Geotechnical Engineering Services

Olympic Drive SE Roadway Improvements
City of Bainbridge Island
Bainbridge Island, Washington

for
City of Bainbridge
c/o SvR Design Company

March 24, 2015

GeoEngineers
Earth Science + Technology

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Geotechnical Engineering Services
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City of Bainbridge Island
Bainbridge Island, Washington

File No. 4045-010-00

March 24, 2015

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INTRODUCTION AND PROJECT UNDERSTANDING

The purposes of this report are to summarize the subsurface soil and groundwater conditions encountered at the site and to provide geotechnical conclusions and recommendations for the Olympic Drive SE Roadway Improvements Project located in Bainbridge Island, Washington. The project area is shown in relation to surrounding improvements on the Vicinity Map, Figure 1 and the Site Plan, Figure 2.

We understand that the proposed roadway improvements will include widening a portion of Olympic Drive SE south of Winslow Way to accommodate travel, transit and bike lane improvements. The proposed improvements may include widening 15, 20 or 25 feet from the southwest edge of the existing right-of-way (ROW). The widening will require construction of retaining walls along about 250 feet of the southwest side of the roadway. The walls will be located on and above sloping ground and will be up to 6½ feet in exposed height, depending on the width of the widening from the edge of the ROW.

SCOPE OF SERVICES

The purpose of GeoEngineers, Inc.'s (GeoEngineers) geotechnical engineering services were to evaluate the subsurface soil and groundwater conditions as a basis for providing recommendations for retaining wall design. Our specific scope of services was completed in accordance with our subconsultant agreement with SrV Design Company executed December 22, 2014. We previously provided a draft version of this report dated March 13, 2015; this version incorporates and supersedes the previous version.

FIELD EXPLORATIONS AND LABORATORY TESTING

Field Explorations

The subsurface soil and groundwater conditions were evaluated by drilling four borings (B-1 through B-4) to depths of approximately 7½ to 14 feet below existing ground surface (bgs) on February 16, 2015. The approximate locations of the explorations are shown on the Site Plan, Figure 2. A description of the subsurface exploration program and logs of the borings are presented in Appendix A.

Laboratory Testing

Soil samples were obtained during the exploration program and taken to our laboratory for further evaluation. Selected samples were tested for the determination of moisture content, fines content (percent passing U.S. No. 200 sieve), and sieve analyses (gradation). A description of the laboratory testing and the test results are presented in Appendix A.

SITE CONDITIONS

Geology

We reviewed the Preliminary Geologic Map of Bainbridge Island, Washington (Haugerud, 2005). The soils in the vicinity of the site are mapped as glacial till. Glacial till typically consists of a medium dense to very dense heterogeneous mixture of sand, gravel, cobbles and occasional boulders in a silt and clay matrix that

were deposited beneath a glacier and subsequently glacially consolidated. A zone of weathered till typically overlies the glacial till to depths of several feet below the ground surface.

Surface Conditions

The ground surface along the existing Olympic Drive SE roadway slopes down from the intersection with Winslow Way south toward the ferry terminal. We understand the southwest corner of the intersection was formerly occupied with a gas station, but this area has been redeveloped into a small park. The proposed widening will occur in an area that slopes down to the southwest from the existing roadway at approximately 5H:1V to 2H:1V (horizontal:vertical).

The existing roadway is four lanes wide along Olympic Drive SE with sidewalks on both sides. Vegetation in the area of the proposed widening includes landscaping at the small park and trees and brush in the sloping areas.

Subsurface Conditions

Based on the borings, subsurface conditions in the area of the proposed improvements generally consist of fill overlying glacial till. The fill is generally loose silty sand with trace organics and extended to depths of about 2½ feet bgs in borings B-1 and B-2, to a depth of 4½ feet bgs in boring B-3 and to a depth of 9½ feet bgs in boring B-4. The glacial till is generally dense to very dense silty sand with variable gravel content and extended to the depths explored, 7½ to 14 feet bgs.

No groundwater was observed during drilling. Perched water was observed in boring B-2 after drilling at approximately 5 feet bgs. These observations represent a short-term condition that may not be representative of the long-term groundwater conditions at the site. Groundwater level is anticipated to vary as a function of precipitation, season and other factors.

CONCLUSIONS AND RECOMMENDATIONS

Critical Areas

Based on review of critical areas maps on Kitsap County graphical interface system (GIS) website and the City of Bainbridge Island municipal code, as well as our observations on site, it is our opinion the site is located in an erosion hazard and landslide hazard area. Provided our recommendations are incorporated in the project plans, it is our opinion the proposed roadway widening will not adversely affect the erosion or landslide hazard areas.

Earthquake Engineering

Design Earthquake Parameters

The seismic design of the proposed improvements should be completed using the design criteria presented in the Washington State Department of Transportation (WSDOT) Geotechnical Design Manual (GDM) and the American Association of State Highway and Transportation Officials (AASHTO) Guide Specifications for Load and Resistance Factor Design (LRFD) Seismic Bridge Design. Recommended parameters are presented in Table 1 below.

TABLE 1. AASHTO/WSDOT SEISMIC PARAMETERS

AASHTO/WSDOT Seismic Parameter	Recommended Value	k_h (design)
Soil Profile Type	D	0.24 (50 percent reduction of A_s)
Effective Peak Ground Acceleration Coefficient $A_S = F_{pga}PGA = (1.036)(0.464)$	0.480 g	
Design Spectral Acceleration Coefficient at 0.2-second period $SD_S = F_aS_s = (1.090)(1.026)$	1.118 g	
Design Spectral Acceleration Coefficient at 1.0-second period $SD_1 = F_vS_1 = (1.703)(0.349)$	0.594 g	

For global stability analyses, we use a horizontal pseudostatic coefficient, k_h, of 0.24 (percent g), per WSDOT GDM, Section 6.4.3.2. This value assumes limited deformation of the slope and retaining wall during earthquake shaking is acceptable.

We completed static and seismic global slope stability analysis of the most critical section using the Slope/W software. Based on our analysis, the static and seismic conditions have factors of safety of at least 1.5 and 1.1, respectively. It is therefore our opinion that the proposed retaining walls will have adequate factors of safety with regard to global stability.

Seismic Hazards

Based on United States Geological Survey (USGS) maps of active faults in the Puget Sound region, the site is located approximately ¾ mile north of the Seattle Fault Zone, which is thought to have a recurrence interval on the order of 1,000 years. Based on the long recurrence interval of the Seattle Fault Zone and distance to the fault, it is our opinion there is a low risk of fault rupture at the site.

We evaluated the site for seismic hazards including liquefaction and lateral spreading, and it is our opinion the site has a low risk for these seismic hazards.

Retaining Walls

We recommend cast-in-place (CIP) retaining walls or WSDOT pre-approved structural earth (SE) or gravity block retaining walls to support proposed grade transitions for the roadway widening. Our recommendations are presented in the following sections.

Subgrade Preparation

We recommend that walls be supported on a minimum of 2 feet of compacted structural fill or on structural fill extending to undisturbed glacial till. For walls supported on structural fill, the zone of structural fill should extend laterally beyond the footing edges a horizontal distance at least equal to the thickness of the fill. A geotextile separator fabric may be used at the base of the overexcavation if loose/soft soils extend below the depth of the overexcavation. We recommend that the footing excavations be examined by a representative of our firm prior to forming footings or placing structural steel.

Design Height and Embedment

The design height of the retaining walls should include the aboveground wall height as well as the full embedment depth of the wall.

The minimum embedment depth for walls founded on sloping ground should be provided as presented in Table 2 below. The minimum embedment depth should be provided below a theoretical 4-foot-wide horizontal bench that extends from the face of the wall and intersects the sloping ground in front of the wall.

TABLE 2. MINIMUM EMBEDMENT DEPTHS FOR RETAINING WALLS

Slope in Front of Wall	Minimum Embedment Depth (feet) [1]
Horizontal	H/20 or 2 feet, whichever is greater
3H:1V	H/10 or 2 feet, whichever is greater
2H:1V	H/7 or 2 feet, whichever is greater

Standard Plan CIP Walls

WSDOT has developed Standard Plans for CIP retaining walls, which are acceptable for this project. The Standard Plan walls have been designed in accordance with the criteria of AASHTO LRFD Bridge Design Specifications.

We recommend that standard plan walls be supported on shallow foundations. The bearing capacity for shallow foundations for Strength, Service and Extreme Limit loading states are presented in Figure 3. We recommend that the LRFD resistance factors listed in Table 3 below be used when evaluating the three limit states for spread footings.

TABLE 3. LRFD SPREAD FOOTING RESISTANCE FACTORS

Limit State	Resistance Factor ϕ		
	Shear Resistance to Sliding	Bearing	Passive Pressure Resistance to Sliding
Strength	0.8	0.45	0.5
Service	1.0	1.0	1.0
Extreme	0.9	0.9	0.9

Footing and wall design parameters are provided below in Table 4; these parameters can also be used for design of SE or gravity block walls discussed below.

TABLE 4. LATERAL EARTH PRESSURES AND SOIL PARAMETERS FOR WALLS AND FOUNDATIONS

Parameter	Value
Backfill, Retained and Foundation Soil Unit Weight, γ	125 pcf
Backfill, Retained and Foundation Soil Friction Angle, ϕ	36°
Active Earth Pressure Coefficient , K_a	0.26
Active Earth Pressure [1]	32 pcf
Passive Earth Pressure Coefficient, K_p	3.85

Parameter	Value
Passive Earth Pressure [1] – Unfactored – Level Toe Slope	481 pcf
Seismic Earth Pressure Coefficient K_{ae}	0.16
Seismic Earth Pressure [1]	20 pcf
Traffic Surcharge Pressure [3]	65 psf
Concrete Wall Foundation Coefficient of Sliding – Unfactored	0.72

Notes:

[1] Equivalent Fluid Density – triangular pressure distribution

[2] H equals the retained wall height

Lateral loads acting on structures supported by shallow foundations may be resisted by passive earth pressure against the embedded portion of the foundation, as well as friction along the base of the foundation. The passive resistance in the upper 12 inches of soil should be ignored.

SE and Gravity Block Walls

SE or gravity block walls may be used where the wall configuration (height, width, temporary backcut, etc.) can be feasibly constructed. Construction of gravity block walls typically requires a base width approximately equal to 60 percent of the wall height, and this type of wall usually has a slight face batter. Construction of SE walls typically requires a base width approximately equal to 80 percent of the wall height. The walls are backfilled with compacted granular soil. SE or gravity block walls should be designed with back drainage as discussed in the "Wall Drainage" section below. The required temporary cut slope and width of the structures should be considered in planning and design. All temporary backcuts should be made in accordance with the "Temporary Slopes" section of this report.

SE or gravity block walls should be designed in accordance with the AASHTO LRFD Bridge Design Manual and the WSDOT GDM or should consist of WSDOT preapproved proprietary wall systems (described in WSDOT GDM Appendix 15-D). The design parameters presented in Table 4 above may be used for design of these walls. SE or gravity block walls should be designed with a factor of safety of 1.5 for sliding and 2 for overturning. We recommend that the wall designs be reviewed by GeoEngineers to verify that valid assumptions were made relative to material properties and other factors.

Settlement

We estimate that postconstruction settlement of retaining walls that are underlain by structural fill or glacial till and are designed and constructed as recommended will be on the order of 1 inch or less, with differential settlement over a 25-foot wall section on the order of half that amount (½ inch). Most of this settlement will occur rapidly as loads are applied.

Wall Backfill and Drainage

Retaining wall backfill materials should consist of gravel backfill for walls as described in Section 9-03.12(2) of the WSDOT Standard Specifications. Placement and compaction of fill behind the walls should be in accordance with WSDOT Section 2-09.3(1)E. Drainage behind CIP walls should be designed and constructed in accordance with WSDOT Standard Plan Sheet D-4.

Drainage behind SE or gravity block walls should be provided by including a 4-inch-diameter perforated collector pipe enveloped within a minimum thickness of 6 inches of gravel backfill for drains conforming to Section 9-03.12(4) of the WSDOT Standard Specifications. A construction geotextile for underground drainage, moderate survivability, conforming to Section 9-33 of the WSDOT Standard Specifications should be placed between the gravel backfill and the native soils to prevent movement of the soils into the drainage backfill.

Earthwork

Earthwork Considerations

Fill and glacial till were observed in the explorations. We anticipate that these soils can be excavated with conventional excavation equipment, such as trackhoes or dozers. Cobbles and boulders are frequently encountered in glacially consolidated soils. Larger horsepower excavators will be more efficient for excavating the very dense, native soils, or if large cobbles and boulders are encountered in the deeper excavations. The contractor should be prepared to deal with debris in the fill and cobbles and boulders in the native soils.

Clearing and Site Preparation

The existing ground surface along the project corridor is typically vegetated or paved as discussed in the "Surface Conditions" section of this report. Embankment areas covered with vegetation should be cleared and grubbed in accordance with Section 2-01 of the WSDOT Standard Specifications.

Subgrade Preparation

Prior to placing new fill, formwork or reinforcing steel, subgrade areas should be probed or proof-rolled if practicable to locate areas of loose, soft or pumping soils. If loose, soft or pumping soils are observed, such unsuitable subgrade soils should be recompacted to achieve the required density for structural fill described below, or be overexcavated and replaced. The depth of overexcavation should be determined by GeoEngineers. Areas that are overexcavated and replaced with structural fill should be reevaluated by probing or proof-rolling.

If deep pockets of soft or pumping soils are encountered, it may be possible to limit the depth of overexcavation by placing a Geotextile for Separation or Soil Stabilization (WSDOT Standard Specification 9-33.2) on the overexcavated subgrade and covering the geotextile with structural fill. We recommend using the specified woven fabric for soil stabilization. The geotextile will provide additional support by bridging over the soft material, and will help reduce fines contamination into the structural fill. The need for geotextile fabric and overexcavation should be evaluated by GeoEngineers during construction.

GeoEngineers should observe the subgrade preparation operations to help determine the depth of removal of soft or pumping soils, and to evaluate whether subgrade disturbance or progressive deterioration is occurring. Subgrade disturbance or deterioration could occur if the subgrade is wet and cannot be dried. If the subgrade deteriorates during proof-rolling or compaction, it may become necessary to modify the proof-rolling or compaction criteria or methods.

Structural Fill Materials

General

Materials used to construct roadways, placed to support retaining structures or foundations, or placed behind retaining structures are classified as structural fill for the purpose of this report. Structural fill material quality varies depending upon its use, as described below:

1. As a minimum, structural fill placed should meet the criteria for common borrow, WSDOT 9-03.14(3). Common borrow will be suitable for use as structural fill during dry weather conditions only. If structural fill is placed during wet weather, the structural fill should consist of gravel borrow, WSDOT 9-03.14(1).
2. Structural backfill for walls should meet the criteria for gravel backfill for walls, WSDOT 9-03.12(2).
3. Structural fill placed in the drainage zone behind retaining walls should meet the criteria for gravel backfill for drains, WSDOT 9-03.12(4).
4. Structural fill placed as crushed surfacing base course below pavements should conform to WSDOT 9-03.9(3).

On-site Soils

The soils observed in the explorations generally contain a high percentage of fines (silt and clay) and are moisture-sensitive. Some of the on-site soils may meet the criteria for common borrow and may be suitable for use during dry weather construction only, provided the soil has a moisture content near optimum.

Fill Placement and Compaction Criteria

Structural fill should be mechanically compacted to a firm, non-yielding condition. Structural fill should be placed in loose lifts not exceeding 1 foot in thickness. Each lift should be conditioned to the proper moisture content and compacted to the specified density before placing subsequent lifts. Structural fill should be compacted to the following criteria:

1. Structural fill placed behind retaining walls should be compacted to at least 90 percent of the maximum dry density (MDD) in general accordance with ASTM International (ASTM) D 1557. Care should be taken when compacting fill near the face of retaining walls to avoid overcompaction and hence overstressing the walls.
2. Structural fill in embankment and new pavement areas, including utility trench backfill, should be compacted to 90 percent of the MDD (ASTM D 1557), except that the upper 2 feet of fill below final subgrade should be compacted to 95 percent of the MDD (ASTM D 1557).
3. Structural fill placed below foundations should be compacted to 95 percent of the MDD (ASTM D 1557).
4. Structural fill placed as crushed rock base course below pavements should be compacted to 95 percent of the MDD (ASTM D 1557).

We recommend that a representative of GeoEngineers be present during placement of structural fill. GeoEngineers will evaluate the adequacy of the subgrade soils and identify areas needing further work as discussed above, perform in-place moisture-density tests in the fill to evaluate whether the work is being done in accordance with the compaction specifications, and advise on any modifications to procedure that may be appropriate for the prevailing conditions.

Weather Considerations

The on-site soils generally contain a high percentage of fines (silt and clay) and are moisture-sensitive. When the moisture content of these soils is more than a few percent above the optimum moisture content, these soils become muddy and unstable, operation of equipment on these soils will be difficult, and it will be difficult or impossible to meet the required compaction criteria. Additionally, disturbance of near-surface soils should be expected if earthwork is completed during periods of wet weather. The contractor will need to take precautions to protect the subgrade during periods of wet weather.

The wet weather season in western Washington generally begins in October and continues through May; however, periods of wet weather may occur during any month of the year. The optimum earthwork period for these types of soils is typically June through September. If wet weather earthwork is unavoidable, we recommend that:

- The ground surface in and around the work area should be sloped so that surface water is directed away from the work area. The ground surface should be graded such that areas of ponded water do not develop. The contractor should take measures to prevent surface water from collecting in excavations and trenches. Measures should be implemented to remove surface water from the work area.
- Erosion control techniques should be implemented to prevent sediment from leaving the site.
- Earthwork activities should not take place during periods of heavy precipitation.
- Slopes with exposed soils should be covered with plastic sheeting.
- The contractor should take necessary measures to prevent on-site soils and soils to be used as fill from becoming wet or unstable. These measures may include the use of plastic sheeting, sumps with pumps, and grading. The site soils should not be left uncompacted and exposed to moisture. Sealing the surficial soils by rolling with a smooth-drum roller prior to periods of precipitation will help reduce the extent that these soils become wet or unstable.
- Construction activities should be scheduled so that the length of time that soils are left exposed to moisture is reduced to the extent practical.

Temporary Slopes

We recommend that temporary unsupported cut slopes greater than 4 feet deep be inclined no steeper than 1½H:1V. Flatter slopes may be necessary if seepage is present on the cut face or if localized sloughing occurs. For open cuts at the site we recommend that:

- No traffic, construction equipment, stockpiles or building supplies be allowed at the top of the cut slopes within a horizontal distance of at least 5 feet from the top of the cut.
- Exposed soil along the slope be protected from surface erosion using waterproof tarps or plastic sheeting.
- Construction activities be scheduled so that the length of time the temporary cut is left open is kept as short as possible.
- Erosion control measures be implemented as appropriate such that runoff from the site is reduced to the extent practical.

- Surface water is diverted away from the excavation.
- The general condition of the slopes be observed periodically by a geotechnical engineer to confirm adequate stability.

If temporary cut slopes experience excessive sloughing or raveling during construction, it may become necessary to modify the cut slopes to maintain safe working conditions and protect adjacent facilities or structures. Slopes experiencing excessive sloughing or raveling can be flattened or can be regraded to add intermediate slope benches.

Since the contractor has control of the construction operations, the contractor should be made responsible for the stability of cut slopes, as well as the safety of the excavations.

Benching

In area where fill will be placed against existing slopes, the fill should be effectively keyed into the existing slope using a benching methodology as described in Section 2-03.3(14) of the WSDOT Standard Specifications.

Permanent Slopes

We recommend that permanent cut and fill slopes be constructed no steeper than 2H:1V. To achieve uniform compaction, we recommend that fill slopes be overbuilt slightly and subsequently cut back to expose properly compacted fill. We recommend that the finished slope faces be compacted by track walking with the equipment running perpendicular to the slope contours so that the track grouser marks help provide an erosion-resistant slope texture.

To reduce erosion, newly constructed slopes should be planted or hydroseeded shortly after completion of grading. Until the vegetation is established, some sloughing and raveling of the slopes should be expected. This may require localized repairs and reseeding. Temporary covering, such as clear heavy plastic sheeting, jute fabric, loose straw, or excelsior or straw/coconut matting, should be used to protect the slopes during periods of rainfall.

Site Drainage

Permanent drainage systems should intercept surface water runoff at the top and/or bottom of cut and fill slopes to prevent it from flowing in an uncontrolled manner across or off the site. The finished ground surface adjacent to new retaining walls should be sloped so that surface water runoff flows away from the structures.

Sedimentation and Erosion Control

In our opinion, the erosion potential of the on-site soils is moderate to high. Construction activities including stripping and grading will expose soils to the erosional effects of wind and water. The amount and potential impacts of erosion are partly related to the time of year that construction actually occurs. Wet weather construction will increase the amount and extent of erosion and potential sedimentation.

Erosion and sedimentation control measures may be implemented by using a combination of interceptor swales, straw bale barriers, silt fences and straw mulch for temporary erosion protection of exposed soils. All disturbed areas should be finish graded and seeded as soon as practicable to reduce the risk of erosion.

Erosion and sedimentation control measures should be installed and maintained in accordance with the requirements of the City of Bainbridge Island.

ADDITIONAL GEOTECHNICAL SERVICES

Throughout this report, recommendations are provided where we consider additional geotechnical services to be appropriate. These additional services are summarized below:

- Plan and specification review. We recommend that we be given the opportunity to review the project plans and specifications prior to issuing the bid set to confirm the recommendations presented in this report have been implemented appropriately.
- During construction, a representative of GeoEngineers should evaluate retaining wall foundation subgrades, evaluate backfill compaction, and observe installation of subsurface drainage measures. The purposes of GeoEngineers' construction phase services are to confirm that the subsurface conditions are consistent with those observed in the explorations and other reasons described in Appendix B, "Report Limitations and Guidelines for Use."

LIMITATIONS

We have prepared this report for the exclusive use of the City of Bainbridge and their authorized agents including SvR Design Company for the proposed Olympic Drive SE Roadway Improvements project in Bainbridge Island, Washington. The data should be provided to prospective contractors for their bidding or estimating purposes, but our report and interpretations should not be construed as a warranty of the subsurface conditions.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

Any electronic form, facsimile or hard copy of the original document (email, text, table, and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by GeoEngineers and will serve as the official document of record.

Please refer to Appendix B titled "Report Limitations and Guidelines for Use" for additional information pertaining to use of this report.

REFERENCES

American Association of State Highway and Transportation Officials, "LRFD Bridge Design Specifications."

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FIGURES

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Data Sources: ESRI Data & Maps, Street Maps 2005

Transverse Mercator, Zone 10 N North, North American Datum 1983
North arrow oriented to grid north

Vicinity Map

Olympic Drive SE Roadway Improvements
Bainbridge Island, Washington

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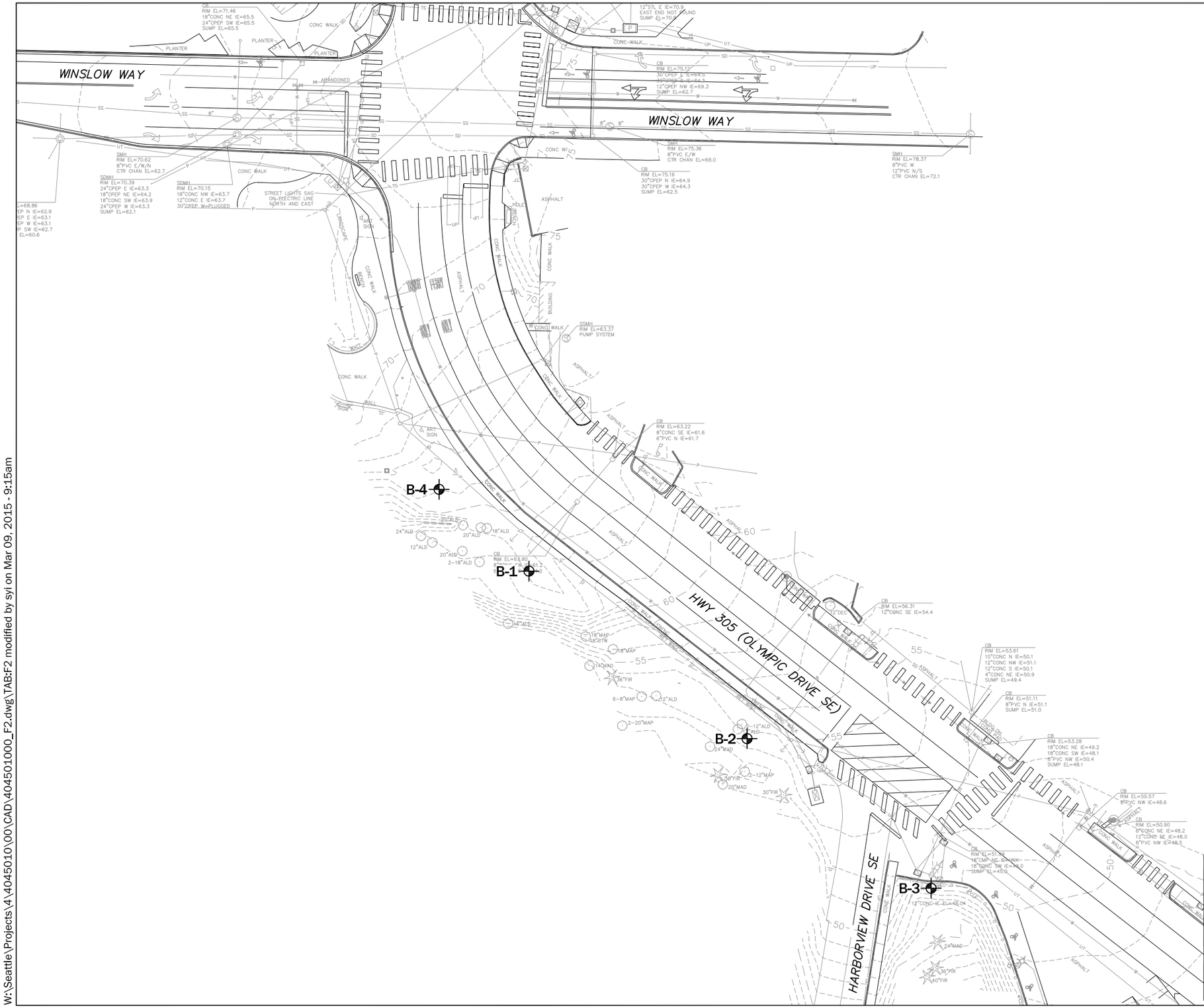
Figure 1

Office: Redmond Path: \red\projects\4\4045010\404501000_F1_VicinityMap.mxd Map Revised: 2/18/2015 EL



Legend

B-1 Boring completed by GeoEngineers (2015)

N
W E
S

50 0 50
Feet

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Reference: Drawing provided by SvR Design Company.

Site Plan

Olympic Drive SE Roadway Improvements
Bainbridge Island, Washington

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Figure 2

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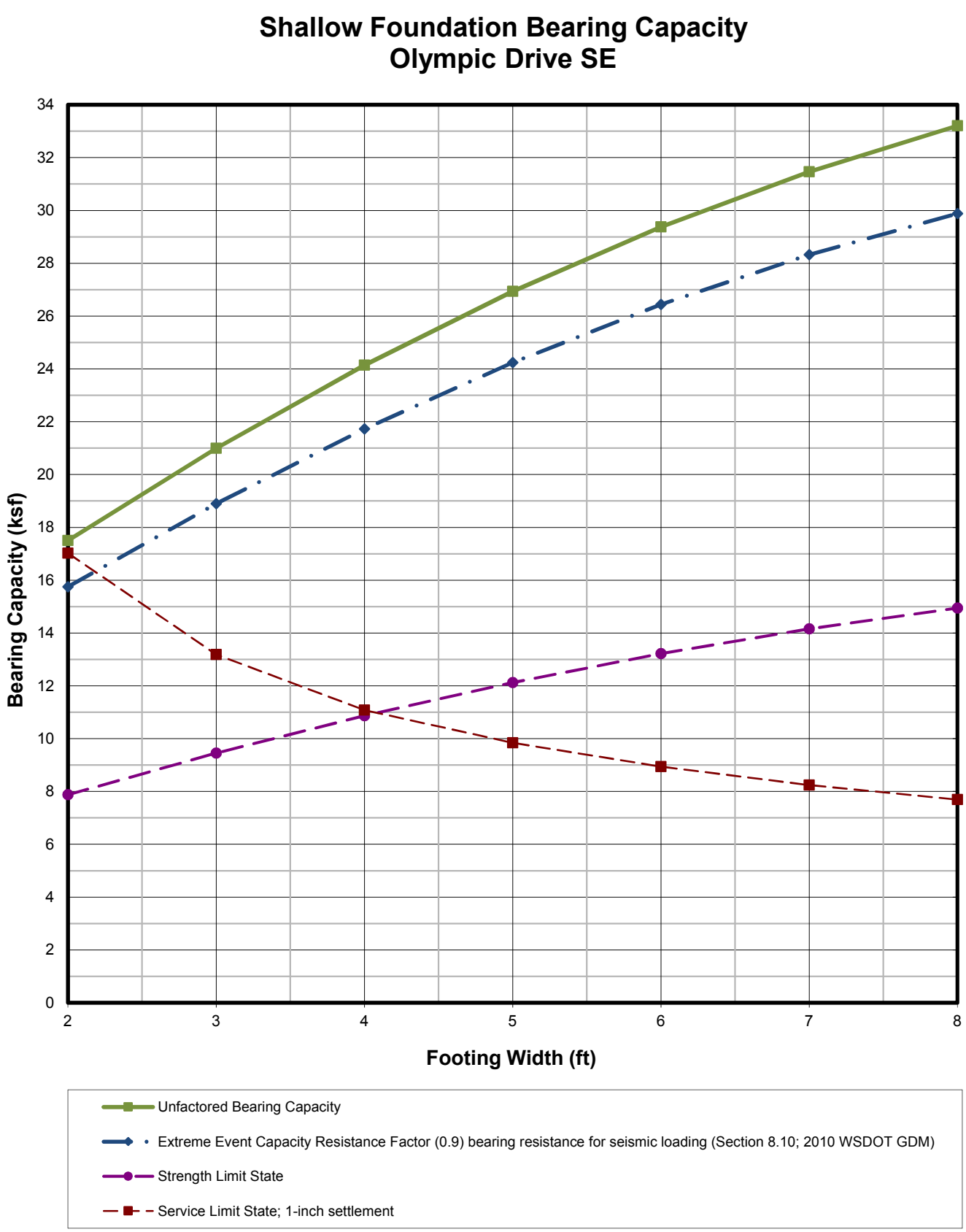

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Shallow Foundation Design

Figure 3

APPENDICES

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APPENDIX A
Field Explorations

APPENDIX A
FIELD EXPLORATIONS AND LABORATORY TESTING

General

Subsurface conditions were explored at the site by drilling four borings (B-1 through B-4). Borings were performed by Geologic Drill, Inc. under subcontract to GeoEngineers on February 16, 2015.

The locations of the explorations were estimated from existing site features. Exploration locations are shown on the Site Plan, Figure 2. Exploration locations should be considered accurate to the degree implied by the method used.

Borings

Borings were completed to depths of 7½ to 14 feet below existing grade using hand-portable, hollow-stem auger drilling equipment.

The borings were continuously monitored by a representative from our firm who visually examined and classified the soils encountered, obtained representative soil samples, observed surface and groundwater conditions and prepared detailed logs of the borings. The samples obtained from the borings were obtained in general accordance with the Standard Penetration Test Method described by the American Society for Testing and Materials (ASTM) D 1586. A 2-inch outside-diameter, split-barrel sampler was used to obtain disturbed samples from the borings. The samplers used were driven into the soil using a 140-pound hammer, free-falling 30 inches. The number of blows required to drive the sampler the last 12 inches, or other indicated distance, is recorded on the boring log. The borings were backfilled in accordance with Washington State Department of Ecology regulations.

Soils encountered in the explorations were visually classified in general accordance with the system described in Figure A-1, which also includes a key to the exploration log symbols. Logs of the borings are presented in Figures A-2 through A-5. The logs are based on our interpretation of the field and laboratory data and indicate the depths at which the subsurface conditions change, although the change might be gradual. If the change occurred between samples, it was interpreted.

Laboratory Testing

Soil samples obtained from the explorations were transported to our laboratory and examined to confirm or modify field classifications, as well as to evaluate index properties of the soil samples. Representative samples were selected for laboratory testing consisting of the determination of the moisture content, fines content (percent passing U.S. No. 200 sieve), and grain size distribution (sieve analysis). The tests were performed in general accordance with test methods of ASTM or other applicable procedures.

Moisture Content Testing

Moisture content tests were completed in general accordance with ASTM D 2216 for representative samples obtained from the explorations. The results of these tests are presented on the exploration logs in Appendix A at the depths at which the samples were obtained.

Percent Passing U.S. No. 200 Sieve

Selected samples were "washed" through the U.S. No. 200 mesh sieve to determine the relative percentages of coarse and fine-grained particles in the soil. The percent passing value represents the percentage by weight of the sample finer than the U.S. No. 200 sieve. These tests were conducted to verify field descriptions and to determine the fines content for analysis purposes. The tests were conducted in general accordance with ASTM D 1140, and the results are shown on the exploration logs in Appendix A at the respective sample depths.

Sieve Analyses

Sieve analyses were performed on selected samples in general accordance with ASTM D 422 to determine the sample grain size distribution. The wet sieve analysis method was used to determine the percentage of soil greater than the U.S. No. 200 mesh sieve. The results of the sieve analyses were plotted, classified in general accordance with the Unified Soil Classification System (USCS), and are presented in Figure A-6.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS
				SP	POORLY-GRADED SANDS, GRAVELLY SAND
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	AC	Asphalt Concrete
	CC	Cement Concrete
	CR	Crushed Rock/ Quarry Spalls
	TS	Topsoil/ Forest Duff/Sod

Groundwater Contact

Measured groundwater level in exploration, well, or piezometer

Measured free product in well or piezometer

Graphic Log Contact

Distinct contact between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Material Description Contact

Distinct contact between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Sampler Symbol Descriptions

2.4-inch I.D. split barrel

Standard Penetration Test (SPT)

Shelby tube

Piston

Direct-Push

Bulk or grab

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

A "P" indicates sampler pushed using the weight of the drill rig.

Laboratory / Field Tests

%F	Percent fines
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PP	Pocket penetrometer
PPM	Parts per million
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
NT	Not Tested

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

KEY TO EXPLORATION LOGS

GEOENGINEERS

FIGURE A-1

Drilled Start 2/16/2015	End 2/16/2015	Total Depth (ft) 7.5	Logged By CEW / Checked By TDB	Driller Geologic Drill	Drilling Method Hollow-stem Auger
Surface Elevation (ft) / Vertical Datum 55		Hammer Data Rope & Cathead 140 (lbs) / 30 (in) Drop		Drilling Equipment Acker Drill Rig	
Easting (X) / Northing (Y)		System Datum		Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft)	
Notes:				Not encountered	

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								SM	Dark brown silty fine to medium sand with organics (leaves, fine roots) (loose, moist to wet) (fill)			
									SM	Brown silty fine to medium sand (very dense, moist) (glacial till)			
			18	71		1 SA					11	33	
50	5		6	50/6"		2				With gravel			Hard drilling
			5	50/5"		3			SM	Brown silty fine to medium sand (very dense, moist)			

Note: See Figure A-1 for explanation of symbols.

Log of Boring B-1

GEOENGINEERS

Project: Olympic Drive SE Way Improvements
Project Location: Bainbridge Island, Washington
Project Number: 4045-010-00

Figure A-2
Sheet 1 of 1

Seattle: Date:3/9/15 Path:\\SEA\PROJECTS\4\4045010\GINT\4045010.GPJ DBTemplate\LibTemplate:GEOENGINEERS8.GDT/GE8_GEOTECH_STANDARD

Drilled Start 2/16/2015 End 2/16/2015	Total Depth (ft) 10.5	Logged By CEW Checked By TDB	Driller Geologic Drill	Drilling Method Hollow-stem Auger
Surface Elevation (ft) Vertical Datum 53		Hammer Data Rope & Cathead 140 (lbs) / 30 (in) Drop		Drilling Equipment Acker Drill Rig
Easting (X) Northing (Y)		System Datum		Groundwater Date Measured / Depth to Water (ft) / Elevation (ft)
Notes:				See Remarks

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0						SM	Dark brown silty fine to medium sand with organics (loose, wet) (fill)			
							SM	Brown with orange stainings silty fine to medium sand with gravel (dense, moist to wet) (glacial till)			
50		16	31	1 SA					12	29	
	5	18	26	2				Becomes medium dense			Perched water observed at 5 feet during drilling
45		9	79/9"	3							
	10	5.5	50/5.5"	4 %F				Becomes very dense	8	36	

Note: See Figure A-1 for explanation of symbols.

Log of Boring B-2

GeoEngineers

Project: Olympic Drive SE Way Improvements
Project Location: Bainbridge Island, Washington
Project Number: 4045-010-00

Figure A-3
Sheet 1 of 1

Seattle: Date:3/9/15 Path:\\SEA\PROJECTS\4\4045010\GINT\4045010.GPJ DBTemplate\LibTemplate\GEOENGINEERS8.GDT/GE8_GEOTECH_STANDARD

Drilled Start 2/16/2015 End 2/16/2015	Total Depth (ft) 10.5	Logged By CEW Checked By TDB	Driller Geologic Drill	Drilling Method Hollow-stem Auger
Surface Elevation (ft) Vertical Datum 50		Hammer Data Rope & Cathead 140 (lbs) / 30 (in) Drop		Drilling Equipment Acker Drill Rig
Easting (X) Northing (Y)		System Datum		Groundwater Date Measured / Depth to Water (ft) / Elevation (ft): Not encountered
Notes:				

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0						SM	Brown silty fine to medium sand with organics (leaves, roots) (loose, moist to wet) (fill)			
								No recovery			
		0	7	1							
45	5	18	49	2 SA			SM	Brown silty fine to medium sand with gravel (dense, moist) (glacial till)	12	36	
		12	82/11"	3			SM	Brown silty fine to medium sand (very dense, moist)			
40	10	5	50/5"	4							

Note: See Figure A-1 for explanation of symbols.

Log of Boring B-3

GEOENGINEERS

Project: Olymipic Drive SE Way Improvements
Project Location: Bainbridge Island, Washington
Project Number: 4045-010-00

Figure A-4
Sheet 1 of 1

Seattle: Date:3/9/15 Path:\\SEA\PROJECTS\4\4045010\GINT\4045010.GPJ DBTemplate\LibTemplate:GEOENGINEERS8.GDT/GE8_GEOTECH_STANDARD

Drilled Start 2/16/2015 End 2/16/2015	Total Depth (ft) 14	Logged By CEW Checked By TDB	Driller Geologic Drill	Drilling Method Hollow-stem Auger
Surface Elevation (ft) Vertical Datum 68		Hammer Data Rope & Cathead 140 (lbs) / 30 (in) Drop		Drilling Equipment Acker Drill Rig
Easting (X) Northing (Y)		System Datum		Groundwater Date Measured / Depth to Water (ft) / Elevation (ft)
Notes:				Not encountered

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								SM	Dark brown silty fine to medium sand with organics (leaves, fine roots) (medium dense, moist to wet) (fill)			
									SM	Brown silty fine to medium sand with trace organics (fine roots) (loose to medium dense, moist) (fill)			
65			6	11		1 MC					27		
	5		10	9		2							
60			16	11		3 %F					16	34	
									SM	Grayish brown silty fine to medium sand with occasional gravel (very dense, moist) (glacial till)			
	10		16	52		4							
55			18	57		5							

Note: See Figure A-1 for explanation of symbols.

Log of Boring B-4

GEOENGINEERS

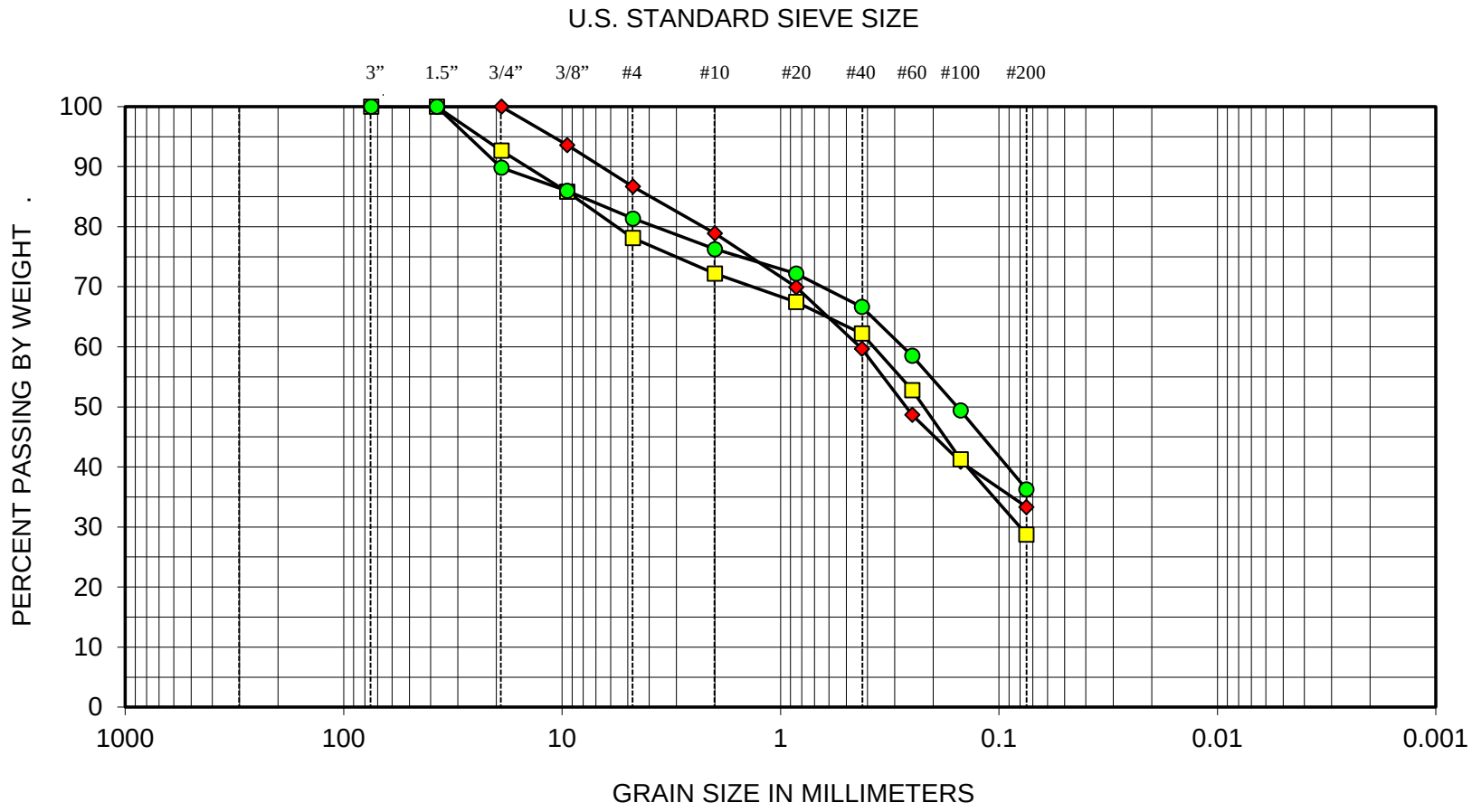
Project: Olympic Drive SE Way Improvements
Project Location: Bainbridge Island, Washington
Project Number: 4045-010-00

Figure A-5
Sheet 1 of 1

Seattle: Date:3/9/15 Path:\\SEA\PROJECTS\4\4045010\GINT\4045010.GPJ DBTemplate\LibTemplate\GEOENGINEERS8.GDT/GE8_GEOTECH_STANDARD

4045-010-00 SAS: SAS 02-24-2015

GEOENGINEERS



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	DEPTH (ft)	SOIL CLASSIFICATION
◆	B-1	2½	Silty fine to medium sand (SM)
□	B-2	2½	Silty fine to medium sand with gravel (SM)
●	B-3	5	Silty fine to medium sand with gravel (SM)

SIEVE ANALYSIS RESULTS

FIGURE A-6

APPENDIX B
Report Limitations and Guidelines for Use

APPENDIX B
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

Geotechnical Services Are Performed for Specific Purposes, Persons and Projects

This report has been prepared for the exclusive use of the City of Bainbridge and their authorized agents, including SvR Design Company for the Olympic Drive SE Roadway Improvements project in Bainbridge Island, Washington. This report may be made available to prospective contractors for their bidding or estimating purposes, but our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions. This report is not intended for use by others, and the information contained herein is not applicable to other sites.

GeoEngineers structures our services to meet the specific needs of our clients. For example, a geotechnical or geologic study conducted for a civil engineer or architect may not fulfill the needs of a construction contractor or even another civil engineer or architect that are involved in the same project. Because each geotechnical or geologic study is unique, each geotechnical engineering or geologic report is unique, prepared solely for the specific client and project site. Our report is prepared for the exclusive use of our Client. No other party may rely on the product of our services unless we agree in advance to such reliance in writing. This is to provide our firm with reasonable protection against open-ended liability claims by third parties with which there would otherwise be no contractual limits to their actions. Within the limitations of scope, schedule and budget, our services have been executed in accordance with our Agreement with the Client and generally accepted geotechnical practices in this area at the time this report was prepared. This report should not be applied for any purpose or project except the one originally contemplated.

A Geotechnical Engineering or Geologic Report Is Based on a Unique Set of Project-Specific Factors

This report has been prepared for the Olympic Drive SE Roadway Improvements project in Bainbridge Island, Washington. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, do not rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

[1] Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or
- project ownership.

If important changes are made after the date of this report, GeoEngineers should be given the opportunity to review our interpretations and recommendations and provide written modifications or confirmation, as appropriate.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by manmade events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. Always contact GeoEngineers before applying a report to determine if it remains applicable.

Most Geotechnical and Geologic Findings Are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied our professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in this report. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

Geotechnical Engineering Report Recommendations Are Not Final

Do not over-rely on the preliminary construction recommendations included in this report. These recommendations are not final, because they were developed principally from GeoEngineers' professional judgment and opinion. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for this report's recommendations if we do not perform construction observation.

Sufficient monitoring, testing and consultation by GeoEngineers should be provided during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective method of managing the risks associated with unanticipated conditions.

A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by other design team members can result in costly problems. You could lower that risk by having GeoEngineers confer with appropriate members of the design team after submitting the report. Also retain GeoEngineers to review pertinent elements of the design team's plans

and specifications. Contractors can also misinterpret a geotechnical engineering or geologic report. Reduce that risk by having GeoEngineers participate in pre-bid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, but recognize that separating logs from the report can elevate risk.

Give Contractors a Complete Report and Guidance

Some owners and design professionals believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering or geologic report, but preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer. A pre-bid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might an owner be in a position to give contractors the best information available, while requiring them to at least share the financial responsibilities stemming from unanticipated conditions. Further, a contingency for unanticipated conditions should be included in your project budget and schedule.

Contractors Are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and to adjacent properties.

Read These Provisions Closely

Some clients, design professionals and contractors may not recognize that the geoscience practices (geotechnical engineering or geology) are far less exact than other engineering and natural science disciplines. This lack of understanding can create unrealistic expectations that could lead to disappointments, claims and disputes. GeoEngineers includes these explanatory "limitations" provisions in our reports to help reduce such risks. Please confer with GeoEngineers if you are unclear how these "Report Limitations and Guidelines for Use" apply to your project or site.

Geotechnical, Geologic and Environmental Reports Should Not Be Interchanged

The equipment, techniques and personnel used to perform an environmental study differ significantly from those used to perform a geotechnical or geologic study and vice versa. For that reason, a geotechnical engineering or geologic report does not usually relate any environmental findings, conclusions or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Similarly, environmental reports are not used to address geotechnical or geologic concerns regarding a specific project.

Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings, or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants and no conclusions or inferences should be drawn regarding Biological Pollutants, as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria, and viruses, and/or any of their byproducts.

If Client desires these specialized services, they should be obtained from a consultant who offers services in this specialized field.

Have we delivered World Class Client Service?

Please let us know by visiting **www.geoengineers.com/feedback**.

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