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November 1, 2016

JN 16298

Catholic Housing Services of Western Washington
100 – 23rd Avenue South
Seattle, Washington 98144

Attention: Jenny Weinstein
via email: jennyw@ccsww.org

Subject: **Transmittal Letter – Geotechnical Engineering Study**
Proposed Housing Project
6107 Berkshire Drive
Everett, Washington

Dear Ms. Weinstein:

We are pleased to present this geotechnical engineering report for the proposed housing project to be constructed in Everett, Washington. The scope of our services consisted of exploring site surface and subsurface conditions, and then developing this report to provide recommendations for general earthwork and design criteria for foundations and retaining walls. This work was authorized by your acceptance of our proposal, P-9493, dated September 21, 2016.

The attached report contains a discussion of the study and our recommendations. Please contact us if there are any questions regarding this report, or for further assistance during the design and construction phases of this project.

Respectfully submitted,

GEOTECH CONSULTANTS, INC.

D. Robert Ward, P.E.
Principal

DRW:mw

GEOTECHNICAL ENGINEERING STUDY
Proposed Housing Project
6107 Berkshire Drive
Everett, Washington

This report presents the findings and recommendations of our geotechnical engineering study for the site of the proposed housing project to be located in Everett.

We have been provided with a site plan for the project that was prepared by Environmental Works dated October 11, 2016. Based on this plan, we understand that the housing building(s) will be located near the center of the property extending long in the north-south direction. Parking will be located along the eastern edge of the property. Some gardens, lawns, terraces, and play-space are proposed on the western side of the property. The site is relatively flat, and we anticipate that the lowest building floor and the other above-noted amenities will be at a grade that is near the existing grade.

If the scope of the project changes from what we have described above, we should be provided with revised plans in order to determine if modifications to the recommendations and conclusions of this report are warranted.

SITE CONDITIONS

SURFACE

The Vicinity Map, Plate 1, illustrates the general location of the site in the southern portion of Everett. The property is located just north of a right-angle corner of Berkshire Drive. The subject Catholic Housing property is the southwestern corner of a much larger property that is owned by the City of Everett. Much of this larger property, as well as the subject property, is nearly flat. However, there is a steep slope, inclined at approximately 45 percent and 25 feet tall, at the western edge of the subject. The eastern edge of the subject property, as well as most of the remainder of the larger property, is covered with pavement. The majority of the flat portion of the subject property is grass covered, although there is a driveway in this area around the southern and western edges of the flat portion of the subject property. The western slope of the subject property is covered with trees, mostly deciduous.

SUBSURFACE

The subsurface conditions were explored by excavating five test pits and three test borings at the approximate locations shown on the Site Exploration Plan, Plate 2. Our exploration program was based on the proposed construction, anticipated subsurface conditions and those encountered during exploration, and the scope of work outlined in our latest proposal.

The test pits were excavated on August 25, 2016 with a rubber-tired backhoe. A geotechnical engineer from our staff observed the excavation process, logged the test pits, and obtained representative samples of the soil encountered. "Grab" samples of selected subsurface soil were collected from the backhoe bucket. The Test Pit Logs are attached to this report as Plates 3 through 5.

The test borings were drilled on October 18, 2016 using a track-mounted, hollow-stem auger drill. Samples were taken at approximate 5-foot intervals with a standard penetration sampler. This split-spoon sampler, which has a 2-inch outside diameter, is driven into the soil with a 140-pound hammer falling 30 inches. The number of blows required to advance the sampler a given distance is an indication of the soil density or consistency. A geotechnical engineer from our staff observed the drilling process, logged the test borings, and obtained representative samples of the soil encountered. The Test Boring Logs are attached as Plates 6 through 8.

Soil Conditions

The upper soils revealed in the test pits and borings was very consistent, consisting of loose to medium-dense, unengineered fill soil that was generally comprised of gravelly silty sand. We suspect that this fill soil was imported to the site from a nearby reservoir site. The depth of the fill varied from approximately 10 to 27 feet. Native soils were revealed below the fill soils. The native soil consisted mostly of gravelly silty sand, but some layers of less silty sand were revealed. The native soil directly below the fill was generally in a loose to medium-dense condition. However, the soil became very dense at depth ranging from approximately 13 to 35 feet, with the greater depths located on the western side of the property. The test borings were the deeper explorations, and they extended to a maximum depth of approximately 41 feet.

Groundwater Conditions

No groundwater seepage was observed in the explorations, but were left open for only a short time period. Therefore, the seepage levels on the logs represent the location of transient water seepage and may not indicate the static groundwater level. Groundwater levels encountered during drilling can be deceptive, because seepage into the boring can be blocked or slowed by the auger itself.

It should be noted that groundwater levels vary seasonally with rainfall and other factors, with the highest and/or the most flow of groundwater generally occurring in the winter and early spring months. It is possible that groundwater could be found in more permeable soil perched on the very dense native soils during this time period.

The stratification lines on the logs represent the approximate boundaries between soil types at the exploration locations. The actual transition between soil types may be gradual, and subsurface conditions can vary between exploration locations. The logs provide specific subsurface information only at the locations tested. Where a transition in soil type occurred between samples in the borings, the depth of the transition was interpreted. The relative densities and moisture descriptions indicated on the test pit and boring logs are interpretive descriptions based on the conditions observed during excavation and drilling.

The compaction of test pit backfill was not in the scope of our services. Loose soil will therefore be found in the area of the test pits. If this presents a problem, the backfill will need to be removed and replaced with structural fill during construction.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

THIS SECTION CONTAINS A SUMMARY OF OUR STUDY AND FINDINGS FOR THE PURPOSES OF A GENERAL OVERVIEW ONLY. MORE SPECIFIC RECOMMENDATIONS AND CONCLUSIONS ARE CONTAINED IN THE REMAINDER OF THIS REPORT. ANY PARTY RELYING ON THIS REPORT SHOULD READ THE ENTIRE DOCUMENT.

The test pits and borings conducted for this study encountered approximately 13 to 35 feet of loose to medium-dense soil, mostly unengineered fill soils at the ground surface of the site. These soils are not suitable to support building loads without the likelihood of extensive settlement. Therefore, we recommend that the building loads be transferred though these non-competent soils done into the very dense underlying soils using deep foundations. It is our opinion that the deep foundations could consist of driven pipe piles or drilled concrete piles. Information regarding both are included with this report.

Another significant geotechnical engineering considerations for this project is the steep slope on the western side of the site that is approximately 25 feet in height. Although there no indications of instability, there is no development near the slope at this time. Based on the condition of the existing fill soil, it is our opinion that any significant development or structures for the project should be held back a distance that equates to an imaginary 2.5:1 (Horizontal:Vertical) slope measured up (eastward) from the base of the steep slope; we believe that the site is very stable east of this line and has a safety factor that is suitable based on code. The area west of this line projection would not possess an adequate safety factor based on code, and has a potential for movement during events such as extreme precipitation or a large earthquake. Based on the information we have received, this line projection is about 10 feet east of the top of the slope.

Placing stormwater from the project is unsuitable from a geotechnical engineering standpoint because it would be discharged into the loose fill soil; because the fill is loose and variable, it the stormwater could cause significant settlement of the fill or destabilize the western steep slope. Therefore, we recommend that the infiltration of stormwater not be done for this project. In addition, no stormwater should be discharged near or on the slope.

The erosion control measures needed during the site development will depend heavily on the weather conditions that are encountered. We anticipate that a silt fence will be needed around the downslope sides of any cleared areas. Existing pavements, ground cover, and landscaping should be left in place wherever possible to minimize the amount of exposed soil. Rocked staging areas and construction access roads should be provided to reduce the amount of soil or mud carried off the property by trucks and equipment. Wherever possible, the access roads should follow the alignment of planned pavements. Trucks should not be allowed to drive off of the rock-covered areas. Cut slopes and soil stockpiles should be covered with plastic during wet weather. Following clearing or rough grading, it may be necessary to mulch or hydroseed bare areas that will not be immediately covered with landscaping or an impervious surface. On most construction projects, it is necessary to periodically maintain or modify temporary erosion control measures to address specific site and weather conditions.

The drainage and/or waterproofing recommendations presented in this report are intended only to prevent active seepage from flowing through concrete walls or slabs. Even in the absence of active seepage into and beneath structures, water vapor can migrate through walls, slabs, and floors from the surrounding soil, and can even be transmitted from slabs and foundation walls due to the concrete curing process. Water vapor also results from occupant uses, such as cooking and bathing. Excessive water vapor trapped within structures can result in a variety of undesirable conditions, including, but not limited to, moisture problems with flooring systems, excessively moist air within occupied areas, and the growth of molds, fungi, and other biological organisms that may be harmful to the health of the occupants. The designer or architect must consider the potential vapor sources and likely occupant uses, and provide sufficient ventilation, either passive or mechanical, to prevent a build up of excessive water vapor within the planned structure.

Geotech Consultants, Inc. should be allowed to review the final development plans to verify that the recommendations presented in this report are adequately addressed in the design. Such a plan review would be additional work beyond the current scope of work for this study, and it may include revisions to our recommendations to accommodate site, development, and geotechnical constraints that become more evident during the review process.

We recommend including this report, in its entirety, in the project contract documents. This report should also be provided to any future property owners so they will be aware of our findings and recommendations.

SEISMIC CONSIDERATIONS

In accordance with the International Building Code (IBC), the site soil profile within 100 feet of the ground surface is best represented by Site Class Type D (Stiff Site Class). As noted in the USGS website, the mapped spectral acceleration value for a 0.2 second (S_s) and 1.0 second period (S_1) equals 1.39g and 0.52g, respectively.

The site soils are not susceptible to seismic liquefaction because of their dense nature and/or the absence of near-surface groundwater.

DRIVEN PIPE PILES

Three-, 4-, or 6-inch-diameter pipe piles driven with a 850- or 1,100- or 2,000-pound hydraulic jackhammer to the following final penetration rates may be assigned the following compressive capacities.

INSIDE PILE DIAMETER	FINAL DRIVING RATE (850-pound hammer)	FINAL DRIVING RATE (1,100-pound hammer)	FINAL DRIVING RATE (2,000-pound hammer)	ALLOWABLE COMPRESSIVE CAPACITY
3 inches	10 sec/inch	6 sec/inch	2 sec/inch	6 tons
4 inches	16 sec/inch	10 sec/inch	4 sec/inch	10 tons
6 inches	n/a	n/a	10 sec/inch	20 tons

Note: The refusal criteria indicated in the above table are valid only for pipe piles that are installed using a hydraulic impact hammer carried on leads that allow the hammer to sit on the top of the pile during driving. If the piles are installed by alternative methods, such as a vibratory hammer or a hammer that is hard-mounted to the installation machine, numerous load tests to 200 percent of the design capacity would be necessary to substantiate the allowable pile load. The appropriate number of load tests would need to be determined at the time the contractor and installation method are chosen.

As a minimum, Schedule 40 pipe should be used. The site soils are not highly organic, and are not located near salt water. As a result, they do not have an elevated corrosion potential. Considering this, it is our opinion that standard "black" pipe can be used, and corrosion protection, such as galvanizing, is not necessary for the pipe piles.

Pile caps and grade beams should be used to transmit loads to the piles. Isolated pile caps should include a minimum of two piles to reduce the potential for eccentric loads being applied to the piles. Subsequent sections of pipe can be connected with slip or threaded couplers, or they can be welded together. If slip couplers are used, they should fit snugly into the pipe sections. This may require that shims be used or that beads of welding flux be applied to the outside of the coupler.

Lateral loads due to wind or seismic forces may be resisted by passive earth pressure acting on the vertical, embedded portions of the foundation. For this condition, the foundation must be either poured directly against relatively level, undisturbed soil or be surrounded by level compacted fill. We recommend using a passive earth pressure of 300 pounds per cubic foot (pcf) for this resistance. If the ground in front of a foundation is loose or sloping, the passive earth pressure given above will not be appropriate. We recommend a safety factor of at least 1.5 for the foundation's resistance to lateral loading, when using the above ultimate passive value.

If lateral resistance from fill placed against the foundations is required for this project, the structural engineer should indicate this requirement on the plans for the general and earthwork contractor's information. Compacted fill placed against the foundations can consist of on-site soil that is tamped into place using the backhoe or is compacted using a jumping jack compactor. It is necessary for the fill to be compacted to a firm condition, but it does not need to reach even 90 percent relative compaction to develop the passive resistance recommended above. Due to their small diameter, the lateral capacity of vertical pipe piles is relatively small. However, if lateral resistance in addition to passive soil resistance is required, we recommend driving battered piles in the same direction as the applied lateral load. The lateral capacity of a battered pile is equal to one-half of the lateral component of the allowable compressive load, with a maximum allowable lateral capacity of 1,000 pounds. The allowable vertical capacity of battered piles does not need to be reduced if the piles are battered steeper than 1:5 (Horizontal:Vertical).

DRILLED CONCRETE PIERS

Drilled, concrete-filled piers may be used, if it is uneconomical to excavate to bearing soil. Based on our explorations, it appears that the piers can be constructed by open-hole methods. These piers should be drilled with conventional auger drills, but the drilling contractor should have access to casing, in case sloughing occurs in the near-surface soil. If water is in a hole at the time of pouring, the concrete should be tremied to the bottom of the hole.

A wide variety of depths and pier diameters are possible, but we recommend using a minimum pile diameter of 16 inches. For a minimum embedment of 5 feet into the very dense soil and a pile diameter of 16 inches, we recommend assuming an allowable compressive capacity of 30 tons per pier. Center-to-center pier spacing should be no less than three times the pile diameter.

We recommend reinforcing each pile its entire length. This typically consists of a cage of rebar extending a portion of the pile's length, with a full-length center bar. For design of the reinforcing, we recommend that the piles be assumed to have a point of fixity (point of maximum bending moment) at a depth of 10 feet below the top of the pile. The lateral capacity of a pile is a function of both the soil that surrounds the pier and the composition of the pile itself. Passive earth pressures on the grade beams will also provide some lateral resistance. If structural fill is placed against the outside of the grade beams, the design passive earth pressure from the fill can be assumed to be equal to that pressure exerted by an equivalent fluid with a density of 300 pcf. This passive resistance is an ultimate value that does not include a safety factor.

FOUNDATION AND RETAINING WALLS

Retaining walls backfilled on only one side should be designed to resist the lateral earth pressures imposed by the soil they retain. The following recommended parameters are for walls that restrain level backfill:

PARAMETER	VALUE
Active Earth Pressure *	35 pcf
Passive Earth Pressure	300 pcf
Soil Unit Weight	130 pcf

Where: pcf is Pounds per Cubic Foot, and Active and Passive Earth Pressures are computed using the Equivalent Fluid Pressures.

*** For a restrained wall that cannot deflect at least 0.002 times its height, a uniform lateral pressure equal to 10 psf times the height of the wall should be added to the above active equivalent fluid pressure.**

The design values given above do not include the effects of any hydrostatic pressures behind the walls and assume that no surcharges, such as those caused by slopes, vehicles, or adjacent foundations will be exerted on the walls. If these conditions exist, those pressures should be added to the above lateral soil pressures. Where sloping backfill is desired behind the walls, we will need to be given the wall dimensions and the slope of the backfill in order to provide the appropriate design earth pressures. The surcharge due to traffic loads behind a wall can typically be accounted for by adding a uniform pressure equal to 2 feet multiplied by the above active fluid density. Heavy construction equipment should not be operated behind retaining and foundation walls within a distance equal to the height of a wall, unless the walls are designed for the additional lateral pressures resulting from the equipment.

The values given above are to be used to design only permanent foundation and retaining walls that are to be backfilled, such as conventional walls constructed of reinforced concrete or masonry. It is not appropriate to use the above earth pressures and soil unit weight to back-calculate soil strength parameters for design of other types of retaining walls, such as soldier pile, reinforced earth, modular or soil nail walls. We can assist with design of these types of walls, if desired. The values for friction and passive resistance are ultimate values and do not include a safety factor. Restrained wall soil parameters should be utilized for a distance of 1.5 times the wall height from corners or bends in the walls. This is intended to reduce the amount of cracking that can occur where a wall is restrained by a corner.

Wall Pressures Due to Seismic Forces

The surcharge wall loads that could be imposed by the design earthquake can be modeled by adding a uniform lateral pressure to the above-recommended active pressure. The recommended surcharge pressure is 8**H** pounds per square foot (psf), where **H** is the design retention height of the wall. Using this increased pressure, the safety factor against sliding and overturning can be reduced to 1.2 for the seismic analysis.

Retaining Wall Backfill and Waterproofing

Backfill placed behind retaining or foundation walls should be coarse, free-draining structural fill containing no organics. This backfill should contain no more than 5 percent silt or clay particles and have no gravel greater than 4 inches in diameter. The percentage of particles passing the No. 4 sieve should be between 25 and 70 percent. The later section entitled ***Drainage Considerations*** should also be reviewed for recommendations related to subsurface drainage behind foundation and retaining walls.

The purpose of these backfill requirements is to ensure that the design criteria for a retaining wall are not exceeded because of a build-up of hydrostatic pressure behind the wall. Also, subsurface drainage systems are not intended to handle large volumes of water from surface runoff. The top 12 to 18 inches of the backfill should consist of a compacted, relatively impermeable soil or topsoil, or the surface should be paved. The ground surface must also slope away from backfilled walls to reduce the potential for surface water to percolate into the backfill. Water percolating through pervious surfaces (pavers, gravel, permeable pavement, etc.) must also be prevented from flowing toward walls or into the backfill zone. The compacted subgrade below pervious surfaces and any associated drainage layer should therefore be sloped away. Alternatively, a membrane and subsurface collection system could be provided below a pervious surface.

It is critical that the wall backfill be placed in lifts and be properly compacted, in order for the above-recommended design earth pressures to be appropriate. The wall design criteria assume that the backfill will be well-compacted in lifts no thicker than 12 inches. The compaction of backfill near the walls should be accomplished with hand-operated equipment to prevent the walls from being overloaded by the higher soil forces that occur during compaction. The section entitled ***General Earthwork and Structural Fill*** contains additional recommendations regarding the placement and compaction of structural fill behind retaining and foundation walls.

The above recommendations are not intended to waterproof below-grade walls, or to prevent the formation of mold, mildew or fungi in interior spaces. Over time, the performance of subsurface drainage systems can degrade, subsurface groundwater flow patterns can change, and utilities can break or develop leaks. Therefore, waterproofing should be provided where future seepage through the walls is not acceptable. This typically includes limiting cold-joints and wall penetrations, and using bentonite panels or membranes on the outside of the walls. There are a variety of different waterproofing materials and systems, which should be installed by an experienced contractor familiar with the anticipated construction and subsurface conditions. Applying a thin coat of asphalt emulsion to the outside face of a wall is not considered waterproofing, and will only help to reduce moisture generated from water vapor or capillary action from seeping through the concrete. As with any project, adequate ventilation of basement and crawl space areas is important to prevent a build up of water vapor that is commonly transmitted through concrete walls from the surrounding soil, even when seepage is not present. This is appropriate even when waterproofing is applied to the outside of foundation and retaining walls. We recommend that you contact an experienced envelope consultant if detailed recommendations or specifications related to waterproofing design, or minimizing the potential for infestations of mold and mildew are desired.

The ***General***, ***Slabs-On-Grade***, and ***Drainage Considerations*** sections should be reviewed for additional recommendations related to the control of groundwater and excess water vapor for the anticipated construction.

SLABS-ON-GRADE

The building floors can be constructed as slabs-on-grade atop firm, non-organic, existing soil that is compacted in-place, or on structural fill. The subgrade soil must be in a firm, non-yielding condition at the time of slab construction or underslab fill placement. Any soft areas encountered should be excavated and replaced with select, imported structural fill. We recommend that extra steel also be placed in the slab.

Even where the exposed soils appear dry, water vapor will tend to naturally migrate upward through the soil to the new constructed space above it. This can affect moisture-sensitive flooring, cause imperfections or damage to the slab, or simply allow excessive water vapor into the space above the slab. All interior slabs-on-grade should be underlain by a capillary break drainage layer consisting of a minimum 4-inch thickness of clean gravel or crushed rock that has a fines content (percent passing the No. 200 sieve) of less than 3 percent and a sand content (percent passing the No. 4 sieve) of no more than 10 percent. Pea gravel or crushed rock are typically used for this layer.

As noted by the American Concrete Institute (ACI) in the *Guides for Concrete Floor and Slab Structures*, proper moisture protection is desirable immediately below any on-grade slab that will be covered by tile, wood, carpet, impermeable floor coverings, or any moisture-sensitive equipment or products. ACI also notes that vapor *retarders* such as 6-mil plastic sheeting have been used in the past, but are now recommending a minimum 10-mil thickness for better durability and long term performance. A vapor retarder is defined as a material with a permeance of less than 0.3 perms, as determined by ASTM E 96. It is possible that concrete admixtures may meet this specification, although the manufacturers of the admixtures should be consulted. Where vapor retarders are used under slabs, their edges should overlap by at least 6 inches and be sealed with adhesive tape. The sheeting should extend to the foundation walls for maximum vapor protection. If no potential for vapor passage through the slab is desired, a vapor *barrier* should be used. A vapor barrier, as defined by ACI, is a product with a water transmission rate of 0.01 perms when tested in accordance with ASTM E 96. Reinforced membranes having sealed overlaps can meet this requirement.

In the recent past, ACI (Section 4.1.5) recommended that a minimum of 4 inches of well-graded compactable granular material, such as a 5/8-inch-minus crushed rock pavement base, be placed over the vapor retarder or barrier for their protection, and as a "blotter" to aid in the curing of the concrete slab. Sand was not recommended by ACI for this purpose. However, the use of material over the vapor retarder is controversial as noted in current ACI literature because of the potential that the protection/blotter material can become wet between the time of its placement and the installation of the slab. If the material is wet prior to slab placement, which is always possible in the Puget Sound area, it could cause vapor transmission to occur up through the slab in the future, essentially destroying the purpose of the vapor barrier/retarder. Therefore, if there is a potential that the protection/blotter material will become wet before the slab is installed, ACI now recommends that no protection/blotter material be used. However, ACI then recommends that, because there is a potential for slab curl due to the loss of the blotter material, joint spacing in the slab be reduced, a low shrinkage concrete mixture be used, and "other measures" (steel reinforcing, etc.) be used. ASTM E-1643-98 "Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs" generally agrees with the recent ACI literature.

We recommend that the contractor, the project materials engineer, and the owner discuss these issues and review recent ACI literature and ASTM E-1643 for installation guidelines and guidance on the use of the protection/blotter material.

The ***General***, ***Permanent Foundation and Retaining Walls***, and ***Drainage Considerations*** sections should be reviewed for additional recommendations related to the control of groundwater and excess water vapor for the anticipated construction.

EXCAVATIONS AND SLOPES

No excavated slopes are anticipated other than for utility trenches. Excavation slopes should not exceed the limits specified in local, state, and national government safety regulations. Temporary cuts to a depth of about 4 feet may be attempted vertically in unsaturated soil, if there are no indications of slope instability. However, vertical cuts should not be made near property boundaries, or existing utilities and structures. Based upon Washington Administrative Code (WAC) 296, Part N, the soil at the subject site would generally be classified as Type B. Therefore, temporary cut slopes greater than 4 feet in height should not be excavated at an inclination steeper than 1:1 (Horizontal:Vertical), extending continuously between the top and the bottom of a cut.

The above-recommended temporary slope inclination is based on the conditions exposed in our explorations, and on what has been successful at other sites with similar soil conditions. It is possible that variations in soil and groundwater conditions will require modifications to the inclination at which temporary slopes can stand. Temporary cuts are those that will remain unsupported for a relatively short duration to allow for the construction of foundations, retaining walls, or utilities. Temporary cut slopes should be protected with plastic sheeting during wet weather. It is also important that surface runoff be directed away from the top of temporary slope cuts. Cut slopes should also be backfilled or retained as soon as possible to reduce the potential for instability. Please note that loose soil can cave suddenly and without warning. Excavation, foundation, and utility contractors should be made especially aware of this potential danger. These recommendations may need to be modified if the area near the potential cuts has been disturbed in the past by utility installation, or if settlement-sensitive utilities are located nearby.

Water should not be allowed to flow uncontrolled over the top of any temporary or permanent slope. All permanently exposed slopes should be seeded with an appropriate species of vegetation to reduce erosion and improve the stability of the surficial layer of soil.

Any disturbance to the existing slope outside of the building limits may reduce the stability of the western slope. Soil from the excavation should not be placed on the slope.

DRAINAGE CONSIDERATIONS

Footing drains should be used where: (1) Crawl spaces or basements will be below a structure; (2) A slab is below the outside grade; or, (3) The outside grade does not slope downward from a building. Drains should also be placed at the base of all earth-retaining walls. These drains should be surrounded by at least 6 inches of 1-inch-minus, washed rock that is encircled with non-woven, geotextile filter fabric (Mirafi 140N, Supac 4NP, or similar material). At its highest point, a perforated pipe invert should be at least 6 inches below the bottom of a slab floor or the level of a crawl space. The discharge pipe for subsurface drains should be sloped for flow to the outlet point. Roof and surface water drains must not discharge into the foundation drain system. A typical drain detail is attached to this report as Plate 9. For the best long-term performance, perforated PVC pipe is recommended for all subsurface drains.

If the structure includes an elevator, it may be necessary to provide special drainage or waterproofing measures for the elevator pit. If no seepage into the elevator pit is acceptable, it will be necessary to provide a footing drain and free-draining wall backfill, and the walls should be waterproofed. If the footing drain will be too low to connect to the storm drainage system, then it will likely be necessary to install a pumped sump to discharge the collected water. Alternatively, the elevator pit could be designed to be entirely waterproof; this would include designing the pit structure to resist hydrostatic uplift pressures.

As a minimum, a vapor retarder, as defined in the ***Slabs-On-Grade*** section, should be provided in any crawl space area to limit the transmission of water vapor from the underlying soils. Crawl space grades are sometimes left near the elevation of the bottom of the footings. As a result, an outlet drain is recommended for all crawl spaces to prevent an accumulation of any water that may bypass the footing drains. Providing even a few inches of free draining gravel underneath the vapor retarder limits the potential for seepage to build up on top of the vapor retarder.

The excavation and site should be graded so that surface water is directed off the site and away from the tops of slopes. Water should not be allowed to stand in any area where foundations, slabs, or pavements are to be constructed. Final site grading in areas adjacent to building(s) should slope away at least 2 percent, except where the area is paved. Surface drains should be provided where necessary to prevent ponding of water behind foundation or retaining walls. A discussion of grading and drainage related to pervious surfaces near walls and structures is contained in the ***Foundation and Retaining Walls***.

GENERAL EARTHWORK AND STRUCTURAL FILL

All building and pavement areas should be stripped of surface vegetation, topsoil, organic soil, and other deleterious material. The stripped or removed materials should not be mixed with any materials to be used as structural fill, but they could be used in non-structural areas, such as landscape beds. We don't anticipate that any significant use of structural fill will be needed for this project except for possibly as utility line backfill.

Structural fill is defined as any fill, including utility backfill, placed under, or close to, a building, behind permanent retaining or foundation walls, or in other areas where the underlying soil needs to support loads. All structural fill should be placed in horizontal lifts with a moisture content at, or near, the optimum moisture content. The optimum moisture content is that moisture content that results in the greatest compacted dry density. The moisture content of fill is very important and must be closely controlled during the filling and compaction process.

The allowable thickness of the fill lift will depend on the material type selected, the compaction equipment used, and the number of passes made to compact the lift. The loose lift thickness should not exceed 12 inches. We recommend testing the fill as it is placed. If the fill is not sufficiently compacted, it can be recompacted before another lift is placed. This eliminates the need to remove the fill to achieve the required compaction. The following table presents recommended relative compactions for structural fill:

LOCATION OF FILL PLACEMENT	MINIMUM RELATIVE COMPACTION
Beneath footings, slabs or walkways	95%
Filled slopes and behind retaining walls	90%
Beneath pavements	95% for upper 12 inches of subgrade; 90% below that level

Where: Minimum Relative Compaction is the ratio, expressed in percentages, of the compacted dry density to the maximum dry density, as determined in accordance with ASTM Test Designation D 1557-91 (Modified Proctor).

Use of On-Site Soil

If grading activities take place during wet weather, or when the silty, on-site soil is wet, site preparation costs may be higher because of delays due to rain and the potential need to import granular fill. The moisture content of the silty, on-site soil must be at, or near, the optimum moisture content, as the soil cannot be consistently compacted to the required density when the moisture content is significantly greater than optimum. The moisture content of the on-site soil was generally at or above the estimated optimum moisture content at the time of our explorations, which was in drier time of the year, but could be wetter in the during the normally wet months of the year. The on-site soil is generally silty and therefore moisture sensitive. Grading operations will be difficult during wet weather, or when the moisture content of this soil exceeds the optimum moisture content. The on-site fill soil underlying the topsoil could be used as structural fill, if grading operations are conducted during hot, dry weather, when drying the wetter soil by aeration is possible. During excessively dry weather, however, it may be necessary to add water to achieve the optimum moisture content.

Moisture-sensitive soil may also be susceptible to excessive softening and "pumping" from construction equipment, or even foot traffic, when the moisture content is greater than the optimum moisture content. It may be beneficial to protect subgrades with a layer of imported sand or crushed rock to limit disturbance from traffic.

Structural fill that will be placed in wet weather should consist of a coarse, granular soil with a silt or clay content of no more than 5 percent. The percentage of particles passing the No. 200 sieve should be measured from that portion of soil passing the three-quarter-inch sieve.

LIMITATIONS

The conclusions and recommendations contained in this report are based on site conditions as they existed at the time of our exploration and assume that the soil and groundwater conditions encountered in the test pits or borings are representative of subsurface conditions on the site. If the subsurface conditions encountered during construction are significantly different from those observed in our explorations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. Unanticipated conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking samples in test pits or borings. Subsurface conditions can also vary between exploration locations. Such unexpected conditions frequently require making additional expenditures to attain a properly constructed project. It is recommended that the owner consider providing a contingency fund to accommodate such potential extra costs and risks. This is a standard recommendation for all projects.

The recommendations presented in this report are directed toward the protection of only proposed structures from damage due to slope movement. Predicting the future behavior of steep slopes and the potential effects of development on their stability is an inexact and imperfect science that is currently based mostly on the past behavior of slopes with similar characteristics. Landslides and soil movement can occur on steep slopes before, during, or after the development of property. However, as noted in the report, structures located outside the line of influence noted in the ***General*** section of this report should remain stable in our opinion.

This report has been prepared for the exclusive use of Catholic Housing Services of Western Washington and its representatives for specific application to this project and site. Our conclusions and recommendations are professional opinions derived in accordance with our understanding of current local standards of practice, and within the scope of our services. No warranty is expressed or implied. The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design. Our services also do not include assessing or minimizing the potential for biological hazards, such as mold, bacteria, mildew and fungi in either the existing or proposed site development.

ADDITIONAL SERVICES

In addition to reviewing the final plans, Geotech Consultants, Inc. should be retained to provide geotechnical consultation, testing, and observation services during construction. This is to confirm that subsurface conditions are consistent with those indicated by our exploration, to evaluate whether earthwork and foundation construction activities comply with the general intent of the recommendations presented in this report, and to provide suggestions for design changes in the event subsurface conditions differ from those anticipated prior to the start of construction. However, our work would not include the supervision or direction of the actual work of the contractor and its employees or agents. Also, job and site safety, and dimensional measurements, will be the responsibility of the contractor.

During the construction phase, we will provide geotechnical observation and testing services when requested by you or your representatives. Please be aware that we can only document site work we actually observe. It is still the responsibility of your contractor or on-site construction team to verify that our recommendations are being followed, whether we are present at the site or not.

The following plates are attached to complete this report:

Plate 1	Vicinity Map
Plate 2	Site Exploration Plan
Plates 3 - 8	Test Pit and Boring Logs
Plate 9	Typical Footing Drain Detail

We appreciate the opportunity to be of service on this project. Please contact us if you have any questions, or if we can be of further assistance.

Respectfully submitted,

GEOTECH CONSULTANTS, INC.

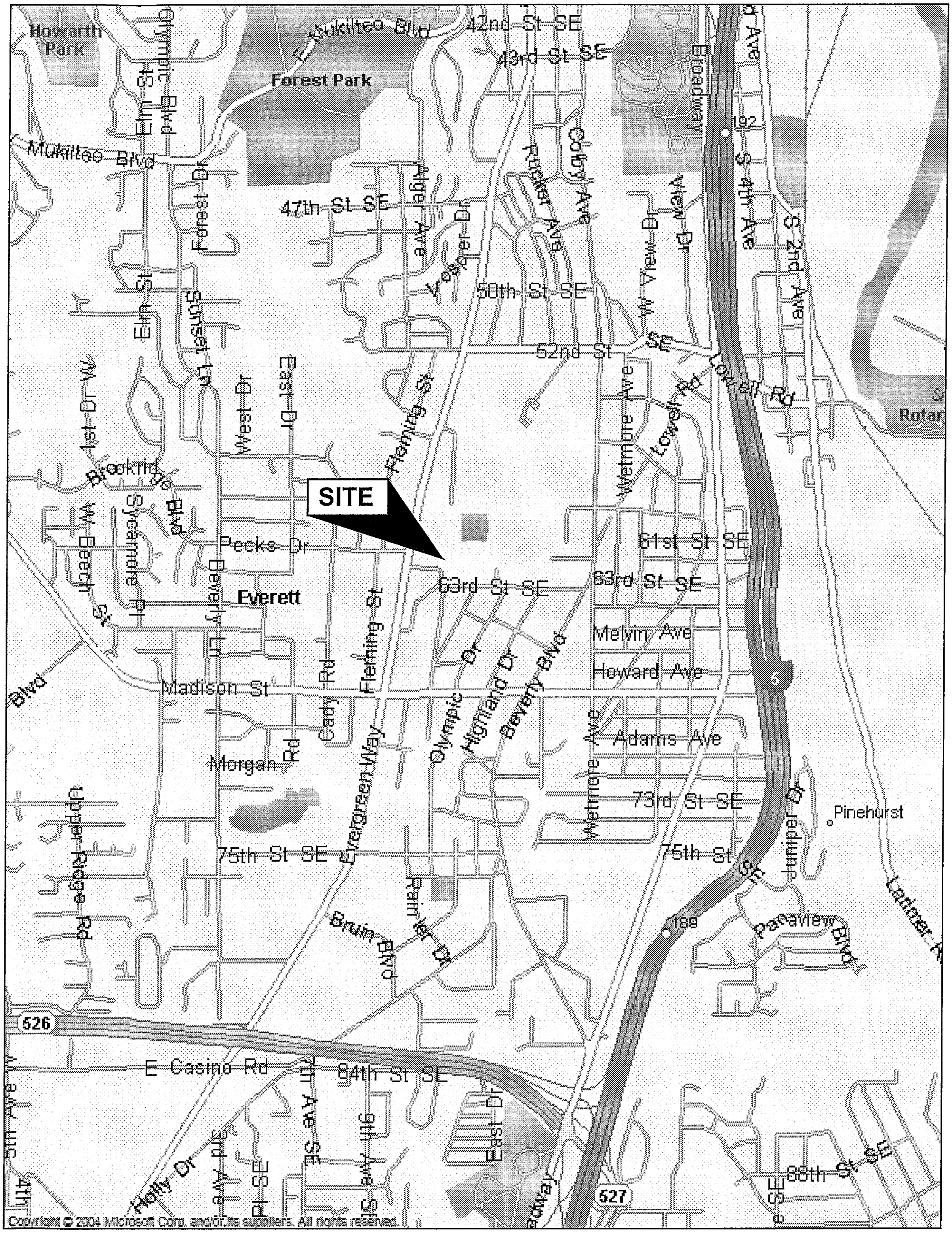
D. ROBERT WARD
STATE OF WASHINGTON
29740
REGISTERED
PROFESSIONAL ENGINEER

11/1/16

D. Robert Ward, P.E.
Principal

DRW:mw

NORTH



(Source: Microsoft MapPoint, 2013)

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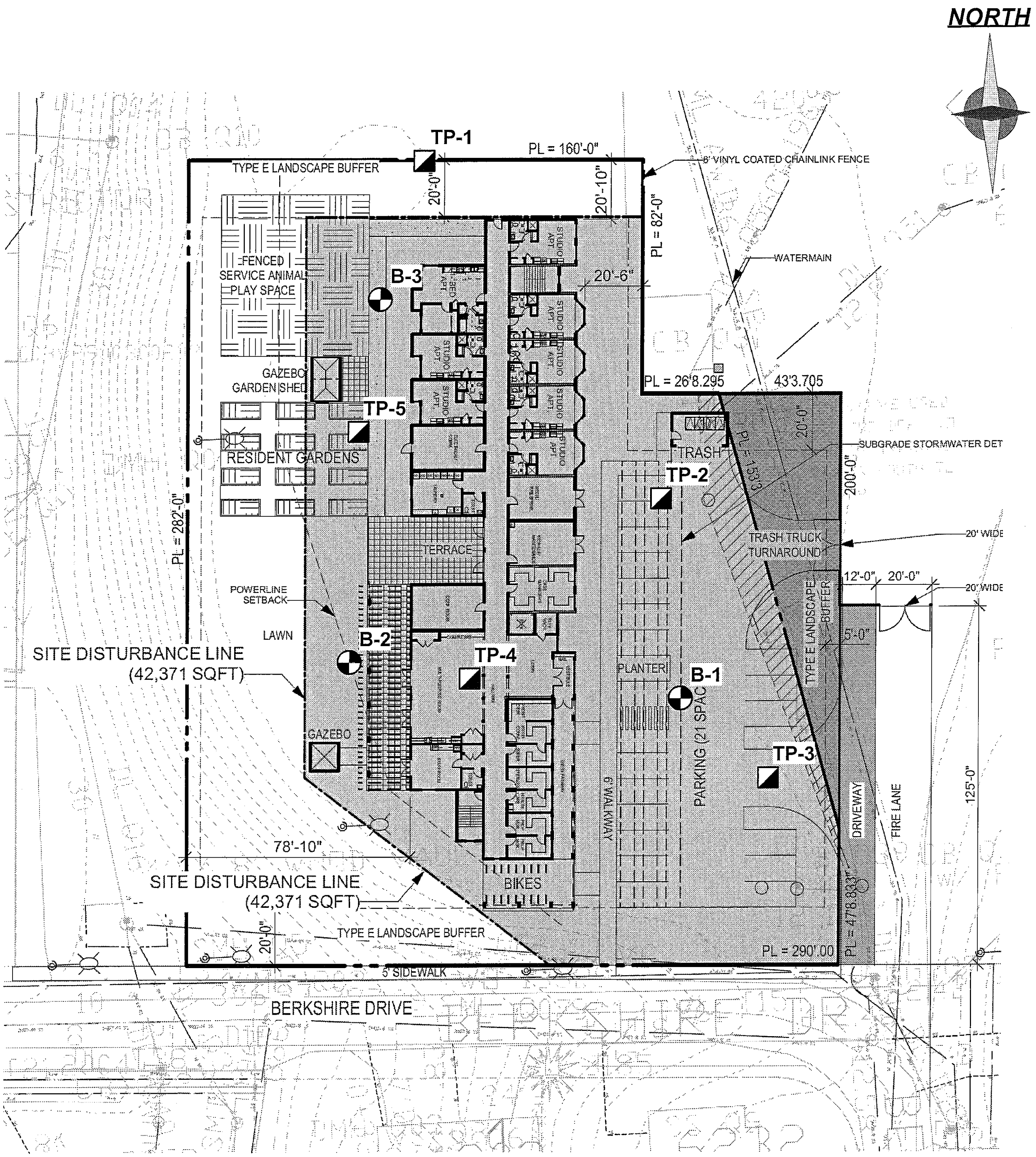
VICINITY MAP

6107 Berkshire Drive
Everett, Washington

Job No:	Date:		Plate:
16298	Nov. 2016		1



Legend:

- Boring Location
- Test Pit Location

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SITE EXPLORATION PLAN

6107 Berkshire Drive
Everett, Washington

Job No:	Date:		Plate:
16298	Nov. 2016	No Scale	2

TEST PIT 1

Depth (ft.)	Moisture Content (%)	Water Table	USCS	Description
0–11			FILL	Grass over: Gray gravelly silty SAND, some root matter, slightly moist, loose to medium-dense (FILL) -reduced gravel and silt content

* Test Pit terminated at 11 feet on August 25, 2016.
* No groundwater observed during excavation.
* No caving observed during excavation.

TEST PIT 2

Depth (ft.)	Moisture Content (%)	Water Table	USCS	Description
0–9.5			FILL	Grass over: Gray gravelly silty SAND, some root matter, slightly moist, loose to medium-dense (FILL) -becomes gray and rust-brown, reduced silt and root content
9.5–11			SM	Rust-brown, mottled, gravelly silty SAND, moist, loose to medium-dense

* Test Pit terminated at 11 feet on August 25, 2016.
* No groundwater observed during excavation.
* No caving observed during excavation.

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TEST PIT LOG

6107 Berkshire Drive
Everett, Washington

Job	Date:	Logged by:	Plate:
16298	Nov. 2016	ASM	3

TEST PIT 3

Depth (ft.)	Moisture Content (%)	Water Table	USCS	Description
			FILL	3 inches crushed rock over: Gray and rust-brown gravelly silty SAND, moist, loose to medium-dense **(FILL)**
5				-with occasional glass debris
				TOPSOIL
			SM	Rust-brown, mottled, gravelly silty SAND, very moist, loose to medium-dense
10				-becomes dense **(Glacial Till)**
15				

* **Test Pit terminated at 10.5 feet on August 25, 2016.**
* **No groundwater observed during excavation.**
* **No caving observed during excavation.**

TEST PIT 4

Depth (ft.)	Moisture Content (%)	Water Table	USCS	Description
				Grass over: Gray and rust-brown, gravelly, slightly silty to silty SAND, slightly moist, loose to medium-dense **(FILL)**
5			FILL	
				-becomes moist
10				
15				

* **Test Pit terminated at 10 feet on August 25, 2016.**
* **No groundwater observed during excavation.**
* **No caving observed during excavation.**

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TEST PIT LOG

6107 Berkshire Drive
Everett, Washington

Job	Date:	Logged by:	Plate:
16298	Nov. 2016	ASM	4

TEST PIT 5

Depth (ft.)	Moisture Content (%)	Water Table	USCS	Description
0–5			FILL	Grass over: Gray gravelly silty SAND, some root matter, slightly moist, loose to medium-dense **(FILL)**
				-reduced gravel and silt content
5–11			FILL	

Depth scale: 5, 10, 15

* **Test Pit terminated at 11 feet on August 25, 2016.**
* **No groundwater observed during excavation.**
* **No caving observed during excavation.**

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TEST PIT LOG

6107 Berkshire Drive
Everett, Washington

Job	Date:	Logged by:	Plate:
16298	Nov. 2016	ASM	5

BORING 1

Depth	Moisture	Water Table	Blows per Foot	Sample	USCS	Description
					FILL	Crushed rock over: Rust-brown silty SAND with gravel, fine to coarse-grained, moist, loose **(FILL)**
			4	1		-becomes gray and brown
5			3	2		
			7	3		
10			6	4		-becomes gray
			40	5	SM	Rust-brown silty SAND with gravel, fine to medium-grained, moist, medium-dense -becomes gray, dense **(Glacial Till)**
15			50/6"	6		-becomes fine to coarse-grained, very dense
20			*50/2"	7		*Overstated blow counts - driving on a rock
					SW	Brown gravelly SAND, fine to coarse-grained, moist, very dense
25			89/11"	8		
30						

*** Test boring was terminated at 26.5 feet on October 18, 2016.**
*** No groundwater seepage was encountered during drilling.**

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BORING LOG
6107 Berkshire Drive
Everett, Washington

Job	Date:	Logged by:	Plate:
16298	Nov. 2016	ASM	6

BORING 2

Depth (ft)	Moisture	Water Table	Blows per Foot	Sample	USCS	Description
0						1-1/4 inch minus crushed rock **(FILL)**
2					FILL	Gray and brown silty SAND with gravel, fine to coarse-grained, moist, loose **(FILL)**
5			3	1		
10			5	2		
15			7	3		-becomes fine to medium-grained
20			12	4		-becomes medium-dense
25			8	5		-becomes loose
27					**SP**	Brown gravelly SAND, fine to medium-grained, moist, medium-dense
30			22	6		
34					**SM**	Gray silty SAND with gravel, fine to medium-grained, moist, very dense **(Glacial Till)**
35			50/5"	7		
36			50/6"	8		

*** Test boring was terminated at 37 feet on October 18, 2016.**
*** No groundwater seepage was encountered during drilling.**

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BORING LOG
6107 Berkshire Drive
Everett, Washington

Job	*Date:*	*Logged by:*	*Plate:*
16298	Nov. 2016	ASM	7

BORING 3

Depth (ft)	Moisture	Water Table	Blows per Foot	Sample	USCS	Description
0					FILL	Grass over: Gray-brown silty SAND with gravel, fine to medium-grained, moist, loose to medium-dense **(FILL)**
5			10	1		
10			4	2		-becomes gray and rust-brown
15			10	3		-becomes medium-dense
20			12	4		
25			15	5		
~27					SM	Reddish-brown silty SAND with gravel, fine to medium-grained, very moist, medium-dense
30			24	6		
35			50/6"	7		-becomes gray, gravelly, very dense **(Glacial Till)**
40			50/3"	8		

*** Test boring was terminated at 40.8 feet on October 18, 2016.**
*** No groundwater seepage was encountered during drilling.**

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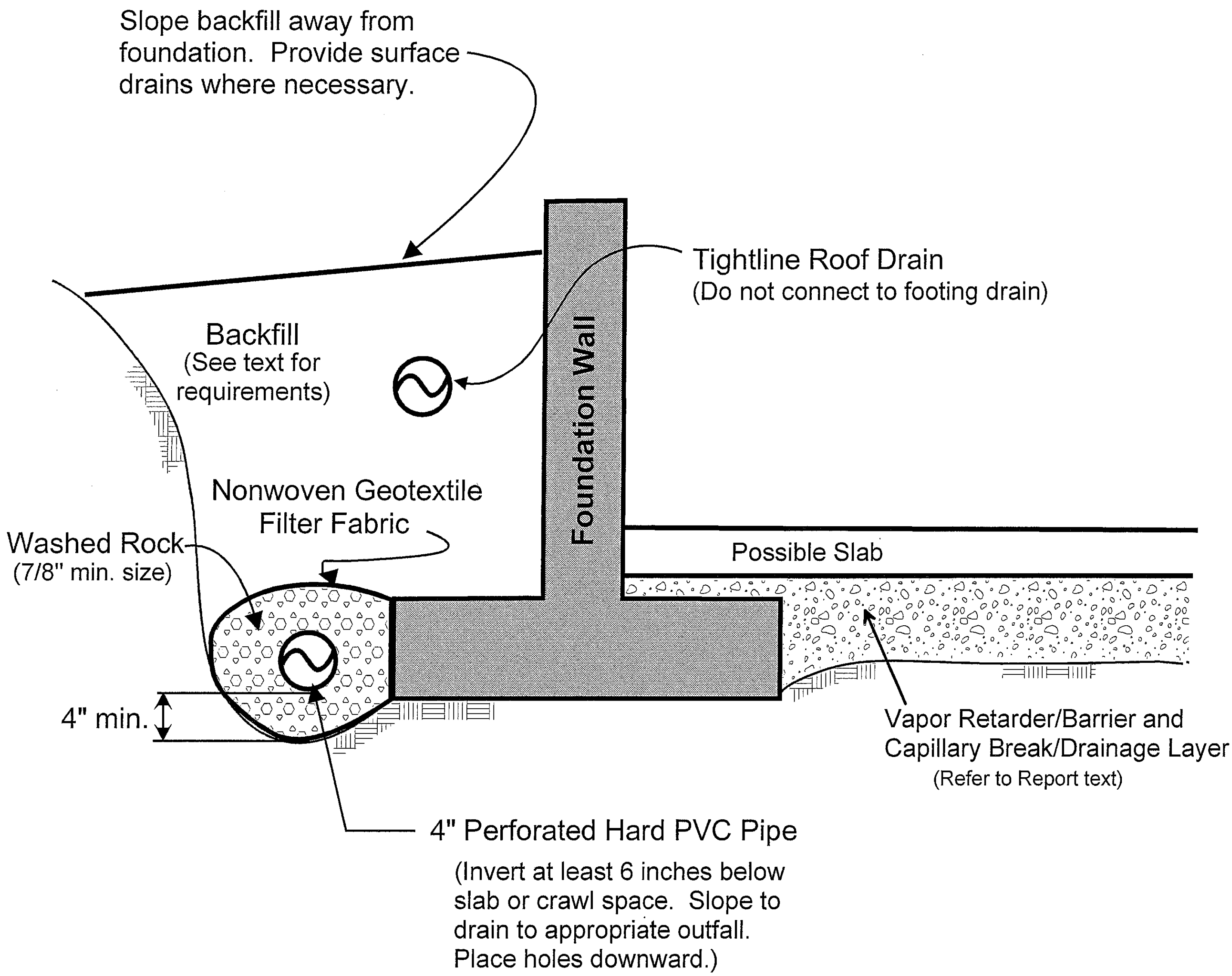
BORING LOG
6107 Berkshire Drive
Everett, Washington

Job	*Date:*	*Logged by:*	*Plate:*
16298	Nov. 2016	ASM	8



NOTES:

(1) In crawl spaces, provide an outlet drain to prevent buildup of water that bypasses the perimeter footing drains.

(2) Refer to report text for additional drainage, waterproofing, and slab considerations.

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FOOTING DRAIN DETAIL

6107 Berkshire Drive
Everett, Washington

Job No:	Date:		Plate:
16298	Nov. 2016		9