April 15, 2019
HWA Project No. 2019-027-21 Task 200

CITY OF SEATTLE
OFFICE OF HOUSING
700 5th Avenue, Suite 5700
Seattle, Washington 98004

Attention: Prithy Korathu

Subject: GEOTECHNICAL REPORT
PROPOSED RESIDENTIAL DEVELOPMENT
7750 28th Avenue NW
Seattle, Washington

Dear Ms. Korathu,

At your request, HWA GeoSciences (HWA) has performed a geotechnical study for the proposed residential development at 7750 28th Avenue NW in Seattle, Washington. The purpose of our work has been to provide geotechnical recommendations for design and construction of the proposed multi-family structure at the site.

SCOPE OF SERVICES AND AUTHORIZATION

Written authorization was provided by Emily Alvarado on March 28, 2019. The scope of work for this task was generally consistent with that provided in writing by HWA including;
performing a reconnaissance of the site and conducting shallow subsurface explorations;
providing bearing capacities for the proposed structures;
providing recommendations for earthwork and drainage and other recommendations, as appropriate. HWA’s recommendations are based on our initial test probing, the available geologic information for the site, and the site survey and building plans provided by the owner.

PROJECT LOCATION AND SITE DESCRIPTION

7750 28th Avenue NW is a vacant lot situated between lots occupied by residential structures to the south and north and is the location of the former Loyal Heights Substation. The site is in a relatively flat, uplands area roughly half a mile east of Golden Gardens Park. The lot is just southeast of the 5-way intersection of 28th Avenue NW, Loyal Way NW and NW 80th Street. Access to the site is via a driveway off 28th Avenue NW.

The lot, King County Parcel No. 4443800245, covers approximately 8,159 square feet and is vegetated around the edges. The property was acquired by Seattle City Light in 1945. The substation was decommissioned in 2001 and the associated equipment
was removed in 2006/2007 following a spill of transformer oil caused by vandals. In 2007, Seattle City Light undertook a cleanup of oil impacted soils. The concrete transformer pad and some of the surrounding soils were removed. Inside the fenced off part of the lot, the ground slopes down to the southeast corner with roughly 2 to 3 feet of relief, with the ground suddenly sloping up to create a lip up to the fences along the south and east sides. This grading creates a depression that likely collects surface runoff from the site.

The current topography at the site is due to the environmental remediation work done by Seattle City Light in 2007 as well as further soil excavation and removal that was completed by NRC Environmental Services with oversight by Hart Crowser in March of 2016.

**PROJECT DESCRIPTION**

It is our understanding that a new 2 to 3 story, multi-family residential structure is to be designed and constructed that will take up most of the property. We assume the structure will be primarily of wood frame construction.

**GEOLOGY**

The geologic map of the site shows that the project lies in an area mapped as Vashon glacial till (Qvt), (Troost et al, 2005). The geologic map also shows a large area nearby to the to the east that is mapped as advance outwash (Qva). The geologic map describes this unit as “well-sorted sand and gravel deposited by streams issuing from advancing ice sheet”.

**Seismicity**

The Puget Sound area is known to be seismically active, as evidenced by recent significant seismic events including the 1949 Olympia (magnitude 7.2), the 1965 Seattle (magnitude 6.5), and the 2001 Nisqually (magnitude 6.8) Earthquakes. The seismic hazard in the area comes from three main sources: (1) Cascade Subduction Zone (interplate), (2) Benioff Zone (intraslab), and (3) shallow crustal earthquakes.

Cascade Subduction Zone earthquakes occur locally when the interface bond between the North American Tectonic Plate and the subducting Juan de Fuca Plate suddenly ruptures. In contrast to similar geologic regimes having subducting plates, such as Alaska or Chile, no earthquakes have been recorded in the Pacific Northwest from thrust fault deformation between plates. However, seismologists believe that the Cascade Subduction Zone created a great interplate earthquake on January 24, 1700, (Magnitude > 8), and is likely to produce future earthquakes with magnitudes up to 9. Significant ground accelerations would occur at the site in the event of a large subduction zone earthquake; however, the long distance to the rupture area would reduce the intensity of shaking. Notwithstanding, the shaking could last several minutes.
Benioff Zone, or intraslab events, occur due to rupture within the subducting Juan de Fuca Plate at depths of approximately 28 to 38 miles. This is the source of the largest historical local earthquakes - 1949 Olympia, 1965 Seattle, and 2001 Nisqually. This source has the potential for events with magnitudes of approximately 7.5. Shaking from a Benioff Zone event could be significant at the site.

Shallow crustal earthquakes occur on shallow faults due to tectonic stresses. The Puget Sound area is underlain by several shallow faults. The notable faults include the Seattle Fault Zone, which is an east-west trending zone of thrust or reverse faults that strikes roughly through downtown Seattle and along I-90. The Whidbey Island Fault Zone extends approximately several kilometers from north of Whidbey Island southward through Woodinville to North Bend and contributes a significant level of risk. Recent research indicates that these fault zones can produce events with magnitudes of 6.5 to 7.5, which could cause severe damage in the Seattle area. The nearest known fault to the site is the northern trace of the Seattle Fault Zone, which is about 7 miles south of the site.

FIELD EXPLORATIONS
Subsurface exploration for this project consisted of a reconnaissance of the site, test probing with a ½” diameter rod (T-probe) which was pushed in under a 150-lb load, and 3 hand augur holes. Test probing was performed across the site, and the results of the test probing revealed generally competent soils, with the T-probe not penetrating more than 6 inches except in a small area in a depression along the east side of the site, where the T-probe was able to penetrate 4 feet into the ground. HH-2 was performed at this location.

SUBSURFACE CONDITIONS
In HH-1, about one foot of gravel fill was encountered above dense advance outwash. HH-2 encountered a couple inches of topsoil over 3.5 feet of medium dense silty fine sand and six inches of stiff silt. Below the silt layer, there was just over another half foot of medium dense sand before the soil transitioned to a dense advance outwash sand. The soil became very dense about 7.4 feet below the ground surface. In HH-3 a couple inches of topsoil covered gravel fill, which transitioned to a dense advance outwash about 1 foot below the ground surface.

No groundwater was observed in any of the subsurface explorations.
CONCLUSIONS AND RECOMMENDATIONS

General

The results of our evaluation indicate that the structure proposed for 7750 28th Ave NW can be supported on spread footings bearing on the medium dense to very dense glacial soils observed in our explorations or on engineered fill placed over the competent native soils. We recommend all existing fill be excavated from the building footprint and replaced as necessary, with compacted structural fill.

If a basement or below grade vault is to be included in the building, the below-grade walls should be designed to resist at-rest lateral earth pressures. Perimeter footing drains should be provided outside the basement walls to prevent the build-up of hydrostatic pressures.

Seismic Design Criteria

We understand the residential structure is being designed in accordance with ASCE 7-10, which requires above-grade structures be designed for the inertial forces induced by a “Maximum Considered Earthquake” (MCE), which corresponds to an earthquake with a 2% probability of exceedance (PE) in 50 years (approximately 2,475-year return period). The relevant probabilistic spectral response parameters were developed using the United States Geological Survey and SEAOC’s website.

ASCE 7-10 accounts for the effects of site-specific subsurface ground conditions on the response of structures in terms of site classes. Site classes are defined by the average density and stiffness of the soil profile underlying the site. The Site Class can be correlated to the average standard penetration resistance ($N_{SPR}$) in the upper 100 feet of the soil profile. Based on our characterization of the subsurface conditions, the subject site classifies as Site Class C. Table 1 presents the design spectral seismic coefficients obtained for this site. The design peak ground acceleration was computed to be 0.5 g.

Table 1. Design Seismic Coefficients for ASCE 7-10 Code Based Evaluation

<table>
<thead>
<tr>
<th>Site Class</th>
<th>Mean Magnitude (M)</th>
<th>Mean Source-to-Site Distance, km (R)</th>
<th>Design Spectral Acceleration at 0.2sec. S0.2s, g</th>
<th>Design Spectral Acceleration at 1.0sec. S0.1s, g</th>
<th>Site Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>7.1</td>
<td>46</td>
<td>0.86</td>
<td>0.44</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Geologic Hazards

There are no steep slopes at the site and the potential for landsliding is very low. Due to the relatively flat slopes and dense nature of the soils there is no perceived landslide or lateral spreading hazard. In the absence of any currently known active faults near the site (Holocene age activity), the ground rupture hazard is low. Therefore, none of these potential seismically-induced phenomena represents a design consideration for the proposed building.

The soils at the site are sufficiently dense that soil liquefaction is not anticipated during a seismic event. We consider there to be a minimal risk of damage due to liquefaction.

Bearing Capacity and Settlement

Footings founded on medium dense to dense native soils or on properly compacted structural fill placed directly on medium dense to dense native soils can be designed for a net allowable bearing capacity up to 4,000 pounds per square foot (psf). For short-term wind and seismic loading conditions, this allowable bearing pressure may be increased by 33 percent. Continuous (wall) footings should have a minimum width of 18 inches. Column footings should have a minimum width of 24 inches. Wall footings should bear at least 18 inches below the nearest adjacent finished grade. Interior column footings should bear at least 6 inches below the lowest adjacent grade.

Footings constructed in accordance with these recommendations should experience no more than ½ inch of total or differential settlement. It is anticipated that most of the estimated settlement will be elastic and will occur as the load is applied during construction. Inadequate preparation/cleaning of foundation subgrades, and improper compaction of fill can result in larger settlements.

Lateral Resistance

Wind, seismic and unbalanced lateral earth pressures could subject the foundation system to lateral forces which will be resisted by sliding base sliding friction and passive resistance against the buried portions of the structure. We recommend a frictional coefficient of 0.5 for estimation of base sliding friction. Passive pressure equal to an equivalent fluid pressure of 460 pounds per cubic foot (pcf) may be considered for footings where drainage is provided and 290 pcf where drainage is not provided such that hydrostatic pressures are possible. The upper foot of passive pressure should be neglected. The recommended friction coefficient and passive pressures are ultimate values and we recommend achieving a factor of safety of 1.5 or more in calculations with their use.

Retaining walls should be considered rigid and designed for at-rest earth pressures. We recommend designing retaining walls for an equivalent fluid pressure of 55 pcf where drainage is provided, and 90 pcf where drainage is not provided such that hydrostatic pressures are possible. Where the backslope above the retaining wall is inclined upward, the at-rest equivalent fluid pressure should be increased by one pound per cubic foot for each degree of inclination.
If below-grade structures or retaining walls will be subjected to the influence of surcharge loading within a horizontal distance equal to or less than the height of the walls, the walls should be designed for the additional horizontal pressure. For area surcharge loads, we recommend adding a lateral surcharge equal to 0.45 times the vertical surcharge pressure. Point or small area loads should be evaluated individually.

Subgrade Preparation

In the proposed building area, subgrade preparation should begin with the removal of all topsoil, existing fill, debris and vegetation. Using a smooth (toothless) bucket, the soils should be excavated to the proposed subgrade elevation. The exposed subgrade should be inspected by the Geotechnical Engineer, or their representative, and any loose or unsuitable soils should be compacted or over-excavated and replaced with properly compacted structural fill. Where over-excavation below the foundation subgrade elevation is required to remove unsuitable material, the width of the excavation should extend beyond the edge of the footing a distance equal to the depth of the over-excavation required to reach the bearing soils.

Because of the moisture-sensitive nature of the soils, care should be taken to prevent water from mixing with the subgrade (i.e. rain or water used in construction).

Structural Fill

Structural fill should have a maximum particle size no larger than 3 inches and its moisture content should be within 3 percent of its optimum. It should be placed in lifts no thicker than 6 inches and each lift should be compacted to at least 95 percent of its maximum dry density, as determined by ASTM D 1557 (Modified Proctor). Achievement of proper compaction depends on the size and type of compaction equipment, the number of passes, thickness of the layer being compacted and its moisture content. In areas where limited space restricts the use of heavy equipment, smaller equipment can be used, but the fill must be placed in thin enough layers to achieve the required relative compaction.

The on-site native soils will generally be suitable for re-use as structural fill providing it is free of organic matter and oversized particles and is not too wet or too dry for proper compaction.

Drainage

We recommend foundation drains be installed around the perimeter of the structure. Footing drains should consist of 4-inch diameter, perforated or slotted plastic pipe bedded in washed, 3/8-inch pea-gravel. The footing drains should be placed at least 24 inches below the finished floor elevation. The pipe should be sloped to drain to an appropriate discharge location. Roof drains (downspouts) and catch basins should flow in separate tightline pipes and should not be connected to foundation subdrains.

The finished ground surface and site pavements should be sloped to drain away from the structure. Catch basins should be installed in low areas to collect precipitation. The soils at the site are generally silty and relatively impermeable. Although infiltration testing was not a part of this scope of work, it is likely that on-site infiltration will not be a suitable means of disposable of surface runoff.
Slabs-On-Grade
Lower floors may be slabs-on-grade bearing on native soils or structural fill. For design of slabs on grade, a modulus of subgrade reaction of 150 pci is recommended.

Floor slabs should be underlain by a 4-inch-(minimum)-thick capillary break layer consisting of washed 3/8-inch pea gravel. A plastic vapor barrier consisting of 10-mil (minimum) thick plastic sheeting should be placed directly over the pea gravel capillary break.

Temporary Excavations
We anticipate that the on-site soils can be excavated using conventional excavating equipment such as backhoes and excavators. Temporary cuts in excess of 4 feet in height should be sloped in accordance with Part N of the Washington Administrative Code (WAC) 296-155 or be shored. The near-surface soils on site classify as Type C soil. Temporary excavations in Type C soils may be no steeper than 1.5H:1V to meet safety requirements for worker access during construction. The recommended maximum allowable temporary slope cut inclinations are applicable to temporary excavations above the water table only. Flatter slopes may be required where groundwater seepage is present, but groundwater seepage in not expected for the shallow excavation depths expected for this project.

Wet Weather Earthwork
General recommendations relative to earthwork performed in wet weather or in wet conditions are presented below. These recommendations should be incorporated into the contract specifications.

- Earthwork should be performed in small areas to minimize exposure to wet weather. Excavation or the removal of unsuitable soil should be followed promptly by the placement of concrete or placement and compaction of structural fill material. The size and type of construction equipment used may need to be limited to prevent soil disturbance.
- The ground surface within the construction area should be graded to promote run-off of surface water and to prevent the ponding of water.
- The ground surface within the construction area should be sealed by a smooth drum roller, or equivalent, and soil should not be left uncompacted and exposed to moisture infiltration.
- Excavation and placement of fill material should be monitored to determine that the work is accomplished in accordance with the project specifications and that the weather conditions do not adversely impact the quality of work.

CONDITIONS AND LIMITATIONS
We have prepared this geotechnical report for the City of Seattle Office of Housing, for use in design, construction and permitting of the proposed multi-family residence on the subject lot. Experience has shown that soil and groundwater conditions can vary significantly over small distances. Inconsistent conditions can occur between explorations and may not be detected by a geotechnical study of this scope.
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Sufficient geotechnical monitoring, testing, and consultation should be provided during construction to confirm that the conditions encountered are consistent with those assumed in this report, to provide recommendations for design changes should conditions revealed during construction differ from those anticipated, and to verify that geotechnical aspects of construction comply with the contract plans and specifications.

Within the limitations of scope, schedule and budget, HWA attempted to execute these services in accordance with generally accepted principles and practices in the fields of geotechnical engineering and engineering geology in the area at the time the report was prepared. No warranty, express or implied, is made. Our scope of work did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous substances in the soil, surface water, or ground water at this site. HWA does not practice or consult in the field of safety engineering. We do not direct the contractor’s operations and we cannot be responsible for the safety of personnel other than our own on the site; the safety of others is the responsibility of the contractor. The contractor should notify the owner if any of the recommended actions presented herein are considered unsafe.

We appreciate the opportunity to be of service.

Sincerely,

HWA GeoSciences Inc.

[Signature]

Shane Miller, E.I.T.
Geotechnical Engineer

Ralph N. Boirum, P.E.
Geotechnical Engineer, Principal

Attachments:

Figure 1 – Site Vicinity Map
Figure 2 – Site and Exploration Plan
Figures 3 through 5 – Exploration Logs
REFERENCES


EXPLORATION LEGEND

APPROXIMATE LOCATION OF THE HANDHOLES (HWA GEOSCIENCES, INC., 2019)
Dense, dark gray, clean to slightly silty, fine to medium sandy, very fine to coarse GRAVEL, moist. Abundant coarse and angular cobbles 4-6" in diameter.

(DILL)

Dense, olive gray, clean to slightly silty, very fine gravelly, fine to medium SAND, moist. Grades to even more gravelly.

(ADVANCE OUTWASH)

Hand hole terminated by refusal in very dense sand and gravel at 2.7' below ground surface (bgs).

Groundwater seepage not observed during exploration.

Hole backfilled with native soil.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
Soft, dark brown, fine sandy, silty, TOPSOIL, moist. No gravel present.


Stiff, olive gray, fine sandy, SILT, moist. Slight rust mottling. No gravel present.

Medium dense, olive gray, clean, fine to medium SAND, moist.

Dense, olive gray, clean, fine to medium SAND, moist.

Becomes slightly fine to medium gravelly at ~5.0'.

Olive gray, clean, fine to coarse SAND, moist.

Moisture content increases greatly and becomes very dense at ~7.0'. Could be approaching an impermeable soil layer.

Hand hole terminated by refusal in very dense soil at 7.4' below ground surface (bgs).

Slight groundwater seepage observed at 7.0' bgs.

Hole backfilled with native soil.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.
Hand hole terminated by refusal in very dense sand and gravel at 2' below ground surface (bgs). Groundwater seepage not observed during exploration. Hole backfilled with native soil. Tried to dig new hole 2' to the east to get deeper but once again encountered very dense soil and refusal at 2'. Soil was the same in upper 2' of both holes.

<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>SYMBOL</th>
<th>USCS SOIL CLASS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>GP</td>
<td>TOSOIL</td>
<td>Medium stiff, dark brown, slightly silty, slightly sandy, moist.</td>
</tr>
<tr>
<td>0</td>
<td>SP</td>
<td>ADVANCE OUTWASH</td>
<td>Dense, olive brown, slightly silty, fine gravelly, fine to medium SAND, moist. Unable to push T-probe even 1&quot; into soil at 2'. Can barely break up any soil with digging bar.</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>(FILL)</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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