



August 30, 2016

Valhalla Engineering Group, LLC  
2629 West Main Street, Suite 190  
Littleton, Colorado 80120

ATTENTION: Mr. Sam Lundgren, P.E., C.E.O.  
[slundgren@valhallaengineering.com](mailto:slundgren@valhallaengineering.com)

Subject: **REPORT OF GEOTECHNICAL EXPLORATION**  
**Mountain Home VA Medical Center – MRI Addition**  
Mountain Home, Tennessee  
GEOServices Project No. 51-16069

Dear Mr. Lundgren:

We are submitting the results of the additional geotechnical exploration performed for the subject project. The following report presents our findings and recommendations for the proposed MRI Addition at Mountain Home Veteran Affairs Medical Center (VAMC) in Mountain Home, Tennessee.

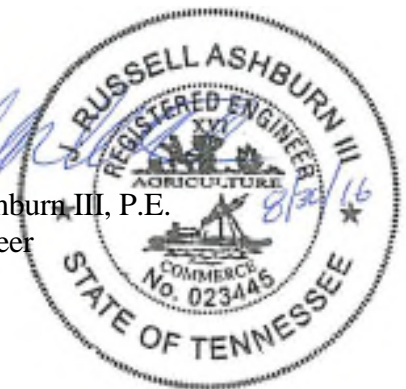
GEOServices sincerely appreciates the opportunity to serve as your geotechnical consultant. Should you have any questions regarding this report, or if we can be of any further assistance, please contact us at your convenience.

Sincerely,

**GEOServices, LLC**

Alex J. Merritt, E.I.  
Staff Professional

J. Russell Ashburn III, P.E.  
Senior Engineer  
TN 23,445



**Submitted to:**

**Valhalla Engineering Group, LLC  
2629 West Main Street, Suite 190  
Littleton, Colorado 80120**

# **REPORT OF GEOTECHNICAL EXPLORATION**

## **MOUNTAIN HOME VA MEDICAL CENTER – MRI ADDITION**

**Mountain Home, Tennessee**

**Submitted by:**

**GEOServices, LLC  
10368 Wallace Alley Street, Suite 5  
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**Phone (423) 212-2163**



**GEOSERVICES, LLC  
PROJECT NO. 51-16069**

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## **1.0 INTRODUCTION**

### **1.1 PURPOSE**

The purpose of this geotechnical exploration was to obtain geotechnical information in order to provide recommendations related to the foundation design and construction of the proposed new MRI Addition at the Mountain Home VAMC in Mountain Home, Tennessee. This report provides recommendations for general site preparation, grading, excavations, and foundation support for the proposed addition.

### **1.2 PROJECT INFORMATION AND SITE DESCRIPTION**

The subject property is located on the Mountain Home Veterans Affairs Medical Center (VAMC) campus in Mountain Home, Tennessee along the west side of the south wing of the main hospital structure (Building #200). Project information was provided by you via email correspondence, dated August 2, 2016, and our telephone conversation on August 8, 2016. Project information was received in the form of *Geotechnical Engineering Report* provided by Terracon Consultants, Inc., dated July 20, 2016; the *Preliminary 35% Submittal* provided by Tysinger, Hampton, & Partners, Inc., dated June 23, 2016; historical boring data of the surrounding campus structure provided by Gresham, Smith and Partners, dated January 13, 1986; and, 35% Schematic Design Plans from you. Based on the information provided, we understand that the subject project will consist of a one-story MRI building addition with a footprint of approximately 3,500 square feet. Structural information was provided by the structural engineer. It is our understanding that the proposed structure will consist of concrete slabs-on-grade and structural steel frame construction with a brick veneer. We anticipate maximum column loads on the order of 60 kips or less and continuous foundation wall loads of 2 to 3 kips per linear foot or less.

Due to previous grading operations during the construction of the surrounding hospital structures, we anticipate the site will require minimal grading operations, with maximum cuts and fills on the order of 3 to 5 feet, to establish final grades.

### **1.3 SCOPE OF STUDY**

This geotechnical exploration involved a site reconnaissance, field drilling, laboratory testing, and engineering analysis. The following sections of this report present discussions of the field exploration, site conditions, and conclusions and recommendations. Following the text of this report, Appendix A presents figures and test boring records. Appendix B presents a summary of laboratory test results.

## 2.0 EXPLORATION AND TESTING PROGRAMS

### 2.1 FIELD EXPLORATION

The site subsurface conditions were explored with five soil test borings (C-1 through C-5). Each of the borings were located within the proposed building footprint. The approximate boring locations are shown on the Boring Location Plan, Figure 2 of Appendix A. The boring locations were marked in the field by GEOServices representatives. The locations were obtained by measuring distances from known site reference points. Drilling was performed on August 29, 2016. The depths reference the ground surface at the site that existed at the time of the exploration. The borings were advanced using 2.25-inch inside diameter hollow stem augers (HSA) with a track-mounted CME 550 ATV drill rig. The drill crew worked in general accordance with ASTM D6151 (HSA Drilling). Sampling of overburden soils was accomplished using the standard penetration test procedure (ASTM D1586). Detailed test boring records are presented in Appendix A.

### 2.2 LABORATORY TEST PROGRAM

Soil samples collected during drilling were transported to our laboratory for visual classification and laboratory testing. The following laboratory testing was performed on select samples to determine various properties of the soil:

- Atterberg Limits (ASTM D4318): One (1) Atterberg Limits tests was performed for this project. This test helps us to confirm our visual classifications according to the Unified Soil Classification System (USCS). The plastic limit and liquid limit represent the moisture content at which a cohesive soil changes from a semi-solid to a plastic state and from a plastic state to liquid state, respectively.
- Natural Moisture Content (ASTM D2216): Moisture content determinations were performed on 30 samples for this project. The natural moisture content is defined as the ratio of the

weight of water present in the soil to the dry weight of soil. The test results are presented on individual laboratory data sheets and a Soil Data Summary, both enclosed in Appendix B.



### **3.0 SUBSURFACE CONDITIONS**

#### **3.1 GEOLOGIC CONDITIONS**

The project site, and most of East Tennessee, lies in the Appalachian Valley and Ridge Physiographic Province. The Province is characterized by elongated, northeasterly-trending ridges formed on highly resistant sandstones and shales. Between ridges, broad valleys and rolling hills are formed primarily on less resistant limestones, dolomites and shales.

Published geologic information indicates that the site is underlain by bedrock of the Knox Group, which is not differentiated into its individual formations in this area. The Knox Group, where undivided, consists of siliceous dolomite and interbedded limestone. These rock units weather to produce a thick residual clay overburden. Silica in the form of chert is resistant to weathering and is scattered in various quantities throughout the clay residuum.

Since the bedrock formation at the site contains limestone, the site is susceptible to the typical carbonate hazards of irregular weathering, cave and cavern conditions, and overburden sinkholes. Carbonate rock, while appearing very hard and resistant, is soluble in slightly acidic water. This characteristic, plus differential weathering of the bedrock mass, is responsible for the hazards. Of these hazards, the occurrence of sinkholes is potentially the most damaging to overlying soil supported structures. In East Tennessee, sinkholes occur primarily due to differential weathering of the bedrock and “flushing” or “raveling” of overburden soils into the cavities in the bedrock. The loss of solids creates a cavity or “dome” in the overburden. Growth of the dome over time or excavation over the dome can create a condition in which rapid, local subsidence or collapse of the roof of the dome occurs.

## **3.2 SUBSURFACE CONDITIONS**

### ***3.2.1 Surficial Materials***

A surface layer of topsoil and root mat was encountered in each of the five soil test borings. The surficial topsoil layer at this site extended to depths ranging from 4 to 6 inches. Existing fill soils were encountered beneath the surficial materials in each of the soil test borings.

### ***3.2.2 Existing Fill***

Beneath the surficial materials, existing fill soils were encountered in each of the borings to depths ranging from 5 to 7.5 feet. Fill is generally classified as material that has been transported and placed by man. The fill materials generally consist of reddish brown clays with varying quantities of rock fragments. The Standard Penetration Test (SPT) N-values are used to evaluate the consistency of the subsurface soils. The N-values of the fill typically ranged from 4 to 17 blows per foot (bpf) of penetration, indicating a relative consistency of firm to very stiff. However, the N-values of the fill materials at this site more typically ranged from about 6 to 13 bpf, indicating a consistency of firm to stiff. The higher blow counts were likely inflated due to the presence of rock fragments.

The natural moisture contents of the fill ranged from 18.1 to 49.0 percent. Atterberg limits testing on one selected sample of the fill revealed a liquid limit (LL) of 70 percent and plasticity index (PI) of 40 percent. The tested soil is classified as CH (fat clay) in general accordance with the Unified Soil Classification System (USCS).

### ***3.2.3 Residual Soils***

Beneath the existing fill in each of the borings residual soils were encountered to auger refusal depths ranging from 15 to 28 feet. Residual soils are classified as soils which have been formed in place from the weathering of the underlying bedrock. The residual soils generally consist of reddish brown and clays and tan to brown silts. The N-values of the residuum ranged from 3 to 50 blows per 1 inches of penetration, indicating a relative consistency of soft to hard. However, N-

values of the residual soils more typically ranged from about 3 to 10 bpf of penetration, indicating a relative consistency of soft to stiff.

The natural moisture contents of the residuum ranged from 28.6 to 53.6 percent and generally increased with depth.

#### **3.2.4 Subsurface Water**

Subsurface water was observed in boring C-1 at the completion of drilling at a depth of 25 feet below the existing ground surface. Subsurface water levels may fluctuate due to seasonal changes in precipitation amounts. Additionally, discontinuous zones of perched water may exist within the overburden and/or at the contact with bedrock. The groundwater information presented in this report is the information that was collected at the time of our field activities.

#### **3.2.5 Auger Refusal Conditions**

Each of the 5 borings were extended to auger refusal materials. Auger refusal was encountered at depths ranging from 15 to 28 feet. A summary of the refusal depths is presented in the table below:

Boring	Refusal Depth (ft.)
C-1	28.0
C-2	23.0
C-3	19.5
C-4	15.0
C-5	18.7

Refusal is a designation applied to any material that cannot be removed by the power auger. Auger refusal may indicate dense gravel or cobble layers, boulders, rock ledges or pinnacles, or the top of continuous bedrock. Since rock coring was beyond the scope of this exploration, the character and continuity of the refusal materials could not be determined; however, based on our

observations and experience with the geology, we anticipate the refusal materials in these borings is the underlying bedrock.

### ***3.2.6 General***

The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The boring logs included in Appendix A should be reviewed for specific information at individual boring locations. The depth and thickness of the subsurface strata indicated on the boring cross-sections were generalized from and interpolated between test locations. The transition between materials will likely be more abrupt than gradual in this geologic setting. Information on actual subsurface conditions exists only at the specific boring locations and is relevant to the time the exploration was performed. Variations may occur and should be expected between boring locations. The stratification lines were used for our analytical purposes and, unless specifically stated otherwise, should not be used as the basis for design or construction cost estimates.

## **4.0 CONCLUSIONS AND RECOMMENDATIONS**

### **4.1 SITE ASSESSMENT**

The results of the field exploration indicate that the site is adaptable for the proposed VAMC MRI Addition. However, like most sites there are some challenges associated with the development of this site. These challenges include the undocumented fill materials, moderate plasticity soils, and underlying karst geology.

#### ***4.1.1 Existing Fill***

Existing fill was encountered in each of the five soil test borings during this exploration to depths ranging from about 5 to 7.5 feet below the existing ground surface. We are not aware of, nor have we been provided with testing records for the fill. We anticipate the fill was placed during construction of the adjacent hospital facilities. Typically, the fill soils encountered at this site were firm to stiff in consistency with N-values ranging from 6 to 13 bpf. Properly placed engineered fills typically produce N-values on the order of about 10 to 12 bpf. During foundation construction, some isolated areas of softer, unsuitable fill soils may likely be encountered. If unsuitable areas are encountered within the foundation excavations, these areas should be undercut to a depth specified by the geotechnical engineer and backfilled with dense-graded aggregate or flowable fill (lean concrete). A GEOServices' geotechnical engineer or his qualified representative should be onsite to observe the individual foundation conditions prior to concrete placement in order to verify that the recommendations herein have been completed.

#### ***4.1.2 Moderate Plasticity Soils***

Based on our experience in the East Tennessee area, soils with plasticity indices (PI) less than 30 percent have a slight potential for volume changes with changes in moisture content, and soils with a PI greater than 50 percent are highly susceptible to volume changes. Between these values, we consider the soils to be moderately susceptible to volume changes. The laboratory test results indicate that the soils at this site are moderately susceptible with a PI of 40 percent for

the sample tested. Based on these values and the proposed structure, we anticipate these soils to be moderately susceptible to volume change. The volume changes are most critical directly beneath lightly loaded foundations and especially lightly loaded floor slabs. We recommend that once the building pad is constructed, additional samples of the near surface soils be obtained and the plasticity index of these soils be evaluated to better determine if the soils directly beneath the foundations and floor slab will be susceptible to volume changes. There are precautions that can be taken, if desired, to reduce the potential of impacts on the structure due to these soils.

Additional considerations are presented in **Section 5.3 Moderate Plasticity Soil Considerations** of this report.

#### **4.1.3 Karst Geology**

This site is underlain by karst geology. There is a certain degree of risk with respect to sinkhole formation and subsidence that should be considered with any site located within geologic areas underlain by potentially soluble rock units. While a rigorous effort to assess the potential for sinkhole formation at this site was beyond the scope of this evaluation, we did not observe any obvious signs of sinkholes or closed depressions at the site. In addition, there were no significant depths (in excess of 10 to 15 feet) of soft to very soft soils above top of rock, which can be an indicator of karst activity, observed in these borings. However, as previously discussed, there is a certain degree of risk for sinkhole formation for any site underlain by karst geology. Based on our site observations and soil test boring data, we do not feel this site has any greater risk for sinkhole formation than other sites in this immediate area.

## **4.2 SITE PREPARATION RECOMMENDATIONS**

### **4.2.1 Subgrade**

Surficial concrete and topsoil, as well as any trees, grass, and other debris should be removed from the proposed construction areas. In addition, any existing utilities beneath the proposed building location should be abandoned and/or removed and replaced with compacted structural fill soils. In previously developed areas, it is not uncommon to encounter pockets of construction debris or

other deleterious material. These materials, if encountered, should be removed and replaced with properly compacted structural soil fill. After completion of any stripping operations and any required excavations to reach subgrade level, we recommend that the subgrade be proofrolled with a fully-loaded, tandem-axle dump truck or other pneumatic-tired construction equipment of similar weight. Consistency of the subgrade material. Areas judged to perform unsatisfactorily should be remediated at the geotechnical engineer's discretion. Typically, remedial options consist of undercutting and replacement with compacted structural soil fill or crushed stone fill.

#### ***4.2.2 Structural Soil Fill***

Material considered suitable for use as compacted fill should be clean soil free of organics, trash, and other deleterious material, containing no rock fragments greater than 6 inches in any one dimension. Preferably, borrow material to be used as structural soil fill should have a standard Proctor maximum dry density of 90 pounds per cubic foot (pcf) or greater and a plasticity index (PI) of 30 percent or less. All material being used as soil fill should be tested and confirmed by the geotechnical engineer to be in accordance with the project requirements before being placed.

Structural soil fill should be placed in loose, horizontal lifts not exceeding 8 inches in thickness. Each lift should be compacted to at least 95 percent of maximum dry density per the standard Proctor method (ASTM D698) and within the range of minus 2 percent to plus 3 percent of the optimum moisture content. Each lift should be compacted and tested by geotechnical personnel to confirm that the contractor's method is capable of achieving the project requirements before placing any subsequent lifts. Any areas which have become soft or frozen should be removed before additional structural fill is placed.

#### ***4.2.3 Compacted Crushed Stone Fill***

Compacted crushed stone (dense-graded aggregate) fill should be Type A, Class A, and Grading E in accordance with Section 903.05 of the Tennessee Department of Transportation specifications. The crushed stone fill should be placed in loose, horizontal lifts not exceeding 10 inches in loose thickness. Each lift should be compacted to at least 98 percent of maximum dry density per the standard Proctor

method (ASTM D698). Each lift should be compacted and tested by geotechnical personnel to confirm that the contractor's method is capable of achieving the project requirements before placing any subsequent lifts.

## 4.3 FOUNDATION RECOMMENDATIONS

### 4.3.1 Shallow Foundations

Foundations for the proposed MRI Addition are anticipated to bear in the existing firm to stiff fill materials. The recommended net allowable bearing capacity for design of the foundations is **2,000 pounds per square foot** (psf). We recommend that continuous foundations be a minimum of 18 inches wide and isolated spread footings be a minimum of 24 inches wide to reduce the possibility of a localized punching shear failure. All exterior footings should be designed to bear at least 18 inches below finished exterior grade to protect against frost heave. If intact rock is encountered at or above the foundation bearing elevations, it should be over excavated at least 12 inches below the foundation bearing elevation and backfilled with either structural soil fill or crushed stone. This is performed to reduce to the potential for point loading the foundations at soil/rock transitions which can cause cracking of the foundations.

Foundation subgrade observations should be performed by a GEOServices geotechnical engineer, or his qualified representative, so that the recommendations provided in this report are consistent with the site conditions encountered. A dynamic cone penetrometer (DCP) is commonly utilized to provide information that is compared to the data obtained in the geotechnical report. Where unacceptable soft materials are encountered, the material should be excavated to stiff, suitable soils or remediated at the geotechnical engineer's direction. Typical remedial measures consist of undercutting any soft materials and replacing with properly compacted fill soil, crushed stone, or flowable fill (lean concrete).



#### 4.3.2 Slabs-on-grade

For slab-on-grade construction, the site should be prepared as described previously. We recommend that the subgrade be topped with a minimum 4-inch layer of crushed stone (mineral aggregate base or a dense graded aggregate base) in the building area to act as a capillary moisture layer. The subgrade should be proofrolled and approved prior to the placement of the crushed stone. Based on the conditions encountered on this site, we recommend that the floor slabs bearing in soil be designed using a subgrade modulus of 125 pounds per cubic inch (pci). This modulus is based on a 1 foot by 1 foot area and should be adjusted (reduced) for wider loads.

#### 4.3.3 Seismic Conditions

##### International Building Code, 2012

The project site is located approximately 400 miles from the New Madrid seismic source zone as designated by the United States Geologic Survey. In accordance with the International Building Code, 2012, we have provided the following table of seismic design information. After evaluating the subsurface conditions at the site, it was determined that this structure would be located within seismic site class C. A table follows, showing the calculated spectral response accelerations for both a short and 1-second period.

Structure	S <sub>s</sub> g	S <sub>1</sub> G	S <sub>DS</sub> g	S <sub>D1</sub> G
Mountain Home VAMC MRI Addition – Mountain Home, Tennessee	0.304	0.104	0.243	0.118

#### 4.3.4 Settlement

We have estimated the total and differential settlements expected at this site based on the Federal Highways Administrations (FHWA) Empirical Settlement Analysis Procedure. This FHWA empirical method allows the use of the SPT N-values in this calculation and includes the type of soil encountered. Based on the conditions encountered in our soil borings and the provided foundation loads, maximum total settlements of less than 1 inch and maximum differential settlements of less than 3/4-inch in 40 feet can be expected.

## 4.4 PAVEMENT DESIGN RECOMMENDATIONS

### 4.4.1 Flexible Pavement Design

AASHTO flexible pavement design methods have been utilized for pavement recommendations. Our recommendations are based on the assumptions that the subgrade has been properly prepared as described previously. Traffic loading had not been provided at the time this report was prepared; however, we anticipate that the traffic will be mainly cars with occasional delivery trucks. Based on our experience with similar projects with flexible pavement we recommend the following light duty and medium duty flexible pavement section:

Recommended Thickness (Inches)		
Pavement Materials	Light Duty	Heavy Duty
Bituminous Asphalt Surface Mix	1.0	1.5
Bituminous Asphalt Base Mix	2.0	2.0
Compacted Crushed Aggregate Base	6.0	8.0

We recommend a base stone equivalent to a Type A, Class A and Grading D in accordance with Section 903.05 of the Tennessee Department of Transportation specifications. The bituminous asphalt pavement should be Grading "E" as per Section 411 for the surface mix and Grading "B" as per section 307 for the binder mix. Compaction requirements for the crushed aggregate base and the bituminous asphalt pavement should generally follow Tennessee Department of Transportation specifications.

The recommended pavement thicknesses presented in this report section are considered typical and minimum for the assumed parameters in the general site area. We understand that budgetary considerations sometimes warrant thinner pavement sections than those presented. However, the

client, the owner, and the project designers should be aware that thinner pavement sections may result in increased maintenance costs and lower than anticipated pavement life.

#### ***4.4.2 Rigid Pavement Design***

If areas could possibly be subjected to heavy vehicle loads, these areas may require the use of rigid pavement. If rigid pavement is required for the unloading or trash dumpster area, we recommend the following rigid pavement section:

<b>Pavement Materials</b>	<b>Recommended Minimum Thickness (Inches)</b>
4,000 psi Type I Concrete	5.0
Compacted Crushed Aggregate Base	4.0

Concrete should be reinforced with welded wire fabric or reinforcing bars to assist in controlling cracking from drying shrinkage and thermal changes. Sawed or formed control joints should be included for each 225 square feet of area or less (15 feet by 15 feet). Saw cuts should not cut through the welded wire fabric or reinforcing steel and dowels should be utilized at formed and/or cold joints.

#### ***4.4.3 General***

Our recommendations are based upon the assumption that the subgrade has been properly prepared as described in previous report sections and that any off-site soil borrow to be used to backfill to the final subgrade meets the requirements for structural soil fill.

All paved areas should be constructed with positive drainage to direct water off-site and to minimize surface water seeping into the pavement subgrade. The subgrade should have a minimum slope of 1 percent. In down grade areas, the basestone should extend through the slope to allow any water entering the basestone a path to exit. For rigid pavements, water-tight seals should also be provided at formed construction and expansion joints.

## **5.0 CONSTRUCTION CONSIDERATIONS**

### **5.1 EXCAVATIONS**

Auger refusal materials were encountered in each of our soil test borings at depths ranging from about 15 to 28 feet. As mentioned previously, we anticipate that minimal site grading will be required to establish final grades at this site with maximum cuts and fills on the order of 3 to 5 feet. Although unlikely, there is still the potential that rock may be encountered at shallower depths due to the erratic weathering of the underlying limestone, and partially weathered rock and/or rock pinnacles or ledges requiring difficult excavation techniques may be encountered in site areas between our boring locations.

Excavations should be sloped or shored in accordance with local, state, and federal regulations, including OSHA (29 CFR Part 1926) excavation trench safety standards. The contractor is usually solely responsible for site safety. This information is provided only as a service and under no circumstances should GEOServices be assumed to be responsible for construction site safety.

### **5.2 MOISTURE SENSITIVE SOILS**

The fine-grained soils encountered at this site will be sensitive to disturbances caused by construction traffic and changes in moisture content. During wet weather periods, increases in the moisture content of the soil can cause significant reduction in the soil strength and support capabilities. Construction traffic patterns should be varied to prevent the degradation of previously stable subgrade. In addition, plastic soils which become wet may be slow to dry and thus significantly retard the progress of grading and compaction activities. We caution if site grading is performed during the wet weather season, methods such as disking and allowing the material to dry will be required to meet the required compaction recommendations. It will, therefore, be advantageous to perform earthwork and foundation construction activities during dry weather.

### **5.3 MODERATE PLASTICITY SOIL CONSIDERATIONS**

Based on our experience in the East Tennessee area, soils with plasticity indices (PI) less than 30 percent have a slight potential for volume changes with changes in moisture content, and soils with a PI greater than 50 percent are highly susceptible to volume changes. Between these values, we consider the soils to be moderately susceptible to volume changes. The laboratory test results indicate that the soils at this site are moderately susceptible with a PI value of 40 percent for one sample tested. We recommend that once subgrade for the new addition is completed, additional samples be obtained for plasticity testing to further evaluate if corrective actions are needed for foundations and/or floor slabs.

Highly plastic soils have the potential to shrink or swell with significant changes in moisture content. Unlike other areas of the country where high plasticity soils cause considerable foundation problems, East Tennessee does not typically endure long periods of severe drought or wet weather. However, in recent years drought conditions have been sufficient to cause soil shrinkage and related structural distress of buildings, floor slabs and pavements at sites underlain by high plasticity soils.

Several construction considerations may reduce the potential for volume changes in the subgrade soils. Foundations should be excavated, checked, and concreted in the same day to prevent excessive wetting or drying of the foundation soils. The site should be graded in order to drain surface water away from the structure's subgrade both during and after construction.

### **5.4 DRAINAGE AND SURFACE WATER CONCERNS**

To reduce the potential for undercut and remediation of the existing soils, water should not be allowed to collect in the foundation excavations or on prepared subgrades of the construction area either during or after construction. Undercut or excavated areas should be sloped toward one corner to facilitate removal of any collected rainwater, subsurface water, or surface runoff. Positive site surface drainage should be provided to reduce infiltration of surface water around the perimeter of the building and beneath the floor slabs. The grades should be sloped away from the structure and

surface drainage should be collected and discharged such that water is not permitted to infiltrate the foundation excavations or construction areas.

## **6.0 LIMITATIONS**

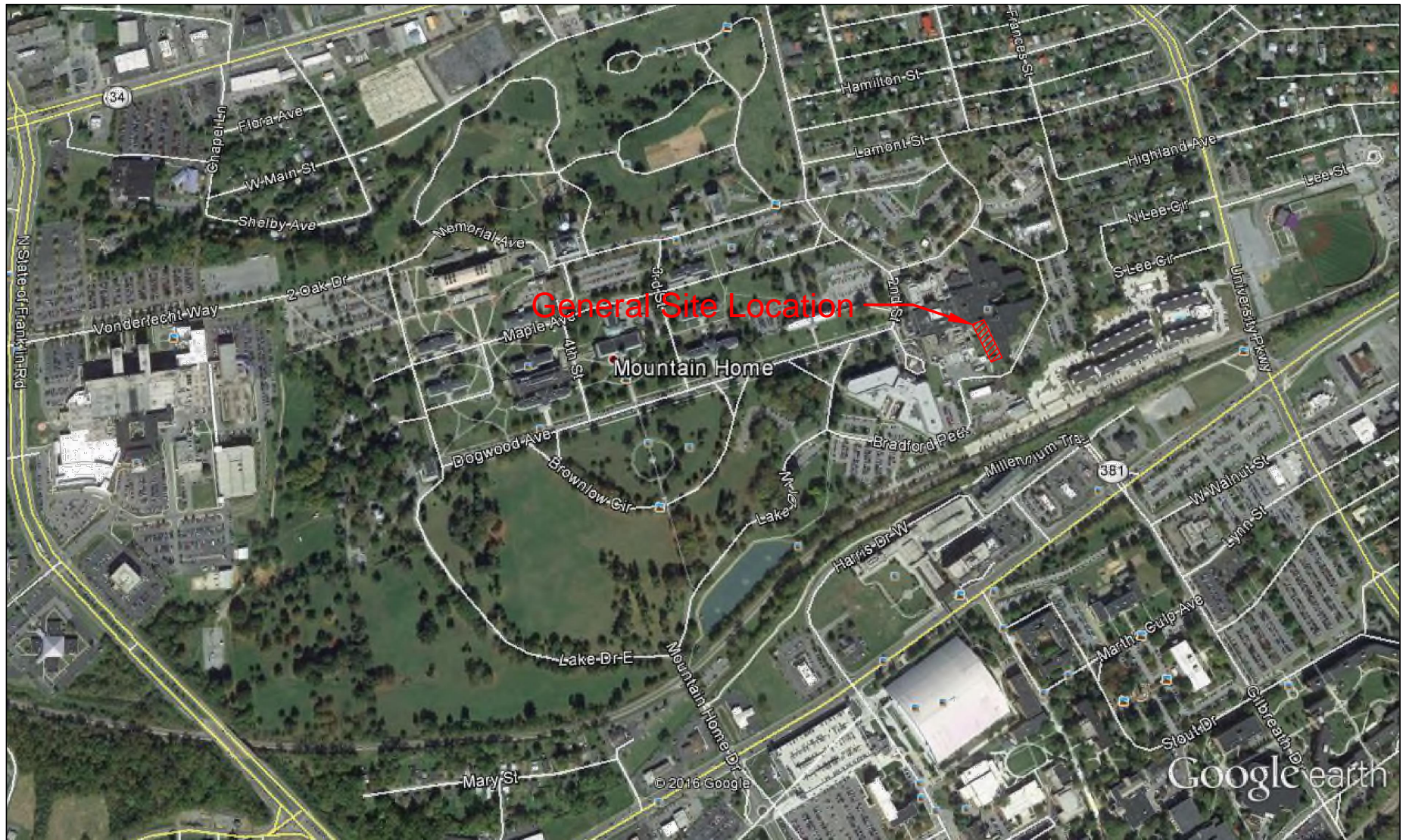
This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. This report is for our geotechnical work only, and no environmental assessment efforts have been performed. The conclusions and recommendations contained in this report are based upon applicable standards of our practice in this geographic area at the time this report was prepared. No other warranty, express or implied, is made.

The analyses and recommendations submitted herein are based, in part, upon the data obtained from the exploration. The nature and extent of variations between the borings will not become evident until construction. We recommend that GEOServices be retained to observe the project construction in the field. GEOServices cannot accept responsibility for conditions which deviate from those described in this report if not retained to perform construction observation and testing. If variations appear evident, then we will re-evaluate the recommendations of this report. In the event that any changes in the nature, design, or location of the project are planned, the conclusions and recommendations contained in this report will not be considered valid unless the changes are reviewed and conclusions modified or verified in writing. Also, if the scope of the project should change significantly from that described herein, these recommendations may have to be re-evaluated.

## **APPENDIX A**

### Figures and Test Boring Records





# NOTES:

1) Base Map: Google Earth

SCALE:	N.T.S.
CHECKED BY:	AJM
DRAWN BY:	DKA
DATE:	08/15/2016



10368 Wallace Alley Street Suite 5  
Kingsport, Tennessee

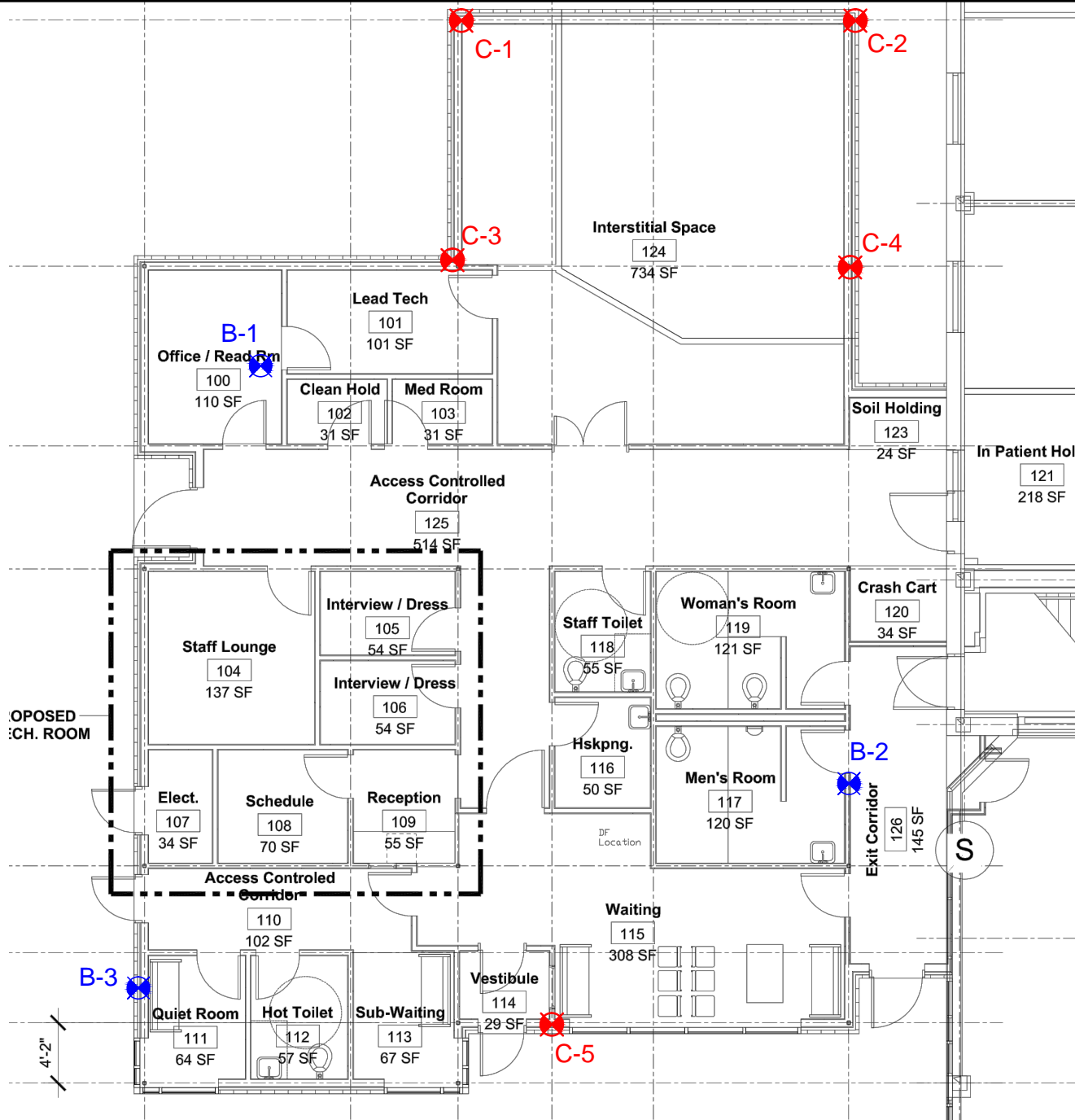
Phone: (423) 212-2163

Site Vicinity Map	
Mountain Home VAMC MRI Addition	
Mountain Home, Tennessee	
JOB NO:	51-16069

FIGURE NO:

1





#### LEGEND:

- 1) Approximate Boring Location.
- 1) Approximate Locations of Borings Performed by Terracon.

#### NOTES:

- 1) Base map provided by Valhalla Engineering Group, LLC.

SCALE: N.T.S.

CHECKED BY: AJM

DRAWN BY: DKA

DATE: 08/23/2016



10368 Wallace Alley Street Suite 5  
Kingsport, Tennessee 37663

Phone: (423) 212-2163

Boring Location Plan

Mountain Home VAMC MRI Addition

Mountain Home, Tennessee

JOB NO:

51-16069

FIGURE NO:

2

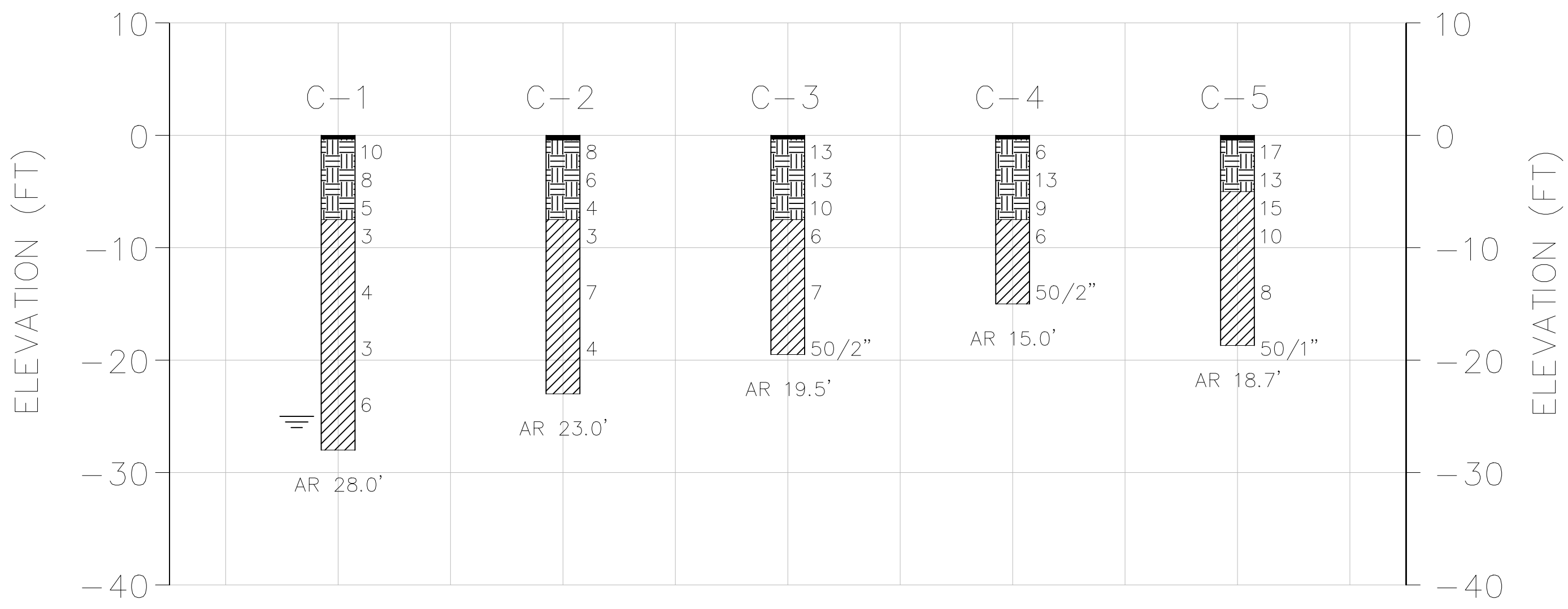
LEGEND:

 TOPSOIL/ROOT MAT

 EXISTING FILL

 RESIDUUM

 WATER LEVEL



**GEOS**  
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SCALE:	NTS
JOB NO.:	51-16069
DATE:	8/24/2016

**Generalized Soil Boring Profile**

**Mountain Home VAMC MRI Addition**

Mountain Home, Tennessee

- NOTES:
- 1.) BORING LOCATIONS ARE SHOWN IN GENERAL ARRANGMENT ONLY.
  - 2.) DO NOT USE BORING LOCATIONS FOR DETERMINATIONS OF DISTANCES OR QUANTITIES.
  - 3.) GROUND SURFACED IS REPRESENTED AS ZERO ELEVATION

FIGURE 3

# GENERAL NOTES

## FINE AND COARSE GRAINED SOIL PROPERTIES

### PARTICLE SIZE

BOULDERS:	GREATER THAN 300 mm
COBBLES:	75 mm to 300 mm
GRAVEL:	4.74 mm to 75 mm
COARSE SAND:	2 mm to 4.74 mm
MEDIUM SAND:	0.425 mm to 2 mm
FINE SAND:	0.075 mm to 0.425 mm
SILTS & CLAYS:	LESS THAN 0.075 mm

### COARSE GRAINED SOILS (SANDS & GRAVELS)

N-VALUE	RELATIVE DENSITY
0 - 4	VERY LOOSE
5 - 10	LOOSE
11 - 30	MEDIUM DENSE
31 - 50	DENSE
OVER 50	VERY DENSE

### FINE GRAINED SOILS (SILTS & CLAYS)

N-VALUE	CONSISTENCY	Qu, PSF
0 - 2	VERY SOFT	0 - 500
3 - 4	SOFT	500 - 1000
5 - 8	FIRM	1000 - 2000
9 - 15	STIFF	2000 - 4000
16 - 30	VERY STIFF	4000 - 8000
OVER 31	HARD	8000 +

## STANDARD PENETRATION TEST (ASTM D1586)

THE STANDARD PENETRATION TEST AS DEFINED BY ASTM D1586 IS A METHOD TO OBTAIN A DISTURBED SOIL SAMPLE FOR EXAMINATION AND TESTING AND TO OBTAIN RELATIVE DENSITY AND CONSISTENCY INFORMATION. THE 1.4 INCH I.D./2.0 INCH O.D. SAMPLER IS DRIVEN 3-SIX INCH INCREMENTS WITH A 140 LB. HAMMER FALLING 30 INCHES. THE BLOW COUNTS REQUIRED TO DRIVE THE SAMPLER THE FINAL 2 INCREMENTS ARE ADDED TOGETHER AND DESIGNATED THE N-VALUE. AT TIMES, THE SAMPLER CAN NOT BE DRIVEN THE FULL 18 INCHES. THE FOLLOWING REPRESENTS OUR INTERPRETATION OF THE STANDARD PENETRATION TEST WITH VARIATIONS.

### BLOWS/FOOT (N-VALUE)

### DESCRIPTION

25.....	.....25 BLOWS DROVE SAMPLER 12" AFTER INITIAL 6" SEATING
75/10".....	.....75 BLOWS DROVE SAMPLER 10" AFTER INITIAL 6" SEATING
50/PR.....	.....PENETRATION REFUSAL OF SAMPLER AFTER INITIAL 6" SEATING

## SAMPLING SYMBOLS

ST:	UNDISTURBED SAMPLE
SS:	SPLIT SPOON SAMPLE
CORE:	ROCK CORE SAMPLE
AU:	AUGER OR BAG SAMPLE

## SOIL PROPERTY SYMBOLS

N:	STANDARD PENETRATION, BPF
M:	MOISTURE CONTENT %
LL:	LIQUID LIMIT %
PI:	PLASTICITY INDEX %
Qp:	POCKET PENETROMETER VALUE, TSF
Qu:	UNCONFINED COMPRESSIVE STRENGTH, TSF
DUW:	DRY UNIT WEIGHT, PCF

## ROCK PROPERTIES

### ROCK HARDNESS

### ROCK QUALITY DESIGNATION (RQD)

PERCENT	QUALITY
90 TO 100	EXCELLENT
75 TO 90	GOOD
50 TO 75	FAIR
25 TO 50	POOR
0 TO 25	VERY POOR

VERY SOFT:	ROCK DISINTEGRATES OR EASILY COMPRESSES TO TOUCH: CAN BE HARD TO VERY HARD SOIL.
SOFT:	ROCK IS COHERANT BUT BREAKS EASILY TO THUMB PRESSURE AT SHARP EDGES AND CRUMBLES WITH FIRM HAND PRESSURE.
MODERATELY HARD:	SMALL PIECES CAN BE BROKEN OFF ALONG SHARP EDGES BY CONSIDERABLE HARD THUMB PRESSURE: CAN BE BROKEN BY LIGHT HAMMER BLOWS.
HARD:	ROCK CAN NOT BE BROKEN BY THUMB PRESSURE, BUT CAN BE BROKEN BY MODERATE HAMMER BLOWS.
VERY HARD:	ROCK CAN BE BROKEN BY HEAVY HAMMER BLOWS.



**Mountain Home VAMC MRI Addition**  
**Mountain Home, Tennessee**  
GEO Services Project No.: 51-16069

LOG OF BORING **C-1**  
SHEET 1 OF 2

DRILLER Shannon Snow  
ON-SITE REP. \_\_\_\_\_

BORING NO. / LOCATION C-1 DRY ON COMPLETION ? No

DATE August 19, 2016 SURFACE ELEV. 0.0 FT.  
REFUSAL: Yes DEPTH 28.0 FT. ELEV. -28.0 FT.  
SAMPLED 28.0 FT. 8.5 M  
TOP OF ROCK DEPTH 28.0 FT. ELEV. -28.0 FT.  
BEGAN CORING DEPTH \_\_\_\_\_ FT. ELEV. \_\_\_\_\_ FT.  
FOOTAGE CORED (LF) \_\_\_\_\_ FT.  
BOTTOM OF HOLE DEPTH 28.0 FT. ELEV. -28.0 FT.

**WATER LEVEL DATA (IF APPLICABLE)**  
COMPLETION: DEPTH 25.0 FT.  
ELEV. -25.0 FT.  
AFTER 24 HRS. DEPTH TNP FT.  
ELEV. \_\_\_\_\_ FT.

BORING ADVANCED BY: \_\_\_\_\_ POWER AUGERING X WASHBORING \_\_\_\_\_

STRATUM DEPTH				SAMPLE DEPTH		SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS		LABORATORY RESULTS			STRATUM DESCRIPTION
				FROM	TO			N-Value	Qp	LL	PI	%M	
FT.	IN	IN	ELEV.	FT.	FT.								
-	-	-											Topsoil/Root Mat 4 Inches
-	-	-											
-	-	-											
2.5	-	-	-2.5	1.0	2.5	1	SS	10				18.5	Fat CLAY (CH) with stone - Brown; slightly moist; stiff (FILL)
-	-	-											
-	-	-											
-	-	-											
5.0	-	-	-5.0	3.5	5.0	2	SS	8				28.7	Fat CLAY (CH) - Red brown; moist; firm (FILL)
-	-	-											
-	-	-											
-	-	-											
7.5	-	-	-7.5	6.0	7.5	3	SS	5				32.8	
-	-	-											
-	-	-											
-	-	-											
10.0	-	-	-10.0	8.5	10.0	4	SS	3				38.5	Fat CLAY (CH) - Red; moist; soft (RESIDUUM)
-	-	-											
-	-	-											
-	-	-											
12.5	-	-	-12.5										
-	-	-											
-	-	-											
-	-	-											
15.0	-	-	-15.0	13.5	15.0	5	SS	4				41.3	Clayey Silt (ML) - Tan brown; moist; soft (RESIDUUM)
-	-	-											
-	-	-											
-	-	-											
17.5	-	-	-17.5										
-	-	-											
-	-	-											
-	-	-											
20.0	-	-	-20.0	18.5	20.0	6	SS	3				28.6	

REMARKS: \_\_\_\_\_





Mountain Home VAMC MRI Addition  
Mountain Home, Tennessee  
GEO Services Project No.: 51-16069

LOG OF BORING **C-2**  
SHEET 1 OF 2

DRILLER Shannon Snow  
ON-SITE REP. \_\_\_\_\_

BORING NO. / LOCATION C-2 DRY ON COMPLETION ? Yes

DATE August 19, 2016 SURFACE ELEV. 0.0 FT.

REFUSAL: Yes DEPTH 23.0 FT. ELEV. -23.0 FT.

SAMPLED 23.0 FT. 7.0 M

TOP OF ROCK DEPTH 23.0 FT. ELEV. -23.0 FT.

BEGAN CORING DEPTH \_\_\_\_\_ FT. ELEV. \_\_\_\_\_ FT.

FOOTAGE CORED (LF) \_\_\_\_\_ FT.

BOTTOM OF HOLE DEPTH 23.0 FT. ELEV. -23.0 FT.

BORING ADVANCED BY: \_\_\_\_\_ POWER AUGERING X WASHBORING \_\_\_\_\_

**WATER LEVEL DATA (IF APPLICABLE)**  
COMPLETION: DEPTH Dry FT.  
ELEV. \_\_\_\_\_ FT.  
AFTER 24 HRS. DEPTH TNP FT.  
ELEV. \_\_\_\_\_ FT.

STRATUM			SAMPLE DEPTH		SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS		LABORATORY RESULTS			STRATUM DESCRIPTION
DEPTH			FROM	TO			N-Value	Qp	LL	PI	%M	
FT.		ELEV.	FT.	FT.								
-												Topsoil/Root Mat 5 Inches
2.5	-	-2.5	1.0	2.5	1	SS	8				20.4	Fat CLAY (CH) with stone - Brown; slightly moist; firm (FILL)
5.0	-	-5.0	3.5	5.0	2	SS	6				33.0	Fat CLAY (CH) with stone - Red tan brown; very moist; soft (FILL)
7.5	-	-7.5	6.0	7.5	3	SS	4				49.0	Elastic Silt (MH) - Red brown; very moist; soft (RESIDUUM)
10.0	-	-10.0	8.5	10.0	4	SS	3				45.1	Clayey Silt (ML) - Tan; very moist; firm to soft (RESIDUUM)
12.5	-	-12.5										
15.0	-	-15.0	13.5	15.0	5	SS	7				53.6	
17.5	-	-17.5										
20.0	-	-20.0	18.5	20.0	6	SS	4				33.8	

REMARKS: Boring Offset 2 feet Northeast to clear utilities



Mountain Home VAMC MRI Addition  
Mountain Home, Tennessee  
GEO Services Project No.: 51-16069

LOG OF BORING **C-2**  
SHEET 2 OF 2

DRILLER Shannon Snow  
ON-SITE REP.

BORING NO. / LOCATION C-2 DRY ON COMPLETION ? Yes

DATE August 19, 2016 SURFACE ELEV. 0.0 FT.  
REFUSAL: Yes DEPTH 23.0 FT. ELEV. -23.0 FT.  
SAMPLED 23.0 FT. 7.0 M  
TOP OF ROCK DEPTH 23.0 FT. ELEV. -23.0 FT.  
BEGAN CORING DEPTH FT. ELEV. FT.  
FOOTAGE CORED (LF) FT.  
BOTTOM OF HOLE DEPTH 23.0 FT. ELEV. -23.0 FT.

**WATER LEVEL DATA (IF APPLICABLE)**  
COMPLETION: DEPTH Dry FT.  
ELEV. FT.  
AFTER 24 HRS. DEPTH TNP FT.  
ELEV. FT.

BORING ADVANCED BY: POWER AUGERING X WASHBORING

STRATUM			SAMPLE DEPTH		SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS		LABORATORY RESULTS			STRATUM DESCRIPTION
DEPTH			FROM	TO			N-Value	Qp	LL	PI	%M	
FT.		ELEV.	FT.	FT.								
-												-
-												-
-												-
-												-
22.5	-	-22.5										-
-												-
-												-
-												-
25.0	-	-25.0										-
-												-
-												-
-												-
27.5	-	-27.5										-
-												-
-												-
-												-
30.0	-	-30.0										-
-												-
-												-
-												-
32.5	-	-32.5										-
-												-
-												-
-												-
35.0	-	-35.0										-
-												-
-												-
-												-
37.5	-	-37.5										-
-												-
-												-
-												-
40.0	-	-40.0										-

Clayey Silt (ML) - Tan; very moist; firm to soft  
(RESIDUUM)  
Auger Refusal at 23.0 feet

REMARKS: Boring Offset 2 feet Northeast to clear utilities





Mountain Home VAMC MRI Addition  
Mountain Home, Tennessee  
GEOservices Project No.: 51-16069

LOG OF BORING **C-3**  
SHEET 1 OF 1

DRILLER Shannon Snow  
ON-SITE REP. \_\_\_\_\_

BORING NO. / LOCATION C-3 DRY ON COMPLETION ? Yes

DATE August 19, 2016 SURFACE ELEV. 0.0 FT.  
REFUSAL: Yes DEPTH 19.5 FT. ELEV. -19.5 FT.  
SAMPLED 19.5 FT. 5.9 M  
TOP OF ROCK DEPTH 19.5 FT. ELEV. -19.5 FT.  
BEGAN CORING DEPTH \_\_\_\_\_ FT. ELEV. \_\_\_\_\_ FT.  
FOOTAGE CORED (LF) \_\_\_\_\_ FT.  
BOTTOM OF HOLE DEPTH 19.5 FT. ELEV. -19.5 FT.

**WATER LEVEL DATA (IF APPLICABLE)**  
COMPLETION: DEPTH Dry FT.  
ELEV. \_\_\_\_\_ FT.  
AFTER 24 HRS. DEPTH TNP FT.  
ELEV. \_\_\_\_\_ FT.

BORING ADVANCED BY: \_\_\_\_\_ POWER AUGERING X WASHBORING \_\_\_\_\_

STRATUM			SAMPLE DEPTH		SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS		LABORATORY RESULTS			STRATUM DESCRIPTION
DEPTH			FROM	TO			N-Value	Qp	LL	PI	%M	
FT.		ELEV.	FT.	FT.								
—	—											Topsoil/Root Mat 4 Inches
2.5	—	-2.5	1.0	2.5	1	SS	13				30.0	Fat CLAY (CH) - Red brown; slightly moist; stiff (FILL)
5.0	—	-5.0	3.5	5.0	2	SS	13				32.6	
7.5	—	-7.5	6.0	7.5	3	SS	10				37.9	
10.0	—	-10.0	8.5	10.0	4	SS	6				40.2	Elastic Silt (MH) - Red tan brown; moist; firm (RESIDUUM)
12.5	—	-12.5										Clayey Silt (ML) - Tan brown; moist; firm (RESIDUUM)
15.0	—	-15.0	13.5	15.0	5	SS	7				40.3	
17.5	—	-17.5										Sandy CLAY (CL) - Brown; very moist; hard (RESIDUUM)
20.0	—	-20.0	18.5	19.2	6	SS	50/2**				30.0	
												Auger Refusal at 19.5 feet

REMARKS: \*Inflated N-values due to encountering rock fragments prior to completion of test interval.

Boring Offset 4 feet Northeast to clear utilities



Mountain Home VAMC MRI Addition  
Mountain Home, Tennessee  
GEOServices Project No.: 51-16069

LOG OF BORING **C-4**  
SHEET 1 OF 1

DRILLER Shannon Snow  
ON-SITE REP. \_\_\_\_\_

BORING NO. / LOCATION C-4 DRY ON COMPLETION ? Yes

DATE August 19, 2016 SURFACE ELEV. 0.0 FT.  
REFUSAL: Yes DEPTH 15.0 FT. ELEV. -15.0 FT.  
SAMPLED 15.0 FT. 4.6 M  
TOP OF ROCK DEPTH 15.0 FT. ELEV. -15.0 FT.  
BEGAN CORING DEPTH \_\_\_\_\_ FT. ELEV. \_\_\_\_\_ FT.  
FOOTAGE CORED (LF) \_\_\_\_\_ FT.  
BOTTOM OF HOLE DEPTH 15.0 FT. ELEV. -15.0 FT.

**WATER LEVEL DATA (IF APPLICABLE)**  
COMPLETION: DEPTH Dry FT.  
ELEV. \_\_\_\_\_ FT.  
AFTER 24 HRS. DEPTH TNP FT.  
ELEV. \_\_\_\_\_ FT.

BORING ADVANCED BY: \_\_\_\_\_ POWER AUGERING X WASHBORING \_\_\_\_\_

STRATUM			SAMPLE DEPTH		SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS		LABORATORY RESULTS			STRATUM DESCRIPTION
DEPTH			FROM	TO			N-Value	Qp	LL	PI	%M	
FT.		ELEV.	FT.	FT.								
—	—	—										Topsoil/Root Mat 4 Inches
2.5	—	-2.5	1.0	2.5	1	SS	6				33.0	Fat CLAY (CH) - Red brown; moist; firm to stiff (FILL)
5.0	—	-5.0	3.5	5.0	2	SS	13				38.2	
7.5	—	-7.5	6.0	7.5	3	SS	9				37.3	
10.0	—	-10.0	8.5	10.0	4	SS	6				40.5	Elastic SILT (MH) - Red tan brown; moist; firm (RESIDUUM)
12.5	—	-12.5										Sandy CLAY (CL) - Tan brown; very moist; hard (RESIDUUM)
15.0	—	-15.0	13.5	14.2	5	SS	50/2"				29.7	
17.5	—	-17.5										Auger Refusal at 15.0 feet
—	—	—										
20.0	—	-20.0										

REMARKS: \*Inflated N-values due to encountering rock fragments prior to completion of test interval.

Boring Offset 3 feet Southwest to clear utilities



Mountain Home VAMC MRI Addition  
Mountain Home, Tennessee  
GEOservices Project No.: 51-16069

LOG OF BORING **C-5**  
SHEET 1 OF 1

DRILLER Shannon Snow  
ON-SITE REP. \_\_\_\_\_

BORING NO. / LOCATION		C-5		DRY ON COMPLETION ?		Yes		
DATE	August 19, 2016		SURFACE ELEV.	0.0		FT.		
REFUSAL:	Yes	DEPTH	18.7	ELEV.		-18.7		
		FT.				FT.		
SAMPLED	18.7	5.7						
		FT. M						
TOP OF ROCK	DEPTH		18.7	ELEV.		-18.7		
		FT.				FT.		
BEGAN CORING	DEPTH			ELEV.				
		FT.				FT.		
FOOTAGE CORED (LF)			FT.					
BOTTOM OF HOLE DEPTH	18.7		ELEV.		-18.7		FT.	
		FT.						
BORING ADVANCED BY:		POWER AUGERING		X		WASHBORING		

<b>WATER LEVEL DATA (IF APPLICABLE)</b>	
COMPLETION:	DEPTH <u>Dry</u> FT.
	ELEV. _____ FT.
AFTER 24 HRS.	DEPTH <u>TNP</u> FT.
	ELEV. _____ FT.

STRATUM			SAMPLE DEPTH		SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS		LABORATORY RESULTS			STRATUM DESCRIPTION
DEPTH			FROM	TO								
FT.		ELEV.	FT.	FT.			N-Value	Qp	LL	PI	%M	
0.0												Topsoil/Root Mat 5 Inches
2.5		-2.5	1.0	2.5	1	SS	17*				18.1	Fat CLAY (CH) with stone - Red brown; moist; very stiff to stiff (FILL)
5.0		-5.0	3.5	5.0	2	SS	13		70	40	33.9	
7.5		-7.5	6.0	7.5	3	SS	15				37.5	
10.0		-10.0	8.5	10.0	4	SS	10				33.7	Elastic Silt (MH) - Red tan brown; moist; stiff to firm (RESIDUUM)
12.5		-12.5										
15.0		-15.0	13.5	15.0	5	SS	8				44.8	
17.5		-17.5										Clayey SILT (ML) with weathered rock - Red brown; moist; hard (RESIDUUM)
18.5			18.5	18.6	6	SS	50/1**				40.2	Auger Refusal at 18.7 feet
20.0		-20.0										

REMARKS: \*Inflated N-values due to encountering rock fragments prior to completion of test interval.  
Boring Offset 6 feet Southwest to clear utilities.

## **APPENDIX B**

### **Soil Laboratory Data**

**SOIL DATA SUMMARY**  
**Mountain Home VAMC MRI Addition - Mountain Home, Tennessee**  
**GEOservices Project No. 51-16069**  
**August 23, 2016**

Boring Number	Sample Number	Depth (feet)	Natural Moisture Content	Atterberg Limits			Soil Type
				LL	PL	PI	
C-1	1	1.0 - 2.5	18.5%				
	2	3.5 - 5.0	28.7%				
	3	6.0 - 7.5	32.8%				
	4	8.5 - 10.0	38.5%				
	5	13.5 - 15.0	41.3%				
	6	18.5 - 20.0	28.6%				
	7	23.5 - 25.0	30.4%				
C-2	1	1.0 - 2.5	20.4%				
	2	3.5 - 5.0	33.0%				
	3	6.0 - 7.5	49.0%				
	4	8.5 - 10.0	45.1%				
	5	13.5 - 15.0	53.6%				
	6	18.5 - 20.0	33.8%				
C-3	1	1.0 - 2.5	30.0%				
	2	3.5 - 5.0	32.6%				
	3	6.0 - 7.5	37.9%				
	4	8.5 - 10.0	40.2%				
	5	13.5 - 15.0	40.3%				
	6	18.5 - 20.0	30.0%				
C-4	1	1.0 - 2.5	33.0%				
	2	3.5 - 5.0	38.2%				
	3	6.0 - 7.5	37.3%				
	4	8.5 - 10.0	40.5%				
	5	13.5 - 15.0	29.7%				
C-5	1	1.0 - 2.5	18.1%				
	2	3.5 - 5.0	33.9%	70	30	40	CH
	3	6.0 - 7.5	37.5%				
	4	8.5 - 10.0	33.7%				
	5	13.5 - 15.0	44.8%				
	6	18.5 - 20.0	40.2%				