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April 16, 2018

JN 18131

Dave Scherf
5413 NE 197th Place
Lake Forest Park, WA 98155

Subject: **Geotechnical Engineering Study**
Proposed Residence
18426 Ballinger Way NE
Lake Forest Park, Washington

Dear Mr. Scherf: via email:

This report presents the findings and recommendations of our geotechnical engineering study for the proposed residence project to be constructed at 18426 Ballinger Way NE in Lake Forest Park. The undersigned associate visited the subject site on March 8, 2018. The purpose of this visit was to observe the existing site conditions, excavate test pits with a client-supplied backhoe, and to develop opinions regarding the soil, slope, infiltration, and the new residence that will be constructed on the site. The recommendations and conclusions presented in this report are professional opinions based on the visual observations made during our site visit and on previous experience with similar projects.

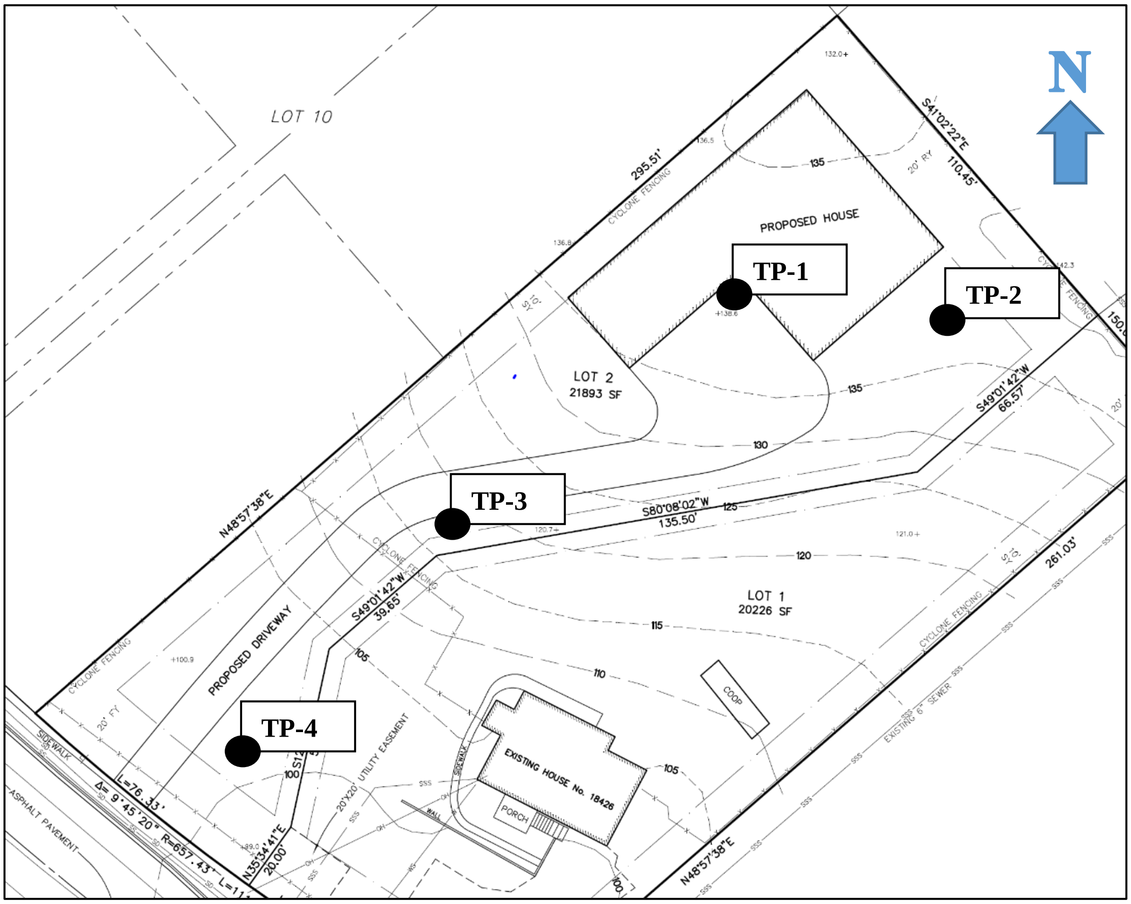
We were provided with preliminary site plans for the proposed addition, and we understand that the house will be constructed on the northern portion of the lot, at the top of the hill. A crawlspace or daylight basement are possibilities. A driveway will be constructed up the hill from Ballinger Way NE near the western property line.

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

The irregularly shaped subject site is shown in the site plan on the next page. The overall site is much larger that shown on the individual lot as the land continues to the south and east of the site. No evidence of slope instability was observed at the site. The subject property is currently developed with a single-family residence located on the southeastern portion of the site. The two-story house has a basement that daylights to the west. A gravel driveway comes in off of Ballinger Way NE from the southeast. The site slopes down from north to southwest. None of the slopes would be considered steep. Surrounding properties are residential and none of the structures are located near the common property lines. We understand that the site is not in a steep slope area.

Our understanding of the subsurface conditions at the site is based on the observations made during our recent site visit and on experience gained from other projects in the site vicinity. During our visit, we observed the excavation of four test pits with a small trackhoe at site. (as depicted below):



TP-1 (Forest Duff)
0-2.0 Red-brown, slightly silty SAND, fine- to medium-grained with occasional gravel, moist, loose [**SP/SM**]
2.0-8.0' Gray SAND, moist, medium-dense [**SP**]
Bottom at 8.0 feet. No Groundwater

TP-2 (Forest Duff)
0-2.0 Red-brown, slightly silty SAND, fine- to medium-grained with occasional gravel, moist, loose [**SP/SM**]
2.0-8.0' Gray SAND, moist, medium-dense [**SP**]
Bottom at 8.0 feet. No Groundwater

TP-3 (Forest Duff)
0-3.0 Red-brown, slightly silty SAND, fine- to medium-grained with occasional gravel, moist, loose [**SP/SM**]
3.0-8.0' Gray SAND, moist, medium-dense [**SP**]
Bottom at 8.0 feet. No Groundwater

TP-4 (Grass)
0-2.0 Brown silty sand with organics, moist, loose [**FILL**]
2.0-5.0' Tan silty sand, very moist, loose to medium-dense [**SM**]
- becomes dense, cemented (Glacial Till-Like) at 3 feet

Bottom at 5.0 feet. Perched Groundwater at 3 feet.

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 proposal.

The test holes were excavated on March 8, 2018 with a mini-track hoe provided by the client. A geotechnical engineer from our staff conducted the excavation process, logged the test holes, and obtained representative samples of the soil encountered.

Soil Conditions

Our test pits on the upland portion of the site found 2-3 feet of weathered, relatively loose slightly sitly sands overlying medium-dense sands. The test pit on the lower portion of the site found some fill soils overlying weathered glacial till and then dense glacial till. These soils are consistent with our experience with other sites in the area. Dense, cemented glacial till-like soils were encountered on the lowest portion of the site at 3 feet.

Obstructions were not revealed by our explorations; but debris, buried utilities, and old foundation and slab elements are commonly encountered on sites that have had previous development.

Groundwater Conditions

No groundwater was observed in our recent upland test holes, but perched groundwater was encountered on the lower portion of the lot along Ballinger Way NE. The test holes were left open for only a short time period. It should be noted that groundwater levels vary seasonally with rainfall and other factors. It is possible that groundwater could be found in more permeable soil layers and between the near-surface weathered soil and the underlying denser soil.

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. The relative densities and moisture descriptions indicated on the test hole logs are interpretive descriptions based on the conditions observed during excavation.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

Our explorations on the site found medium-dense, native sands underlying varying depths of loose fill and weathered soils. Conventional foundations should be excavated to bear on the medium-dense to dense native soils. The native soils are Type B soils, so cuts may be made at 1:1 (H:V). The upper weathered soils and the glacial till soils on-site are moisture-sensitive and should only be used in dry weather.

The sands on the upland portion of the site (above the 110’ contour) could support infiltration of the stormwater from the house. But, the site soils on the lower portion of the site (along Ballinger Way NE) consist of silty sands overlying dense, silty sands (glacial till) that are impermeable. There does not appear to be ample clearance between the bottom of any proposed drywells or trenches (typically a minimum of 3 feet below grade) and the potential impermeable layers (3 feet below ground surface) in the lower portion of the site. Based on our experience, placing a very shallow infiltration system in this area of the site is infeasible as it could cause system flooding due to the underlying impermeable glacial till soils. Therefore, dispersal of the concentrated stormwater on the lower portion of the site would be the preferred practical means of dealing with the stormwater on this area of the subject site.

The erosion control measures needed during the site development will depend heavily on the weather conditions that are encountered. While site clearing will expose a large area of bare soil, the erosion potential on the site is relatively low due to the gentle slope of the ground. We anticipate that a silt fence will be needed around the downslope sides of any cleared areas. Existing catch basins in, and immediately downslope of, the planned work areas should be protected with pre-manufactured silt socks. Cut slopes and soil stockpiles should be covered with plastic during wet weather.

We recommend that Geotech Consultants, Inc. be afforded the opportunity to review the development plans, to amend our recommendations as necessary, and 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 International Building Code (IBC), the site soil profile within 100 feet of the ground surface is best represented by Soil Profile Type D (Stiff Soil). As required by the SBC, the design criteria presented in this report consider the effects of a one-in-100-years seismic event for slope stability.

The site soils in the area of the proposed structures are not susceptible to seismic liquefaction because of their dense nature and/or the absence of shallow groundwater. This statement regarding liquefaction includes the knowledge of the determined peak ground acceleration noted above.

CONVENTIONAL FOUNDATIONS

The proposed structures can be supported on conventional continuous and spread footings bearing on undisturbed, medium-dense to dense native soil, or on structural fill placed above this competent native soil. See the section entitled ***General Earthwork and Structural Fill*** for recommendations regarding the placement and compaction of structural fill beneath structures. Adequate compaction of structural fill should be verified with frequent density testing during fill placement. Prior to placing structural fill beneath foundations, the excavation should be observed by the geotechnical engineer to document that adequate bearing soils have been exposed. We recommend that continuous and individual spread footings have minimum widths of 16 and 24 inches, respectively. Footings should also be bottomed at least 18 inches below the lowest adjacent finish ground surface. The local building codes should be reviewed to determine if different footing widths or embedment depths are required. Footing subgrades must be cleaned of loose or disturbed soil prior to pouring concrete. Depending upon site and equipment constraints, this may require removing the disturbed soil by hand.

An allowable bearing pressure of 2,000 pounds per square foot (psf) is appropriate for footings supported on competent native soil. A one-third increase in this design bearing pressure may be used when considering short-term wind or seismic loads. For the above design criteria, it is anticipated that the total post-construction settlement of footings founded on competent native soil will be less than one inch.

Lateral loads due to wind or seismic forces may be resisted by friction between the foundation and the bearing soil, or by passive earth pressure acting on the vertical, embedded portions of the foundation. For the latter condition, the foundation must be either poured directly against relatively level, undisturbed soil or be surrounded by level structural fill. We recommend using the following ultimate values for the foundation's resistance to lateral loading:

Parameter	Ultimate Value
Coefficient of Friction	0.45
Passive Earth Pressure	350 pcf

Where: (i) pcf is pounds per cubic foot, and (ii) passive earth pressure is computed using the equivalent fluid density.

If the ground in front of a foundation is loose or sloping, the passive earth pressure given above will not be appropriate. We recommend maintaining a safety factor of at least 1.5 for the foundation's resistance to lateral loading, when using the above ultimate values.

PERMANENT 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 *	30 pcf
Passive Earth Pressure	350 pcf
Coefficient of Friction	0.45
Soil Unit Weight	125 pcf

Where: (i) pcf is pounds per cubic foot, and (ii) 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 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. The passive pressure given is appropriate for the depth of level structural fill placed in front of a retaining or foundation wall only. The values for friction and passive resistance are ultimate values and do not include a safety factor. We recommend a safety factor of at least 1.5 for overturning and sliding, when using the above values to design the walls. 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.

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.

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 7**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 onsite weathered soils are silty and poorly drained, so should not be used as backfill directly against retaining walls. Free-draining sandy soil should be used for retaining wall backfill and a drainage composite similar to Miradrain 6000 should be placed against the backfilled retaining walls. The drainage composites should be hydraulically connected to the foundation drain system. Free-draining backfill or gravel should be used for the entire width of the backfill where seepage is encountered. For increased protection, drainage composites should be placed along cut slope faces, and the walls should be backfilled entirely with free-draining soil. 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. 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.

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 a specialty 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 existing non-organic soils, 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.

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. All interior slabs-on-grade must be underlain by a capillary break or drainage layer consisting of a minimum 4-inch thickness of 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. 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, are typically used. A vapor retarder is defined as a material with a permeance of less than 0.3 US perms per square foot (psf) per hour, 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 plastic sheeting is used under slabs, joints 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 0.00 perms per square foot per hour 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, should be placed over the vapor retarder or barrier for protection of the retarder or barrier 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 cure 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. Our opinion is that with impervious surfaces that all means should be undertaken to reduce water vapor transmission.

EXCAVATIONS AND SLOPES

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 unsaturated, dense native soil at the subject site would generally be classified as Type B. Therefore, temporary cut slopes greater than 4 feet in height cannot 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 water be directed away from temporary slope cuts. The cut slopes should also be backfilled or retained as soon as possible to reduce the potential for instability. Please note that sand and/or 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.

All permanent cuts into native soil should be inclined no steeper than 2:1 (H:V). 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.

DRAINAGE CONSIDERATIONS

We recommend that foundation drains be used at the base of all foundation and earth-retaining walls. These drains should be surrounded by at least 6 inches of 1-inch-minus, washed rock and then wrapped in 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, and it should be sloped for drainage. All roof and surface water drains must be kept separate from the foundation drain system. For the best long-term performance, perforated PVC pipe is recommended for all subsurface drains. The City of Seattle typically requires that Schedule 40 PVC pipe be used beneath structures.

No groundwater was observed in the upland portion of the site during our field work. If seepage is encountered in an excavation, it should be drained from the site by directing it through drainage ditches, perforated pipe, or French drains, or by pumping it from sumps interconnected by shallow connector trenches at the bottom of the excavation.

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 buildings 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.

GENERAL EARTHWORK AND STRUCTURAL FILL

All building and pavement areas should be stripped of surface vegetation, topsoil, organic soil, and other deleterious material. It is important that existing foundations be removed before site development. 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.

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%**

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).

The **General** section should be reviewed for considerations related to the reuse of on-site soils. 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.

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.

LIMITATIONS

The analyses, conclusions, and recommendations contained in this report are based on site conditions, as they existed at the time of our site visit. If the subsurface conditions encountered during construction are significantly different from those anticipated, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. Unanticipated soil conditions are commonly encountered on construction sites. Such unexpected conditions frequently require making additional expenditures to attain a properly constructed project.

This report has been prepared for the exclusive use of the Dave Scherf, and his representatives for specific application to this project and site. Our recommendations and conclusions are based on the site materials observed and on previous experience with sites that have similar observed conditions. The conclusions and recommendations are professional opinions derived in accordance with current standards of practice within the limited scope of our services. No warranty is expressed or implied.

We trust that this report meets your immediate needs for the proposed development. Please contact us if we can be of further service.

Respectfully submitted,

GEOTECH CONSULTANTS, INC.

4/16/18

James H. Strange, Jr., P.E.
Associate

JHS: jhs