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Job No. 17-0765

Columbia Development
13110 NE 177th Place, Suite 202
Woodinville, Washington, 98072

Attn: Mr. Hegger

Re: Monroe Townhomes
Blueberry Lane and Kelsey Street
Monroe, WA 98272

Dear Mr. Hegger

As requested, GeoTest Services, Inc. is pleased to submit this report summarizing the results of our geotechnical engineering evaluation for the proposed Monroe Townhomes project located at the above referenced address. The purpose of this evaluation was to establish general subsurface conditions beneath the proposed development for use in project design. Specifically our scope of services included the following tasks:

- Exploration of soil and groundwater conditions underlying the site by excavating 10 test pits to evaluate subsurface soil conditions.
- Provide this written report containing a description of the general geologic conditions, subsurface soils and groundwater conditions. Also presented in this report are our findings and recommendations pertaining to site preparation and earthwork, fill and compaction, wet weather construction and seismic design considerations. Included in these recommendations are foundation support and settlement, surcharge program, slab-on-grade construction, foundation and site drainage, utilities, stormwater infiltration, LID, and geotechnical consultation and construction monitoring recommendations.

PROJECT DESCRIPTION

We understand that a new multi-family residential development is planned for the property referenced above. The property does not currently have a formal address, but is located at the northwest corner of Blueberry Lane and Kelsey Street. A formal development plan has not been finalized at the time of this report. Conversations with Mr. Hegger indicate that the planned construction will consist of several multi-story buildings containing approximately 32 units in total. We anticipate the use of frame construction, shallow conventional footings, and slab-on-grade floors. Structural loads are expected to be relatively light

SITE CONDITIONS

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

Surface Conditions

The site is currently vacant and vegetated with blackberry bushes and shrubs except within the northwest portion of the property where it is surfaced with gravel. A walking path running east and west crosses the property. The property is relatively level with very little elevation change across the site. The flat topography suggests historic grading activities on the property. Notably, properties to the north and south have been developed. At the time of our visits, surface water was observed ponding in the vicinity of test pits TP-5, TP-6, TP-7, and TP-9 (See figure 2).

Subsurface Soil Conditions

Subsurface soil conditions were explored by excavating ten test pits throughout the site on 12-6-17. The exploratory test pits (TP-1 through TP-10) were advanced with a tracked excavator to depths of 6 to 11 feet below ground surface (BGS). Test pits were advanced to refusal (dense soil) or to the limits of the provided equipment. Grab soil samples were obtained from the side wall of the test pit excavation. All explorations were continuously observed by a staff geologist from our firm. See the attached Site and Exploration Map (Figure 2) for the approximate locations of our Test Pit explorations.

The on-site subsurface soils generally consisted of approximately of 0.25 to 1 feet of topsoil over variable fill soils over native sand and gravel Alluvium. These fill soils extended to depths of 4 feet to greater than 11 feet BGS across the site, with medium dense to dense sandy gravel (Alluvium – Stream Channel Deposits) below and to the base of all explorations except for test pits TP-3, TP-5, TP-6, and TP-9. In TP-3, TP-5, and TP-9 uncontrolled fill soils were encountered to the limits of exploration. The uncontrolled fill soils appeared to be generally thickest to the east and thinnest within the central portion of the property. The southeast corner of the site encountered a greater thickness of uncontrolled fill before exposing native sandy, gravel, but this appears to be limited to a relatively small area.

Historical Site Development

Based on a review of Snohomish county historical aerial imagery, the majority of the project site and the site bordering to the west appear to have been used as a gravel pit. GeoTest's review of historical images show gravel mine operations as recently as 2001. The presence of existing fill soils on the project site, in conjunction with the halting of mining operations, suggest that the site was reclaimed in general accordance with a Department of Ecology/Department of Natural Resources reclamation plan. GeoTest is not aware of the source of the fill on the project site, nor is GeoTest aware of its means and methods of placement. Thus, GeoTest is treating the fill as an "uncontrolled" fill source.

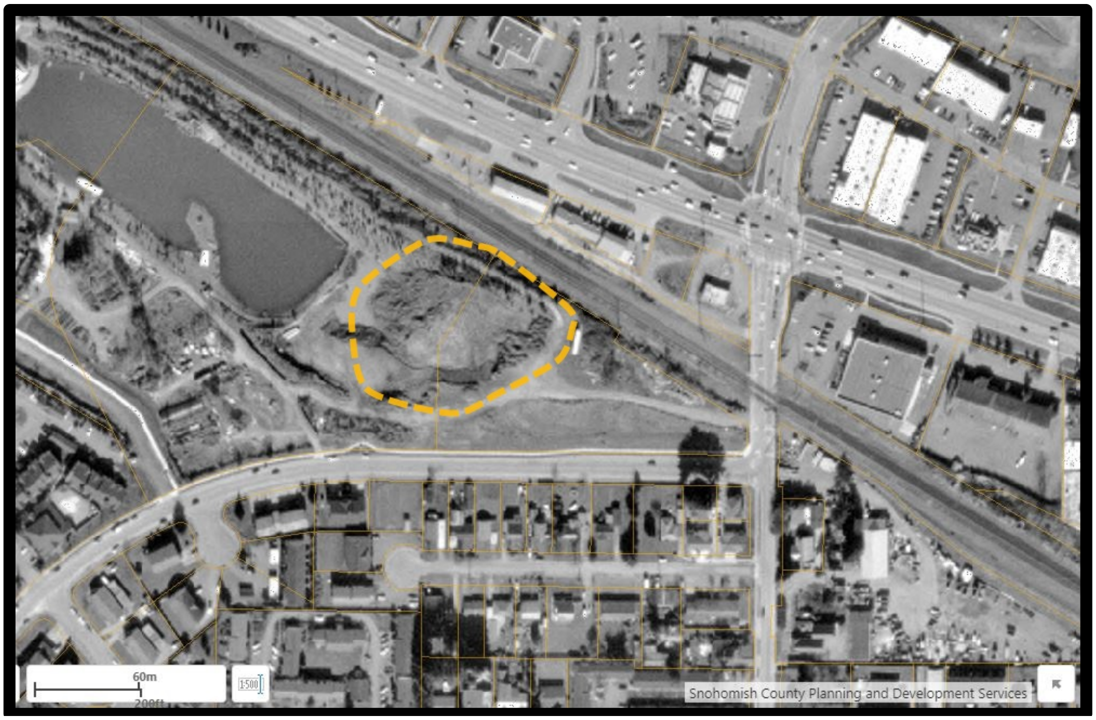


Photo 1: 2001 aerial imagery of proposed residence site. Note topographic depression in northwest corner of parcel (Yellow Dashed Line).

Photo 2: 2002-2003 aerial imagery of proposed residence site. Note disappearance of topographic depression in northwest corner of parcel (Yellow Dashed Line).

Based on our subsurface explorations and review of aerial photography, the northwest portion of the project site appears to have been subject to significant historic grading operations. The large pond to the northwest (off-site) appears to have been part of a gravel mining operation.

General Geologic Conditions

Geologic information for the project site was obtained from the interactive *Geologic Map of Washington State*, published by the Washington State Department of Natural Resources (DNR). According to the DNR map, subsurface soils in the vicinity of the project consist of Quaternary Alluvium Deposits (Q_a).

Soils defined as Alluvium typically consists irregularly layered sands and gravels deposited in river and stream channels, with silts, clays, and peats deposited in the surrounding floodplain.

Native soils consistent with the river and stream channel alluvial deposits (sands and gravels) were encountered during the subsurface exploration program.

Groundwater Seepage and Seasonal Groundwater

For the purposes of this report, observed groundwater seepage represents either the existing surface of a groundwater table or the surface of perched seepage. The groundwater table is referred to as the atmospheric pressure surface that coincides with the top of the zone of saturation and is the surface that dictates the development design recommendations in this report. Perched seepage is referred to as a saturated zone that develops where a restrictive surface (i.e. dense, fine grained soils or bedrock) limits the vertical, downward migration of near-surface water. The groundwater table or perched seepage surface should be considered when determining methods of earthwork construction but is not used to dictate development design.

Groundwater Observations

At the time of our visit on December 6, 2017, a rapid groundwater seep was encountered at approximately 4' BGS within test pit TP-5. Although ponded surface water was observed in the northwest portion of the parcel, this is like due to the high silt content, and relative density of the surficial fill soils in that area, and not a regional groundwater condition. A review of publicly available well data for the city of Monroe indicates that wet-season groundwater elevations near the project vicinity are approximately 10-15 feet below the ground surface.

Seasonal Groundwater Fluctuation Observations

A distinct mottled horizon or "rust line," was not encountered within the test pit explorations. Mottling (reddish-brown, orange, or yellow splotches or mottles) is typically indicative of soils that experience fluctuating moisture conditions, generally due to seasonal wetting and drying.

Considerations

The groundwater conditions reported on the test pit logs are for the specific locations and dates indicated, and therefore may not necessarily be indicative of other locations and/or times. Please consider that groundwater table levels are generally higher (at shallower depths) during the wetter months (October through May).

It is the client's and their (his/her) representative's responsibility to inform GTS of variations in groundwater conditions and/or any modifications to project designs so that a review of and revision to report recommendations can be made, if necessary. Unless specifically requested, GTS is not responsible to provide monitoring of groundwater conditions beyond the time of our site investigations. Please keep in mind that groundwater conditions may be different if there is a substantial lapse of time between submission of this report and the start of construction. If this is the situation, GTS recommends we be contacted to evaluate groundwater conditions in order to determine whether our report conclusions and recommendations remain applicable.

CONCLUSIONS AND RECOMMENDATIONS

Existing fill soils were encountered in all explorations on site. These soils were found to be moisture sensitive, ranged from soft/loose to very dense/hard, and contained organic material and construction debris. Our subsurface explorations suggest that existing fill soils are between 4 feet thick within the central and southern portion of the property, and greater than 11 feet thick within the northwestern portion. The eastern quadrant of the property was found to contain approximately 10 feet of this existing fill soil. The fill thicknesses have the potential to impact construction costs, especially in the northwestern portion of the site.

Due to the variable and uncontrolled nature of the existing fill soils on site, there is significant risk of differential settlement across foundation elements if these elements were to be placed on existing fill soils. Thus, it is our opinion that the in-place fill soils are not suitable for shallow conventional foundation support, or for reuse as structural fill for shallow conventional foundation support. If shallow conventional foundations are planned, existing fill must be completely removed below these foundations. Alternatively, a deep foundation system extending through existing fill soils could be considered.

Underlying the fill soils were medium dense to dense, undisturbed Alluvium that is considered suitable for the support of shallow conventional foundations. Alternatively, structural fill or Controlled Density Fill placed on medium dense to dense Alluvium is considered to be suitable for the support of new foundations.

GeoTest understands that it may not be feasible or cost-effective to remove existing fill soils from below pavement sections on this project. The Owner may elect to leave the existing fill in place, with the understanding that parking lot areas and/or drive paths will have an increased risk of post-construction settlements or above-average maintenance costs. GTS has presented recommendations with respect to leaving existing fill soils in place elsewhere in this report.

The stormwater infiltration potential of the Alluvium on site is generally favorable. However, these soils are overlain by very silty fill soils that would not be suitable for infiltration under the Snohomish County Stormwater Manual. GTS anticipates that any infiltration must bypass existing fill soils at depth and utilize native soil if it is to meet the intent of the County's Stormwater Manual. GTS is not aware of any specific infiltration plan or concept at the time of this report and it is expected that additional evaluations and/or considerations will be needed to develop stormwater concepts. Shallow groundwater was not, however, observed in the majority of the explorations, so groundwater mounding does not appear to be a concern at this time.

Site Preparation and Earthwork

The portions of the site to be occupied by proposed foundations and floor slabs should be prepared by removing any existing topsoil, existing fill, debris, deleterious material and/or significant accumulations of organics from the area to be developed. Prior to placement of foundation elements or structural fill, the exposed native subgrade should observed by the engineer. The purpose of this effort is to identify possible loose or soft soil deposits, where applicable, and then remedially compact soft soil or soil disturbed during site excavation activities.

Prior to the placement of structural fill, the exposed subgrade under all areas should be recompacted to a dense and unyielding condition and proof rolled with a loaded dump truck, large self-propelled vibrating roller, or equivalent piece of equipment applicable to the size of the excavation. The purpose of this effort is to identify possible loose or soft soil deposits and recompact the soil exposed during site excavation activities.

Where applicable, exposed subgrades should be proof rolled to confirm firm and unyielding conditions. Areas exhibiting significant deflection, pumping, or are observed to have elevated moisture contents that prevent the soil from being adequately compacted should be over-excavated to firm soil. Over-excavated areas should be backfilled with structural fill as recommended elsewhere in this report. During periods of wet weather, proof rolling could damage the exposed subgrade. Under these conditions, qualified geotechnical personnel should observe subgrade conditions to determine if proof rolling is feasible.

Fill and Compaction

In general, non-organic, predominantly granular soil may be used as structural fill provided the material is properly moisture conditioned prior to placement and compacted to at least 95 percent of the maximum dry density, as determined using test method ASTM D1557. Material containing topsoil, wood, trash, organic material, or other debris is not recommended for reuse as structural fill and should be properly disposed offsite or placed in nonstructural areas.

Soils containing more than approximately 5 percent fines are considered moisture sensitive. These soils are very difficult to compact to a firm and unyielding condition when over the optimum moisture content by more than approximately 2 percent. The optimum moisture content is that which allows the greatest dry density to be achieved at a given level of compactive effort.

Reuse of Onsite Soil

It is our opinion that existing fill soils encountered across the majority of the site should not be used as structural fill due to their variability, fines content, and the presence of trash, debris, and elevated organic contents. Complete removal of these materials from foundation areas or using the existing fill in non-structural applications should be expected.

As with any uncontrolled fill, it is possible that the fill contains contaminants that were not identified during our explorations. It should be noted, however, that our field screening methods did not indicate soil contamination at the time of our investigation. In a similar fashion, concentrations of organic debris may exist in greater quantities that what was observed during our site visit. The Owner should be aware that the potential for encountering contaminated soils during construction exists and should be prepared for this contingency.

Native soils were generally not encountered in the upper portions of our subsurface soil explorations. It is generally assumed that native soil is overlain by existing fill and will not be available to be reused in structural fill applications.

Imported Granular Structural Fill

We recommend that imported granular structural fill consist of clean, well-graded sandy gravel, gravelly sand, or other approved naturally occurring granular material (pit run) with at least 30 percent retained on the No. 4 sieve, or a well-graded crushed rock. Structural fill for dry weather construction may contain on the order of 10 percent fines (that portion passing the U.S. No. 200 sieve) based on the portion passing the U.S. No. 4 sieve. Soil containing more than about 5 percent fines cannot consistently be compacted to a dense, non-yielding condition when the water content is greater than optimum. Accordingly, we recommend that imported structural fill with less than 5 percent fines be used during wet weather conditions.

Due to wet weather or wet site conditions, soil moisture contents could be high enough that it may be very difficult to compact even “clean” imported select granular fill to a firm and unyielding condition. Soils with over-optimum moisture contents should be either scarified and dried back to more suitable moisture contents during periods of dry weather or removed and replaced with fill soils at a more suitable range of moisture contents.

Backfill and Compaction

Structural fill should be placed in horizontal lifts 8 to 10 inches in loose thickness and thoroughly compacted. All structural fill placed under load bearing areas should be compacted to at least 95 percent of the maximum dry density, as determined using test method ASTM D1557. The top of the compacted structural fill should extend outside all foundations and other structural improvements a minimum distance equal to the thickness of the fill. We recommend that compaction be tested periodically throughout the fill placement.

Wet Weather Earthwork

It is generally assumed that it will be difficult to control the moisture content of the site soils during the wet season. Contractors must be aware of the limitations of the near-surface soils on this property and have contingencies for addressing over-optimum moisture content soils. If construction is accomplished during wet weather, we recommend that structural fill consist of imported, clean, well-graded sand or sand and gravel as described above. If fill is to be placed or earthwork is to be performed in wet weather or under wet conditions, the contractor may reduce, but not eliminate, soil disturbance by:

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

Seismic Design Considerations

The Pacific Northwest is seismically active and the site could be subject to ground shaking from a moderate to major earthquake. Consequently, moderate levels of earthquake shaking should be anticipated during the design life of the project, and the proposed structure should be designed to resist earthquake loading using appropriate design methodology.

For structures designed using the seismic design provisions of the 2015 International Building Code, the native soil interpreted to underlie the site within the upper 100 feet classifies as Site Class D, according to 2010 ASCE -7 Standard – Table 20.3-1, Site Class Definitions. The corresponding values for calculating a design response spectrum for the assumed soil profile type is considered appropriate for the site.

Please reference the following values for seismic structural design purposes:

Conterminous 48 States – 2015 International Building Code
Zip Code 98272
Central Latitude = 47.860056, Central Longitude = -121.978654

<u>Short Period (0.2 sec) Spectral Acceleration</u>
Maximum Considered Earthquake (MCE) Value of $S_s = 1.201$(g)
Site Response Coefficient, $F_a = 1.019$ (Site Class D)
Adjusted spectral response acceleration for Site Class D, $S_{MS} = S_s \times F_a = 1.225$ (g)
Design spectral response acceleration for Site Class D, $S_{DS} = 2/3 \times SM_s = 0.702$ (g)

<u>One Second Period (1 sec) Spectral Acceleration</u>

Maximum Considered Earthquake (MCE) Value of $S_1 = 0.454$ (g)
Site Response Coefficient, $F_v = 1.546$ (Site Class D)
Adjusted spectral response acceleration for Site Class D, $S_{M1} = S_1 \times F_v = 0.702$ (g)
Design spectral response acceleration for Site Class D, $S_{D1} = 2/3 \times SM_1 = 0.457$ (g)

Foundation Support System

Foundation support for the proposed buildings may be provided by continuous or isolated spread footings founded on undisturbed or recompacted Alluvium (sandy gravel) Alternatively, structural fill or controlled density fill may be placed over undisturbed or suitably recompacted Alluvium (sandy gravel). To provide proper support for the foundations, we recommend that all existing topsoil, fill, or loose native soil be removed from beneath the building foundation area(s). Our subsurface explorations suggest that existing fill soils are between 4 feet and greater than 11 feet thick. Thus, significant effort should be expected to expose suitable native soil if conventional spread foundations are utilized. All foundations should be buried a minimum of 18 inches below the lowest adjacent final grade for freeze/thaw protection. The footings should be sized in accordance with the structural engineer's prescribed design criteria and seismic considerations.

<u>Conventional Shallow Footings on Native Alluvium</u>

As a construction mitigation to limit the amount of differential settlement across a singular building pad, GTS typically recommends that foundations bear entirely on similar soil conditions. We anticipate that placing individual building foundations entirely on the same soil condition will be challenging on this property due to the varying depth to Alluvium. However, we anticipate that differential settlement across a singular building will be minimal when foundations are placed entirely on medium dense to dense Alluvium, or a combination of Alluvium and structural fill. We recommend that qualified geotechnical personnel verify that suitable bearing conditions have been reached prior to the placement of foundation formwork.

Conventional Shallow Footings on Structural Fill or Controlled Density Fill

In areas where overexcavation of unsuitable materials extends to competent native soil, the limits of the overexcavation and replacement with structural fill should extend laterally beyond the edge of each side of the footing a distance equal to the depth of the excavation. Alternatively, localized overexcavation of site soils could be backfilled to the design footing elevation with Controlled Density Fill (CDF) provided that the CDF bears directly on medium dense to dense Alluvium. If CDF is used to backfill the soil over-excavation, the limits of the over-excavation need only extend about 1 foot beyond either side of the footing.

Alternative Foundation Support Options

The options presented above are generally only applicable to mitigation of differential settlements in the case of relatively shallow fills. If the design calls for the support of foundation elements over deeper fills, such as those encountered within the northwest portion of the property, alternative methods to mitigate differential settlement should be considered. These options are likely to include some form of pile system to transfer vertical loads through the existing fill to competent native soil or the use of a rammed aggregate pier system to densify and improve existing fill soils. At the time of this report, GTS is not considering these options due to the preliminary nature of the project. GeoTest can assist with the design and selection of an alternative foundation support option if it becomes necessary to do so.

Allowable Bearing Capacity

Assuming the above foundation support criteria are satisfied, continuous or isolated spread footings founded directly on the medium dense to dense Alluvium may be proportioned using a maximum net allowable soil bearing pressure of 2,000 pounds per square foot (psf). For foundations that are placed on structural fill or CDF overlying medium dense to dense Alluvium, they may also be proportioned using a maximum net allowable soil bearing pressure of 2,000 psf.

The term "net allowable bearing pressure" refers to the pressure that can be imposed on the soil at foundation level resulting from the total of all dead plus live loads, exclusive of the weight of the footing or any backfill placed above the footing. The net allowable bearing pressure may be increased by one-third for transient wind or seismic loads.

Foundation Settlement

Settlement of shallow foundations depends on foundation size and bearing pressure, as well as the strength and compressibility characteristics of the underlying soil. Assuming construction is accomplished as previously recommended and for the maximum allowable soil bearing pressure recommended above, we estimate the total settlement of building foundations should be less than 1 inch and differential settlement between two adjacent load-bearing components supported on competent soil should be less than one half the total settlement. The soil/rock response to applied stresses caused by building and other loads is expected to be predominantly elastic in nature, with most of the settlement occurring during construction as loads are applied.

Floor Support

Floors for the proposed construction may consist of either concrete slab-on-grade floors placed over native soil or structural fill over native soil. GTS does not recommend placing slab-on-grade floors over existing fill soils due to the elevated risks for long-term slab cracking and/or post-construction settlement. It should be understood that the more fill that remains in place, the greater the risk that settlement under the slab could occur over time. Alternatively, a grade beam-supported floor may be considered.

Recommendations for each system are presented below.

Concrete Slabs-on-Grade

Conventional slab-on-grade floor construction is considered feasible for the planned site improvements if the floor slab is placed on firm and unyielding native soil, or structural fill placed over native soil. A modulus of subgrade reaction of 200 pounds per cubic inch (pci) should be appropriate for use in design of floor slabs constructed with these recommendations. Prior to placement of structural fill, the native soil should be proof-rolled as recommended in the *Site Preparation and Earthwork* section of this report.

We recommend that interior concrete slab-on-grade floors be underlain by a minimum of 6 inches of compacted, clean, free-draining gravel with less than 3 percent passing the U.S. Standard No. 200 sieve (based on a wet sieve analysis of that portion passing the U.S. Standard No. 4 sieve). We typically recommend a 5/8" clear crushed rock (no fines) or similar product. The purpose of this layer is to provide uniform support for the slab, provide a capillary break, and act as a drainage layer. To help reduce the potential for water vapor migration through floor slabs, at a minimum a continuous impermeable membrane of 10-mil polyethylene sheeting with tape-sealed joints should be installed below the slab. The American Concrete Institute (ACI) guidelines suggest that the slab may either be poured directly on the vapor retarding membrane or on a granular curing layer placed over the vapor retarding membrane depending on conditions anticipated during construction. We recommend that the architect or structural engineer specify if a curing layer should be used. If construction is planned during the wet season or if the slab-on-grade will be exposed to rain, we do not recommend the use of a curing layer over the vapor retarding membrane. If moisture control within the building is critical, we recommend an inspection of the vapor retarding membrane to verify that all openings have been properly sealed. Also, upgrading to a true vapor barrier membrane product is usually recommended.

Grade Beam Support

Grade beam-supported floors may be a desirable option for floor support. With this option, floors may be structurally supported by grade beams placed upon foundation elements that extend down to firm native soil, or on structural fill/CDF extending to competent native materials. With this approach, floor support problems, including excessive settlement resulting from uneven ground surfaces, loose soil below the floor, or wet subgrades are reduced. The soil below the floor system, however, should be covered with an impervious moisture barrier to reduce dampness as indicated in the Concrete Slabs-on-Grade section of this report.

Foundation and Site Drainage

To reduce the potential for perched groundwater and surface water to seep into interior spaces we recommend that an exterior footing drain system be constructed around the perimeter of new building foundations as shown in the Typical Footing and Wall Drain Section, Figure 3. The drain should consist of a minimum 4-inch diameter perforated PVC pipe, surrounded by a minimum 12 inches of filtering media with the discharge sloped to carry water to a suitable collection system. The filtering media may consist of open-graded drain rock wrapped by a nonwoven geotextile fabric (such as Mirafi 140N or equivalent) or a graded sand and gravel filter. The drainage backfill should be carried up the back of wall and contain less than 3 percent by weight passing the U.S. Standard No. 200 sieve (based on a wet sieve analysis of that portion passing the U.S. Standard No. 4 sieve). The invert of the footing drain pipe should be placed slightly below the elevation of the bottom of the footing or 12 inches below the adjacent floor slab grade, whichever is deeper, so that water will not seep through walls or floor slabs. The footing drain should discharge to an approved drain system and include cleanouts to allow periodic maintenance and inspection.

Positive surface gradients should be provided adjacent to the proposed building to direct surface water away from the foundation and toward suitable drainage facilities. Roof drainage should not be introduced into the perimeter footing drains, but should be separately discharged directly to the stormwater collection system or other appropriate outlet. Pavement and sidewalk areas should be sloped and drainage gradients should be maintained to carry all surface water away from the building towards the local stormwater collection system. Surface water should not be allowed to pond and soak into the ground surface near buildings or paved areas during or after construction. Construction excavations should be sloped to drain to sumps where water from seepage, rainfall, and runoff can be collected and pumped to a suitable discharge facility.

Resistance to Lateral Loads

The lateral earth pressures that develop against retaining walls will depend on the method of backfill placement, degree of compaction, slope of backfill, type of backfill material, provisions for drainage, magnitude and location of any adjacent surcharge loads, and the degree to which the wall can yield laterally during or after placement of backfill. If the wall is allowed to rotate or yield so the top of the wall moves an amount equal to or greater than about 0.001 to 0.002 times its height (a yielding wall), the soil pressure exerted will be the active soil pressure. When a wall is restrained against lateral movement or tilting (a nonyielding wall), the soil pressure exerted is the at-rest soil pressure. Wall restraint may develop if a rigid structural network is constructed prior to backfilling or if the wall is inherently stiff.

We recommend that yielding walls under drained conditions be designed for an equivalent fluid density of 35 pounds per cubic ft (pcf) for structural fill (import pit run) in active soil conditions. Nonyielding walls under drained conditions should be designed for an equivalent fluid density of 55 pcf for structural fill in at-rest conditions. The design of walls should include appropriate lateral pressures caused by surcharge loads located within a horizontal distance equal to or less than the height of the wall. For uniform surcharge pressures, a uniformly distributed lateral pressure equal to 35 percent and 50 percent of the vertical surcharge pressure should be added to the lateral soil pressures for yielding and nonyielding walls, respectively. GTS also recommends that a seismic surcharge pressure of 12H be included where H is the wall height in feet. The seismic surcharge should be modeled as a rectangular distribution with the resultant applied at the midpoint of the wall.

Passive earth pressures developed against the sides of building foundations, in conjunction with friction developed between the base of the footings and the supporting subgrade, will resist lateral loads transmitted from the structure to its foundation. For design purposes, the passive resistance of well-compacted fill placed against the sides of foundations may be considered equivalent to a fluid with a density of 250 pounds per cubic feet. The recommended value includes a safety factor of about 1.5 and is based on the assumption that the ground surface adjacent to the structure is level in the direction of movement for a distance equal to or greater than twice the embedment depth. The recommended value also assumes drained conditions that will prevent the buildup of hydrostatic pressure in the compacted fill. Retaining walls should include a drain system constructed in general accordance with the recommendations presented in the *Foundation and Site Drainage* section of this report. In design computations, the upper 12 inches of passive resistance should be neglected if the soil is not covered by floor slabs or pavement. If future plans call for the removal of the soil providing resistance, the passive resistance should not be considered.

An allowable coefficient of base friction of 0.35, applied to vertical dead loads only, may be used for the Alluvium or imported granular structural fill and the base of the footing. If passive and frictional resistance are considered together, one half the recommended passive soil resistance value should be used since larger strains are required to mobilize the passive soil resistance as compared to frictional resistance. We do not recommend increasing the coefficient of friction to resist seismic or wind loads.

Temporary and Permanent Slopes

Actual construction slope configurations and maintenance of safe working conditions, including temporary excavation stability, should be the responsibility of the contractor, who is able to monitor the construction activities and has direct control over the means and methods of construction. All applicable local, state, and federal safety codes should be followed. All open cuts should be monitored during and after excavation for any evidence of instability. If instability is detected, the contractor should flatten the side slopes or install temporary shoring.

Temporary excavations in excess of 4 ft should be shored or sloped in accordance with Safety Standards for Construction Work Part N, WAC 296-155-66403

Temporary unsupported excavations in the existing fill soils encountered at the project site are classified as a Type C soil according to WAC 296-155-66403 and may be sloped as steep as 1.5H:1V (34º) (Horizontal: Vertical). Temporary unsupported excavations in the native soils encountered at the project site are classified as a Type C soil according to WAC 296-155-66403 and also may be sloped as steep as 1.5H:1V (34º) (Horizontal: Vertical). All soils encountered are classified as Type C soil in the presence of groundwater seepage. Flatter slopes or temporary shoring may be required in areas where groundwater flow is present and unstable conditions develop.

Temporary slopes and excavations should be protected as soon as possible using appropriate methods to prevent erosion from occurring during periods of wet weather.

We recommend that permanent cut or fill slopes be designed for inclinations of 2H:1V or flatter. Permanent cut or fill slopes that are part of detention ponds, retention ponds, infiltration facilities, or other earth structures intended to receive stormwater should be designed for inclinations of 3H:1V or flatter. All permanent cut slopes should be vegetated or otherwise protected to limit the potential for erosion as soon as practical after construction. Permanent slopes requiring immediate protection from the effects of erosion should be covered with either mulch or erosion control netting/blankets. Areas requiring permanent stabilization should be seeded with an approved grass seed mixture, or hydroseeded with an approved seed-mulch-fertilizer mixture.

Utilities

It is important that utility trenches be properly backfilled and compacted to reduce the risk of cracking or localized loss of foundation, slab, or pavement support. It is anticipated that excavations for new underground utilities will be in variable fill soils, but deeper excavations could encounter Alluvium and/or groundwater at depth. GTS anticipates that excavations in existing fill can be accomplished with conventional excavation equipment, however the contractor should be prepared to address the presence of construction debris within the excavation.

Trench backfill in improved areas (beneath structures, pavements, sidewalks, etc.) should consist of structural fill as defined earlier in this report. GTS does not recommend the reuse of existing fill soils as structural fill. As such, the use of imported, granular soil should be anticipated for backfill in improved areas. Outside of improved areas and where allowed for in the plans and specifications prepared for this project, non-structural backfill may consist of onsite soil. Trench backfill should be placed and compacted in accordance with the report section *Fill and Compaction*.

Surcharge loads on trench support systems due to construction equipment, stockpiled material, and vehicle traffic should be included in the design of any anticipated shoring system. The contractor should implement measures to prevent surface water runoff from entering trenches and excavations. In addition, vibration as a result of construction activities and traffic may cause caving of the trench walls.

Actual trench configurations should be the responsibility of the contractor. All applicable local, state, and federal safety codes should be followed. All open cuts should be monitored by the contractor during excavation for any evidence of instability. If instability is detected, the contractor should flatten the side slopes or install temporary shoring. If groundwater or groundwater seepage is present, and the trench is not properly dewatered, the soil within the trench zone may be prone to caving, channeling, and running. Trench widths may be substantially wider than under dewatered conditions.

Pavement Subgrade Preparation

Selection of a pavement section is typically a compromise between higher initial cost and lower long term maintenance costs or lower initial cost with more frequent maintenance. For this reason, we recommend that the owner participate in the selection of proposed pavement improvements planned for the site. Site grading plans should include provisions for sloping of the subgrade soils in proposed pavement areas, so that passive drainage of the pavement section(s) can proceed uninterrupted during the life of the project.

At the time of this report, GTS does not have a formal development plan that addresses the presence of the uncontrolled fill on the project site. It is generally assumed that the costs to remove the entirety of the fill from below pavement sections would be prohibitive. As such, GTS is assuming that the Owner will elect to either leave the existing fill in place and accept the likelihood of a shorter design life, or perform limited amounts of overexcavation and replacement with a geotextile product and structural fill underlying pavement subgrades to extend the life of the pavement. In all cases, GTS anticipates that the subgrade will be prepared through remedially compacting near-surface soils to a firm and unyielding condition prior to proof rolling the subgrades in general accordance with the *Site Preparation and Earthwork* section of this report.

Stormwater Design Recommendations/Infiltration Potential

Test Pit Gradation Results

From the explorations excavated in the areas of interest, 4 representative soil samples were selected and mechanically tested for grain size distribution and calculation according to the 2016 Snohomish County Drainage Manual soil grain size analysis method (Section 3.3.6). A summary of these results are reproduced in Table 1 below.

Table 1
Preliminary Infiltration Results Based on Grain Size Analysis

Test Pit Exploration Number and Depth	Geologic Description	Uncorrected K_{sat} Infiltration Rate [in/hr]	Corrected K_{sat} Infiltration Rate [in/hr]
TP-1 (5.0 ft)	Alluvium	68.12	14.71
TP-6 (6.0 ft)	Silty Fill	3.72	0.80
TP-7 (9.0 ft)	Alluvium	85.18	18.40
TP-8 (6.0 ft)	Alluvium	116.36	25.13

In the simplified approach (Section 3.3.4) the infiltration rate is derived by applying appropriate correction factors to the measured saturated hydraulic conductivity (K_{sat}) from the ASTM 422 grain size analysis.

Saturated hydraulic conductivity is a quantitative measure of a saturated soil's ability to transmit water when subjected to a hydraulic gradient. It can be thought of as the ease with which pores of a saturated soil permit water movement.

Saturated Hydraulic Conductivity is expressed as follows:

$$log_{10}(K_{sat}) = -1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08f_{fines}$$

Where D_{10}, D_{60}, and D_{90} are the grain sizes in mm for which 10 percent, 60 percent, and 90 percent is more fine and f_{fines} is the fraction of the soil (by weight) that passes the U.S. No. 200 sieve. K_{sat} is measured in cm/sec.

With this equation, we can determine the saturated hydraulic conductivity for our representative samples. See example below:

Test Pit TP-1 at 5.0 feet BGS: K_{sat} = 0.048 cm/sec, or approximately 68.12 inches/hour.

Applying correction factors for site variability (0.6), test method (0.4) and degree of influent control to prevent siltation and bio-buildup (0.9) gives a corrected preliminary design rate of 14.71 inches/hour for the example above. This rate does not take into consideration the effects of ground water mounding.

Given the variability of the site, **we recommend utilizing a preliminary design rate of 10 inches/hour** in the native Alluvium to account for potential restrictive layers or high groundwater. If higher rates are required for design, in-situ infiltration testing is required such as a Pilot Infiltration Testing (PIT Testing). GeoTest does not recommend locating infiltration facilities in uncontrolled fill soils.

Please note that preliminary infiltration rates calculated per the 2016 Snohomish County Drainage Manual assume loose, unconsolidated soil. It should be noted that stormwater infiltration design is an iterative process and that Snohomish County may require additional information, such as seasonal groundwater monitoring, a mounding analysis, or Pilot Infiltration Testing (PIT Testing). GeoTest can provide these services as part of a separate scope of work.

Infiltration Considerations

Infiltration areas should be protected from construction traffic, compaction activities, or other ground disturbing activities. Densification of the soils due to construction activities has the potential to significantly reduce their infiltration capacity. The degree of reduction is highly dependent on both the material type and relative compaction. Infiltration capacity reductions of an order of magnitude or more may occur in soils with significant silt or clay contents. We recommend the client and/or contractor consider protecting infiltration area soils from unintended densification by surrounding these areas with temporary construction fencing or similar temporary obstructions.

The above rates should be considered preliminary in nature and may warrant modification based on changes in facility type, location, or additional subsurface information. Alternatively, the stormwater designer may wish to conduct their own analysis to obtain design rates that best account for the specifics of their system design. Appropriate incorporation of these recommendations into stormwater design is at the discretion of the designer.

The initial saturated hydrologic conductivity of site soils was determined by the Grain Size Analysis Method with applied correction factors. This method produces **estimates** of real-world behavior only. Determination by in-situ testing methods, such as a PIT (Pilot Infiltrating Test), would be anticipated to produce rates more reflective of real-world behavior. GeoTest is available to assist with additional assessment or testing of site soils upon request.

Stormwater Pollutant Treatment

Prior to offsite discharge, stormwater may require some form of pollutant pre-treatment or treatment with an amended soil. It is our opinion, based on past experience, that the re-use of onsite topsoil is often the most sustainable and cost effective method for pollutant treatment purposes. Cation exchange capacities and organic contents of site topsoil and shallow subsurface soils were determined to establish their pollutant treatment suitability.

Cation Exchange Capacity and Organic Content Testing

Two composite samples were collected during our subsurface explorations for pollutant treatment purposes. Cation exchange capacity (CEC) and organic content (OC) tests were performed by Northwest Agricultural Consultants. Laboratory test results are presented in Table 2.

Table 2 CEC & Organic Content Laboratory Test Results			
Test Pit Exploration Number and Depth	**Geologic Description**	**Cation Exchange Capacity (meq/100 grams)**	**Organic Content (%)**
TP-2 (0.5 ft)	Topsoil	21.5	9.09
TP-8 (0.5 ft)	Topsoil	20.1	9.57

Based on the results listed in Table 2, the fine-grained, near-surface soil (topsoil and weathered soils) appear to be suitable for onsite pollutant treatment purposes based on the *2016 Snohomish County Drainage Manual.* The Manual also states that cation exchange capacity must be greater than or equal to 5.0 meq/100 grams for treatment purposes. Thus, the fine-grained, near-surface soils would also appear to be suitable for this purpose, although low rates of infiltration can be expected if the on-site soils are amended due to their high silt contents.

Geotechnical Consultation and Construction Monitoring

GeoTest Services recommends that we be involved in the project design review process. The purpose of the review is to verify that the recommendations presented in this report have been properly interpreted and incorporated in the design and specifications.

We recommend that geotechnical construction monitoring services be provided. These services should include observation by GeoTest personnel during fill placement/compaction activities and subgrade preparation operations to verify that design subgrade conditions are obtained beneath the proposed building(s). There are challenging conditions that exist on the project site and it is imperative that the recommendations presented in this report be implemented during construction. We recommend that periodic field density testing be performed to verify that the appropriate degree of compaction is obtained for structural fill. The purpose of these services would be to observe compliance with the design concepts, specifications, and recommendations of this report, and in the event subsurface conditions differ from those anticipated before the start of construction, provide revised recommendations appropriate to the conditions revealed during construction. GeoTest Services would be pleased to provide these services for you.

GeoTest Services is also available to provide a full range of materials testing and special inspection during building construction as required by the local building department and the International Building Code. This may include specific construction inspections on materials such as reinforced concrete, reinforced masonry, wood framing and structural steel. These services are supported by our fully accredited materials testing laboratory.

USE OF THIS REPORT

GeoTest Services has prepared this report for the exclusive use of William Hegger and his design consultants for specific application to the design of the proposed Monroe Townhomes Project in Monroe, Washington. Use of this report by others or for another project is at the user's sole risk. Our services have been conducted in accordance with generally accepted practices of the geotechnical engineering profession; no other warranty, either express or implied, is made as to the professional advice included in this report.

Our site explorations indicate subsurface conditions at the dates and locations indicated. It is not warranted that they are representative of subsurface conditions at other locations and times. The analyses, conclusions, and recommendations contained in this report are based on site conditions to the limited depth of our explorations at the time of our exploration program, a brief geological reconnaissance of the area, and review of published geological information for the site. We assume that the explorations are representative of the subsurface conditions throughout the site during the preparation of our recommendations. If variations in subsurface conditions are encountered during construction, we should be notified for review of the recommendations of this report, and revision of such if necessary. If there is a substantial lapse of time between submission of this report and the start of construction, or if conditions change due to construction operations at or adjacent to the project site, we recommend that we review this report to determine the applicability of the conclusions and recommendations contained herein.

The earthwork contractor is responsible to perform all work in conformance with all applicable WISHA/OSHA regulations. GeoTest Services, Inc. should not be assumed to be responsible for job site safety on this project, and this responsibility is specifically disclaimed.

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

Respectfully Submitted,
GeoTest Services, Inc.

EDWARDO A. GARCIA
STATE OF WASHINGTON
40819
REGISTERED
PROFESSIONAL ENGINEER

12-28-17

Noah Griffin G.I.T
Staff Geologist

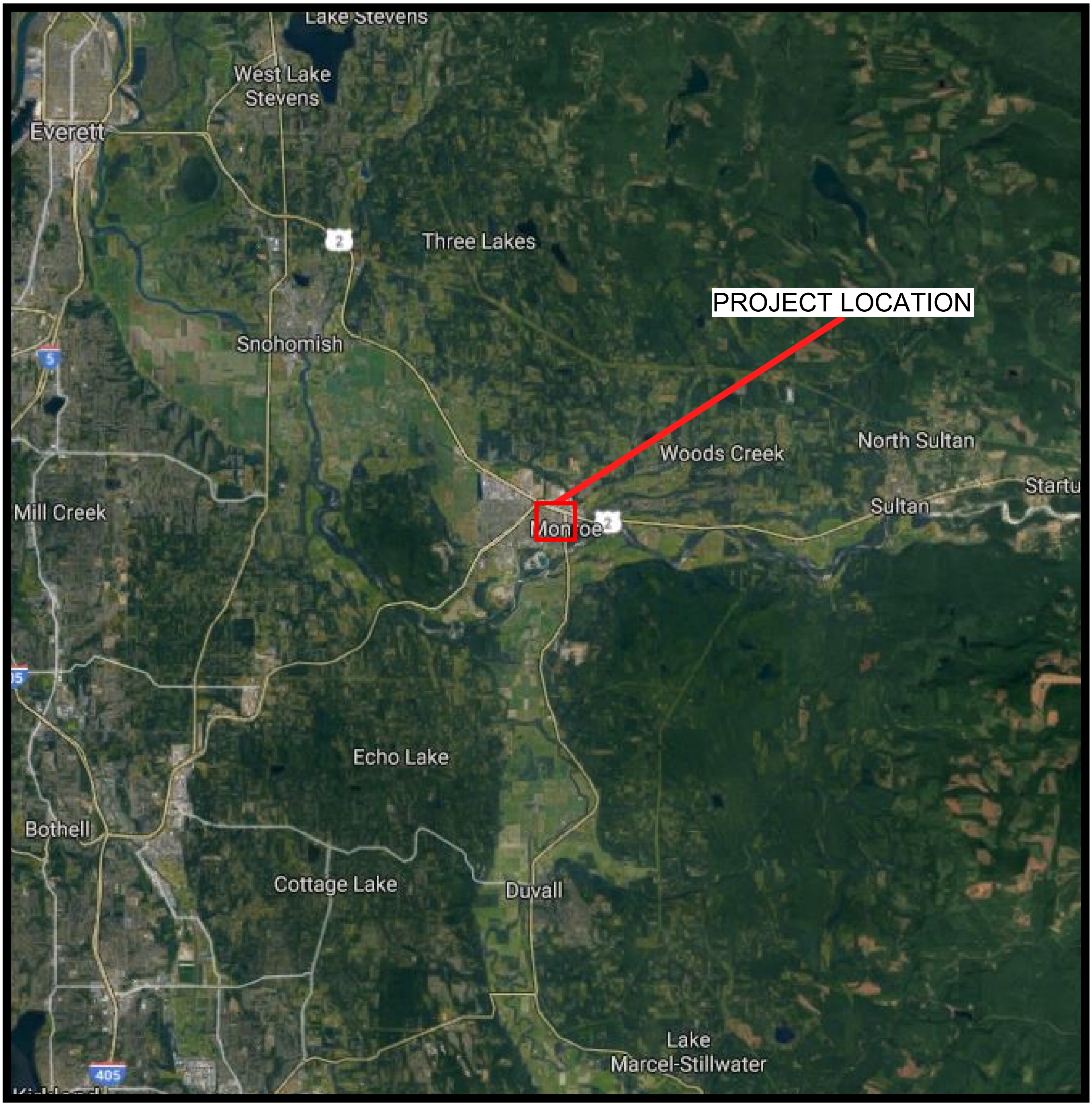
Edwardo Garcia, P.E.
Geotechnical Department Manager

Attachments:	Figure 1	Vicinity Map
	Figure 2	Site and Exploration Plan
	Figure 3	Soil Classification System and Key
	Figures 4-8	Test Pit Logs
	Figure 9	Grain Size Analysis
	Attachment:	Report Limitations and Guidelines

REFERENCES

Interactive Geologic Map of Washington State. Online interactive services provided by the Washington State Department of Natural Resources.

Snohomish County Drainage Manual, 2016.



N

2 miles

MAP REFERENCED FROM GOOGLE MAPS

GEOTEST SERVICES, INC.
741 Marine Drive
Bellingham, WA 98225
phone: (360) 733-7318
fax: (360) 733-7418

Date: 12-15-17	By: NG	Scale: As Shown	Project 17-0765
SITE VICINITY MAP **MONROE TOWNHOMES** **BLUEBERRY LANE AND KELSEY STREET** **MONROE, WASHINGTON**			Figure 1

100 Feet

N

TP-# = Approximate Test Pit Location

REFERENCE DRAWING FROM GOOGLE EARTH

GEOTEST SERVICES, INC. 741 Marine Drive Bellingham, WA 98225 phone: (360) 733-7318 fax: (360) 733-7418	Date: 12-15-17	By: NG	Scale: As Shown	Project **17-0765**
	SITE AND EXPLORATION PLAN **MONROE TOWNHOMES** **BLUEBERRY LANE AND KELSEY STREET** **MONROE, WASHINGTON**			Figure 2

Soil Classification System

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

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

Notes: 1. Soil descriptions are based on the general approach presented in the *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, as outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the *Standard Test Method for Classification of Soils for Engineering Purposes*, as outlined in ASTM D 2487.
2. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	> 50%	- "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and ≤ 50%	- "very gravelly," "very sandy," "very silty," etc.
	> 12% and ≤ 30%	- "gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and ≤ 12%	- "slightly gravelly," "slightly sandy," "slightly silty," etc.
	≤ 5%	- "trace gravel," "trace sand," "trace silt," etc., or not noted.

Drilling and Sampling Key

SAMPLE NUMBER & INTERVAL

- 1 — Sample Identification Number
- Recovery Depth Interval
- Sample Depth Interval
- Portion of Sample Retained for Archive or Analysis

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Other - See text if applicable

Groundwater

▽ ATD — Approximate water elevation at time of drilling (ATD) or on date noted. Groundwater levels can fluctuate due to precipitation, seasonal conditions, and other factors.

Field and Lab Test Data

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

TP-1

Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	Soil Profile	Groundwater
					Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0–1	1	d		SM/OH	Loose, brown, moist, silty, SAND with organics and rootlets (Topsoil)	Groundwater not encountered.
1–3	2	d		GM/SM	Dense, brown, silty, very gravelly, SAND with scattered organics and angular to subangular gravel (Fill)	
3–4				SM/ML	Soft, reddish brown, sandy, SILT with scattered organics (Fill)	
4–9.5	3	d	W = 6 GS	GP/GM	Medium Dense to Dense, brown, damp, slightly silty, sandy, GRAVEL with cobble sized grains (Alluvium)	

Test Pit Completed 12/06/17
Total Depth of Test Pit = 9.5 ft.

TP-2

Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	Soil Profile	Groundwater
					Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0–1	4	d		SM/OH	Loose, brown, moist, silty, SAND with organics, rootlets, and scattered debris (Topsoil)	Groundwater not encountered.
1–5	5	d		SM/ML	Soft, brown/tan, moist, sandy, SILT with scattered organics, trace gravel, and occasional cobbles (Fill)	
5–8	6	d		GP	Medium Dense to Dense, brown, damp, slightly silty, sandy, GRAVEL, medium to coarse sand, rounded to subrounded gravel, with cobble sized grains (Alluvium)	

Test Pit Completed 12/06/17
Total Depth of Test Pit = 8.0 ft.

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

TP-3

Excavation Method: Tracked Excavator

Ground Elevation (ft): Undetermined

Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	Soil Profile	Groundwater
0				SM/OH	Loose, brown, moist, silty, SAND with organics, rootlets, and scattered debris (Topsoil)	Groundwater not encountered.
				SM	Loose, tan/blue, silty, SAND with scattered organics (FIll)	
2	7	d		SM	Loose to medium dense, tan/blue, gravelly, very silty, SAND with angular gravel, organics, and debris (Fill)	
	8	d			Increasing organic and debris content with depth	
7					Test pit terminated at ~7' BGS due to encountering unmarked, defunct, utilities	

Test Pit Completed 12/06/17
Total Depth of Test Pit = 7.0 ft.

TP-4

Excavation Method: Tracked Excavator

Ground Elevation (ft): Undetermined

Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	Soil Profile	Groundwater
0				SM/OH	Loose, brown, moist, silty, SAND with organics, rootlets, and scattered debris (Topsoil)	Groundwater not encountered.
				SM	Ponded surface water in upper 0.5'	
				SM	Hard/Very Dense, brown, moist, gravelly, silty, SAND (Fill)	
				GM	Hard/Very Dense, blue, moist, gravelly, silty, SAND (Fill)	
4				ML	Hard, brown/blue, sandy, very silty, GRAVEL, large angular cobbles (FIll)	
	9	d			Hard, brown/black, gravelly, sandy, SILT with scattered organics (Fill)	
6				GP/GM	Medium Dense to Dense, brown, damp, slightly silty, sandy, GRAVEL with cobble sized grains (Alluvium)	

Test Pit Completed 12/06/17
Total Depth of Test Pit = 8.0 ft.

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

TP-5

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0					SM/OH	Loose, brown, moist, silty, SAND with organics and rootlets (Topsoil)	
1					SM	Medium dense, grey, wet, slightly gravelly, slightly silty, SAND (Fill)	
2	10	d					
3						Increasing moisture content with depth	
4						Sidewalls caving @ 4' BGS	Rapid seep @ ~4' BGS groundwater seepage encountered at 4.0 ft.
7						Test pit terminated due to sidewalls caving	

Test Pit Completed 12/06/17
Total Depth of Test Pit = 7.0 ft.

TP-6

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0					SM/OH	Loose, brown, moist, silty, SAND with organics and rootlets (Topsoil)	Groundwater not encountered.
1					SM	Medium dense, grey, wet, slightly gravelly, slightly silty, SAND (Fill)	
3.5	11	d					
4					ML	Medium stiff, blue, wet, sandy, low plasticity SILT with scattered organics and woody debris (Fill)	
6	12	d	W = 15 GS				
7						Increasing organic content with depth	
8.5						Chain link fence in sidewall @ ~8.5' BGS	

Test Pit Completed 12/06/17
Total Depth of Test Pit = 10.0 ft.

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

GEOTEST

Monroe Townhomes
Blueberry Lane and Kelsey Street
Monroe, Washington

Log of Test Pits

Figure 6 (3 of 5)

TP-7

Excavation Method: Tracked Excavator

Ground Elevation (ft): Undetermined

Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	Soil Profile	Groundwater
0				SM/OH	Loose, brown, moist, silty, SAND with organics and rootlets (Topsoil)	Groundwater not encountered.
				SM/ML	Hard/Very Dense, brown/blue, moist, silty, very gravelly, SAND (Fill)	
4				SM/ML	Hard/Very Dense, brown, moist, silty, very gravelly, SAND with scattered organics and debris (Fill)	
9	13	d	W = 4 GS	GP	Medium Dense to Dense, tan, very sandy, GRAVEL (Alluvium)	

Test Pit Completed 12/06/17
Total Depth of Test Pit = 11.0 ft.

TP-8

Excavation Method: Tracked Excavator

Ground Elevation (ft): Undetermined

Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	USCS Symbol	Soil Profile	Groundwater
0				SM/OH	Loose, brown, moist, silty, SAND with organics and rootlets (Topsoil)	Groundwater not encountered.
	14	d		SM	Loose, brown, moist, very silty, slightly gravelly, SAND with scattered organics and debris (Fill)	
4				GP	Medium Dense to Dense, tan, very sandy, GRAVEL (Alluvium)	
	15	d	W = 5 GS			

Test Pit Completed 12/06/17
Total Depth of Test Pit = 6.0 ft.

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

TP-9

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0					SM/OH		Groundwater not encountered.
					SM/ML	Loose, brown/grey, wet, very gravelly, very sandy, SILT with scattered organics (Fill) Pieces of fabric @~2.5' BGS Piece of rebar @~5' BGS Grades to increased silt and moisture content with depth	

Test Pit Completed 12/06/17
Total Depth of Test Pit = 11.0 ft.

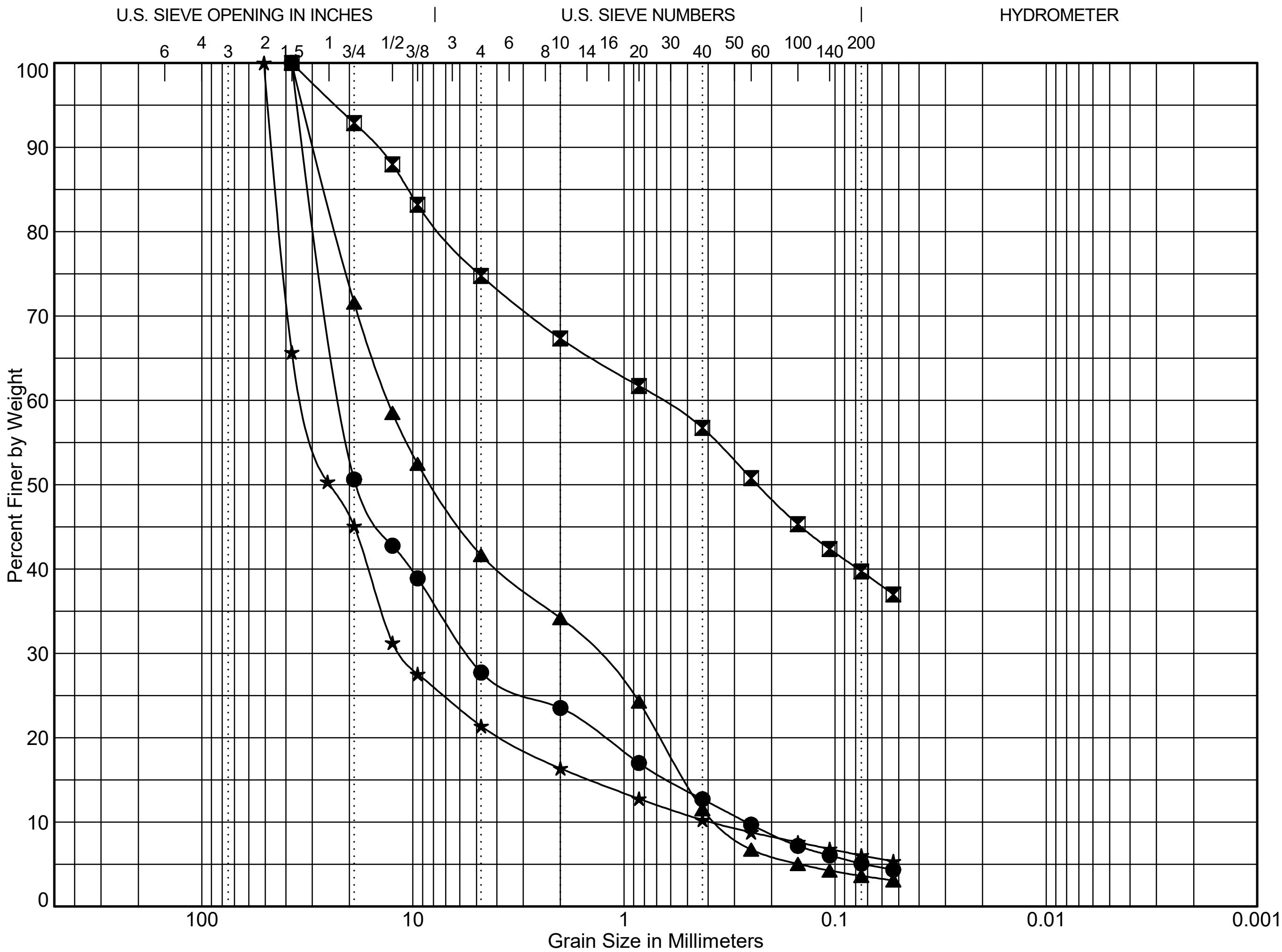
TP-10

SAMPLE DATA				SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0					SM/OH	Loose, brown, moist, silty, SAND with organics and rootlets (Topsoil)	Groundwater not encountered.
					SM/ML	Loose, tan, wet, slightly gravelly, silty, SAND with scattered organics and debris (Fill)	
					WD	Layer of wood timbers	
					ML/OH	Loose, blue/black, wet, slightly gravelly, very sandy, SILT with numerous organics (Fill)	
6	16	d					
10					GP	Medium Dense to Dense, tan, very sandy, GRAVEL (Alluvium)	

Test Pit Completed 12/06/17
Total Depth of Test Pit = 11.0 ft.

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

GEOTEST	Monroe Townhomes Blueberry Lane and Kelsey Street Monroe, Washington	Log of Test Pits	Figure 8 (5 of 5)



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

Point	Depth	Classification	LL	PL	PI	C_c	C_u
● TP-1	5.0	SLIGHTLY SILTY, SANDY, GRAVEL (GP/GM)				5.25	82.04
⧗ TP-6	6.0	GRAVELLY, VERY SILTY, SAND (SM)					
▲ TP-7	9.0	VERY SANDY, GRAVEL (GP)				0.41	36.54
★ TP-8	6.0	SLIGHTLY SILTY, SANDY, GRAVEL (GP/GM)				10.31	83.77

Point	Depth	D_{100}	D_{60}	D_{50}	D_{30}	D_{10}	%Coarse Gravel	% Fine Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Fines
● TP-1	5.0	37.5	21.618	18.377	5.468	0.264	49.4	22.9	4.2	10.8	7.6	5.1
⧗ TP-6	6.0	37.5	0.67	0.233			7.1	18.1	7.4	10.6	17.0	39.7
▲ TP-7	9.0	37.5	13.109	8.11	1.393	0.359	28.4	29.9	7.5	22.7	7.9	3.6
★ TP-8	6.0	50.8	32.458	24.935	11.384	0.387	54.9	23.7	5.0	6.1	4.2	6.1

$C_c = D_{30}^2/(D_{60} * D_{10})$ To be well graded: $1 < C_c < 3$ and

$C_u = D_{60}/D_{10}$ $C_u > 4$ for GW or $C_u > 6$ for SW

GEOTEST

Monroe Townhomes
Blueberry Lane and Kelsey Street
Monroe, Washington

Grain Size Test Data

Figure 9

REPORT LIMITATIONS AND GUIDELINES FOR ITS USE[1]

Subsurface issues may cause construction delays, cost overruns, claims, and disputes. While you cannot eliminate all such risks, you can manage them. The following information is provided to help:

Geotechnical Services are Performed for Specific Purposes, Persons, and Projects

At GeoTest our geotechnical engineers and geologists structure their services to meet specific needs of our clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of an owner, a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the client. No one except you should rely on your geotechnical engineer who prepared it. And no one – not even you – should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report is Based on a Unique Set of Project-Specific Factors

GeoTest's geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the clients goals, objectives, and risk management preferences; the general nature of the structure involved its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless GeoTest, who conducted the study specifically states otherwise, do not rely on a geotechnical engineering report that was:

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

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed, for example, from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed construction,
- alterations in drainage designs; or
- composition of the design team; the passage of time; man-made alterations and construction whether on or adjacent to the site; or by natural alterations and events, such as floods, earthquakes or groundwater fluctuations; or project ownership.

Always inform GeoTest's geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

[1]Information in this document is based upon material developed by ASFE, Professional Firms Practicing in the Geosciences(asfe.org)

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. Do not rely on the findings and conclusions of this report, whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. Always contact GeoTest before applying the report to determine if it is still relevant. A minor amount of additional testing or analysis will help determine if the report remains applicable.

Most Geotechnical and Geologic Findings are Professional Opinions

Our site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoTest's engineers and geologists review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ – sometimes significantly – from those indicated in your report. Retaining GeoTest who developed this report to provide construction observation is the most effective method of managing the risks associated with anticipated or unanticipated conditions.

A Report's Recommendations are *Not* Final

Do not over-rely on the construction recommendations included in this report. Those recommendations are not final, because geotechnical engineers or geologists develop them principally from judgment and opinion. GeoTest's geotechnical engineers or geologists can finalize their recommendations only by observing actual subsurface conditions revealed during construction. GeoTest cannot assume responsibility or liability for the report's recommendations if our firm does not perform the construction observation.

A Geotechnical Engineering or Geologic Report may be Subject to Misinterpretation

Misinterpretation of this report by other design team members can result in costly problems. Lower that risk by having GeoTest confer with appropriate members of the design team after submitting the report. Also, we suggest retaining GeoTest to review pertinent elements of the design teams plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having GeoTest participate in pre-bid and preconstruction conferences, and by providing construction observation.

Do not Redraw the Exploration Logs

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

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, but preface it with a clearly written letter of transmittal. In that letter, consider advising the contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the GeoTest and/or to conduct

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additional study to obtain the specific types of information they need or prefer. A pre-bid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might you be in a position to give contractors the best information available, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. In addition, it is recommended that a contingency for unanticipated conditions be included in your project budget and schedule.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering or geology is far less exact than other engineering disciplines. This lack of understanding can create unrealistic expectations that can lead to disappointments, claims, and disputes. To help reduce risk, GeoTest includes an explanatory limitations section in our reports. Read these provisions closely. Ask questions and we encourage our clients or their representative to contact our office if you are unclear as to how these provisions apply to your project.

Environmental Concerns Are Not Covered in this Geotechnical or Geologic Report

The equipment, techniques, and personnel used to perform an environmental study differ significantly from those used to perform a geotechnical or geologic study. For that reason, a geotechnical engineering or geologic report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated containments, etc. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk management guidance. Do not rely on environmental report prepared for some one else.

Obtain Professional Assistance to Deal with Biological Pollutants

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts biological pollutants from growing on indoor surfaces. Biological pollutants includes but is not limited to molds, fungi, spores, bacteria and viruses. To be effective, all such strategies should be devised for the express purpose of prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional biological pollutant prevention consultant. Because just a small amount of water or moisture can lead to the development of severe biological infestations, a number of prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of this study, the geotechnical engineer or geologist in charge of this project is not a biological pollutant prevention consultant; none of the services preformed in connection with this geotechnical engineering or geological study were designed or conducted for the purpose of preventing biological infestations.

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