code (WAC) 296-155-657, or shored.

We recommend that permanent cut or fill slopes be designed for inclinations of 2H:1V or flatter. All permanent cut or fill slopes should be vegetated or otherwise protected to limit the potential for erosion as soon as practical after construction. Permanent slopes requiring immediate protection from the effects of erosion should be covered with either mulch or erosion control netting/blankets. Areas requiring permanent stabilization should be seeded with an approved grass seed mixture, or hydroseeded with an approved seed-mulch-fertilizer mixture.

3.2 SEISMIC CONSIDERATIONS

The Pacific Northwest is seismically active and the site could be subject to strong ground shaking from a moderate to major earthquake. The medium dense condition of the native soil and the general absence of saturated conditions effectively precludes seismically-induced soil liquefaction. In addition, it is anticipated that the site would not be subject to seismically induced landslides, lateral spreading, or other ground failure. No mapped faults are located within about four kilometers of the site; ground rupture during an earthquake is not likely.

We understand that the proposed Facility will be designed using the seismic design provisions of the 2009 International Building Code (IBC) (International Code Council 2009). k IBC 2009, an earthquake with a 2 percent probability of exceedance in 50 years (2,475-year return interval) is used. The subject site is underlain by relatively medium dense glacial soil, and, therefore, the site can be classified as Site Class D according to Table 1613.5.2 in IBC 2009. We obtained estimates of spectral response accelerations for an earthquake with a 2,475-year return interval from the USGS *U.S. Seismic Design Maps* (USGS 2002). Based on the project location (Latitude 48.05024 and Longitude -122.8179), the following spectral accelerations should be used to estimate the design response spectrum:

Spectral Acceleration for short periods (Ss):	118.0% of gravity (1.180g)
Spectral Acceleration for 1-second period (S_1):	43.2% of gravity (0.432g)

For Site Class D and the above spectral accelerations, a value of 1.028 should be used for site coefficient F_a, and 1.568 for site coefficient F_v.

Earthquake performance of retaining walls on competent foundation soils is generally quite good for earthquakes with site adjusted peak ground accelerations (PGA) of up to about 0.4g, especially for shorter walls. The design level earthquake for the project site is expected to produce a PGA of about this level. Therefore, seismic design is not considered to be mandatory for the retaining wall proposed for this project. This no-seismic-analysis approach is consistent with current AASHTO design procedures.

3.3 FOUNDATION SUPPORT AND SETTLEMENT

Conventional shallow isolated and continuous footings and slab-on-grade floors are appropriate for support of the proposed maintenance and administration building. Footings should bear either directly on the granular soil located below the uppermost clay, which was encountered to depths of between 1 to 3½ ft BGS, or else bear on structural fill placed and compacted above a native granular subgrade. This may require deepening the footings somewhat or accomplishing some amount of overexcavation to remove the uppermost clay and backfilling with compacted structural fill up to the design footing elevation. Footings bearing in the sand and gravelly sand underlying the clay (either directly or with intervening structural fill) will be capable of providing an allowable net bearing pressure of 3,500 psf. The term “allowable net soil bearing pressure” refers to the pressure that can be imposed on the soil at foundation level resulting from the total of all dead plus live loads, including the weight of the footing and any backfill placed above the footing. The allowable bearing pressure may be increased by one-third for transient wind or seismic loads. Continuous and isolated spread footings should have minimum widths of 18 and 24 inches, respectively, and should be founded a minimum of 18 inches below the lowest adjacent final grade.

Footing subgrade soil disturbed during foundation excavation should either be properly recompacted or removed. All subgrade soil directly below and around footings should be compacted to at least 95 percent of maximum dry density (ASTM D 1557) prior to placement of forms and reinforcing steel. Where compacted structural fill is used below a footing, the limits of the overexcavation should extend laterally beyond the edge of each side of the footing a distance equal to the depth of the excavation below the base of the footing. All backfill beneath and around the sides of footing should consist of imported structural fill selected, placed, and compacted as described in Section 3.1.2.

Settlement of spread foundations depends on foundation size and bearing pressure, as well as the strength and compressibility characteristics of the underlying bearing soil. Assuming typical loads for a building of this type and construction conducted in accordance with the recommendations of this report, we estimate footing settlements of ½ inch or less would occur. Differential settlement between footings would likely be approximately ¼ inch or less. Settlement would occur primarily during load placement or within a short time afterwards. Post-construction settlements are expected to be relatively small.

Resistance to lateral loads may be assumed to be provided by friction acting on the base of footings and by passive lateral earth pressures acting against the sides of footings. An allowable coefficient of sliding resistance of 0.50, applied to the vertical dead loads only, may be used to compute frictional resistance developed on the underside of footings. This coefficient of sliding resistance includes a factor of safety of about 1.25. For design purposes, the passive resistance of undisturbed, medium dense to dense native soil or well-compacted fill placed against the sides of foundations may be considered equivalent to a fluid with a density of 250 pcf. The upper 1 ft of passive resistance should be neglected in design if not covered by pavement or floor slabs. The value for the foundation passive earth pressure has been reduced by a factor of about 2 to limit deflections to less than 1 percent of the embedded depth.

3.4 CONCRETE SLABS-ON-GRADE

Conventional slab-on-grade floor construction is considered feasible for floors of the planned maintenance and administration building. Floor slabs may be supported on properly compacted structural fill placed over compacted native clay subgrade soil prepared as described in Section 3.1. The presence of a dense, unyielding subgrade should be confirmed by proof rolling. As noted in Section 3.1, the clay subgrade is moisture sensitive; the quality and durability of slab-on-grade floors will be affected by earthwork conditions at the time of construction. For this reason, we reiterate that slabs-on-grade would ideally be placed during the dry season.

We recommend that interior concrete slab-on-grade floors be underlain by a minimum of 6 inches of compacted, clean, free-draining gravel with less than 2 percent passing the U.S. Standard No. 200 sieve. Gravel Backfill for Drains or Gravel Backfill for Drywells, as described in sections 9-03.12(4) and 9-03.12(5) of WSDOT's *Standard Specifications* satisfy this recommendation. Other suitable free-draining products may be available locally and could be proposed by the contractor. The purpose of this layer is to provide uniform support for the slab and to provide a capillary break. The drainage layer should be hydraulically connected to an appropriate drainage collection system. To reduce the potential for water vapor migration through floor slabs, a continuous impermeable membrane should be installed below the slab as a vapor retarder.

Exterior slabs may be supported directly on undisturbed native soil or properly placed and compacted structural fill; however, long-term performance will be enhanced if exterior slabs are placed on a layer of clean, durable, well-draining granular material.

3.5 PAVEMENT DESIGN

The pavement subgrade soil will consist of generally medium stiff to stiff sandy clay and silty clay. This soil will perform adequately for pavement subgrade, provided that the earthwork recommendations discussed in Section 3.1 are followed.

The following pavement section discussion is based upon a few assumptions (which should be confirmed by the design team):

1) Lacking conventional traffic count data, the “Low-Volume Road Design” approach presented in the American Association of State Highway and Transportation Officials’ *Design of Pavement Structures* (AASHTO 1993) is appropriate for design of pavement at the facility;
2) The following traffic assumptions are valid: 0.57 equivalent single axle loads (ESALs) per bus, 90 bus trips per day, 270 operating days per year, and a 20-year pavement design life with no traffic growth expectation;
3) Use of the climate and subgrade descriptors presented in the standard design catalog for flexible and rigid pavements contained in AASHTO 1993 is appropriate for this site in western Washington; and
4) Performance at the 50-percent or 75-percent “inherent reliability level” is acceptable to JTA over the pavement design life.

Based upon the relatively low traffic loading over a 20-year design period (280,000 ESALs), a Hot Mix Asphalt (HMA) flexible pavement section consisting of 4 inches of asphalt pavement atop a 10-inch thick aggregate surfacing layer can support the expected traffic at the entrance drive, PnR loop, and in the fleet parking area at the 50- to 75-percent inherent reliability levels. As an alternative, a rigid pavement consisting of 5 inches of Portland cement concrete (PCC) atop 3 inches of aggregate crushed surfacing material could provide a similar level of pavement service. Where only small-auto traffic will be present (i.e., the Visitor/PnR parking area), the HMA pavement section may be reduced to 3 inches of asphalt pavement atop an 8-inch thick aggregate layer. The PCC pavement section should not be reduced in these areas.

The upper 1½- to 2-inch thick wearing course of the asphalt pavement should consist of HMA Class ½-inch. The asphalt pavement below the wearing course should consist of HMA Class ¾-inch. The asphalt binder should be PG64-22. Crushed surfacing material should meet the gradation requirements in Section 9-09.3(9) of the 2012 WSDOT *Standard Specifications* (WSDOT 2012). The top 2 inches of crushed surfacing material should consist of crushed surfacing top course (CSTC) with the remainder consisting of crushed surfacing base course (CSBC). The entire thickness of crushed surfacing beneath a Portland cement concrete pavement may consist of CSBC.

Crushed surfacing should be compacted in accordance with Section 4-04.3(5) of the 2012 WSDOT *Standard Specifications.* Alternatively, the maximum dry density could be determined by the ASTM D 1557 test procedure. Prevention of road-base saturation is essential for pavement durability; thus, efforts should be made to limit the amount of water entering the base course during construction and by providing proper "crowning" of the subgrade to promote drainage towards the edges of paved areas.

3.6 SITE AND FOUNDATION DRAINAGE

The regional groundwater level is well below the ground surface and special subsurface drainage provisions are not anticipated. However, seasonal perched groundwater may be present in the site subgrade. Also, stormwater runoff from the building roof and impervious pavements could collect in low areas around the proposed exterior walls. Site grading should include positive grades away from the building as described in Section 1804.3 of the *International Building Code* (International Code Council 2009), with a 2-percent slope extending at least 10 feet from exterior walls. We recommend that an exterior footing drain system or gravel curtain be installed around the perimeter of the building foundations.

Footing drains should be installed at the footing elevation and should consist of HDPE or PVC perforated pipe. The pipe should be bedded on all sides with 4 inches of clean, uniformly-graded fine gravel, such as that meeting the requirements of Gravel Backfill for Drains in Section 9-03.12(4) of the WSDOT 2012 *Standard Specifications.* A gravel curtain, if used, should consist of Gravel Backfill for Drains placed and compacted in a trench extending below the surficial clay soil and at least 12 inches into more permeable, underlying granular soil. The roof drainage system should not be introduced into the perimeter drain system, but should be discharged directly to the stormwater collection system or other appropriate outlet via a separate pipe system.

3.7 STORMWATER INFILTRATION

It is our understanding that stormwater facilities constructed to mitigate flows generated by the proposed project will be designed in accordance with the requirements of the 2005 *Stormwater*

Management Manual for Western Washington (2005 *SMMWW*) published by the Washington State Department of Ecology (Ecology 2005). These facilities would be designed to include treatment and infiltration of surface water flows into the subsurface. Proposed stormwater features include three landscaped infiltration ponds between the Visitor/PnR parking lot and the bus loop/access road, as shown on Figure 2. We understand these locations could change somewhat during final design. Additional infiltration using dispersion will likely be included in stormwater design around the perimeter of the fleet parking area.

Soils near the Visitor/PnR parking lot and the bus loop/access road were explored by test pits TP-1, TP-2, and TP-4, which indicate that 2½ to 3½ ft of low-permeability silty to sandy clay (USDA: silt loam) is present above 3½ to 7½ ft of fine to medium sand with a trace of gravel (USDA: sand and medium sand). Coarser sand and gravelly sand (USDA: very gravelly sand) was encountered near the bottom of these test pits. We expect that the bottoms of infiltration ponds at these locations would extend below the bottom of the silty to sandy clay soil. Provided that the infiltration pond bottom extends into soils classified by the USDA as sand, a long-term infiltration rate of 1 to 2 inches per hour may be used for design. This conclusion is based upon guidance from Tables 3.7 and 3.8 of the 2005 *SMMWW*.

It will be necessary to provide treatment to flows generated from pollution generating surfaces such as pavement carrying vehicle traffic. It should be noted that sand (USDA definition) would need to meet minimum cation exchange capacity (CEC) and organic content levels to provide treatment below the infiltration pond floor. We did not perform CEC or organic content tests for samples at these locations; however, based upon the visual appearance of the samples, it is not likely that they meet the requirements to provide pollution treatment. Thus, treatment will need to be provided up-stream of the infiltration location. This could probably be achieved through the use of vegetated bioswales located in the silty and sandy clay soil (USDA: silt loam) encountered within the upper few feet across the project site. This uppermost soil could also provide pollution treatment for dispersed stormwater flows.

3.8 ONSITE SEPTIC DESIGN CONSIDERATIONS

It is our understanding that an onsite septic (OSS) system will be included in the project design. Although the OSS system will be designed by another member of the design team, we can provide comments on the soil types encountered during exploration. We assume that OSS design will be in accordance with the requirements of the Jefferson County health authority and with the Washington Department of Health requirements.

The silty to sandy clay encountered near the ground surface at each test pit location is classified as Type 6 soil according to the DOH system and is unsuitable for disposal of septic effluent. Beneath the silty to sandy clay, typically fine to medium sand with minor amounts of silt and gravel is present and is classified as Type 2A or Type 2B soil, depending on the specific amount of gravel and coarse sand at a given location. Type 2A and 2B soils are excellent soils for the purpose of OSS design, and can often be used for the design of simple, gravity-type systems. However, where the top of Type 2 soils are encountered at a depth greater than 3 ft below the finish grade, imported Type 2A sand may need to be used to raise the top of the OSS sand media to within 3 ft of the finish grade. A loading rate of 1.0 gallons per day per square foot of trench area is recommended for the Type 2A and 2B soils encountered during exploration. This application rate is based upon guidance provided in the DOH publications *Design Standards for Large On-Site Sewage Systems* (DOH 1993) and *Sand Lined Trench Systems* (DOH 2007).

At least 2 ft of Type 2A or 2B sand must be present below the bottom of the OSS trenches to provide adequate septic treatment. Very gravelly to extremely gravelly sands (USDA) were encountered at relatively shallow depths at some of the test pits around the maintenance and administration building. These soils, which are classified as Type 1A soils (DOH), are overly permeable and do not provide adequate retention time for treatment of OSS effluents. If the OSS system is sited where Type 1A (or 1B) soil is present near the ground surface, sand-lined trenches and the use of imported Type 2A sand may be necessary for OSS design, as described in DOH 2007.

4.0 DESIGN REVIEW/CONSTRUCTION MONITORING

Landau Associates recommends that a general review of the earthwork and foundation portions of the design drawings and specifications be accomplished by a geotechnical engineer familiar with the project design. The purpose of the review is to verify that the recommendations presented in this report have been properly interpreted and implemented in the design and specifications.

We recommend that geotechnical construction monitoring services be provided. All building areas and footing excavations should be observed by a representative of the geotechnical engineer. Observations should also be conducted at footing excavations after the reinforcing steel has been placed, within about 24 hours prior to placing concrete.

We recommend that a geotechnical field representative be present to observe removal of existing topsoil and other loose soil from within the building areas and other excavations, to monitor fill placement and compaction activities, to observe proof-rolling operations, to document that design subgrade conditions are obtained beneath building areas, and to confirm that appropriate drainage materials are used and properly placed. We recommend that in-place density testing be performed on footing and floor subgrades. Conformance testing of imported materials may also be needed to verify compliance with project specifications and our recommendations.

The purpose of these services would be to observe compliance with the design concepts, specifications, and recommendations of this report, and to simplify design or construction changes in the event subsurface conditions differ from those anticipated before the start of construction. Landau Associates would be pleased to provide these services for you.

5.0 USE OF THIS REPORT

Landau Associates has prepared this geotechnical report for the exclusive use of Jefferson Transit Authority, TCF Architecture, and the other project consultants for specific application to the design of the proposed Jefferson Transit Authority Maintenance and Administration Facility project. Use of this report by others or for another project is at the user's sole risk. Within the limitations of scope, schedule, and budget, our services have been conducted in accordance with generally accepted practices of the geotechnical engineering profession; no other warranty, express or implied, is made as to the professional advice included in this report.

The conclusions and recommendations contained in this report are based in part upon the subsurface data obtained from the explorations completed for this study. There may be some variation in subsurface soil and groundwater conditions at the project site, and the nature and extent of the variations may not become evident until construction. Accordingly, a contingency for unanticipated conditions should be included in the construction budget and schedule.

If variations in subsurface conditions are encountered during construction, we should be notified for review of the recommendations of this report, and revision of such if necessary. If there is a substantial lapse of time between submission of this report and the start of construction, or if conditions change due to construction operations at or adjacent to the project alignment, we recommend that we review this report to determine the applicability of the conclusions and recommendations contained herein.

We appreciate the opportunity to provide geotechnical services on this project and look forward to assisting you during the final design and construction phase. If you have any questions or comments regarding the information contained in this report, or if we may be of further service, please call.

LANDAU ASSOCIATES, INC.

CHAD THOMAS McMULLEN
43688

AUGUST 23, 2013

Chad McMullen, P.E.
Senior Project Geotechnical Engineer

for

Dennis R. Stettler, P.E.
Principal

CTM/DRS/rgm

6.0 REFERENCES

AASHTO. 1993. *AASHTO Guide for Design of Pavement Structures.* ISBN # 1-56051-055-2. American Association of State Highway and Transportation Officials. Washington D.C.

DOH. 1993. *Design Standards for Large On-Site Sewage Systems.* Washington State Department of Health. December. Amended July 1994.

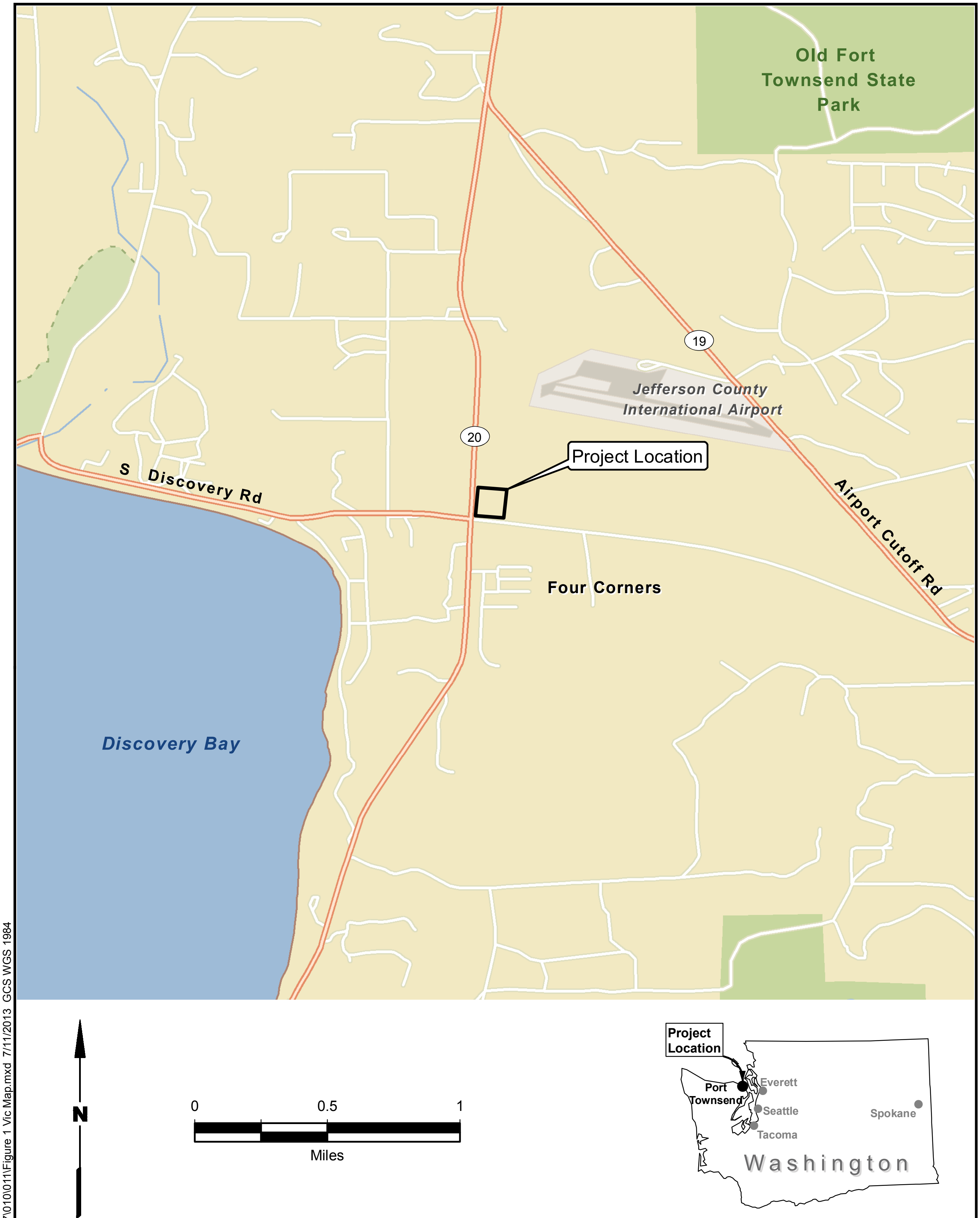
DOH. 2007. *Recommended Standards and Guidance for Performance, Application, Design, and Operation and Maintenance for Sand Lined Trench Systems.* Washington State Department of Health, Publication #337-013. July.

Henry W. Schasse and Stephen L. Slaughter. 2005. *Geologic Map of the Port Townsend South and Part of the Port Townsend North 7.5-minute Quadrangles, Jefferson County, Washington.* Washington Department of Natural Resources.

International Code Council. *2009 International Building Code*. ISBN # 1-58001-725-1. Country Club Hills, IL. February.

USGS website. 2002. *U.S. Seismic Design Maps*. http://geohazards.usgs.gov/designmaps/us/application.php. U.S. Geological Survey, Geologic Hazards Science Center. Accessed July 8, 2013.

WSDOT. 2012. *Standard Specifications for Road, Bridge and Municipal Construction*. M 41-10. Washington State Department of Transportation.



Data Source: Esri 2012

V:\813\007\010\011\Figure 1 Vic Map.mxd 7/11/2013 GCS WGS 1984

LANDAU ASSOCIATES

Jefferson Transit Authority
Maintenance and
Administration Facility
Jefferson County, Washington

Vicinity Map

Figure
1

Legend

TP-1 ▚ Test Pit Location and Designation

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 100 200
Scale in Feet

Source: TCF Architecture 2013

Jefferson Transit Authority
Maintenance and
Administration Facility
Jefferson County, Washington

Site and Exploration Plan

Figure
2

LANDAU ASSOCIATES

LANDAU ASSOCIATES, INC. | V:\813\007\010\011\Figure 2 Site plan.dwg (A) "Figure 2" 7/11/2013

APPENDIX A

Field Explorations

APPENDIX A
FIELD EXPLORATIONS

Subsurface conditions within the limits of the project area were explored on April 19, 2013. The exploration program consisted of advancing and sampling twelve test pits. The exploratory test pits were advanced to depths ranging from about 11 to 16 ft below existing ground surface (BGS) using a tracked excavator. Jamestown Excavating, Inc. of Sequim, Washington advanced the test pits under subcontract to Landau Associates. The actual exploration locations were determined in the field by a recreation-grade GPS unit. The approximate ground surface elevations and proposed test pit locations were determined by the project surveyor prior to test pit digging; some adjustments to test pit locations were made during digging. The test pit locations shown on Figure 2 represent the actual locations explored.

The field exploration program was coordinated and monitored by a geotechnical engineer from our staff, who also obtained representative soil samples, maintained a detailed record of the observed subsurface soil and groundwater conditions, and described the soil encountered by visual and textural examination. Each representative soil type observed in our test pits was described using the soil classification system shown on Figure A-1, in general accordance with ASTM D2488, *Standard Recommended Practice for Description of Soils (Visual-Manual Procedure)*. Logs of the exploratory test pits are presented on Figures A-2 through A-7. These logs represent our interpretation of subsurface conditions identified during the field exploration program. The stratigraphic contacts shown on the logs represent the approximate boundaries between soil types; actual transitions may be more gradual. The soil and groundwater conditions depicted are only for the specific dates and locations reported and, therefore, are not necessarily representative of other locations and times. A further discussion of the soil and groundwater conditions observed is contained in the text portion of this report.

Soil grab samples were collected from the sides or bottom of the test pit or, as the excavation progressed below 4 ft, from the excavator bucket. Samples were logged and examined as described above and then preserved in zip lock bags for laboratory testing. Laboratory testing is further discussed in Appendix B. After reaching the final depth, test pits were backfilled with the excavation spoils and tamped with the excavator bucket in several lifts.

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS [2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)	▨	**GW**	Well-graded gravel; gravel/sand mixture(s); little or no fines
			▨	**GP**	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)	▨	**GM**	Silty gravel; gravel/sand/silt mixture(s)
			▨	**GC**	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)	▨	**SW**	Well-graded sand; gravelly sand; little or no fines
			▨	**SP**	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)	▨	**SM**	Silty sand; sand/silt mixture(s)
			▨	**SC**	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)		▨	**ML**	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
			▨	**CL**	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
			▨	**OL**	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)		▨	**MH**	Inorganic silt; micaceous or diatomaceous fine sand
			▨	**CH**	Inorganic clay of high plasticity; fat clay
			▨	**OH**	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL		▨	**PT**	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT	■ ▨	**AC** or **PC**	Asphalt concrete pavement or Portland cement pavement
ROCK	▨	**RK**	Rock (See Rock Classification)
WOOD	▨	**WD**	Wood, lumber, wood chips
DEBRIS	▨	**DB**	Construction debris, garbage

Notes:
1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the Standard Test Method for Classification of Soils for Engineering Purposes, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	> 50%	- "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and ≤ 50%	- "very gravelly," "very sandy," "very silty," etc.
	> 15% and ≤ 30%	- "gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and ≤ 15%	- "with gravel," "with sand," "with silt," etc.
	≤ 5%	- "with trace gravel," "with trace sand," "with trace silt," etc., or not noted.

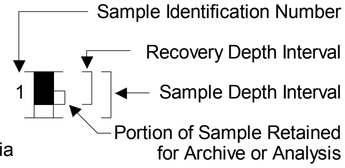
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

Drilling and Sampling Key

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Single-Tube Core Barrel
f	Double-Tube Core Barrel
g	2.50-inch O.D., 2.00-inch I.D. WSDOT
h	3.00-inch O.D., 2.375-inch I.D. Mod. California
i	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Vibrocore (Rotosonic/Geoprobe)
5	Other - See text if applicable

SAMPLE NUMBER & INTERVAL



Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

Groundwater

▽	Approximate water level at time of drilling (ATD)
▼	Approximate water level at time other than ATD

LANDAU ASSOCIATES

Jefferson Transit Authority
Maintenance and Administration Facility
Jefferson County, Washington

Soil Classification System and Key

Figure
A-1

TP- 1

SAMPLE DATA

SOIL PROFILE

GROUNDWATER

Excavation Method: Tracked Excavator
Ground Elevation (ft): 130.8
Excavated By: Jamestown Excavating
Logged By: CTM

Depth (ft)	Elevation (ft)
0	130
	128
5	126
	124
	122
10	120
	118
	116
15	114

Sample Number & Interval	Sampler Type	Test Data
1	d	
2	d	
3	d	
4	d	

USCS Symbol	Soil Profile	Groundwater
SC	Dark brown, clayey, fine to medium SAND with abundant roots (loose, moist) **(TOPSOIL)**	Groundwater not encountered.
CL	Brown, sandy CLAY with occasional roots (USDA: SILT LOAM. DOH: Type 6) (medium stiff to stiff, damp) **(GLACIOMARINE DEPOSITS)**	
SP-SM	Brown, fine to medium SAND with silt and gravel, uniform (USDA: Medium SAND, type 2B) (medium dense, moist)	
SW/SP	Gray, very gravelly SAND (USDA: Very gravelly SAND. DOH: Type 1A) (medium dense, moist)	

-- moderate caving from 9 to 13 ft

Test Pit Completed 04/19/13
Total Depth of Test Pit = 13.0 ft.

TP- 2

SAMPLE DATA

SOIL PROFILE

GROUNDWATER

Excavation Method: Tracked Excavator
Ground Elevation (ft): 135.3
Excavated By: Jamestown Excavating
Logged By: CTM

Depth (ft)	Elevation (ft)
0	134
	132
5	130
	128
	126
10	124
	122
	120
15	118

Sample Number & Interval	Sampler Type	Test Data
1	d	W = 21 AL
2	d	
3	d	

USCS Symbol	Soil Profile	Groundwater
CL	Dark brown sandy, silty CLAY with abundant organics and wood debris (loose, moist) **(TOPSOIL)**	Groundwater not encountered.
CL	Gray-brown silty CLAY with sand to silty, sandy CLAY, occasional roots (USDA: SILT LOAM. DOH: Type 6) (medium stiff to stiff, damp) **(GLACIOMARINE DEPOSITS)**	
SP-SM	Brown, fine to medium SAND with silt, slight gray-brown mottling at top (USDA: SAND. DOH: Type 2B) (medium dense, damp)	
SW/SP	Gray, fine to coarse SAND, trace of silt and fine gravel (USDA: SAND. DOH: Type 1A) (medium dense, damp)	

Test Pit Completed 04/19/13
Total Depth of Test Pit = 13.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Jefferson Transit Authority
Maintenance and Administration Facility
Jefferson County, Washington

Log of Test Pits

Figure
A-2

TP- 3

SAMPLE DATA

Sample Number & Interval	Elevation (ft)	Sampler Type	Test Data
1		d	
2	132	d	W = 13 GS
3	124	d	

Depth (ft): 0, 5, 10, 15

Elevation (ft): 134, 132, 130, 128, 126, 124, 122, 120, 118

Test Pit Completed 04/19/13
Total Depth of Test Pit = 16.0 ft.

SOIL PROFILE

Excavation Method: Tracked Excavator
Ground Elevation (ft): 135.5
Excavated By: Jamestown Excavating
Logged By: CTM

USCS Symbol	Description
CL	Dark brown, sandy CLAY with abundant fine organics (medium stiff to stiff, moist) **(TOPSOIL)**
CL SP	Gray-brown CLAY with sand to sandy CLAY, occasional roots and wood debris (USDA: SILT LOAM. DOH: Type 6) (medium stiff to stiff, damp) **(GLACIOMARINE DEPOSITS)**
SW/ SP	Brown, fine to medium SAND, trace of gravel, occasional cobbles (USDA: Medium SAND. DOH: Type 2B) (medium dense, damp)
	Gray, very gravelly SAND, trace silt, subangular to subround gravel (USDA: Very gravelly SAND. DOH: Type 1A) (medium dense, damp)
	-- moderate caving from 7 to 16 ft

GROUNDWATER

Groundwater not encountered.

TP- 4

SAMPLE DATA

Sample Number & Interval	Elevation (ft)	Sampler Type	Test Data
1	134	d	W = 23 AL
2	132	d	
3		d	

Depth (ft): 0, 5, 10, 15

Elevation (ft): 134, 132, 130, 128, 126, 124, 122, 120, 118

Test Pit Completed 04/19/13
Total Depth of Test Pit = 11.5 ft.

SOIL PROFILE

Excavation Method: Tracked Excavator
Ground Elevation (ft): 135.4
Excavated By: Jamestown Excavating
Logged By: CTM

USCS Symbol	Description
CL CL	Dark brown, SILT with sand and small roots (medium stiff, damp) **(TOPSOIL)**
SP- SM	Gray-brown (slight mottling) SILT with fine sand, scattered roots (USDA: SILT LOAM. DOH: Type 6) (medium stiff to stiff, damp) **(GLACIOMARINE DEPOSITS)**
SW/ SP	Brown, fine to medium SAND with gravel, trace of silt to with silt, occasional fine roots near top (USDA: SAND. DOH: Type 2B) (medium dense, damp)
	Gray to gray-brown, gravelly SAND, trace silt and cobbles (USDA: very gravelly SAND. DOH: Type 1A) (medium dense, damp)

GROUNDWATER

Groundwater not encountered.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Jefferson Transit Authority
Maintenance and Administration Facility
Jefferson County, Washington

Log of Test Pits

Figure
A-3

TP- 5

SAMPLE DATA | **SOIL PROFILE** | **GROUNDWATER**

Excavation Method: Tracked Excavator
Ground Elevation (ft): 135.1
Excavated By: Jamestown Excavating
Logged By: CTM

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data
	134	1	d	
	132	2	d	W = 4 GS

USCS Symbol	
CL	Brown, gravelly, sandy CLAY with scattered fine roots (medium stiff, damp to moist) **(TOPSOIL)**
SC	Brown, gravelly, very clayey SAND with scattered roots (USDA: SANDY LOAM. DOH: Type 4) (medium dense to dense, moist) **(GLACIOMARINE DEPOSITS)**
SP	Brown, very gravelly SAND with angled stringers of gravelly SAND with silt (USDA: Extremely gravelly COARSE SAND, DOH: Type 1A) (medium dense, damp)
GP	Gray, very sandy fine GRAVEL (DOH: Type 1A) -- rapid caving and sloughing (medium dense, damp)

Test Pit Completed 04/19/13
Total Depth of Test Pit = 11.0 ft.

Groundwater not encountered.

TP- 6

SAMPLE DATA | **SOIL PROFILE** | **GROUNDWATER**

Excavation Method: Tracked Excavator
Ground Elevation (ft): 135.3
Excavated By: Jamestown Excavating
Logged By: CTM

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data
	134	1	d	W = 26 AL
	132	2	d	W = 12 GS
	124	3	d	

USCS Symbol	
CL	Brown to gray brown, sandy CLAY with scattered to abundant roots (medium stiff to stiff, moist) **(TOPSOIL)**
CL	Gray silty CLAY with fine sand to trace of sand (USDA: SILT LOAM. DOH: Type 6) (medium stiff, moist) **(GLACIOMARINE DEPOSITS)** -- faint mottling
SP-SM	Gray, fine to medium SAND with silt to trace of silt (USDA: Coarse SAND DOH: Type 2A) (medium dense, moist) -- sandy gravel seam from 5 to 6 ft

Test Pit Completed 04/19/13
Total Depth of Test Pit = 12.0 ft.

Groundwater not encountered.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Jefferson Transit Authority
Maintenance and Administration Facility
Jefferson County, Washington

Log of Test Pits

Figure
A-4

TP- 7

SAMPLE DATA				SOIL PROFILE		GROUNDWATER
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	

Excavation Method: Tracked Excavator
Ground Elevation (ft): 134.9
Excavated By: Jamestown Excavating
Logged By: CTM

Sample Number & Interval	Sampler Type	Test Data
1	d	
2	d	W = 16 GS
3	d	

USCS Symbol	Description
CL	Dark brown CLAY with fine sand, abundant fine to medium roots (medium stiff, moist) **(TOPSOIL)**
CL	Gray-brown, faintly mottled, CLAY with sand to sandy CLAY (USDA: SILT LOAM. DOH: Type 6) (medium stiff to stiff, moist) **(GLACIOMARINE DEPOSITS)**
SP-SM	Gray-brown, fine to medium SAND with silt (USDA: LOAMY medium SAND. DOH: Type 3) (medium dense to dense, moist)
GW/GP	Gray, gravelly to very gravelly SAND and sandy GRAVEL, trace of silt and cobbles (USDA: Very gravelly SAND. DOH: Type 1A) (medium dense, moist)

Groundwater not encountered.

Test Pit Completed 04/19/13
Total Depth of Test Pit = 13.0 ft.

Depth (ft): 0, 5, 10, 15
Elevation (ft): 134, 132, 130, 128, 126, 124, 122, 120, 118

TP- 8

SAMPLE DATA				SOIL PROFILE		GROUNDWATER
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	

Excavation Method: Tracked Excavator
Ground Elevation (ft): 135.5
Excavated By: Jamestown Excavating
Logged By: CTM

Sample Number & Interval	Sampler Type	Test Data
1	d	
2	d	W = 10 GS
3	d	

USCS Symbol	Description
CL	Dark brown silty CLAY with sand and abundant fine roots (medium stiff, moist) **(TOPSOIL)**
CL	Gray (with faint mottling) CLAY with fine sand to trace of sand and occasional fine roots (USDA: SILT LOAM. DOH: Type 6) (medium stiff to stiff, moist) **(GLACIOMARINE DEPOSITS)**
SW	Brown, well graded SAND with gravel, trace silt (USDA: Very gravelly coarse SAND. DOH: Type 1A) (medium dense, damp)
GW/SW	Gray, very gravelly SAND to very sandy GRAVEL, trace of cobbles (USDA: Very gravelly to extremely gravelly SAND. DOH: Type 1A) (medium dense to dense, damp) -- moderate to serious caving from 6 to 11 ft

Groundwater not encountered.

Test Pit Completed 04/19/13
Total Depth of Test Pit = 11.0 ft.

Depth (ft): 0, 5, 10, 15
Elevation (ft): 134, 132, 130, 128, 126, 124, 122, 120, 118

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU
ASSOCIATES

Jefferson Transit Authority
Maintenance and Administration Facility
Jefferson County, Washington

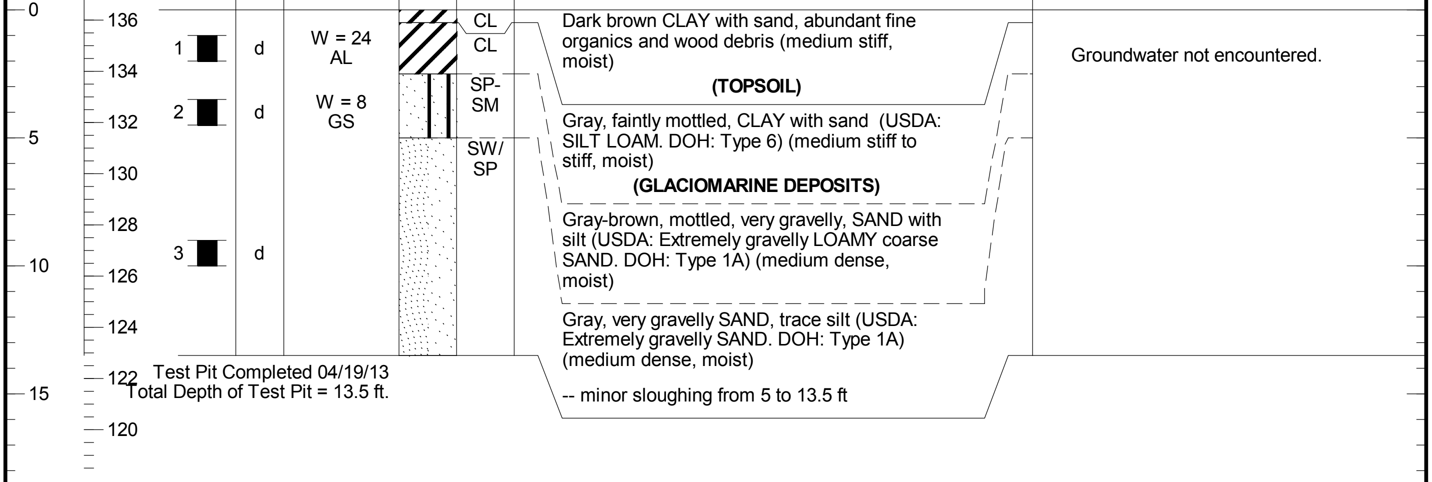
Log of Test Pits

Figure
A-5

TP- 9

SAMPLE DATA | **SOIL PROFILE** | **GROUNDWATER**

Excavation Method: Tracked Excavator
Ground Elevation (ft): 136.4
Excavated By: Jamestown Excavating
Logged By: CTM



Sample Number & Interval	Sampler Type	Test Data
1	d	W = 24 AL
2	d	W = 8 GS
3	d	

Dark brown CLAY with sand, abundant fine organics and wood debris (medium stiff, moist)

(TOPSOIL)

Gray, faintly mottled, CLAY with sand (USDA: SILT LOAM. DOH: Type 6) (medium stiff to stiff, moist)

(GLACIOMARINE DEPOSITS)

Gray-brown, mottled, very gravelly, SAND with silt (USDA: Extremely gravelly LOAMY coarse SAND. DOH: Type 1A) (medium dense, moist)

Gray, very gravelly SAND, trace silt (USDA: Extremely gravelly SAND. DOH: Type 1A) (medium dense, moist)

-- minor sloughing from 5 to 13.5 ft

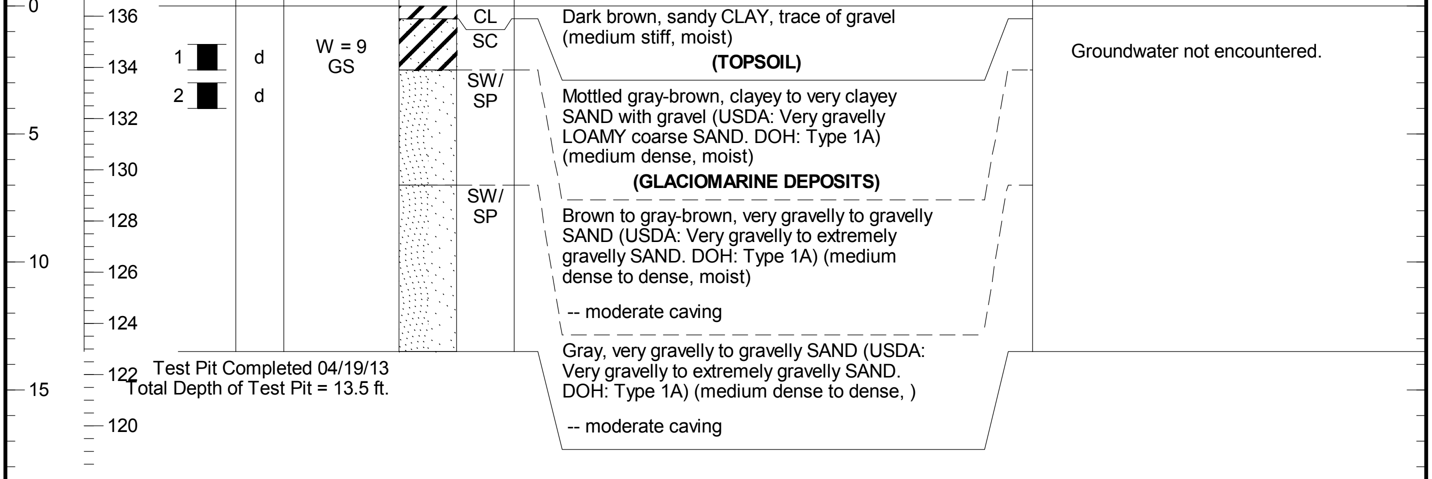
Test Pit Completed 04/19/13
Total Depth of Test Pit = 13.5 ft.

Groundwater not encountered.

TP-10

SAMPLE DATA | **SOIL PROFILE** | **GROUNDWATER**

Excavation Method: Tracked Excavator
Ground Elevation (ft): 136.4
Excavated By: Jamestown Excavating
Logged By: CTM



Sample Number & Interval	Sampler Type	Test Data
1	d	W = 9 GS
2	d	

Dark brown, sandy CLAY, trace of gravel (medium stiff, moist)

(TOPSOIL)

Mottled gray-brown, clayey to very clayey SAND with gravel (USDA: Very gravelly LOAMY coarse SAND. DOH: Type 1A) (medium dense, moist)

(GLACIOMARINE DEPOSITS)

Brown to gray-brown, very gravelly to gravelly SAND (USDA: Very gravelly to extremely gravelly SAND. DOH: Type 1A) (medium dense to dense, moist)

-- moderate caving

Gray, very gravelly to gravelly SAND (USDA: Very gravelly to extremely gravelly SAND. DOH: Type 1A) (medium dense to dense,)

-- moderate caving

Test Pit Completed 04/19/13
Total Depth of Test Pit = 13.5 ft.

Groundwater not encountered.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Jefferson Transit Authority
Maintenance and Administration Facility
Jefferson County, Washington

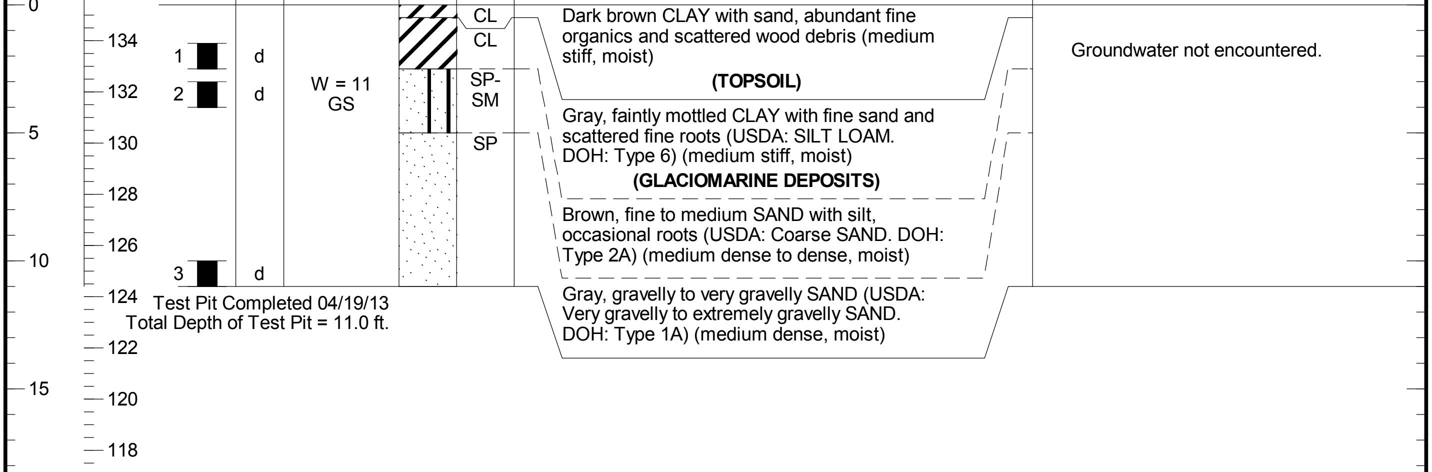
Log of Test Pits

Figure
A-6

TP-11

SAMPLE DATA				SOIL PROFILE	GROUNDWATER
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data	

Excavation Method: Tracked Excavator
Ground Elevation (ft): 135.4
Excavated By: Jamestown Excavating
Logged By: CTM



Dark brown CLAY with sand, abundant fine organics and scattered wood debris (medium stiff, moist)
(TOPSOIL)

Gray, faintly mottled CLAY with fine sand and scattered fine roots (USDA: SILT LOAM. DOH: Type 6) (medium stiff, moist)
(GLACIOMARINE DEPOSITS)

Brown, fine to medium SAND with silt, occasional roots (USDA: Coarse SAND. DOH: Type 2A) (medium dense to dense, moist)

Gray, gravelly to very gravelly SAND (USDA: Very gravelly to extremely gravelly SAND. DOH: Type 1A) (medium dense, moist)

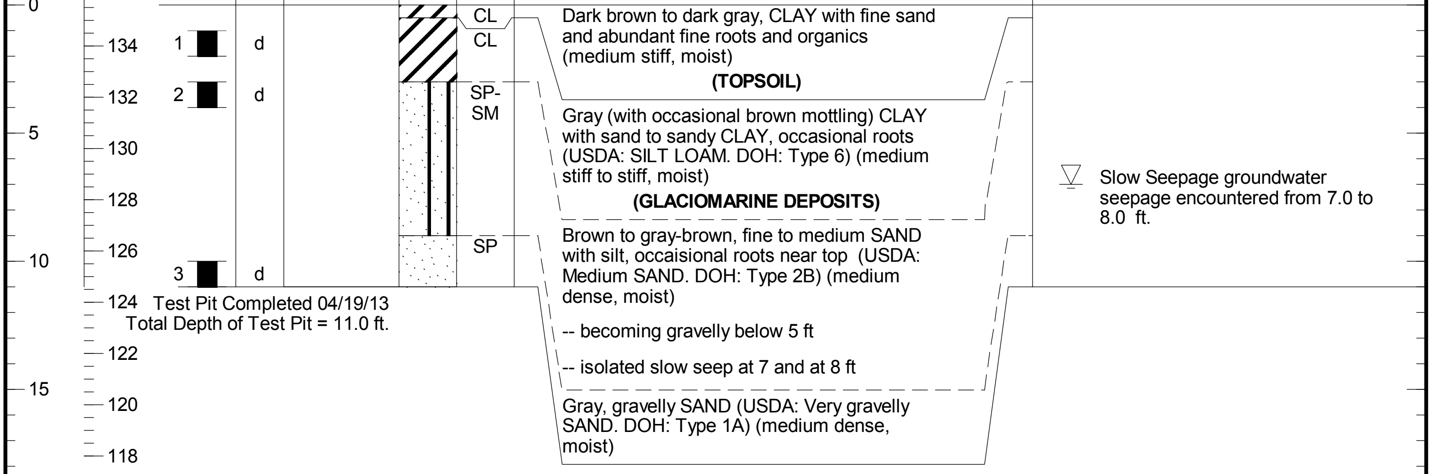
Groundwater not encountered.

Test Pit Completed 04/19/13
Total Depth of Test Pit = 11.0 ft.

TP-12

SAMPLE DATA				SOIL PROFILE	GROUNDWATER
Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data	

Excavation Method: Tracked Excavator
Ground Elevation (ft): 135.6
Excavated By: Jamestown Excavating
Logged By: CTM



Dark brown to dark gray, CLAY with fine sand and abundant fine roots and organics (medium stiff, moist)
(TOPSOIL)

Gray (with occasional brown mottling) CLAY with sand to sandy CLAY, occasional roots (USDA: SILT LOAM. DOH: Type 6) (medium stiff to stiff, moist)
(GLACIOMARINE DEPOSITS)

Brown to gray-brown, fine to medium SAND with silt, occaisional roots near top (USDA: Medium SAND. DOH: Type 2B) (medium dense, moist)

-- becoming gravelly below 5 ft

-- isolated slow seep at 7 and at 8 ft

Gray, gravelly SAND (USDA: Very gravelly SAND. DOH: Type 1A) (medium dense, moist)

▽ Slow Seepage groundwater seepage encountered from 7.0 to 8.0 ft.

Test Pit Completed 04/19/13
Total Depth of Test Pit = 11.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES	Jefferson Transit Authority Maintenance and Administration Facility Jefferson County, Washington	Log of Test Pits	Figure A-7

APPENDIX B

Laboratory Testing

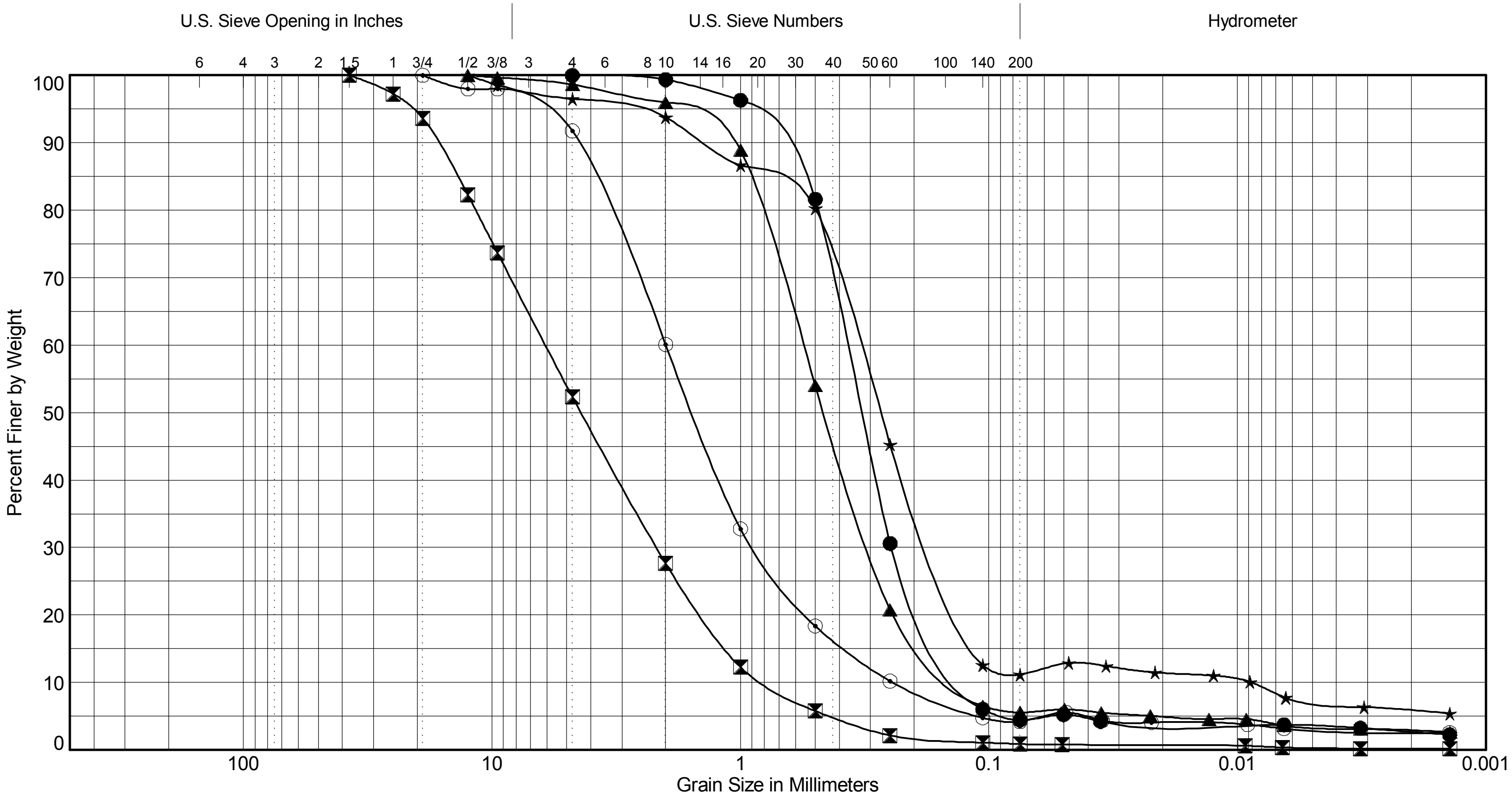
APPENDIX B
LABORATORY TESTING

Soil samples were collected from test pits during field exploration as described in Appendix A. Samples were checked in our Edmonds laboratory against the field log descriptions, which were updated where appropriate in general accordance with ASTM D 2487, *Standard Test Method for Classification of Soils for Engineering Purposes*, which is consistent with the Unified Soil Classification System. Following laboratory testing, the test results were used to further adjust the USCS classifications and to append these with descriptions according to the USDA and Washington Department of Health soil classification systems. Index laboratory tests were performed on selected samples to estimate engineering properties of the soils at the project site. Index tests performed include moisture content determinations, grain-size distribution, and Atterberg limits.

Natural moisture content determinations were performed in general accordance with ASTM D2216 on soil samples obtained from the borings. The natural moisture content is shown as “W=xx” (percent of dry weight) at the respective sample depth in the column labeled “Test Data” on the test pit logs.

Grain-size distribution was determined in accordance with ASTM D 422 and included both mechanical sieving and hydrometer analysis; sieves were selected to facilitate full classification according to both the USCS and USDA systems (including use of the #270 sieve). The results of grain-size testing are plotted as size distribution curves on Figures B-1 and B-2; the clay, silt, and sand constituents are plotted in the form of a USDA triangle on Figure B-3. Samples selected for grain-size testing are designated with a “GS” in the column labeled “Test Data” on the test pit logs.

Atterberg limit determinations were performed on representative soil samples obtained from the test pits in accordance with ASTM D 4318. Samples selected for Atterberg limits are designated with an “AL” in the column labeled “Test Data” on the test pit logs. The results of the Atterberg Limits are shown on Figure B-4 in this appendix.



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

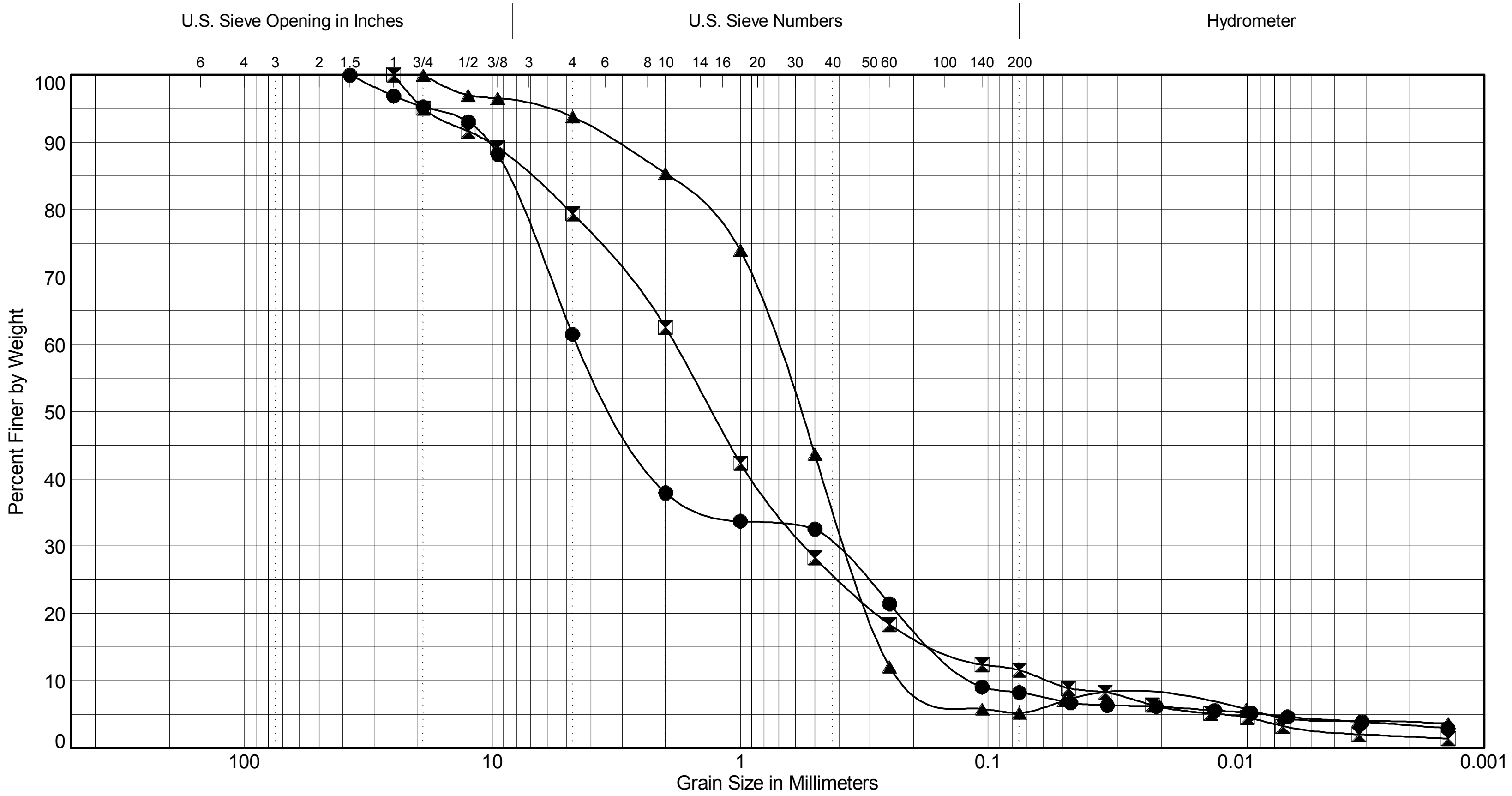
Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TP- 3	S-2	3.0	13	Fine to medium SAND, trace of silt	SP
⧗	TP- 5	S-2	3.0	4	Very gravelly SAND	SP
▲	TP- 6	S-2	3.0	12	Fine to medium SAND with silt, trace gravel	SP-SM
★	TP- 7	S-2	4.0	16	Fine to medium SAND with silt, trace of fine gravel	SP-SM
⊙	TP- 8	S-2	3.5	10	SAND with gravel, trace of silt	SW

LANDAU ASSOCIATES

Jefferson Transit Authority
Maintenance and Administration Facility
Jefferson County, Washington

Grain Size Distribution

Figure
B-1



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

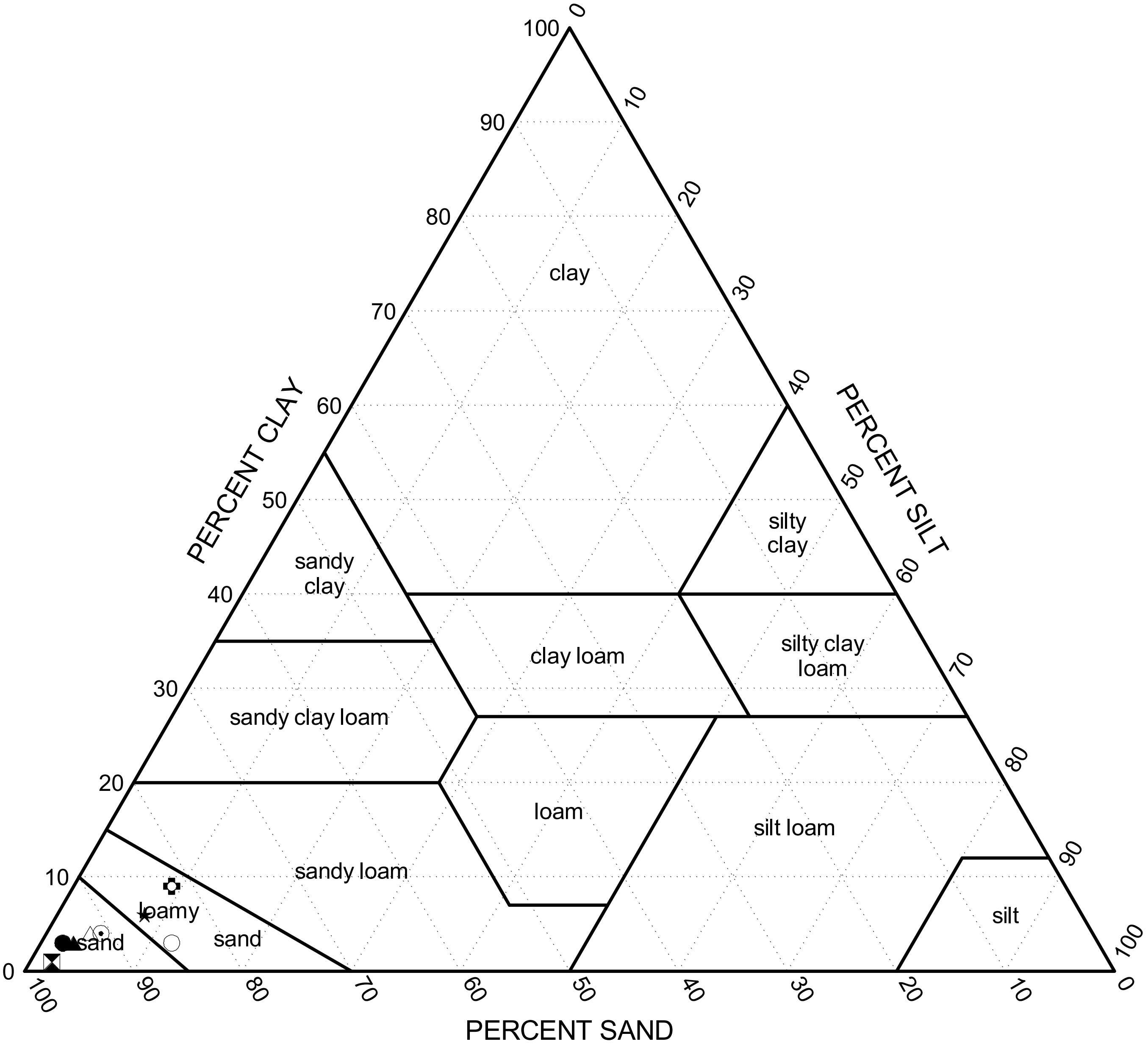
Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TP- 9	S-2	3.5	8	Very gravelly SAND with silt	SP-SM
⧗	TP-10	S-1	1.5	9	Gravelly SAND with silt	SW-SM
▲	TP-11	S-2	3.0	11	Fine to medium SAND with gravel and silt	SP-SM

LANDAU ASSOCIATES

Jefferson Transit Authority
Maintenance and Administration
Facility
Jefferson County, Washington

Grain Size Distribution

Figure
B-2



	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	USDA Textural Classification	USCS Classification
●	TP- 3	S-2	3.0	13	SAND	SP
⧗	TP- 5	S-2	3.0	4	SAND	SP
▲	TP- 6	S-2	3.0	12	SAND	SP-SM
★	TP- 7	S-2	4.0	16	LOAMY SAND	SP-SM
⊙	TP- 8	S-2	3.5	10	SAND	SW
✿	TP- 9	S-2	3.5	8	LOAMY SAND	SP-SM
○	TP-10	S-1	1.5	9	LOAMY SAND	SW-SM
△	TP-11	S-2	3.0	11	SAND	SP-SM

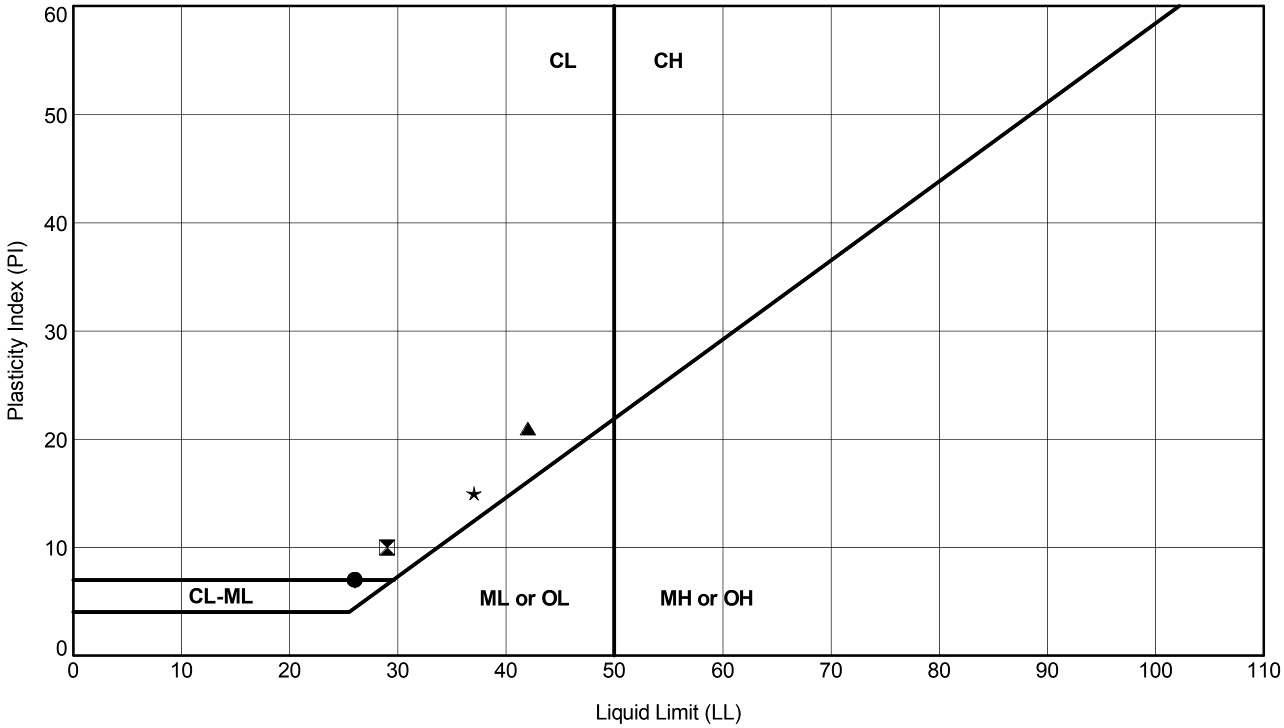
813007.01 7/10/13 N:\PROJECTS\813007.010.GPJ USDA TEXTURAL CLASSIFICATION

LANDAU ASSOCIATES

Jefferson Transit Authority
Maintenance and Administration Facility
Jefferson County, Washington

USDA Textural Classification Chart

Figure
B-3



ATTERBERG LIMIT TEST RESULTS

Symbol	Exploration Number	Sample Number	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	TP- 2	S-1	2.0	26	19	7	21	Gray-brown, sandy CLAY	CL
⧗	TP- 4	S-1	1.0	29	19	10	23	Gray-brown CLAY with fine sand	CL
▲	TP- 6	S-1	1.0	42	21	21	26	Gray CLAY with fine sand to trace of sand	CL
★	TP- 9	S-1	1.0	37	22	15	24	Gray CLAY with sand	CL

ASTM D 4318 Test Method

LANDAU
ASSOCIATES

Jefferson Transit Authority
Maintenance and Administration
Facility
Jefferson County, Washington

Plasticity Chart

Figure
B-4