Geotechnical Engineering Report

Proposed Improvements to Nashville National Cemetery

Nashville, Tennessee

January 14, 2014

Terracon Project No. 18135044

Prepared for:

FourFront Design, Inc.

Rapid City, South Dakota

Prepared by:

Terracon Consultants, Inc.

Nashville, Tennessee

January 14, 2014

Terracon

FourFront Design, Inc.
517 Seventh Street
Rapid City, SD 57701

Attn: Mr. David Jolly

Re: Geotechnical Engineering Report
Proposed Improvements to Nashville National Cemetery
Nashville, TN
Terracon Project Number 18135044

Dear Mr. Jolly:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with our proposal number P18130216b dated December 5, 2013.

This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

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Enclosures
cc: 1 – Client (PDF)
1 – File

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EXECUTIVE SUMMARY

A geotechnical investigation has been performed for the proposed improvements to existing Nashville National cemetery located in Nashville, Tennessee. Five (5) borings were advanced to auger refusal depths of approximately 5 to 7 ½ feet below the existing ground surface within the proposed building areas. The following geotechnical considerations were identified:

- Beneath the topsoil cover, all borings except B-1 encountered about 1½ to 4 feet of cohesive fill over stiff natural clay to auger refusal. Stiff to very stiff natural clay was encountered beneath the topsoil cover and extending to auger refusal in boring B-1.

- The fill encountered in Columbarium/Shed building borings B-2 through B-5 was generally free of debris and/or deleterious material, and appears to have been placed with compactive effort. However, we have no records or density test results of the former fill operations and some inconsistencies could exist within the fill, which poses a geotechnical concern for building support. This risk cannot be eliminated without removing the fill in its entirety and replacing it with approved engineered fill.

- Our recommendations for grade supported shallow footings are predicated upon undercutting old fill, where present, from beneath foundations, so that they may bear in new engineered fill or stiff natural soils as described in Section 4.1, and review and approval of exposed subgrades by the geotechnical engineer at the time of grading. Shallow footings can be designed for a net allowable bearing pressure of 2,500 psf for isolated column and wall footings. Existing fill within the proposed floor slab area could be left in place provided the fill is documented as stable under proofroll and the fill conditions are thoroughly evaluated by the Terracon engineer.

- Based on the quality of fill samples obtained from the borings, we expect a portion of the undercut fill can be reused as engineered fill, provided the material meets our fill criteria and placed per our recommendations outlined herein.

- The 2012 IBC Table 1613.3.3 IBC seismic site classification for this site is B, assuming overburden thickness beneath footing bearing levels will be less than 10 feet.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
PROPOSED IMPROVEMENTS TO NASHVILLE NATIONAL CEMETERY
NASHVILLE, TENNESSEE

Terracon Project No. 18135044
January 14, 2014

1.0 INTRODUCTION

A geotechnical engineering report has been completed for the proposed improvements to the Nashville National Cemetery located in Nashville, Tennessee. Five (5) borings were drilled to auger refusal depths of approximately 5 to 7½ feet below the existing ground surface within the area proposed for construction. Logs of the borings along with a boring location plan are included in Appendix A.

The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- earthwork
- foundation design and construction
- seismic considerations
- slab design and construction
- lateral earth pressures

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Proposed improvements (all single story buildings)	■ Construct new Columbarium near NW site corner ■ Construct new Committal Shelter near NW site corner ■ Public restroom addition to Lodge Building
Building construction	Unknown but presumed to incorporate: o masonry, precast concrete, and/or steel framing o slab on grade o stone veneer
Finished floor elevation	Assumed to be close to existing grade or to match existing FFE
Maximum loads	Columns: 30 kips (assumed) Walls: 2.5 klf (assumed) Slabs: 100 psf max (assumed)
Grading requirements	Estimated to be less than 3 feet of cut and fill
Cut and fill slopes	Assumed to be no steeper than 3H:1V (Horizontal to Vertical)
Free-standing retaining walls	Not expected
Below Grade Areas	

2.2 Site Location and Description

Item	Description
Location	Northwest Corner of Gallatin Pike South and Walton Lane, Nashville, TN Latitude/Longitude: 36° 14.4885' / 86° 43.5836'
Existing improvements (germane to the requested services)	■ Admin Building: ≈ 2,000 SF ■ Lodge Building: ≈ 1,600 SF Footprint ■ Committal Shelter: ≈ 1,000 SF
Current ground cover	Grass, weeds and bare ground across most construction area. A portion of Columbarium pad was covered with two storage containers at the time of our field exploration.
Existing topography	Near level across Columbarium pad and gently sloping across restroom and shelter pads. Existing grades reportedly vary from about El.515 to El. 517 across restroom building pad, El. 514½ to El. 515½ across Columbarium pad and El. 505 to El. 510 across Committal Shelter pad, per review of topographic survey.

3.0 SUBSURFACE CONDITIONS

3.1 Geology

Formation	Description
Bigby-Cannon Limestone [1]	Light to medium gray, thin to medium bedded limestone containing thin shale partings

1. *Geologic Map of the Nashville East Quadrangle, Tennessee* published by the State of Tennessee Department of Conservation, Division of Geology (1966).

The carbonate limestone underlying the site is susceptible to formation of karst topography. Any construction in karst topography is accompanied by some degree of risk for future internal soil erosion and ground subsidence that could affect the stability of the proposed structures. Our review of the available topographic mapping did not reveal any sinkholes within the proposed development area. Furthermore, our borings did not disclose any obvious signs of impending overburden collapse or sinkhole activity within the depths explored

3.2 Typical Profile

Based on the results of the borings, subsurface conditions on the project site can be generalized as follows:

Proposed Public Restroom Building: Boring B-1 was drilled within the proposed public restroom building addition area near existing Lodge building. Beneath the topsoil cover, the boring encountered natural lean and fat clay to auger refusal on apparent limestone bedrock at about 7½ feet below existing grade. The clay exhibited a stiff to very stiff consistency based on standard penetration test (SPT) N-values ranging from 9 to 19 blows per foot (bpf).

Proposed Columbarium Building: Borings B-2 through B-4 were drilled within the proposed Columbarium building footprint. Beneath the surface topsoil cover, these borings encountered about 1½ to 4 feet of existing fill or possible fill. The fill typically consisted of lean clay with some limestone fragments. Natural lean clay was encountered below the existing fill and extended to auger refusal depths of about 5 feet below grade on apparent limestone bedrock. The SPT N-values in the fill was 10 bpf. In our opinion this N-value is exaggerated by the presence of limestone fragments within fill. Natural clay exhibited a stiff to very stiff consistency based on N-values ranging from 11 to 17 bpf.

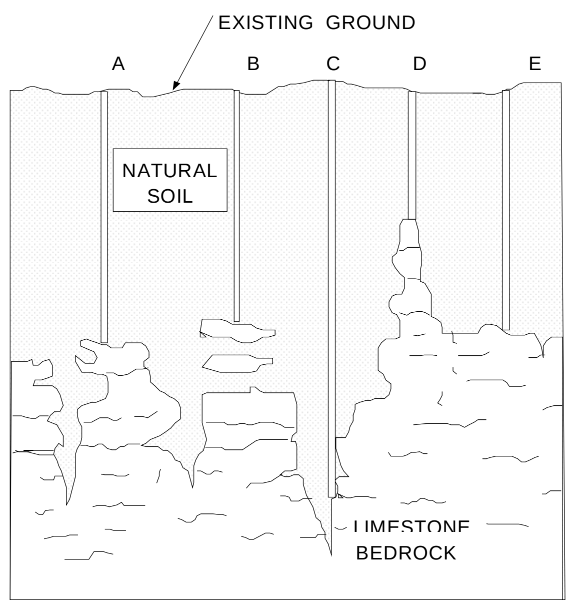
Proposed Committal Shelter: Boring B-5 was drilled within the proposed shelter building footprint. Beneath the surface topsoil cover, the boring encountered about 2 feet of existing fill. The fill consisted of lean clay with some limestone fragments. Natural lean clay was encountered below the existing fill and extended to auger refusal depth of about 6 feet on apparent limestone bedrock. The SPT N-value in the fill was 12 bpf. In our opinion, this N-value may be exaggerated by the presence of limestone fragments within fill. Natural clay at this boring exhibited a very stiff consistency based on an N-value of 17 bpf.

The upper native clay was classified as lean clay and was of low plasticity and had the following measured liquid limits, plastic limits, and plasticity indices:

Sample Location, Depth	Liquid Limit, (%)	Plastic Limit, (%)	Plasticity Index, (%)
Boring B-1, 2.5 – 5 ft.	60	30	30

The depth to auger refusal at our boring locations was relatively shallow, ranging from 5 to 7 ½ feet below the present ground surface. The following table summarizes the depth to auger refusal at each boring location. Auger refusal is defined as the depth below the ground surface at which a test boring can no longer be advanced with the soil drilling technique being used. In an area of limestone bedrock, auger refusal can result on slabs of unweathered limestone suspended in the residual soil matrix ("floaters"), on rock "pinnacles" rising above the surrounding bedrock surface, in widened joints that may extend well below the surrounding bedrock surface, or on the upper surface of continuous bedrock. Several of these possible auger refusal conditions are illustrated in the adjacent figure.

AUGER REFUSAL ILLUSTRATION



THIS FIGURE IS FOR ILLUSTRATIVE PURPOSES ONLY AND DOES NOT NECESSARILY DEPICT THE SPECIFIC BEDROCK CONDITIONS AT THIS SITE

Rock coring procedures are generally required to determine the character and continuity of the auger refusal material and these factors must be considered when evaluating the depth to auger refusal in those test borings that are not cored. Rock coring was not performed due to refusal depths being below that which would impact the proposed design.

Boring No.	Approximate Refusal Depth (feet)
B-1	7 ½
B-2	5 ½
B-3	5
B-4	5
B-5	6

Conditions encountered at each boring location are indicated on the individual logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in situ, the transition between materials may be gradual. Details for each of the borings can be found on the logs in Appendix A. A discussion of field sampling procedures is included in Appendix A and laboratory testing procedures are presented in Appendix B.

3.3 Groundwater

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was not observed in the borings while drilling, or for the short duration that the borings were allowed to remain open. Due to the low permeability of the soils encountered in the borings, a relatively long period of time may be necessary for a groundwater level to develop and stabilize in a borehole in these materials. Long term observations in piezometers or observation wells sealed from the influence of surface water are often required to define groundwater levels in materials of this type.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Perched water can develop on top of bedrock or in porous horizons in the existing fill. These conditions should be considered when developing the design and construction plans for the project.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

About 1½ to 4 feet of undocumented cohesive fill was encountered in Columbarium/Shelter building borings B-2 through B-5. The fill was generally free of deleterious material and appears to have been placed with some compactive effort. However, we have no records or density test results of former fill operations. It should be noted that our borings were limited in scope and some inconsistencies could exist within the fill which poses a geotechnical concern for building support. This risk cannot be eliminated without removing the fill and replacing it with approved engineered fill.

Considering the limited thickness and uncertainties associated with the undocumented fill, we recommend undercutting the existing fill to suitable natural soils beneath the proposed foundations. Natural subgrades exposed at the undercut limits should be evaluated by Terracon for stability and for acceptance for placement of new fill. Any soft or unsuitable soil exposed at this elevation should be undercut at the discretion of the Terracon engineer. The undercut areas should be backfilled with approved engineered fill as outlined in Section 4.3.2. After the site is prepared as recommended herein, the proposed buildings may be supported on shallow spread footings bearing on new engineered fill or stiff natural soils.

Existing fill within the proposed floor slab areas could possibly be left in place provided the fill is documented as stable under proofroll, and the conditions are thoroughly evaluated, by a Terracon engineer by observing test pit excavations, probings and/or DCP testing.

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Based on the quality of fill samples obtained from borings, we expect a portion of the undercut fill can be reused as engineered fill, provided the material meets our fill criteria and is moisture-conditioned and is placed per our recommendations outlined in this report.

Support of floor slabs above existing fill soils is discussed in this report. However, even with the recommended construction testing services, there is an inherent risk for the owner that compressible fill or unsuitable material within or buried by the fill will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill, but can be reduced by performing the additional testing and evaluation by a Terracon engineer at the time of construction as outlined herein.

Based on auger refusal depths encountered in our borings, we do not expect rock excavation in building excavations assuming no significant grading cuts will be performed. It is possible that some deeper utility excavations may extend into bedrock. Use of rock excavation equipment such as hoe-ram, jack hammers, or rock trenchers may be required to remove bedrock and achieve desired excavation depths.

4.2 Earthwork

4.2.1 Site Preparation

Prior to placing any fill, all existing above and below grade structures, vegetation, topsoil, and any otherwise unsuitable material should be removed from the construction areas. Wet or dry material should either be removed or moisture conditioned and recompacted. After stripping and grubbing, the subgrade should be proof-rolled where possible to aid in locating loose or soft areas. Proof-rolling can be performed with a loaded tandem axle dump truck. Soft, dry and low-density soil should be removed or compacted in place prior to placing fill. Where instability is perceived to be shallow (i.e., less than about 12 inches), acceptable remediation might consist of scarification, aeration and recompaction.

As discussed in Section 4.1, the existing fill should be undercut to stiff natural soils from beneath and near the foundations. Geometry of the undercut area is illustrated by the sketches in Section 4.3.2. Undercut areas should be backfilled with approved engineered fill. Existing fill could possibly be left in place beneath floor slab finished subgrades provided the fill is stable under proofroll and the conditions are thoroughly evaluated by a Terracon engineer. The engineer should observe test pit excavations, proofrolling, and other testing to confirm the suitability of existing fill for slab support.

Several buried utilities are reportedly present within the proposed restroom building pad. All buried utilities and associated fill should be removed from the proposed building footprint.

Excavations resulting from removal of buried features should be repaired and backfilled with approved engineered fill as described hereinafter. Backfill placed in deeper excavations should be properly benched in with existing soils. The benches should have a minimum vertical face height of 1 foot and a maximum vertical face height of 3 feet and should be cut wide enough to accommodate the compaction equipment. This benching will help provide a positive bond between the fill and natural soils and reduce the possibility of failure along the fill/natural soil interface.

4.2.2 Material Requirements

Compacted structural fill should meet the following material property requirements:

Engineered Fill Description and Recommended Uses		
Fill Type [1]	**USCS Classification**	**Acceptable Location for Placement**
Lean clay	CL (LL<45)	All locations and elevations
Lean to fat clay [2]	CL/CH, CH (LL>45)	> 1 ft. below finished subgrade unless tested and meets low volume change material criteria
Well graded granular	GW [3]	All locations and elevations
Clean shot rock, < 5% soil; max. particle size is 1 ft. [4]	-	All locations and elevations
Existing Fill	CL	A portion of the existing fill can be reused as engineered fill provided the fill is clean and free of debris and unsuitable material and meets the above fill criteria. A Terracon engineer should field evaluate fill material for reuse.

1. Controlled, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.
2. Delineation of fat clay should be performed by a geotechnical engineer or his representative.
3. Similar to TDOT Section 903.05 Type A, Grading D crushed limestone aggregate, limestone screenings, or granular material such as well graded gravel or crushed stone.
4. Approval of any shot rock should be made prior to placement to verify gradation and particle size.

4.2.3 Compaction Requirements

Item	Description
Fill Lift Thickness	9 inches or less in loose thickness when heavy, self-propelled compaction equipment is used
	4 to 6 inches in loose thickness when hand-guided equipment (*i.e.* jumping jack or plate compactor) is used
	Shot rock can be placed in 12 to 18 inch thick horizontal layers, depending on particle size and compaction equipment weight
Compaction Requirements	At least 98% of the materials standard Proctor maximum dry density (ASTM D 698)
Moisture Content Cohesive Soil	Within the range of 1% below to 2% above the optimum moisture content value as determined by the standard Proctor test at the time of placement and compaction
Moisture Content Granular Material	Moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the cohesionless fill material pumping when proofrolled.

We recommend that engineered fill be tested for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.

Shot rock fill should be compacted in lifts not exceeding 1½ feet using a D-8 class Dozer (10 ton class vibratory roller) or equivalent. Each lift of fill should be compacted using a minimum of ten passes, five in one direction and five that are at a right angle to the initial passes. A complete pass consists of complete coverage of the surface with the tracks (roller).

4.2.4 Utility Trench Backfill

All trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. Utility trenches are a common source of water infiltration and migration. All utility trenches that penetrate beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate below the building.

4.2.5 Grading and Drainage

Final surrounding grades should be sloped away from the proposed structures on all sides to prevent ponding of water. Gutters and downspouts that drain water a minimum of 10 feet beyond the footprint of the proposed structures are recommended. This can be accomplished through the use of splash-blocks, downspout extensions, and flexible pipes that are designed to attach to the end of the downspout. Flexible pipe should only be used if it is daylighted in such a manner that it gravity-drains collected water. Splash-blocks should also be considered below hose bibs and water spigots.

4.2.6 Earthwork Construction Considerations

Based on auger refusal depths encountered in our borings, we do not expect rock excavation in building excavations, assuming no significant grading cuts will be performed. It is possible that some deeper utility excavations may extend into bedrock. Use of rock excavation equipment such as hoe-ram, jack hammers, or rock trenchers may be required to remove bedrock and achieve desired excavation depths.

Although the exposed subgrade is anticipated to be relatively stable upon initial exposure, unstable subgrade conditions could develop during general construction operations, particularly if the soils are wetted and/or subjected to repetitive construction traffic. Should unstable subgrade conditions develop, stabilization measures will need to be employed.

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of floor slabs and pavements. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompacted prior to floor slab and pavement construction.

Depending upon final grades and depths of required excavations, lower limits of some cuts might encroach within a few feet of bedrock. Our experience indicates that soils relatively close to bedrock can become unstable, especially when seepage occurs along the bedrock interface and the construction traffic occurs over the soils. The contractor should be prepared to undercut these soils to bedrock and backfill with shot rock or other granular fill.

Temporary excavations will probably be required during grading operations. The grading contractor, by his contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom. All excavations should be sloped or braced to comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

The geotechnical engineer should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation; proof-rolling; placement and compaction of controlled compacted fills; backfilling of excavations into the completed subgrade, and just prior to construction of building floor slabs.

4.3 Foundations

After addressing existing fill and proper site preparation as discussed herein, the proposed buildings can be supported by shallow spread footings bearing on the stiff natural clay or newly placed engineered fill. Design recommendations for shallow foundations for the proposed structure are presented in the following paragraphs.

4.3.1 Foundation Design Recommendations

Description	Column	Wall
Net allowable bearing pressure [1]	2,500 psf	2,500 psf
Minimum dimensions	24 inches	18 inches
Minimum embedment below finished grade for frost protection [2]	18 inches	18 inches
Approximate total settlement [3]	<1 inch	<1 inch
Estimated differential settlement	<¾ inch between columns	<¾ inch over 40 feet
Allowable passive pressure [4]	750 psf	
Ultimate coefficient of sliding friction [4]	0.35	

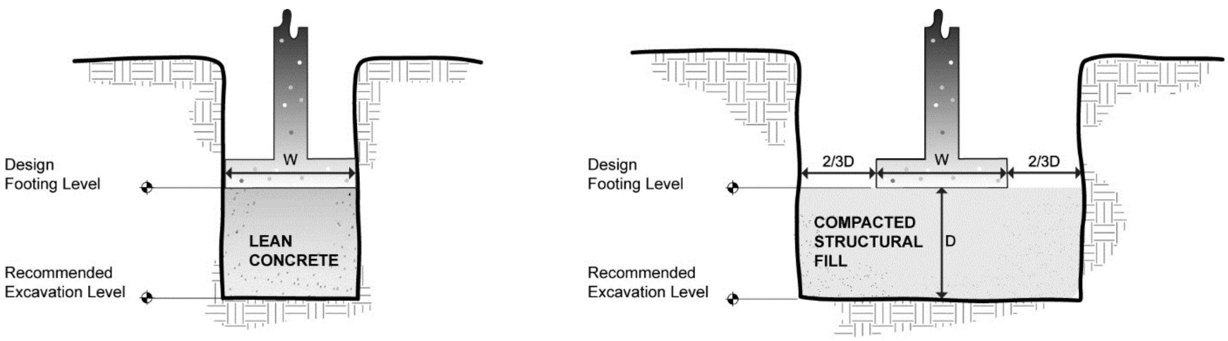
1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. Assumes existing fill, any unsuitable or soft soils, if encountered, will be undercut and replaced with approved engineered fill.
2. For perimeter footing and footings beneath unheated areas. Also to reduce the effects of seasonal moisture variations in the subgrade soils.
3. The foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of compacted fill, and the quality of the earthwork operations.
4. The sides of the excavation for spread footings must be nearly vertical and the concrete should be placed neat against these vertical faces for the passive earth pressure value to be valid. If the loaded side is sloped or benched, and then backfilled, the allowable passive pressure will be significantly reduced. Passive resistance in the upper 3 feet of the soil profile should be neglected.

4.3.2 Foundation Construction Considerations

The base of all foundation excavations should be free of water and loose soil and rock prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Should the soils at bearing level become excessively dry, disturbed or saturated, or frozen, the affected soil should be removed prior to placing concrete. A lean concrete mud-mat should be placed over the bearing soils if the excavations must remain open for an extended period of time. We recommend that the geotechnical engineer be retained to observe and test the soil foundation bearing materials.

Due to the presence of the existing fill within the proposed Columbarium and Committal Shelter building pads, we recommend the foundation construction and subgrade preparation be evaluated by a Terracon geotechnical engineer or his representative.

Where existing fill or unsuitable bearing soils are encountered in footing excavations, the excavation could be extended deeper to suitable natural soils and the footing could bear directly on the natural soils at the lower level or on lean concrete backfill placed in the excavations. As an alternative, the footings could also bear on properly compacted engineered backfill extending down to the suitable natural soils. Overexcavation for compacted engineered fill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing base elevation. The overexcavation should then be backfilled up to the footing base elevation with well graded granular material placed in lifts of 9 inches or less in loose thickness (6 inches or less if using hand-guided compaction equipment) and compacted to at least 98 percent of the material's standard proctor maximum dry density (ASTM D 698). The overexcavation and backfill procedure is described in the following figure.



Lean Concrete Backfill **Overexcavation / Backfill**

NOTE: Excavations in sketches shown vertical for convenience. Excavations should be sloped as necessary for safety.

4.4 Floor Slabs

4.4.1 Floor Slab Design Recommendations

Item	Description
Floor slab support	Approved compacted fill or stiff natural soils[1]
Modulus of subgrade reaction	100 pounds per square inch per in (psi/in) for point loading conditions
Aggregate base course/capillary break [2]	4 inches of free draining granular material
Vapor barrier	Project Specific [3]

1. Assumes the subgrade will be prepared as recommended in this report.
2. The floor slab design should include a capillary break, comprised of free-draining, compacted, granular material, at least 4 inches thick. Free-draining granular material should have less than 5 percent fines (material passing the #200 sieve). Other design considerations such as cold temperatures and condensation development could warrant more extensive design provisions.
3. The use of a vapor retarder should be considered beneath concrete slabs on grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Floor slabs should be structurally independent of any building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation. Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates that any differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks that occur beyond the length of the structural dowels. The structural engineer should account for this potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

4.4.2 Floor Slab Construction Considerations

Prior to construction of grade supported slabs, varying levels of remediation may be required to reestablish stable subgrades within slab areas due to construction traffic, rainfall, disturbance, desiccation, etc. As a minimum, the following measures are recommended.

- Confirm that interior trench backfill placed beneath slabs is compacted in accordance with recommendations outlined in the Earthwork section of this report.

- All floor slab subgrade areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to placement of the stone base and concrete.

4.5 Seismic Considerations

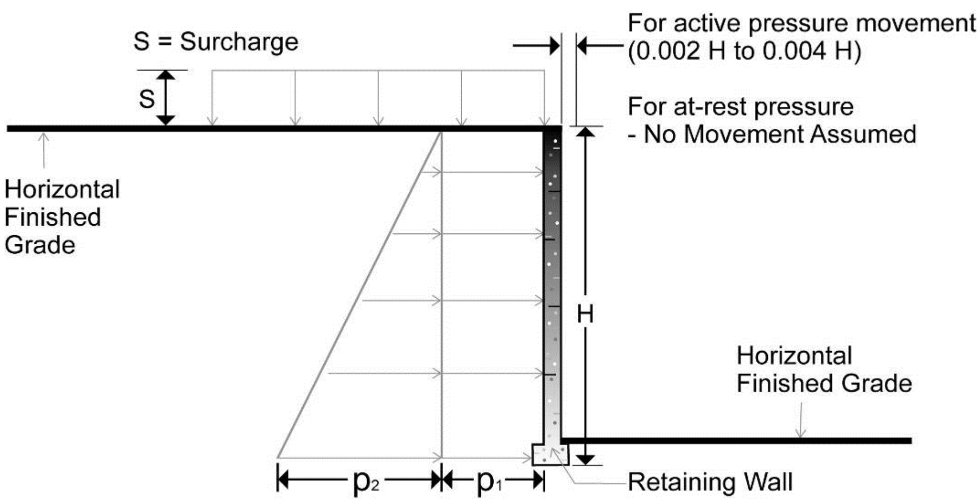
Code Used	Site Classification
2012 International Building Code (IBC) [1]	B [2, 3, 4]

1. In general accordance with the 2012 *International Building Code,* Table 1613.3.3.
2. Based on the boring data and assuming natural bedrock is present below auger refusal depths of about 5 to 7½ feet below existing grade.
3. Site Class B is defined by the 2012 IBC as the "Rock" Category. The 2012 IBC does not permit the use of Site Class B if more than 10 feet of soil is between the rock surface and the bottom of the spread footing or mat foundation. However, based on our assumption of proposed grading and building construction configuration, no excessive fill will be placed within the building pads and limestone bedrock exists below auger refusal depths.

4.6 Lateral Earth Pressures

The lateral earth pressure recommendations given in the following paragraphs are applicable to the design of rigid retaining walls subject to slight rotation, such as cantilever, or gravity type concrete walls. These recommendations are not applicable to the design of modular block - geogrid reinforced backfill (MSE) walls.

Reinforced concrete walls with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to those indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls.



Earth Pressure Coefficients

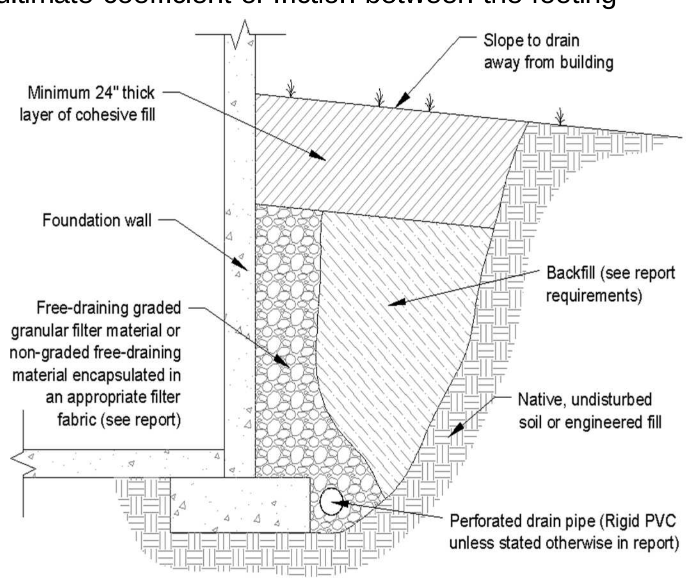
Earth Pressure Conditions	Coefficient for Backfill Type	Equivalent Fluid Density (pcf)	Surcharge Pressure, p_1 (psf)	Earth Pressure, p_2 (psf)
Active (Ka)	Granular - 0.33 Lean Clay - 0.42	40 50	(0.33)S (0.42)S	(40)H (50)H
At-Rest (Ko)	Granular - 0.46 Lean Clay - 0.58	55 70	(0.46)S (0.58)S	(55)H (70)H
Passive (Kp)	Granular - 3.0 Lean Clay - 2.4	360 288	--- ---	--- ---

<u>Applicable conditions to the above include:</u>

- For active earth pressure, wall must rotate about base, with top lateral movements of about 0.002 **H** to 0.004 **H**, where **H** is wall height
- For passive earth pressure to develop, wall must move horizontally to mobilize resistance
- Uniform surcharge, where S is surcharge pressure
- In-situ soil backfill weight a maximum of 120 pcf
- Horizontal backfill, compacted between 95 and 98 percent of standard Proctor maximum dry density
- Loading from heavy compaction equipment not included
- No hydrostatic pressures acting on wall
- No dynamic loading
- No safety factor included in soil parameters
- Ignore passive pressure in frost zone

Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. On-site fat clays are not suitable for use as backfill behind walls. For the granular values to be valid, the granular backfill must extend out from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively. To calculate the resistance to sliding, a value of 0.35 should be used as the ultimate coefficient of friction between the footing and the underlying soil.

To control the water level behind the wall, we recommend a perimeter drain be installed at the foundation level as shown on the adjacent figure and described in the following notes.



- Granular backfill in this case consists of ASTM No. 67 stone or equivalent.
- Perforated pipe should be rigid PVC, sized to transport the expected water.

- Exterior ground surface should consist of a 24 inch clay cap sloped to drain from building.
- The clay cap can be replaced by a pavement section
- Weep holes can be considered in lieu of perimeter drains for retaining walls if the water seepage will not impact adjacent structures

If adequate drainage is not possible, then combined hydrostatic and lateral earth pressures should be calculated for lean clay backfill using an equivalent fluid weighing 90 and 100 pcf for active and at-rest conditions, respectively. For granular backfill, an equivalent fluid weighing 85 and 90 pcf should be used for active and at-rest, respectively. These pressures do not include the influence of surcharge, equipment, or floor loading, which should be added. Heavy equipment should not operate within a distance closer than the exposed height of retaining walls to prevent lateral pressures more than those provided.

5.0 GENERAL COMMENTS

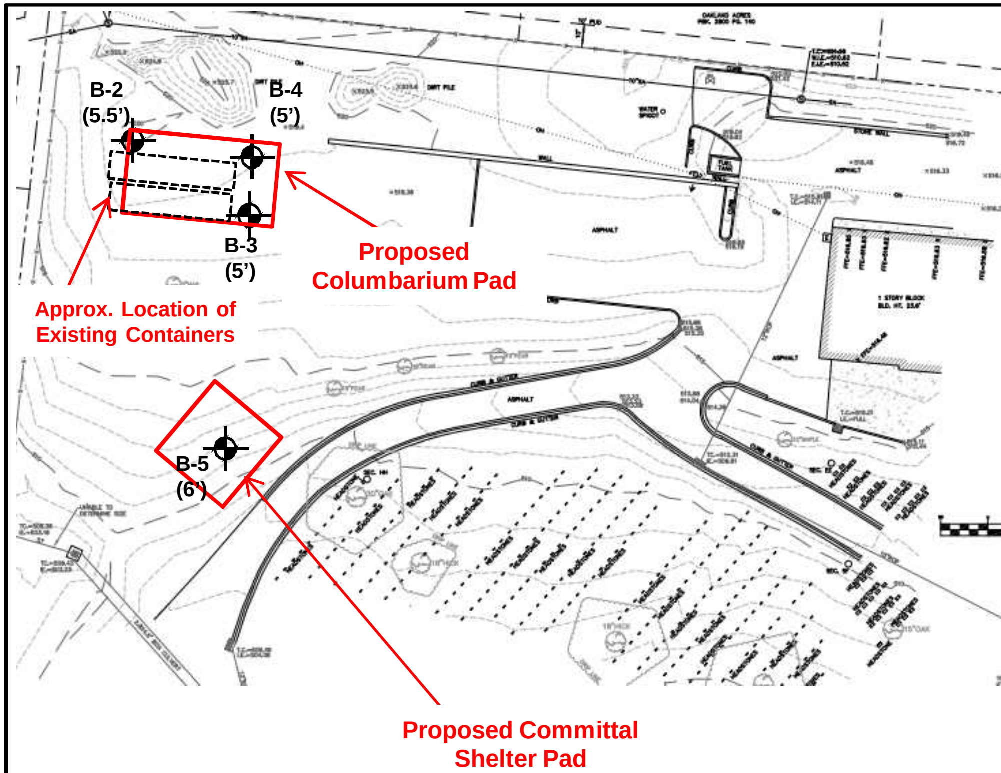
Per our approved scope of work, we understand Terracon will be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

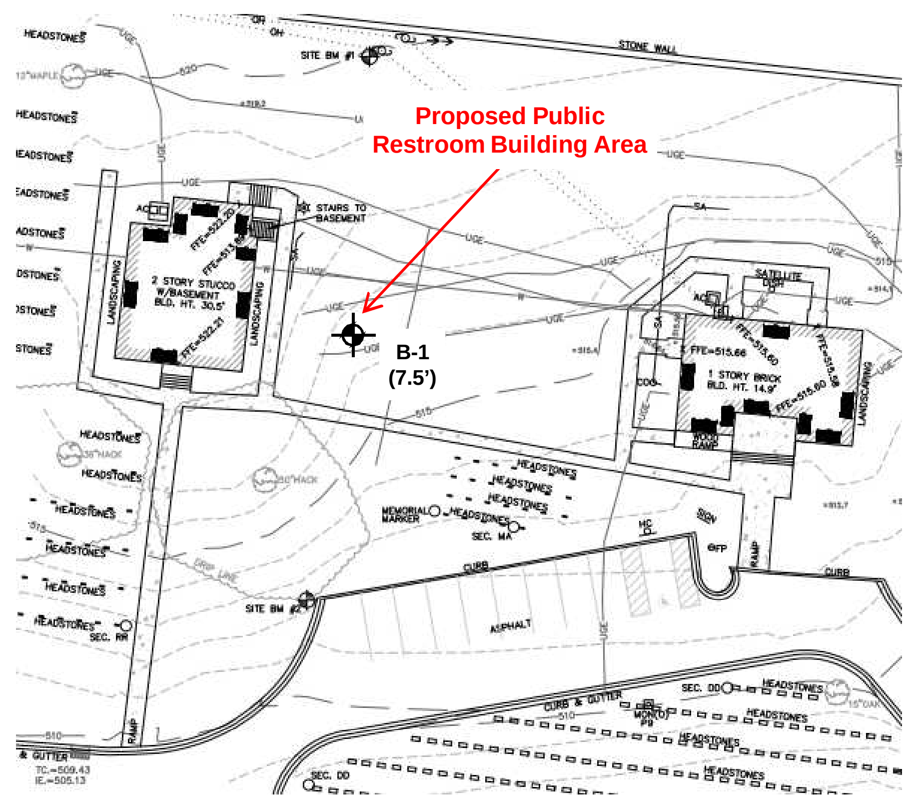
The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction, time, or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A
FIELD EXPLORATION





Notes

1. Sketch adapted from site plan provided by client.
2. Boring locations are approximate and were established via pacing and/or wheel counter.
3. Borings drilled on January 9, 2014

N

Legend

⌖ Approximate Boring Location

(5') Approximate Auger Refusal Depth (ft)

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager: AM	Project No. 18135044	Terracon Consulting Engineers & Scientists	BORING LOCATION PLAN
Drawn by: AM	Scale: N.T.S.	5217 Linbar Drive, Suite 309 Nashville, Tennessee 37211	PROPOSED IMPROVEMENTS TO NASHVILLE, NATIONAL CEMETERY Nashville, TN
Checked by: SV	File Name: Exh. A-1	PH. (615) 333-6444 FAX (615) 333-6443	Exhibit
Approved by: SV	Date: 14Jan2014		A-1

Field Exploration Description

The boring locations were laid out by a Terracon engineer. Distances from these locations to the reference features indicated on the attached diagram are approximate and were measured by pacing. Right angles for the boring location measurements were estimated. Ground surface elevations indicated on the boring logs were interpolated from the topographic survey and are rounded to the nearest ½ foot. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

The borings were drilled with a Geoprobe® drill rig using hollow-stem augers to advance the boreholes. Samples of the soil encountered in the borings were obtained using the split barrel sampling procedure. In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140 pound automatic hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in-situ relative density of cohesionless soils and consistency of cohesive soils. Upon completion of drilling, boreholes were backfilled with auger cuttings.

A CME automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A significantly greater efficiency is achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. This higher efficiency has an appreciable effect on the SPT-N value. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. Information provided on the boring logs attached to this report includes soil descriptions, consistency evaluations, boring depths, sampling intervals, and groundwater conditions. The borings were backfilled with auger cuttings prior to the drill crew leaving the site.

A field log of each boring was prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on laboratory observation and tests of the samples.

BORING LOG NO. B-1

PROJECT: National Cemetery Improvements

CLIENT: FourFront Design, Inc. Rapid City, SD

SITE: 1420 Gallatin Pike Madison, TN

LOCATION See Exhibit A-1

Surface Elev.: 512.5 (Ft.)

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
	0.3	**TOPSOIL**	512								
		LEAN CLAY (CL), brown, stiff					4-4-5 N=9	2.5 (HP)		23	
	3.0	**FAT CLAY (CH)**, light brown & tan, stiff to very stiff	509.5				4-4-6 N=10	2.5 (HP)		33	60-30-30
				5			7-9-10 N=19	2.75 (HP)		28	
	7.5	***Auger Refusal at 7.5 Feet***	505								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
5217 Linbar Dr., Suite 309
Nashville, Tennessee

Boring Started: 1/9/2014	Boring Completed: 1/9/2014
Drill Rig: Geoprobe 7822	Driller: T. Williams
Project No.: 18135044	Exhibit: A-3

BORING LOG NO. B-2

PROJECT: National Cemetery Improvements

CLIENT: FourFront Design, Inc. Rapid City, SD

SITE: 1420 Gallatin Pike Madison, TN

LOCATION See Exhibit A-1

Surface Elev.: 515 (Ft.)

DEPTH	Material Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.4	**TOPSOIL**	514.5								
	FILL - LEAN CLAY, grayish-brown				X	4-4-6 N=10	3.5 (HP)		15	
4.0	some limestone fragments in upper 3'	511								
5.5	**LEAN CLAY (CL)**, light brown, very stiff	509.5	5		X	6-7-10 N=17	4.5 (HP)		21	

Auger Refusal at 5.5 Feet

NOTE: Boring offset 2' west refused at 6'

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
5217 Linbar Dr., Suite 309
Nashville, Tennessee

Boring Started: 1/9/2014	Boring Completed: 1/9/2014
Drill Rig: Geoprobe 7822	Driller: T. Williams
Project No.: 18135044	Exhibit: A-4

BORING LOG NO. B-3

PROJECT: National Cemetery Improvements

CLIENT: FourFront Design, Inc. Rapid City, SD

SITE: 1420 Gallatin Pike Madison, TN

LOCATION See Exhibit A-1

Surface Elev.: 515 (Ft.)

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.4	**TOPSOIL**	514.5								
	FILL - LEAN CLAY, trace limestone fragments, dark brown				X	4-5-5 N=10	4.5 (HP)		29	
2.5		512.5								
	LEAN CLAY, dark brown to brown, very stiff									
	some limestone fragments below 3.5'				X	12-14-50/1" N=50/1"	1.5 (HP)		26	
5.0		510	5							

Auger Refusal at 5 Feet

NOTE: Offset boring refused at 5.5'

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method: Hollow Stem Auger

Abandonment Method: Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
5217 Linbar Dr., Suite 309
Nashville, Tennessee

Boring Started: 1/9/2014	Boring Completed: 1/9/2014
Drill Rig: Geoprobe 7822	Driller: T. Williams
Project No.: 18135044	Exhibit: A-5

BORING LOG NO. B-4

PROJECT: National Cemetery Improvements

CLIENT: FourFront Design, Inc. Rapid City, SD

SITE: 1420 Gallatin Pike Madison, TN

LOCATION See Exhibit A-1

Surface Elev.: 515 (Ft.)

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.2	**TOPSOIL**	515								
1.5	**LEAN CLAY (CL)**, trace limestone fragments, dark brownish-gray, stiff, possible fill	513.5				4-4-7 N=11	2.25 (HP)		27	
5.0	**LEAN CLAY/FAT CLAY (CL/CH)**, dark brown to brown, stiff fat clay below 3' trace limestone below 4'	510	5			50/2" N=50/2"	2.5 (HP)		33	

Auger Refusal at 5 Feet

NOTE: Offset boring refused at 5.5'

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
5217 Linbar Dr., Suite 309
Nashville, Tennessee

Boring Started: 1/9/2014	Boring Completed: 1/9/2014
Drill Rig: Geoprobe 7822	Driller: T. Williams
Project No.: 18135044	Exhibit: A-6

BORING LOG NO. B-5

PROJECT: National Cemetery Improvements

CLIENT: FourFront Design, Inc. Rapid City, SD

SITE: 1420 Gallatin Pike Madison, TN

LOCATION See Exhibit A-1

Surface Elev.: 508 (Ft.)

DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	LABORATORY TORVANE/HP (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI
0.3	**TOPSOIL**	507.5								
2.0	**FILL - LEAN CLAY**, occasional limestone fragments, dark brown & gray	506			X	5-5-7 N=12	4.5 (HP)		12	
6.0	**LEAN CLAY (CL)**, grayish-brown, very stiff with limestone fragments below 3'	502	5		X	11-10-7 N=17	3.5 (HP)		21	

Auger Refusal at 6 Feet

NOTE: Offset boring refused at 6.5'

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Borings backfilled with soil cuttings upon completion.

See Exhibit A-2 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
5217 Linbar Dr., Suite 309
Nashville, Tennessee

Boring Started: 1/9/2014	Boring Completed: 1/9/2014
Drill Rig: Geoprobe 7822	Driller: T. Williams
Project No.: 18135044	Exhibit: A-7

APPENDIX B
LABORATORY TESTING

Laboratory Testing

The laboratory testing program consisted of performing water content tests and an Atterberg Limits test on representative soil samples. Information from these tests was used in conjunction with field penetration test data to evaluate soil strength in-situ, volume change potential, and soil classification. In addition, a hand penetrometer was used to estimate the approximate unconfined compressive strength of some samples. The hand penetrometer has been correlated with unconfined compression tests and provides a better estimate of soil consistency than visual examination alone. The test results are provided on the boring logs included in Appendix A.

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING		WATER LEVEL		FIELD TESTS	
Standard Penetration Test		▽ Water Initially Encountered ▽ Water Level After a Specified Period of Time ▼ Water Level After a Specified Period of Time Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.		(HP) Hand Penetrometer (T) Torvane (DCP) Dynamic Cone Penetrometer (PID) Photo-Ionization Detector (OVA) Organic Vapor Analyzer	

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.