

# **SUBSURFACE EXPLORATION AND GEOTECHNICAL EVALUATION**

McGuire Veterans Administration Medical Center  
Spinal Cord Injury and Disorder Center Addition  
Richmond, Virginia



Prepared For:

A|E Works

Project Manager:

Diane Glarrow, AIA

**August 6, 2014**



Prepared By:





**Draper Aden Associates**  
*Engineering • Surveying • Environmental Services*

DAA Project Number: R05432-10G

### 3<sup>RD</sup> PARTY REVIEW

This Report has been subjected to technical and quality reviews by:

  
Name: Jessica L. Ewald, P.E., LEED AP      Signature  
Design Engineer/Project Manager      Date 8/6/14

  
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Quality Reviewer      Date 8/6/14

## **TABLE OF CONTENTS**

<b>1.0</b>	<b>AUTHORIZATION .....</b>	<b>1</b>
<b>2.0</b>	<b>OBJECTIVE AND SCOPE OF SERVICES .....</b>	<b>2</b>
<b>3.0</b>	<b>SUBSURFACE EXPLORATION.....</b>	<b>3</b>
3.1	General Site Description .....	3
3.2	Exploration Program .....	3
<b>4.0</b>	<b>SUBSURFACE CONDITIONS.....</b>	<b>5</b>
4.1	Regional Geology .....	5
4.2	Local Geology .....	5
4.3	Encountered Soil Conditions .....	6
4.3.1	General .....	6
4.3.2	Subsurface Soils .....	6
4.3.3	Anomalous Conditions .....	7
4.4	Subsurface Water .....	7
<b>5.0</b>	<b>LABORATORY TEST RESULTS .....</b>	<b>8</b>
<b>6.0</b>	<b>DESIGN RECOMMENDATIONS .....</b>	<b>9</b>
6.1	General .....	9
6.2	Structure Characteristics .....	9
6.3	Shallow Foundations .....	9
6.4	Slabs-on-Grade .....	10
6.5	Slope Stability for Excavations .....	11
6.6	Soil Permeability .....	11
6.7	Seismic Considerations .....	11
6.8	Pavement .....	12
<b>7.0</b>	<b>CONSTRUCTION CONSIDERATIONS .....</b>	<b>13</b>
7.1	Demolition of Existing Utilities .....	13
7.2	Site Preparation .....	13
7.3	Foundation Construction .....	14
7.4	Reuse of Onsite Soils .....	14
7.5	Fill Material .....	14
7.6	Field Observation .....	15
<b>8.0</b>	<b>LIMITATIONS .....</b>	<b>16</b>

## **TABLES**

Table 1:	Summary of Laboratory Results .....	8
Table 2:	Site Infiltration Rate(s) .....	11
Table 3:	Pavement Section.....	12
Table 4:	Fill Material Requirements .....	15

## **PHOTOGRAPHS**

Photo 1:	Project Site Aerial .....	3
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## **APPENDICES**

Section I	Boring Location Plan
Section II	Key to Boring Logs Boring Logs B-1 through B-5
Section III	In-situ Infiltration Test Results
Section IV	Laboratory Test Results
Section V	Geotechnical Test Methods

## **1.0 AUTHORIZATION**

Draper Aden Associates is pleased to present our report of the geotechnical study completed for the proposed Addition to the Spinal Cord Injury and Disorder Center at the McGuire Veterans Administration Medical Center in Richmond, Virginia. This geotechnical study was completed in general accordance with Draper Aden Associates' letter proposal dated June 18, 2014.

## **2.0 OBJECTIVE AND SCOPE OF SERVICES**

The objective of this study was to generally characterize subsurface conditions to provide information and develop geotechnical engineering recommendations related to the subsurface soil conditions, groundwater conditions, floor slab design, pavement design, foundation design, soil permeability, earthwork and construction of the proposed addition. Our scope of services included:

- ❖ A subsurface exploration consisting of:
  - Three (3) exploratory soil borings with Standard Penetration Testing (SPT) with proposed depths ranging from 25 to 100 feet below existing grade within the proposed addition footprint.
  - Two (2) exploratory soil borings with SPT to a depth of 15 feet below existing grade in the vicinity of proposed stormwater management areas.
  - Two (2) borings to a depth 6 feet below existing grade to facilitate constant-head permeability testing.
- ❖ Laboratory testing of representative split-spoon and bulk samples in order to develop pertinent data related to the on-site soils to support our design recommendations.
- ❖ Preparation of this geotechnical engineering report which summarizes our exploration program, laboratory testing, and geotechnical recommendations.

### 3.0 SUBSURFACE EXPLORATION

#### 3.1 General Site Description

The project site is located south and east of the existing Spinal Cord Injury and Disorder Center. The site is grassed, relatively flat, and bordered with concrete sidewalks.



**Photo 1: Project Site Aerial**

#### 3.2 Exploration Program

Our exploration program was performed on June 30<sup>th</sup> and July 1<sup>st</sup>, 2014. The approximate locations of the seven borings and two in-situ permeability tests are indicated on the Boring Location Plan included in Section I of the Appendices. The subsurface borings, executed by Fishburne Drilling, were logged and observed by a Draper Aden Associates field representative. Appendix Section II contains logs of the five SPT borings prepared by Draper Aden Associates. Boring elevations included on the logs were interpolated from the available site topographic information.

During advancement of the five soil borings, utilizing 2¼-inch hollow-stem auger, the subsurface soils were continuously sampled for the first 10 feet and at intervals of 5 feet, thereafter. Split spoon samples were taken by driving a 1⅜-inch-I.D. split spoon sampler in accordance with ASTM D1586-11. The sampler was first seated 6 inches to penetrate loose cuttings and then driven an additional 18 inches with a 140-pound hammer free falling 30 inches. The number of hammer blows required to drive the sampler the middle 12 inches was designated as the penetration resistance or N-value. The N-value provides an indication of the relative density of the subsurface soil, and it is used in empirical geotechnical correlation to estimate the approximate shear strength properties of the soils.

It is not always practical to drive the split spoon sampler the full 24 inches. During a subsurface exploration whenever more than 50 blows are required to drive the sampler 6 inches, the condition is called spoon refusal (SR). Split spoon refusal conditions will occur when the material being tested has very dense or hard soil strength or if an obstruction is encountered. The blow count recorded at spoon refusal conditions indicates the depth of sampler penetration over the 6 inch increment, i.e. 50/4 or 50 blows over 4 inches. The N-value for split spoon refusal conditions is typically estimated as greater than 100 blows per foot (bpf) for this condition.

Two (2) borings were drilled utilizing 2¼-inch hollow-stem auger to a depth of 5 feet below grade. The final 12 inches of the boring were advanced utilizing a smaller diameter hand auger in order to accommodate the constant-head permeability testing equipment, the constant head borehole permeameter or Amoozemeter, at 6 feet below grade.

The soil test borings were backfilled with excavated spoil prior to departure from the site. No long term groundwater measurements were taken as a part of this study.



## **4.0 SUBSURFACE CONDITIONS**

### **4.1 Regional Geology**

The site is located within the Fall Line, which is the boundary between the Coastal Plain and Piedmont physiographic provinces. The Fall Line is characterized as a low-profile, east-facing scarp that separates crystalline rocks of the Piedmont province (west) from Cretaceous-age [ $>65$  million years (Ma)] to Quaternary-age (current), less-resistant, marine and terrigenous sediments of the Coastal Plain province (east).

The Coastal Plain province is composed of an eastward-thickening wedge of terrigenous and marine sediments of late Jurassic ( $\approx 208$  Ma) to Quaternary ( $\approx 3$  Ma – present) in age. The sediments are generally composed of clays, silts, sands, and gravels, which were deposited on an eroded surface of igneous and metamorphic “basement” rocks [Precambrian ( $> 570$  Ma) to late Mesozoic ( $\geq 65$  Ma)]. The thickness of these sediments collectively ranges from  $< 1$  foot near the Fall Line, to greater than 10,000 feet beneath the continental shelf to the east.

The Piedmont province is a rolling to hilly area that extends from the Fall Line, to the foot of the Blue Ridge Mountains to the west. The crystalline rocks of the Piedmont province are Precambrian-age ( $>570$  Ma) and Cambrian-age (570-225 Ma) metamorphic and igneous rocks, and within the Piedmont province are several Triassic-age basins that contain sedimentary rocks.

### **4.2 Local Geology**

According to the Geologic Map of Virginia (1993)<sup>1</sup>, the project site is located within the first member of the Bacon’s Castle Formation. The Tb<sup>1</sup> member of the Bacon’s Castle Formation is generally described as massive to thick-bedded pebble and cobble gravel grading upward into cross-bedded pebbly sand and sandy and clayey silt and silty fine sand.

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<sup>1</sup> Rader, E.K., and Evans, N.H., editors, 1993, Geologic Map of Virginia: Virginia Division of Mineral Resources.

### **4.3 Encountered Soil Conditions**

#### **4.3.1 General**

Section II of the Appendices contains the boring logs which represent the subsurface conditions encountered at the time of exploration. Soil strata inferences, discussed below and indicated on the boring logs, represent an estimate of the subsurface conditions based on visual classifications of soils and laboratory classification test results. It should be noted that the transitions between soil strata are generally less distinct than shown on the boring logs and are interpolated between the boring locations. For specific subsurface soil information refer to the boring logs.

#### **4.3.2 Subsurface Soils**

A depth of approximately 1 to 2 inches of topsoil was encountered at our field explorations in green areas. The following descriptions generally describe the subsurface conditions encountered at our exploration locations:

**Stratum S1:** The Stratum S1 soils generally consisted of fine-grained soils that were visually classified as SILT (ML), Sandy Fat CLAY (CH), Fat CLAY with Sand (CH), Sandy Lean CLAY (CL) and Lean CLAY with Sand (CL). The Stratum S1 material was encountered below the topsoil and extended to depths ranging from 6 to 18 feet below existing grade. The S1 material exhibited N-values ranging from 13 to 33 blows per foot (bpf).

**Stratum S2:** The Stratum S2 soils generally consisted of coarse-grained soils that were visually classified as Silty SAND (SM), Clayey SAND (SC), and Clayey SAND with Gravel (SC). The Stratum S2 material was encountered below the S1 soils and extended to approximately 53 feet below existing grade. The S1 material exhibited N-values ranging from 2 to 31 bpf.

**Stratum S3:** The Stratum S3 soils generally consisted of fine-grained soils that were visually classified as Sandy Lean CLAY (CL) and Sandy Fat CLAY (CH). The Stratum S3 material was encountered below the S2 soils and extended to approximately 63.5 feet below existing grade. The S3 material exhibited N-values ranging from 2 to 4 bpf.

**Stratum S4:** Stratum S4 consisted of Partially Weathered Rock (PWR). PWR is a transitional material between soil and rock, with very hard to dense relative densities. The Stratum S4 material was encountered below the stratum S3 soils and extended to auger refusal conditions at 68.5 feet below grade. The S4 material exhibited N-values of 100+ bpf.

**Refusal:** Auger refusal conditions were encountered at an approximate depth of 68.5 feet below existing grade.

#### 4.3.3 Anomalous Conditions

At boring locations B-1 and B-3, auger refusal conditions were encountered at depths of 6 and 5 feet below grade, respectively. The boring was then offset 5 feet for a second attempt, which in both cases was successfully advanced beyond the previous boring termination depth.

#### 4.4 Subsurface Water

Subsurface water was not encountered during our subsurface exploration. Historic Groundwater readings within the footprint of the Hospital indicated that water was encountered at elevations ranging from El. 162 to 171.5. Based on the proposed construction, a need for groundwater control is not anticipated.

Note that groundwater levels may fluctuate due to rainfall, season, temperature and other factors that are different from those prevailing at the time of our subsurface exploration. If dewatering becomes an issue during construction the contractor should determine and employ appropriate dewatering methods.

## 5.0 LABORATORY TEST RESULTS

Select split-spoon and bulk samples, obtained during our field exploration, were tested in accordance with applicable American Society for Testing and Materials (ASTM) methods for Classification (ASTM 2487), Percent passing No. 200 sieve (ASTM D1140), Natural Moisture Content (ASTM D2216), Atterberg Limits (ASTM D4318), standard Proctor (ASTM D698), California Bearing Ratio (ASTM D1883).

The following table summarizes the results of index laboratory testing conducted by Draper Aden Associates' U.S. Corps of Engineers Qualified Materials Testing Laboratory, which was performed to aid in our design recommendations. Detailed laboratory results are contained within Section III of the Appendices.

**Table 1: Summary of Laboratory Results**

Sample ID	Sample Depth	Natural Moisture Content	% Passing the No. 200 Sieve	Atterberg Limits			USCS Classification
				L.L.	P.L.	P.I.	
B-1	38'-40'	37.9%	41.0%	40	26	14	Silty SAND (SM)
B-2	0'-5'	14.4%	57.1%	40	14	26	Sandy Lean CLAY (CL)
B-3	6'-8'	15.6%	39.9%	78	29	49	Clayey SAND with Gravel (SC)
B-4	13'-15'	11.3%	20.8%	40	24	16	Clayey SAND with Gravel (SC)
B-5	4'-6'	13.2%	34.7%	75	17	58	Clayey SAND with Gravel (SC)

## **6.0 DESIGN RECOMMENDATIONS**

The following conclusions and recommendations are made subject to the limitations set forth in Section 8.0.

### **6.1 General**

Our recommendations and geotechnical evaluations are based on observations made during our subsurface explorations, results of the laboratory test program, our understanding of the proposed construction, and experience with similar projects. Our foundation recommendations as well as estimation of geotechnical design criteria have been developed based on laboratory data, using generally established correlations and methods commonly exercised by members of the geotechnical engineering profession. If building locations, loading conditions, or finish floor elevations are changed, or differ from our assumptions, we request that we be advised and be allowed to re-evaluate our recommendations. We request the opportunity to review the final foundation design to verify that the intent of our recommendations is met.

### **6.2 Structure Characteristics**

According to information provided by AE Works, the following describes the structural concept of the proposed addition:

- ❖ Footprint Size = Approx. 20,000 square feet
- ❖ Probable Column Grid = 30 feet x 30 feet
- ❖ Maximum Column Load = 300 kips

### **6.3 Shallow Foundations**

In our opinion, the proposed building can be supported by a shallow foundation system. We recommend that foundations be designed based on a maximum net allowable bearing pressure of 3,500 pounds per square foot. Minimum widths of 2 feet and 4 feet should be adopted for continuous and spread footings, respectively, to reduce the potential for local shear failures.

We anticipate that shallow foundations supporting column loads of up to approximately 300 kips and wall loads of up to approximately 15 kips per linear foot, when founded on approved subgrade

that has been prepared, tested, and protected in accordance with our recommendations, would experience total settlements no greater than 1 inch and differential settlement no greater than a ½ inch.

Based on the result of our laboratory testing, the subgrade soils exhibit a low potential for shrink-swell. We recommend that exterior footings bear a minimum of 24 inches below final exterior grade to provide frost protection. A coefficient of sliding friction of 0.30 may be used for design for mass concrete on approved soil subgrade.

#### **6.4 Slabs-on-Grade**

The ground floor slabs may be designed as slabs-on-grade. We recommend that interior floor slabs, protected from frost action, be underlain by a minimum 6-inch-thick granular base course to provide uniform support and to act as a capillary break against moisture transmission through the slab. Where Portland cement concrete (PCC) slabs are exposed to exterior weather conditions, we recommend that the slabs be underlain by a minimum thickness of 12 inches of processed granular material.

For PCC walkways that will be used for both pedestrian and light maintenance vehicle traffic, we recommend that the walkway consist of a minimum 6-inch-thick PCC section underlain with a 4-inch-thick granular base course. Subgrades below the base course should be proof rolled in accordance with Section 7, Construction Considerations.

The granular base course should consist of well-graded gravel or crushed rock with a maximum nominal size of 1-inch and having less than 7 percent by weight passing the No. 200 sieve. The base course should be compacted to at least 95 percent of its maximum dry unit weight as measured by the standard Proctor test (ASTM D698).

Based on the results of our laboratory testing, slabs-on-grade founded on native soils with a minimum 6-inch-thick base course may be designed based on a modulus of subgrade reaction of 200 psi/in.

If materials will be stored directly and permanently on the floor slab or a glued down impervious floor covering will be utilized, such as tile and linoleum, a minimum 10-mil-thick vapor barrier should be placed over the granular base course, prior to concrete placement, to reduce moisture transmission through the slab and joints. If the vapor barrier is required, it may be preferable to specify a base course of 4 inches of crushed stone covered by 2 inches of clean sand to reduce puncturing of the membrane.

## **6.5 Slope Stability for Excavations**

During construction excavation, the contractor must evaluate slope inclinations in accordance with regulations established by Occupational Safety and Health Administration (OSHA). The contractor's "responsible person" must evaluate the slope protection requirements consistent with the soils encountered and the means and methods of excavation and dewatering selected by the contractor. Temporary spoil must be placed no closer than 10 feet from the surface edge of an excavation. Spoil should be placed so that it channels rainwater and other run-off water away from the excavation. Excavations shall be inspected and maintained by the contractor as required by OSHA.

## **6.6 Soil Permeability**

The following projected infiltration rates were measured at a depth of 6 feet below existing grade near boring locations B-2 and B-3. The detailed in-situ test results are contained in Section

**Table 2: Site Infiltration Rate(s)**

Test Location	USCS	Measured Infiltration Rate (in/hr)
K1/B-2	Sandy Lean CLAY	0.027
K2/B-3	Clayey SAND with Gravel	0.067

## **6.7 Seismic Considerations**

Per our review of the International Building Code (IBC 2012); Section 1613.3.2 Site class definitions and Chapter 20 of ASCE 7, we recommend that this site be classified as Site Class D.

Based on our review of the US Seismic Hazard Map 2008, we recommend spectral acceleration coefficients of 19.24 and 5.34 %g for  $S_s$  and  $S_1$  (for 0.2- and 1-second periods), respectively.

## 6.8 Pavement

Draper Aden Associates developed the following flexible pavement design recommendations for vehicles based on the VDOT Secondary Pavement Design Guide, an average design CBR value of 2.6 and an average daily traffic count of 600 vehicles per day with fewer than 5 percent heavy vehicles. We offer the following minimum pavement section recommendation:

**Table 3: Pavement Section**

Pavement Course	Thickness & Material Notation
Surface	1.5 inches VDOT SM-9.5A
Base	3.0 inches VDOT BM-25
Subbase	6.0 inches VDOT 21A or B

Should the traffic loading requirements be higher than we have assumed, Draper Aden Associates should be notified so we can review the pavement design.



## **7.0 CONSTRUCTION CONSIDERATIONS**

### **7.1 Demolition of Existing Utilities**

All underground utilities and any other underground structures must be completely removed from within and 10 feet beyond the footprint of the proposed addition. The final excavated subgrade should be proof rolled and/or explored with shallow test pits (1 to 2 feet deep) to confirm removal of all unsuitable material.

Backfill of the utilities should be completed in controlled lifts in accordance with Section 7.5—Fill Material, and compacted to a minimum of 98 percent of its respective maximum dry density and within  $\pm 2$  percentage points of its optimum moisture content as determined by a standard Proctor test.

### **7.2 Site Preparation**

Based on the results of our laboratory testing, the existing subgrade should be generally suitable for earthwork activity. Prior to construction operations, all topsoil, roots, or other deleterious non-soil material should be stripped within and five feet beyond the proposed footprint of areas intended for foundations and slabs. It should be noted that unknown obstructions were encountered at boring locations B-1 and B-3 at depths of 6 and 5 feet below existing grade. Test pitting is recommended in these areas prior to foundation construction in order to determine if any deleterious materials requiring removal exist within the building footprint.

Proof rolling, observed and evaluated by a representative of the geotechnical engineer, should be performed on subgrade areas intended for support of the structural fill material or pavement. Soils designated as unsatisfactory following strength verification operations should be removed and replaced as recommended by the Geotechnical Engineer or their designated representative. Proof rolls should be performed using a 20- to 30-ton loaded truck or pneumatic-tired vehicle of similar weight. Proof rolling should not be performed while the site is wet, frozen, or severely dry. If conditions warrant, the extent of undercutting and/or in-place stabilization required can be best determined by the geotechnical engineer at the time of construction.

### **7.3 Foundation Construction**

Excavations should be made in such a way as to provide bearing surfaces free of loose, soft, or wet soil and debris. We recommend that excavations for foundations be completed in manner that will limit disturbance of the bearing surface. All loose soil at or below subgrade level should be removed. Prior to placing forms and reinforcing, compact the bottom of foundations level. Cease compaction if unstable or wet subgrade conditions develop. If low strength soils are encountered during foundation construction, localized undercutting and/or in-place stabilization of bearing subgrade may be required as assessed and recommended by the Geotechnical Engineer or their designated representative. Foundation concrete must not be placed on frozen soil. Placement of concrete and backfilling of footings should occur as soon as practicable to limit water collection near the base of the foundation and damage to the bearing surface.

### **7.4 Reuse of Onsite Soils**

Approximately 1 to 2 inches of topsoil was encountered at our field explorations in green areas. This material may be stockpiled for use in green areas.

Based on the results of our borings and laboratory testing, upper on-site material, free of organics, that classifies as Sandy Lean CLAY (CL) and Clayey SAND (SC) may be suitable for use as fill material under structures and foundations provided the moisture content is properly controlled to within two percent of the optimum moisture content as determined by the Standard Proctor test. The fill material obtained on- or off-site should comply with the requirements contained in Section 7.5. Fill derived from onsite excavation may require moisture conditioning and must be protected from precipitation prior to placement and compaction in the work.

### **7.5 Fill Material**

Fill material obtained on- or off-site should meet the requirements indicated in the table below. When practical, requests to use soils that do not precisely meet requirements may be evaluated by the geotechnical engineer.

**Table 4: Fill Material Requirements**

Fill Material Use	Recommended USCS Material Classifications	Index Property Limitations
Under Structures, Foundations, and Under Paved Sections, or as Backfill	GW, GP, GC, GM, SW, SP, SC, SM, CL, & ML	Less than 65% passing the No. 200 sieve & L.L. $\leq$ 50
General Site Grading	GW, GP, GC, GM, SW, SP, SC, SM, CL, ML, CH, & MH	None

The maximum particle size of all fill material should be less than three inches largest dimension, except in the uppermost lift of fill, where the maximum particle size should be less than two inches largest dimension. Maximum sized particles should not be in excess of 20 percent of the volume of the fill material, and such particles shall be well distributed throughout the mass. Fill material shall not contain frozen masses of soil and shall not be placed on over-saturated, frozen, or frost-covered subgrade. Fill material should be placed in such a way to provide positive drainage from the fill area. Fill materials should be free of organics and debris.

Soil fill below structures and pavements should be placed in a maximum of an 8-inch-thick loose lift and compacted to a minimum of 98 and 95 percent, respectively, of its respective maximum dry density and within  $\pm 2$  percentage points of its optimum moisture content as determined by a standard Proctor test.

## **7.6 Field Observation**

We recommend that the foundation construction be observed by our Geotechnical Engineer or our qualified representative to observe that the required minimum soil requirements are met. For greater continuity and proper implementation of the recommendations contained herein, we recommend Draper Aden Associates be retained for construction observation services during this project.

## **8.0 LIMITATIONS**

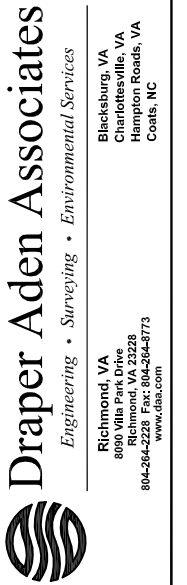
This report has been prepared for the exclusive use of AE Works and their designated representatives for specific application to the addition to the Spinal Cord Injury and Disorder Center at the McGuire Veterans Administration Medical Center in Richmond, Virginia. Our conclusions and recommendations have been rendered in a manner consistent with the level and skill ordinarily exercised by members of the geotechnical engineering profession in the Commonwealth of Virginia at the time of our study. We make no other warranty, express or implied.

Our conclusions and recommendations are based on design information furnished to us and our experience. They do not necessarily reflect variations in the subsurface conditions, which have potential to exist intermediate of our borings and in unexplored areas of the site due to inherent variability of the subsurface conditions in this geologic region, as well as past land use. Should such variations become apparent during construction, it will be necessary for us to re-evaluate our conclusions and recommendations based upon on-site observations of the conditions.

If changes are made in the location or nature of the structure, then the recommendations presented in this report must not be considered valid unless the changes are reviewed by Draper Aden Associates, and our recommendations are modified or verified in writing. We request the opportunity to review the foundation plan, grading plan and applicable portions of the project specifications when the design is finalized. This review will allow us to check whether these documents are consistent with the intent of our recommendations. Draper Aden Associates is not responsible for the conclusions, opinions or recommendations of others based on the data in this report.

## **Section I**

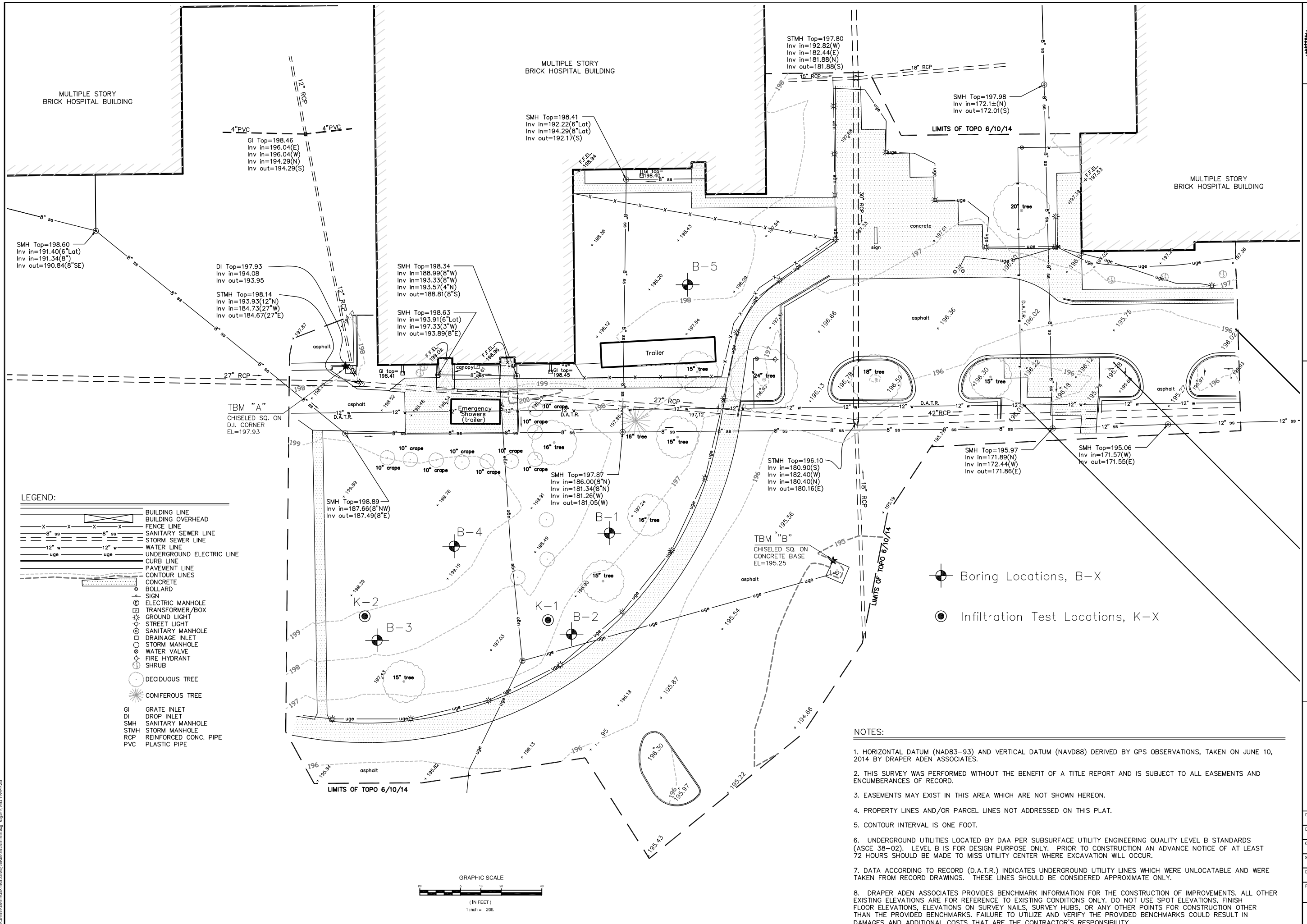
### **Boring Location Plan**



McGuire, V.A. Medical Center  
CITY OF RICHMOND, VIRGINIA

DESIGNED BY:	
DRAWN BY:	PCB
CHECKED BY:	TWI
SCALE:	1"= 20'
DATE:	06/10 /2014
PROJECT NUMBER:	R05432-10G

1 OF 1



2-IP05W4001P05432-10SCADwmgP05432-10G-BORINGS.dwg August 6, 2014 11:29:15 AM

**APPENDIX**  
**Section II**

**Key to Boring Logs**  
**Boring Logs B-1 through B-5**



# Draper Aden Associates

Blacksburg • Richmond, Virginia  
Engineering • Surveying • Environmental Services

## Key to Boring Log

	Well Graded Sand (SW)		Silt (ML)		Lean Clay (CL)
	Poorly Graded Sand (SP)		Silt with Sand (ML)		Lean Clay with Sand (CL)
	Silty Sand (SM)		Sandy Silt (ML)		Sandy Lean Clay (CL)
	Clayey Sand (SC)		Elastic Silt (MH)		Fat Clay (CH)
	Silty-Clayey SAND (SC-SM)		Elastic Silt with Sand (MH)		Fat Clay with Sand (CH)
	Topsoil		Sandy Elastic Silt (MH)		Sandy Fat Clay (CH)
			Silty-Clay (ML-CL)		Weathered Rock

Soil Description Format:

PRIMARY CONSTITUENT, color, major modifier, minor modifiers, moisture content,.

## Soil Strength

### Relative Density

Coarse Grained Soil, SAND

N-Value	Relative Density
0-4	Very Loose
5-10	Loose
11-30	Medium Dense
31-50	Dense
>50	Very Dense

### Consistency

Fine Grained Soil, SILT or CLAY

N-Value	Relative Density
0-1	Very Soft
2-4	Soft
5-8	Medium Stiff
9-15	Stiff
16-29	Very Stiff
>29	Hard

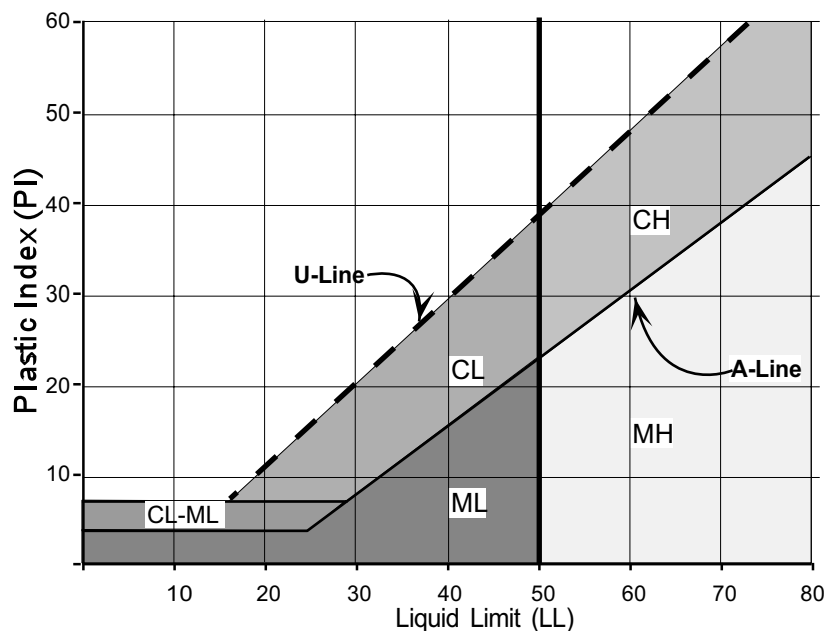
### Moisture Content

Dry	No apparent moisture, dusty.
Damp	Apparent moisture, below the Plastic Limit
Moist	Significant moisture, at or above the Plastic Limit (can be rolled into a 1/8" thread).
Wet	Appears saturated, free water in voids and pores.

### Further Descriptors

Mottled	Irregularly marked with patches of different colors, variegated.
Micaceous	Contains the mineral mica.
Relict Rock Structure	Distinct pattern of mineralization from parent rock.

## Cassagrande's Plasticity Chart







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# Boring Log

## B - 1

Page 1 of 4

**Client:** AE Works

6587 Hamilton Avenue, Pittsburgh, PA 15206

**Project:** H.H. McGuire VAMC Spinal Cord Addition

**Date:** 6/30/14

**DAA No.** R05432-10G

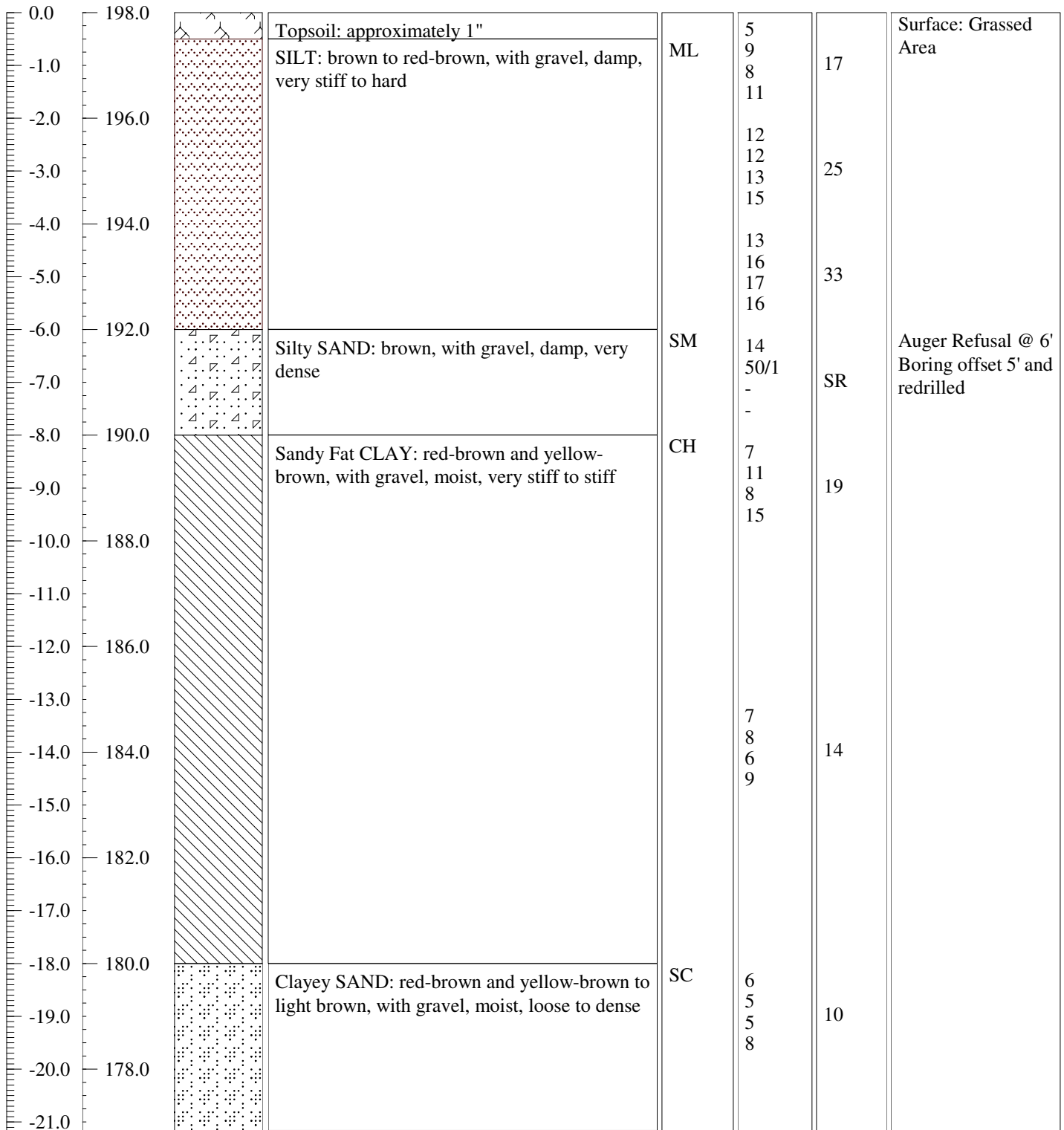
**Logged By:** DT

**Drill Type:** Mud Rotary

**Drilled By:** Fishburne Drilling

**Location:** See Location Plan

Depth ft.	Elevation ft.	Legend	Description	USCS Symbol	SPT Blow Count	N- Value	Notes
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# Boring Log

## B - 1

Page 2 of 4

**Client:** AE Works

6587 Hamilton Avenue, Pittsburgh, PA 15206

**Project:** H.H. McGuire VAMC Spinal Cord Addition

**Date:** 6/30/14

**DAA No.** R05432-10G

**Logged By:** DT

**Drill Type:** Mud Rotary

**Drilled By:** Fishburne Drilling

**Location:** See Location Plan

Depth ft.	Elevation ft.	Legend	Description	USCS Symbol	SPT Blow Count	N- Value	Notes
--------------	------------------	--------	-------------	----------------	----------------------	-------------	-------

-22.0	176.0						
-23.0					7		
-24.0	174.0				7	14	
-25.0					7		
-26.0	172.0				6		
-27.0							
-28.0	170.0				7		
-29.0					11	31	
-30.0	168.0				20		
-31.0					22		
-32.0	166.0						
-33.0					14		
-34.0	164.0				12	24	
-35.0					12		
-36.0	162.0				14		
-37.0							
-38.0	160.0						
-39.0			Silty SAND: yellow-brown, moist, soft	SM	12		
-40.0	158.0				2	3	
-41.0					1		
-42.0	156.0				1		



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 Fax: (804) 264-8773

# Boring Log

## B - 1

Page 3 of 4

**Client:** AE Works

6587 Hamilton Avenue, Pittsburgh, PA 15206

**Project:** H.H. McGuire VAMC Spinal Cord Addition

**Date:** 6/30/14

**DAA No.** R05432-10G

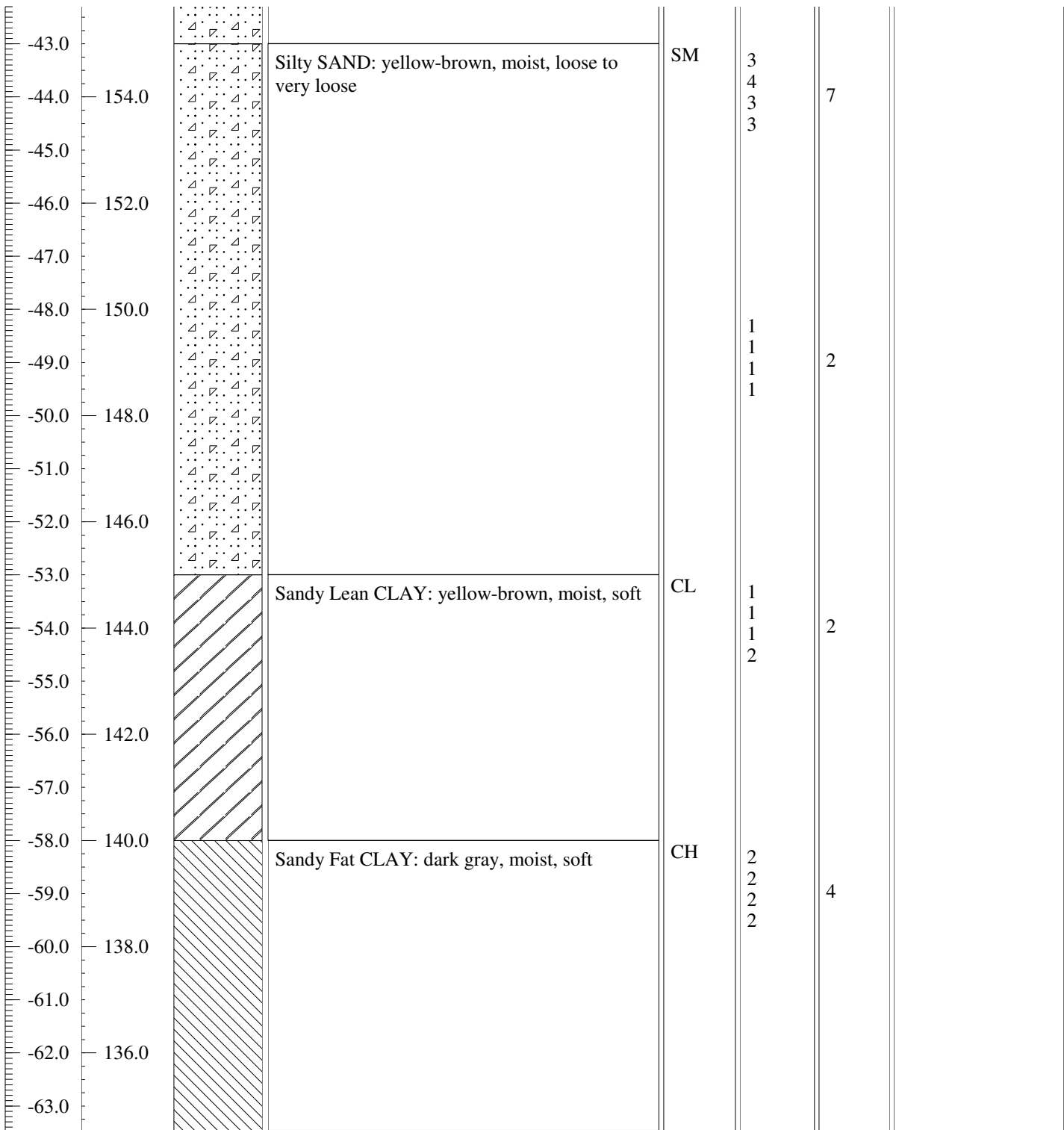
**Logged By:** DT

**Drill Type:** Mud Rotary

**Drilled By:** Fishburne Drilling

**Location:** See Location Plan

Depth ft.	Elevation ft.	Legend	Description	USCS Symbol	SPT Blow Count	N- Value	Notes
--------------	------------------	--------	-------------	----------------	----------------------	-------------	-------





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# Boring Log

## B - 1

Page 4 of 4

**Client:** AE Works

6587 Hamilton Avenue, Pittsburgh, PA 15206

**Project:** H.H. McGuire VAMC Spinal Cord Addition

**Date:** 6/30/14

**DAA No.** R05432-10G

**Logged By:** DT

**Drill Type:** Mud Rotary

**Drilled By:** Fishburne Drilling

**Location:** See Location Plan

Depth ft.	Elevation ft.	Legend	Description	USCS Symbol	SPT Blow Count	N- Value	Notes
--------------	------------------	--------	-------------	----------------	----------------------	-------------	-------

-64.0	134.0		Weathered Rock: no recovery, very dense	WR	50/5 - -	SR	
-65.0							
-66.0	132.0						
-67.0							
-68.0	130.0		Auger Refusal: @ 68.5' below existing grade		50/0 -		Subsurface water not encountered
-69.0							



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# Boring Log

## B - 2

Page 1 of 1

**Client:** AE Works

6587 Hamilton Avenue, Pittsburgh, PA 15206

**Project:** H.H. McGuire VAMC Spinal Cord Addition

**Date:** 6/30/14

**DAA No.** R05432-10G

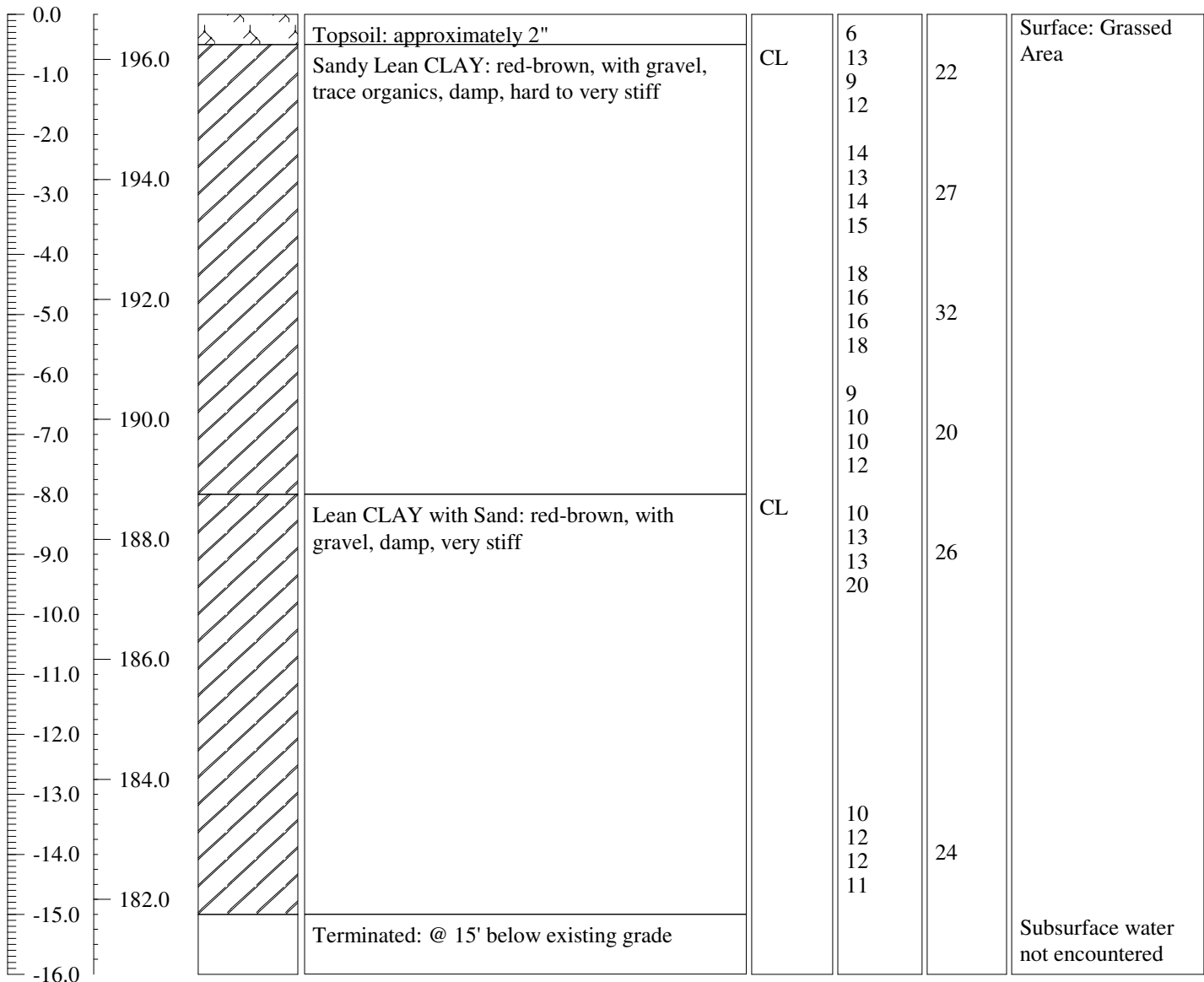
**Logged By:** DT

**Drill Type:** 2-1/4" HSA w/ SPT

**Drilled By:** Fishburne Drilling

**Location:** See Location Plan

Depth ft.	Elevation ft.	Legend	Description	USCS Symbol	SPT Blow Count	N- Value	Notes
--------------	------------------	--------	-------------	----------------	----------------------	-------------	-------





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# Boring Log

**B - 3**

Page 1 of 1

**Client:** AE Works

6587 Hamilton Avenue, Pittsburgh, PA 15206

**Project:** H.H. McGuire VAMC Spinal Cord Addition

**Date:** 6/30/14

**DAA No.** R05432-10G

**Logged By:** DT

**Drill Type:** 2-1/4" HSA w/ SPT

**Drilled By:** Fishburne Drilling

**Location:** See Location Plan

Depth ft.	Elevation ft.	Legend	Description	USCS Symbol	SPT Blow Count	N- Value	Notes
0.0			Topsoil: approximately 1"		5		Surface: Grassed Area
-1.0	198.0		SILT with Sand: brown, damp, stiff	ML	8		
			Fat CLAY with Sand: red-brown, with gravel, stiff to hard	CH	7	15	
-2.0					8		
					10		Boring offset 5' and redrilled to 5' below existing grade
-3.0	196.0				14	27	
					13		
-4.0					19		
					50/5		
-5.0	194.0				-	SR	
					-		
-6.0					-		
			Clayey SAND with Gravel: red-brown and brown, with gravel, damp, very stiff to stiff	SC	8		
-7.0	192.0				8		
					10	18	
-8.0					9		
			Clayey SAND: red-brown, with gravel, damp, medium dense		3		
-9.0	190.0				4	10	
					6		
-10.0					13		
			Clayey SAND: red-brown, with gravel, damp, medium dense	SC	6		
-11.0	188.0				6		
					8	14	
-12.0					9		
			Clayey SAND: red-brown, with gravel, damp, medium dense		6		
-13.0	186.0				6		
					8		
-14.0					9		
			Clayey SAND: red-brown, with gravel, damp, medium dense		6		
-15.0	184.0				6		
					8		
-16.0					9		
			Terminated: @ 15' below existing grade				Subsurface water not encountered



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# Boring Log

**B - 4**

Page 1 of 2

**Client:** AE Works

6587 Hamilton Avenue, Pittsburgh, PA 15206

**Project:** H.H. McGuire VAMC Spinal Cord Addition

**Date:** 7/1/14

**DAA No.** R05432-10G

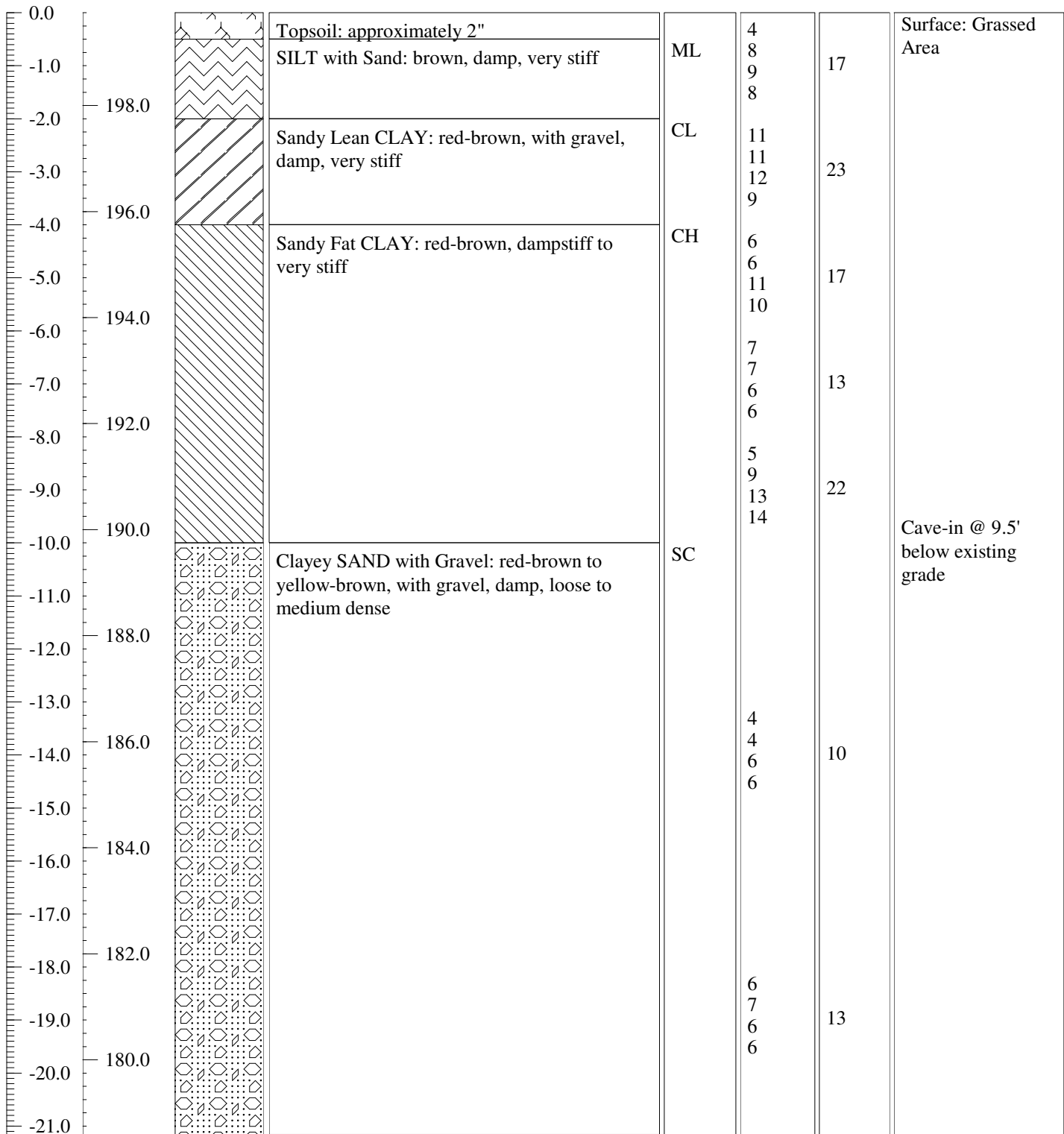
**Logged By:** DT

**Drill Type:** 2-1/4" HSA w/ SPT

**Drilled By:** Fishburne Drilling

**Location:** See Location Plan

Depth ft.	Elevation ft.	Legend	Description	USCS Symbol	SPT Blow Count	N- Value	Notes
--------------	------------------	--------	-------------	----------------	----------------------	-------------	-------





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# Boring Log

## B - 4

Page 2 of 2

**Client:** AE Works

6587 Hamilton Avenue, Pittsburgh, PA 15206

**Project:** H.H. McGuire VAMC Spinal Cord Addition

**Date:** 7/1/14

**DAA No.** R05432-10G

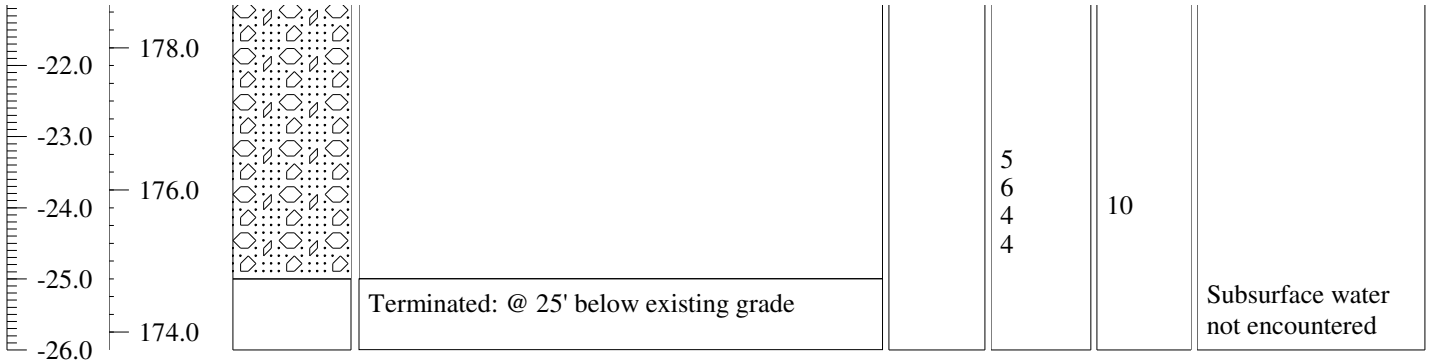
**Logged By:** DT

**Drill Type:** 2-1/4" HSA w/ SPT

**Drilled By:** Fishburne Drilling

**Location:** See Location Plan

Depth ft.	Elevation ft.	Legend	Description	USCS Symbol	SPT Blow Count	N- Value	Notes
--------------	------------------	--------	-------------	----------------	----------------------	-------------	-------







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# Boring Log

## B - 5

Page 1 of 2

**Client:** AE Works

6587 Hamilton Avenue, Pittsburgh, PA 15206

**Project:** H.H. McGuire VAMC Spinal Cord Addition

**Date:** 7/1/14

**DAA No.** R05432-10G

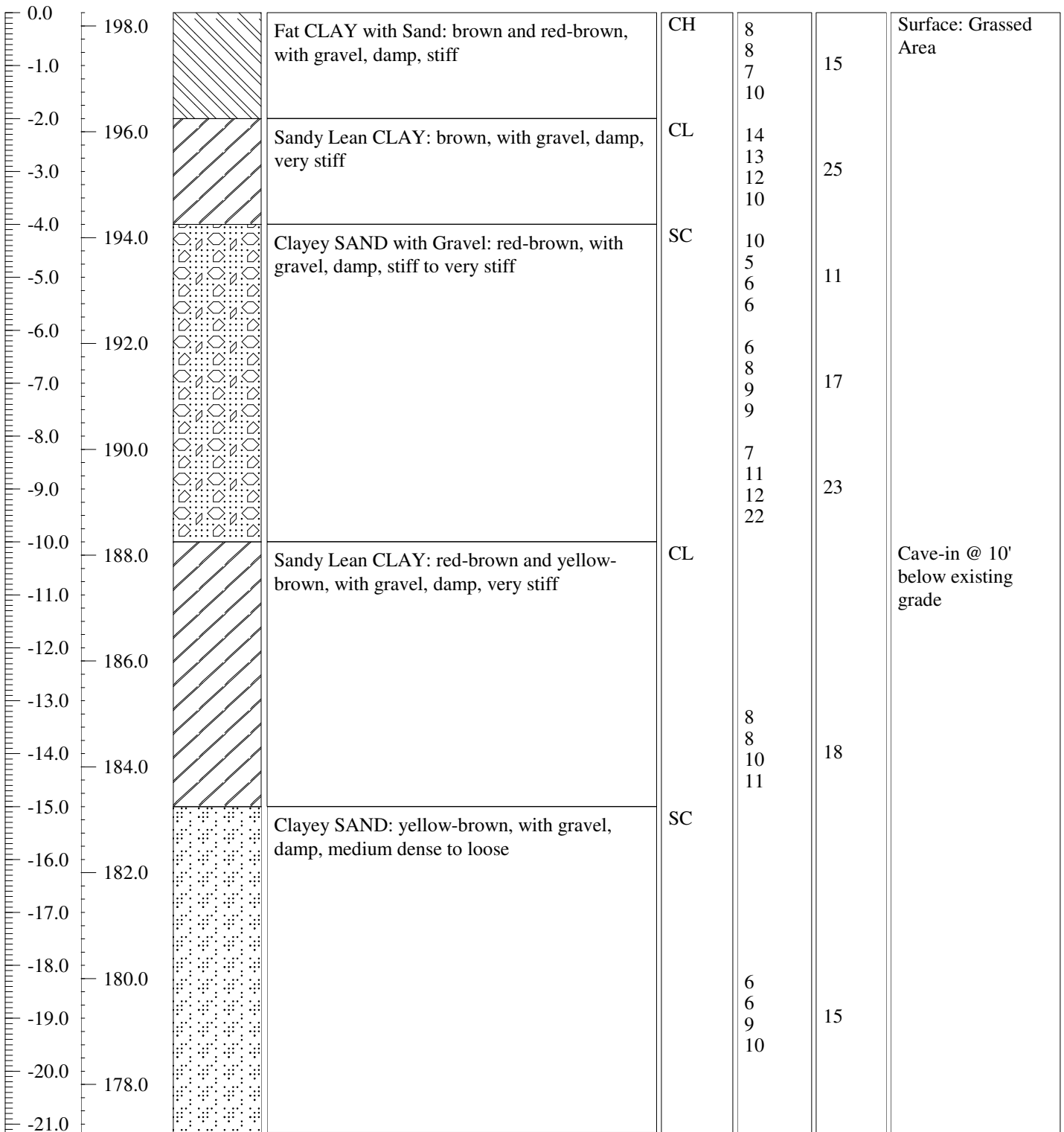
**Logged By:** DT

**Drill Type:** 2-1/4" HSA w/ SPT

**Drilled By:** Fishburne Drilling

**Location:** See Location Plan

Depth ft.	Elevation ft.	Legend	Description	USCS Symbol	SPT Blow Count	N- Value	Notes
--------------	------------------	--------	-------------	----------------	----------------------	-------------	-------





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# Boring Log

## B - 5

Page 2 of 2

**Client:** AE Works  
6587 Hamilton Avenue, Pittsburgh, PA 15206

**Project:** H.H. McGuire VAMC Spinal Cord Addition

**Date:** 7/1/14

**DAA No.** R05432-10G

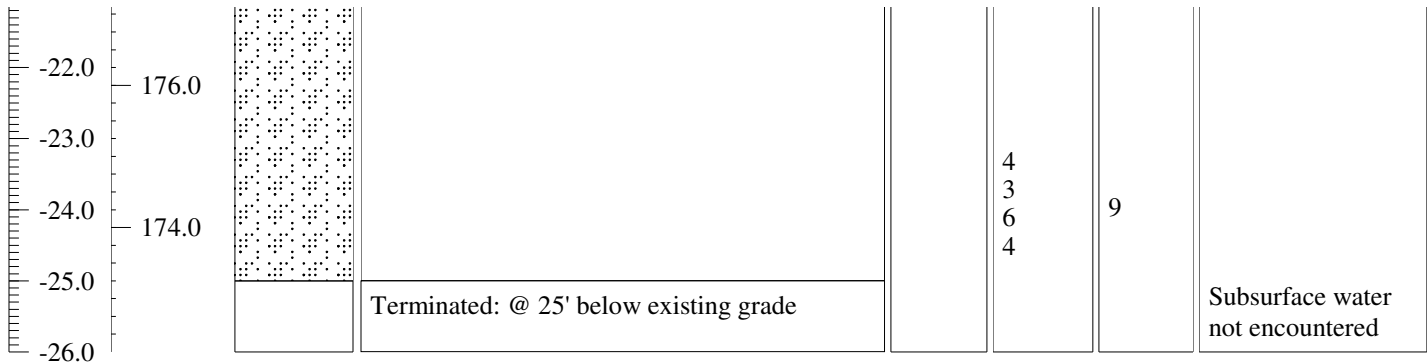
**Logged By:** DT

**Drill Type:** 2-1/4" HSA w/ SPT

**Drilled By:** Fishburne Drilling

**Location:** See Location Plan

Depth ft.	Elevation ft.	Legend	Description	USCS Symbol	SPT Blow Count	N- Value	Notes
--------------	------------------	--------	-------------	----------------	----------------------	-------------	-------



**APPENDIX**  
**Section III**

**In-situ Infiltration Test Results**

Hole No. K-1  
 Location: McGuire Hospital

Date: 7/1/2014 Temp: 90F

Measured (Actual) Water Level in hole:

Initial	15	cm
Final	14	cm
Conversion Factor (CF)	105	cm <sup>2</sup>
Hole Depth:	72 in.	183 cm
	11	cm
	194	cm
	15	cm
	200	cm
	3	cm
	0.001166	1/cm <sup>2</sup>

Distance between reference level and soil surface  
 Distance from the hole bottom to the reference level (D)  
 Desired water depth in hole (H)  
 Constant-head tube setting (d)  
 Radius of hole ( r )  
 Constant from Chart (A)

Clock Time (h:min)	Reservoir Reading (cm)	D t (min)	Change in Water Level (cm)	Flow Volume (cm <sup>2</sup> )	Q (cm <sup>3</sup> /min)	Q (cm <sup>3</sup> /h)	A (1/cm <sup>2</sup> )	Ksat (cm/hr)
10:40	46.2							
10:50	45.7	10	0.5	52.5	5.25	315	0.001166	0.367
11:00	45.6	10	0.1	10.5	1.05	63	0.001166	0.073
11:10	45.5	10	0.1	10.5	1.05	63	0.001166	0.073
11:20	45.4	10	0.1	10.5	1.05	63	0.001166	0.073
11:30	45.3	10	0.1	10.5	1.05	63	0.001166	0.073

Average of last three measurements:

Ksat = 0.07 cm/hour  
 Ksat = 1.76 cm/day  
 0.058 ft/day

Comments:

Hole No. K-2  
 Location: McGuire Hospital

Date: 7/1/2014 Temp: 90F

Measured (Actual) Water Level in hole:

Initial	16	cm
Final	17	cm
Conversion Factor (CF)	105	cm <sup>2</sup>
Hole Depth:	72 in.	183 cm
	11	cm
	194	cm
	15	cm
	200	cm
	3	cm
	0.000879	1/cm <sup>2</sup>

Distance between reference level and soil surface  
 Distance from the hole bottom to the reference level (D)  
 Desired water depth in hole (H)  
 Constant-head tube setting (d)  
 Radius of hole ( r )  
 Constant from Chart (A)

Clock Time (h:min)	Reservoir Reading (cm)	D t (min)	Change in Water Level (cm)	Flow Volume (cm <sup>2</sup> )	Q (cm <sup>3</sup> /min)	Q (cm <sup>3</sup> /h)	A (1/cm <sup>2</sup> )	Ksat (cm/hr)
12:00	36							
12:10	33.9	10	2.1	220.5	22.05	1323	0.000879	1.163
12:20	33.6	10	0.3	31.5	3.15	189	0.000879	0.166
12:30	33.3	10	0.3	31.5	3.15	189	0.000879	0.166
12:40	33.0	10	0.3	31.5	3.15	189	0.000879	0.166
12:50	32.7	10	0.3	31.5	3.15	189	0.000879	0.166

Average of last three measurements:

Ksat = 0.17 cm/hour  
 Ksat = 3.99 cm/day  
 0.131 ft/day

Comments:

**APPENDIX**  
**Section IV**

**Laboratory Test Results**

## Lab Data Summary

### H.H. McGuire VAMC Spinal Cord Addition

DAA # R05432-10G

Prepared By: JAC



**Draper Aden Associates**

Blacksburg • Richmond, Virginia  
Engineering • Surveying • Environmental Services

#### Sample Data

Sample ID	B-1	B-2	B-3	B-4	B-5
Sample Depth	38'-40'	0-5'	6'-8'	13'-15'	4'-6'
Sample Type	Split-Spoon	Bulk	Split-Spoon	Split-Spoon	Split-Spoon

#### Classification Data

Natural Moisture Content, %	37.9%	14.4%	15.6%	11.3%	13.2%
Liquid Limit	40	40	78	40	75
Plastic Limit	26	14	29	24	17
Plastic Index	14	26	49	16	58
Passing No. 200 Sieve, %	41.0%	57.1%	39.9%	20.8%	34.7%
USCS Group Symbol	SM	CL	SC	SC	SC

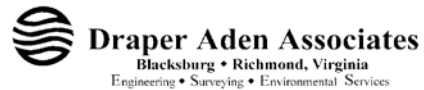
#### Standard Proctor Data

Maximum Dry Density, pcf	111.1
Optimum Moisture Content, %	15.5%

#### CBR Data

Compacted Dry Density, pcf	109.4
Compacted Moisture Content, %	17.1%
Deviation from Optimum, %	1.6%
Compaction, %	98%
Swell, %	-0.1%
<b>CBR Value @ 0.1"</b>	4.5
<b>CBR Value @ 0.2"</b>	3.9

**Soil Classification Calculations**  
**H.H. McGuire VAMC Spinal Cord Addition**  
**DAA # R05432-10G**  
**Prepared By: JAC**



Sample ID B-1  
Sample Depth 38'-40'  
Visual Sample Description Red-Brown Silty SAND

**Natural Moisture Content: ASTM D 2216**

Pan ID 3  
Pan Wt 193.39 grams  
Pan + Soil (wet) 304.24 grams  
Pan + Soil (dry) 273.79 grams  
*Natural Moisture Content* 37.9%

**Coarse or Fine Grained: ASTM D 422**

Pan + Soil retained on No. 200 sieve  
(dry) 240.85 grams  
Percent Passing No. 200 Sieve 41.0%  
Pan + Soil retained on No. 4 sieve  
(dry) 193.39 grams  
Percent Passing No. 4 Sieve 100.0%  
*Soil Classifies as Coarse-Grained Soil*

**Atterberg Limits: ASTM D 4318**

**Liquid Limit**

No of Blows	16	26	35
Pan ID	93	91	104
Pan Wt	30.17	24.58	26.35
Pan + Soil (wet)	41.99	36.38	37.80
Pan + Soil (dry)	38.50	33.05	34.57
Moisture Content	41.9%	39.3%	39.3%
Liquid Limit	40	40	41
<i>Liquid Limit</i>	40		

**Plastic Limit**

Pan ID	13	79
Pan Weight	4.30	4.24
Pan + Soil (wet)	14.79	15.82
Pan + Soil (dry)	12.61	13.45
Moisture Content	26.2%	25.7%
<i>Plastic Limit</i>	26	
<i>Plastic Index</i>	14	

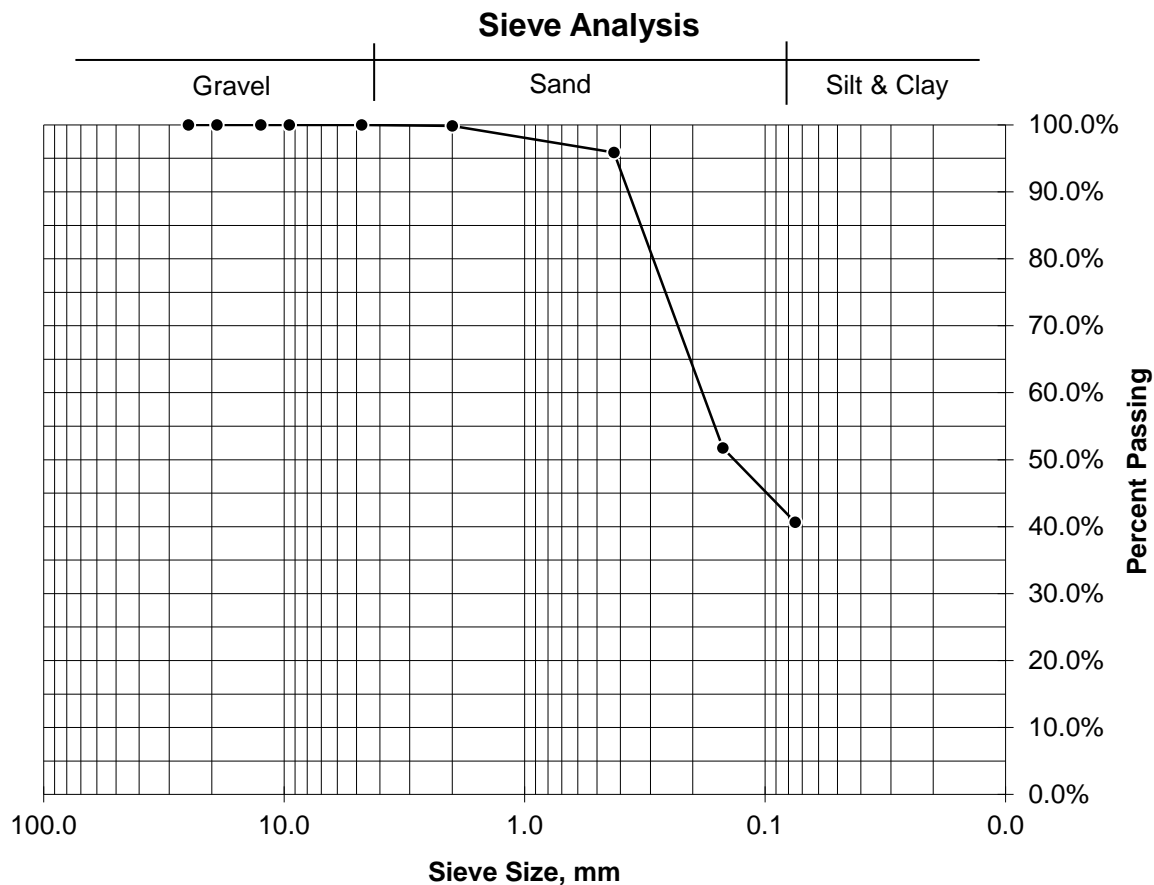
**USCS Classification: ASTM D 2487**

Group Symbol **SM**  
Group Name **Silty SAND**



**Grain Size Distribution Calculations****H.H. McGuire VAMC Spinal Cord Addition****DAA # R05432-10G****Prepared By: JAC****Draper Aden Associates**Blacksburg • Richmond, Virginia  
Engineering • Surveying • Environmental ServicesSample ID B-1  
Sample Depth 38'-40'**Mechanical Sieve Analysis: ASTM D 422**

Sieve Size	Weight Retained	Percent Retained	Sieve Size, mm	Percent Passing
1"	0.00	0.0%	25.0	100.0%
3/4"	0.00	0.0%	19.0	100.0%
1/2"	0.00	0.0%	12.5	100.0%
3/8"	0.00	0.0%	9.5	100.0%
No. 4	0.00	0.0%	4.75	100.0%
No. 10	0.13	0.2%	2.0	99.8%
No. 40	3.20	4.0%	0.425	95.9%
No. 100	35.45	44.1%	0.15	51.8%
No. 200	8.92	11.1%	0.075	40.7%
Pan	0.00	0.0%		
Total	47.70	59.3%		



**Soil Classification Calculations**  
**H.H. McGuire VAMC Spinal Cord Addition**  
**DAA # R05432-10G**  
**Prepared By: JAC**



**Draper Aden Associates**  
Blacksburg • Richmond, Virginia  
Engineering • Surveying • Environmental Services

Sample ID B-2  
Sample Depth 0-5'  
Visual Sample Description Dark Brown Sandy Lean CLAY

**Natural Moisture Content: ASTM D 2216**

Pan ID	11
Pan Wt	187.69 grams
Pan + Soil (wet)	496.80 grams
Pan + Soil (dry)	457.90 grams
Natural Moisture Content	14.4%

**Coarse or Fine Grained: ASTM D 422**

Pan + Soil retained on No. 200 sieve	
(dry)	303.52 grams
Percent Passing No. 200 Sieve	57.1%
Pan + Soil retained on No. 4 sieve	
(dry)	198.38 grams
Percent Passing No. 4 Sieve	96.0%
Soil Classifies as	Fine-Grained Soil

**Atterberg Limits: ASTM D 4318**

**Liquid Limit**

No of Blows	16	27	35
Pan ID	103	104	108
Pan Wt	27.39	26.24	33.16
Pan + Soil (wet)	41.27	41.20	47.53
Pan + Soil (dry)	37.08	37.08	43.68
Moisture Content	43.2%	38.0%	36.6%
Liquid Limit	41	38	38
Liquid Limit	40		

**Plastic Limit**

Pan ID	79	83
Pan Weight	4.23	4.22
Pan + Soil (wet)	15.99	15.81
Pan + Soil (dry)	14.56	14.40
Moisture Content	13.8%	13.9%
Plastic Limit	14	
Plastic Index	26	

**USCS Classification: ASTM D 2487**

Group Symbol	CL
Group Name	Sandy Lean CLAY

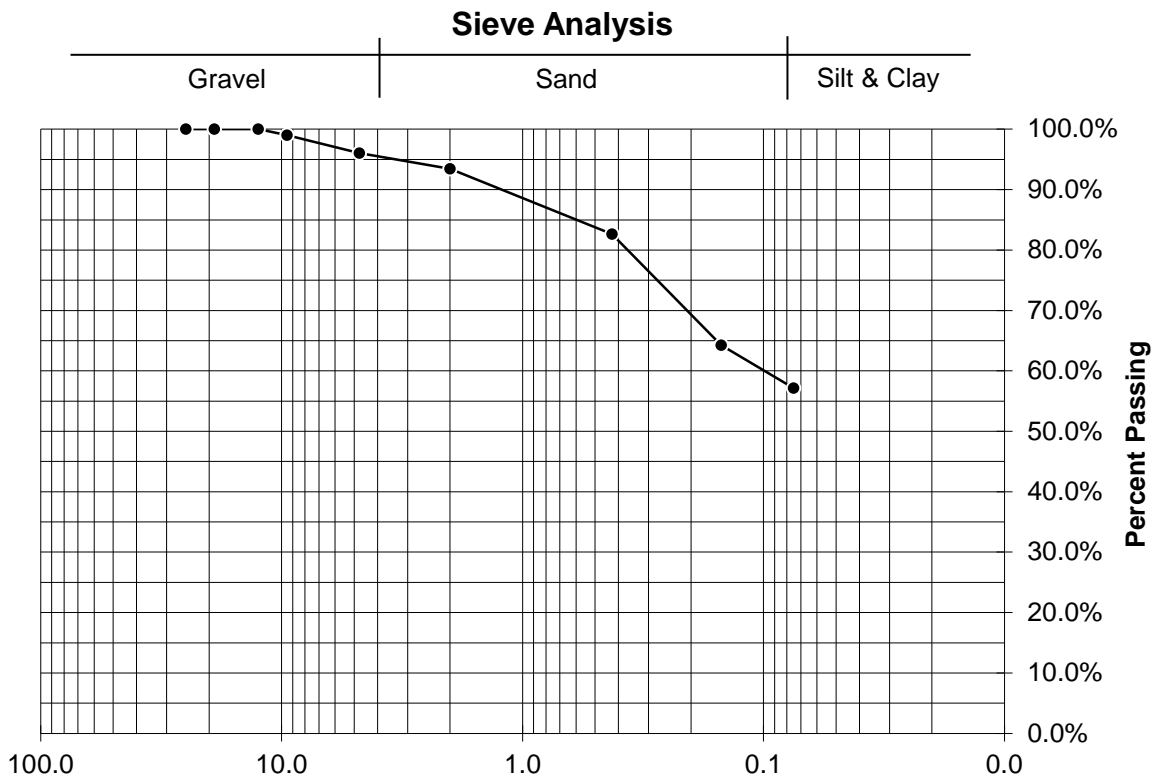
**Grain Size Distribution Calculations****H.H. McGuire VAMC Spinal Cord Addition****DAA # R05432-10G****Prepared By: JAC****Draper Aden Associates**Blacksburg • Richmond, Virginia  
Engineering • Surveying • Environmental Services

Sample ID B-2

Sample Depth 0-5'

**Mechanical Sieve Analysis: ASTM D 422**

Sieve Size	Weight Retained	Percent Retained	Sieve Size, mm	Percent Passing
1"	0.00	0.0%	25.0	100.0%
3/4"	0.00	0.0%	19.0	100.0%
1/2"	0.00	0.0%	12.5	100.0%
3/8"	2.63	1.0%	9.5	99.0%
No. 4	8.06	3.0%	4.75	96.0%
No. 10	7.03	2.6%	2.0	93.4%
No. 40	29.15	10.8%	0.425	82.7%
No. 100	49.69	18.4%	0.15	64.3%
No. 200	19.17	7.1%	0.075	57.2%
Pan	0.03	0.0%		
<b>Total</b>	<b>115.76</b>	<b>42.8%</b>		



**Proctor Test Report****H.H. McGuire VAMC Spinal Cord Addition****DAA # R05432-10G****Prepared by ADC****Draper Aden Associates**

Blacksburg • Richmond, Virginia

Engineering • Surveying • Environmental Services

**Soil and Test Method Data**

Sample ID B-2

Sample Depth 0-5'

Sample Classification Sandy Lean CLAY

USCS Group Symbol CL

Test Method ASTM D698, Method B, with mechanical hammer

Sample Preparation Air dried and sieved through a 3/8" sieve.

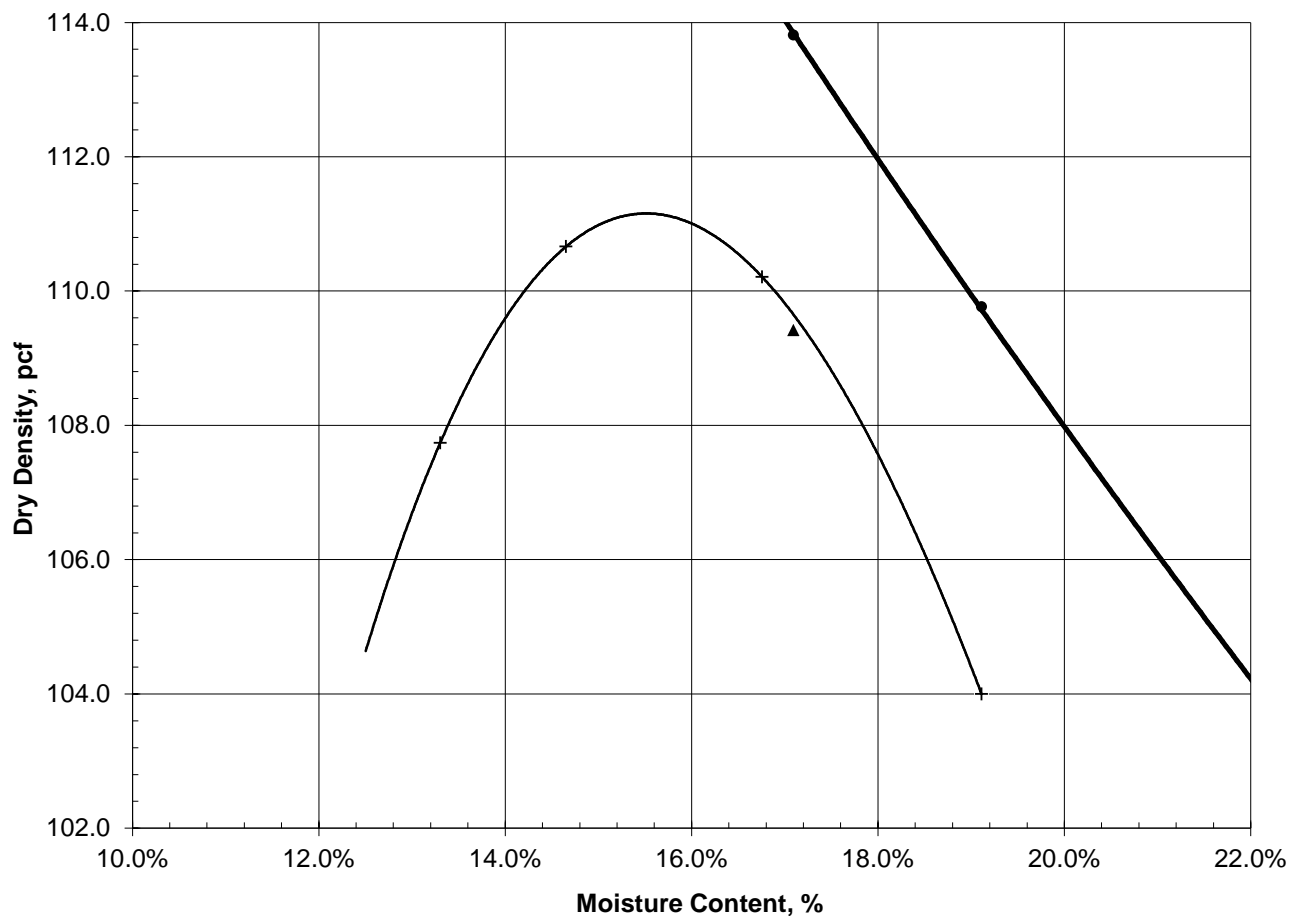
Mold Size, in 4.0

Assumed Specific Gravity: 2.65

Test Data	#1	#2	#3	#4	#5
Moisture Content	13.3%	14.7%	16.8%	19.1%	
Dry Density, pcf	107.7	110.7	110.2	104.0	

**Moisture-Density Curve**

Maximum Dry Density, pcf = 111.1, Optimum Moisture, % = 15.5



• Zero Air Voids    + Proctor Points    ▲ CBR Points

**CBR Test Report****H.H. McGuire VAMC Spinal Cord Addition****DAA # R05432-10G****Prepared by ADC****Draper Aden Associates**Blacksburg • Richmond, Virginia  
Engineering • Surveying • Environmental Services**Soil and Test Method Data**

Sample ID B-2

Sample Depth 0-5'

Sample Classification Sandy Lean CLAY

USCS Group Symbol CL

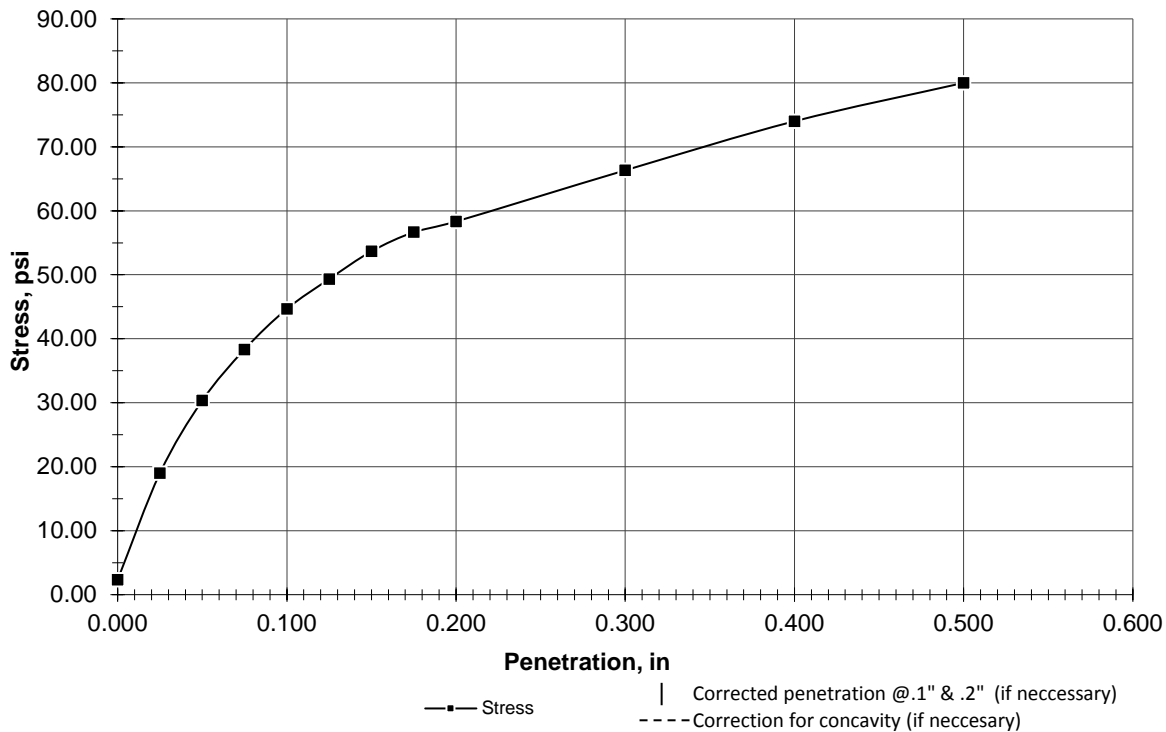
Test Method ASTM D1883, compacted with mechanical hammer

Sample Preparation Air dried, sieved through a 3/8" sieve and moisture conditioned.

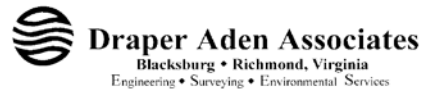
Soak &gt;96 hours

**Test Data**

Compacted Moisture Content	17.1%
Compacted Dry Density	109.4
Percent Compaction	98%
Percent Swell	-0.1%
<b>CBR @ 0.1"</b>	<b>4.5</b>
<b>CBR @ 0.2"</b>	<b>3.9</b>



**Soil Classification Calculations**  
**H.H. McGuire VAMC Spinal Cord Addition**  
**DAA # R05432-10G**  
**Prepared By: JAC**



Sample ID B-3  
Sample Depth 6'-8'  
Visual Sample Description Red-Brown Clayey SAND with Gravel

**Natural Moisture Content: ASTM D 2216**

Pan ID 39  
Pan Wt 193.18 grams  
Pan + Soil (wet) 304.28 grams  
Pan + Soil (dry) 289.30 grams  
*Natural Moisture Content 15.6%*

**Coarse or Fine Grained: ASTM D 422**

Pan + Soil retained on No. 200 sieve  
(dry) 250.93 grams  
Percent Passing No. 200 Sieve 39.9%  
Pan + Soil retained on No. 4 sieve  
(dry) 221.77 grams  
Percent Passing No. 4 Sieve 70.3%  
*Soil Classifies as Coarse-Grained Soil*

**Atterberg Limits: ASTM D 4318**

**Liquid Limit**

No of Blows	14	22	33
Pan ID	91	107	201
Pan Wt	24.56	25.13	27.70
Pan + Soil (wet)	36.07	36.97	44.23
Pan + Soil (dry)	30.86	31.80	37.15
Moisture Content	82.7%	77.5%	74.9%
Liquid Limit	77	76	77
<i>Liquid Limit</i>	78		

**Plastic Limit**

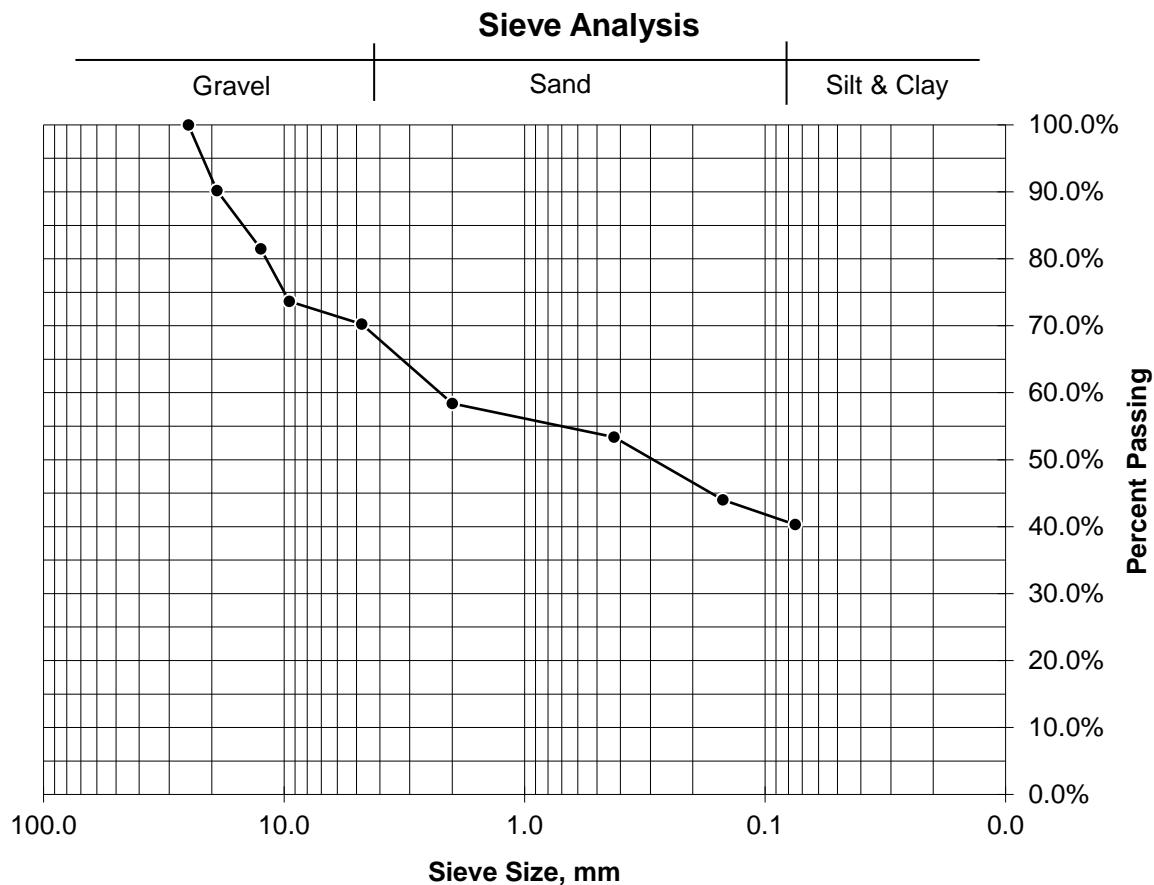
Pan ID	317	352
Pan Weight	8.06	9.07
Pan + Soil (wet)	14.53	15.61
Pan + Soil (dry)	13.11	14.14
Moisture Content	28.1%	29.0%
<i>Plastic Limit</i>	29	
<i>Plastic Index</i>	49	

**USCS Classification: ASTM D 2487**

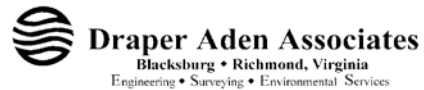
Group Symbol **SC**  
Group Name **Clayey SAND with Gravel**

**Grain Size Distribution Calculations****H.H. McGuire VAMC Spinal Cord Addition****DAA # R05432-10G****Prepared By: JAC****Draper Aden Associates**Blacksburg • Richmond, Virginia  
Engineering • Surveying • Environmental ServicesSample ID B-3  
Sample Depth 6'-8'**Mechanical Sieve Analysis: ASTM D 422**

Sieve Size	Weight Retained	Percent Retained	Sieve Size, mm	Percent Passing
1"	0.00	0.0%	25.0	100.0%
3/4"	9.45	9.8%	19.0	90.2%
1/2"	8.35	8.7%	12.5	81.5%
3/8"	7.55	7.9%	9.5	73.6%
No. 4	3.24	3.4%	4.75	70.3%
No. 10	11.42	11.9%	2.0	58.4%
No. 40	4.80	5.0%	0.425	53.4%
No. 100	9.03	9.4%	0.15	44.0%
No. 200	3.54	3.7%	0.075	40.3%
Pan	0.06	0.1%		
<b>Total</b>	<b>57.44</b>	<b>59.7%</b>		



**Soil Classification Calculations**  
**H.H. McGuire VAMC Spinal Cord Addition**  
**DAA # R05432-10G**  
**Prepared By: JAC**



Sample ID B-4  
Sample Depth 13'-15'  
Visual Sample Description Red-Brown Clayey SAND with Gravel

**Natural Moisture Content: ASTM D 2216**

Pan ID 6  
Pan Wt 195.60 grams  
Pan + Soil (wet) 300.85 grams  
Pan + Soil (dry) 290.18 grams  
*Natural Moisture Content* 11.3%

**Coarse or Fine Grained: ASTM D 422**

Pan + Soil retained on No. 200 sieve  
(dry) 270.53 grams  
Percent Passing No. 200 Sieve 20.8%  
Pan + Soil retained on No. 4 sieve  
(dry) 224.77 grams  
Percent Passing No. 4 Sieve 69.2%  
*Soil Classifies as Coarse-Grained Soil*

**Atterberg Limits: ASTM D 4318**

**Liquid Limit**

No of Blows	15	22	32
Pan ID	97	98	101
Pan Wt	26.16	30.38	24.04
Pan + Soil (wet)	38.77	43.74	35.90
Pan + Soil (dry)	34.94	39.82	32.63
Moisture Content	43.6%	41.5%	38.1%
Liquid Limit	41	41	39
<i>Liquid Limit</i>	40		

**Plastic Limit**

Pan ID	74	76
Pan Weight	4.29	4.24
Pan + Soil (wet)	15.45	15.38
Pan + Soil (dry)	13.90	13.87
Moisture Content	16.1%	15.7%
<i>Plastic Limit</i>	16	
<i>Plastic Index</i>	24	

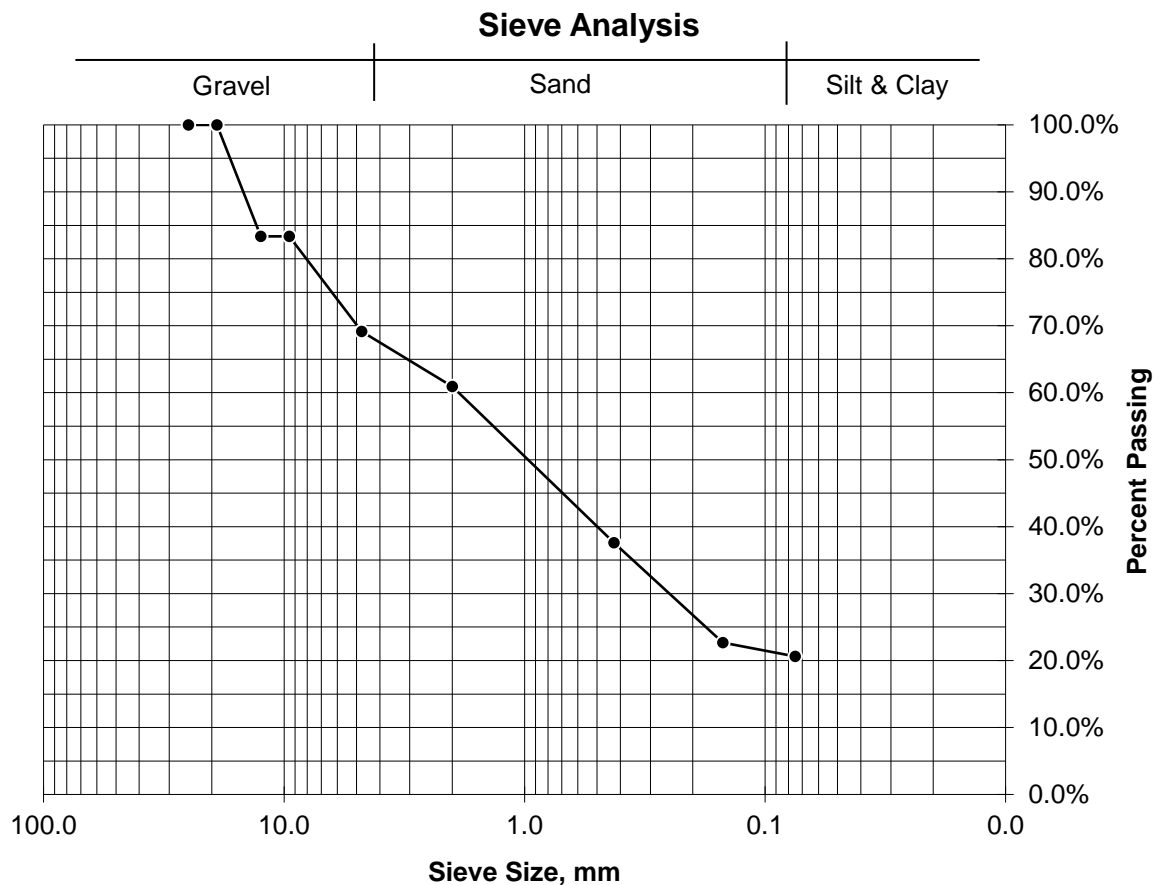
**USCS Classification: ASTM D 2487**

Group Symbol **SC**  
Group Name **Clayey SAND with Gravel**

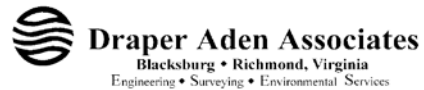


**Grain Size Distribution Calculations****H.H. McGuire VAMC Spinal Cord Addition****DAA # R05432-10G****Prepared By: JAC****Draper Aden Associates**Blacksburg • Richmond, Virginia  
Engineering • Surveying • Environmental ServicesSample ID B-4  
Sample Depth 13'-15'**Mechanical Sieve Analysis: ASTM D 422**

Sieve Size	Weight Retained	Percent Retained	Sieve Size, mm	Percent Passing
1"	0.00	0.0%	25.0	100.0%
3/4"	0.00	0.0%	19.0	100.0%
1/2"	15.73	16.6%	12.5	83.4%
3/8"	0.00	0.0%	9.5	83.4%
No. 4	13.44	14.2%	4.75	69.2%
No. 10	7.78	8.2%	2.0	60.9%
No. 40	22.08	23.3%	0.425	37.6%
No. 100	14.12	14.9%	0.15	22.7%
No. 200	1.93	2.0%	0.075	20.6%
Pan	0.00	0.0%		
<b>Total</b>	<b>75.08</b>	<b>79.4%</b>		



**Soil Classification Calculations**  
**H.H. McGuire VAMC Spinal Cord Addition**  
**DAA # R05432-10G**  
**Prepared By: JAC**



Sample ID B-5  
Sample Depth 4'-6'  
Visual Sample Description Red-Brown Clayey SAND with Gravel

**Natural Moisture Content: ASTM D 2216**

Pan ID 38  
Pan Wt 193.85 grams  
Pan + Soil (wet) 299.99 grams  
Pan + Soil (dry) 287.59 grams  
*Natural Moisture Content* 13.2%

**Coarse or Fine Grained: ASTM D 422**

Pan + Soil retained on No. 200 sieve  
(dry) 255.07 grams  
Percent Passing No. 200 Sieve 34.7%  
Pan + Soil retained on No. 4 sieve  
(dry) 216.11 grams  
Percent Passing No. 4 Sieve 76.3%  
*Soil Classifies as Coarse-Grained Soil*

**Atterberg Limits: ASTM D 4318**

**Liquid Limit**

No of Blows	16	22	34
Pan ID	105	96	94
Pan Wt	29.28	24.85	23.91
Pan + Soil (wet)	39.37	34.41	34.25
Pan + Soil (dry)	34.90	30.28	29.93
Moisture Content	79.5%	76.1%	71.8%
Liquid Limit	75	75	74
<i>Liquid Limit</i>	75		

**Plastic Limit**

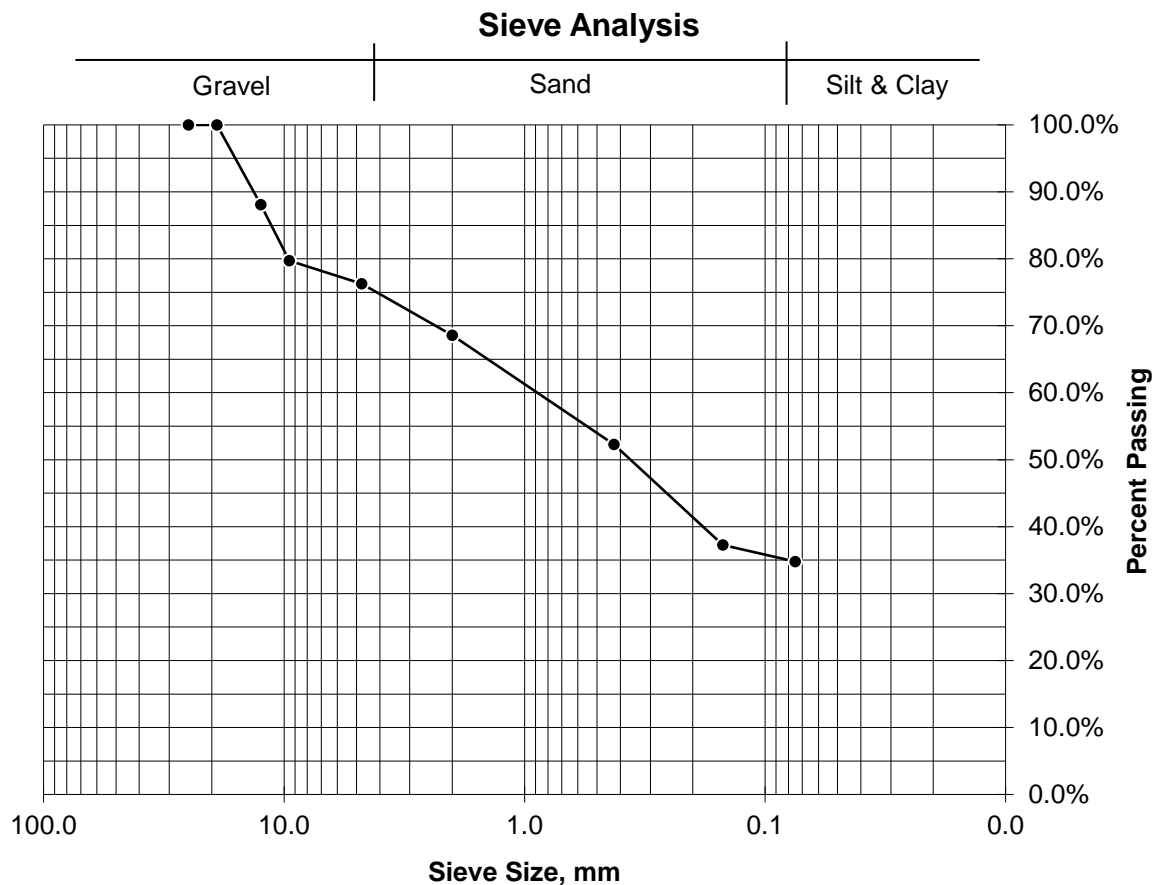
Pan ID	315	352
Pan Weight	9.15	9.07
Pan + Soil (wet)	19.71	19.54
Pan + Soil (dry)	18.20	18.03
Moisture Content	16.7%	16.9%
<i>Plastic Limit</i>	17	
<i>Plastic Index</i>	58	

**USCS Classification: ASTM D 2487**

Group Symbol **SC**  
Group Name **Clayey SAND with Gravel**

**Grain Size Distribution Calculations****H.H. McGuire VAMC Spinal Cord Addition****DAA # R05432-10G****Prepared By: JAC****Draper Aden Associates**Blacksburg • Richmond, Virginia  
Engineering • Surveying • Environmental ServicesSample ID B-5  
Sample Depth 4'-6'**Mechanical Sieve Analysis: ASTM D 422**

Sieve Size	Weight Retained	Percent Retained	Sieve Size, mm	Percent Passing
1"	0.00	0.0%	25.0	100.0%
3/4"	0.00	0.0%	19.0	100.0%
1/2"	11.18	11.9%	12.5	88.1%
3/8"	7.85	8.4%	9.5	79.7%
No. 4	3.23	3.4%	4.75	76.3%
No. 10	7.20	7.7%	2.0	68.6%
No. 40	15.29	16.3%	0.425	52.3%
No. 100	14.08	15.0%	0.15	37.2%
No. 200	2.30	2.5%	0.075	34.8%
Pan	0.00	0.0%		
<b>Total</b>	<b>61.13</b>	<b>65.2%</b>		



**APPENDIX**  
**Section V**

**Geotechnical Test Methods**



## Draper Aden Associates

Blacksburg • Richmond, Virginia  
Engineering • Surveying • Environmental Services

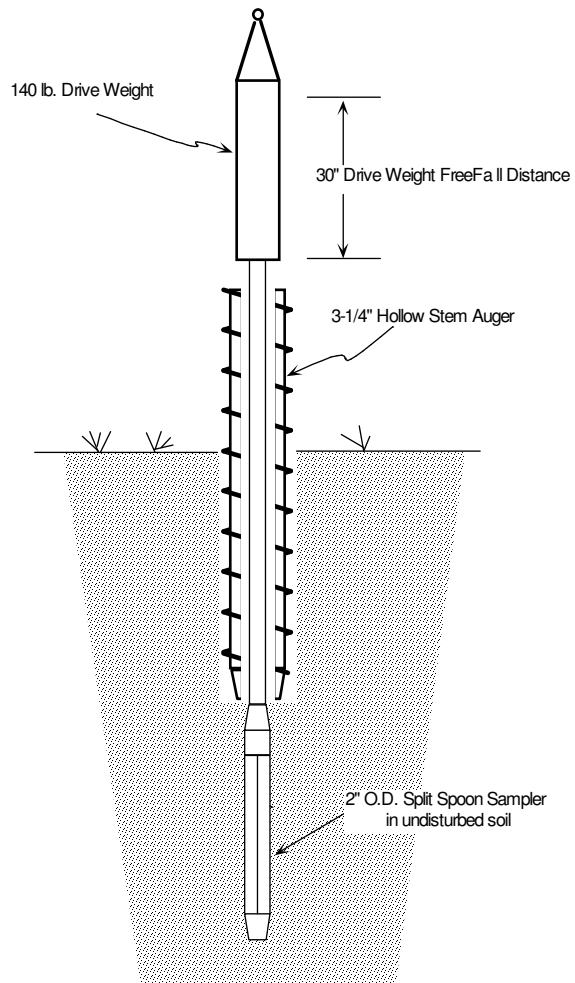
# Standard Penetration Test

Split Spoon Sampling is an in-situ technique of obtaining samples of both cohesive and cohesionless soils. The sample is taken by actually driving the split spoon sampler into the “undisturbed” soil at the bottom of the bore hole. The bore hole is advanced using a hollow stem auger.

The Split Spoon Sampler is made up of a split steel barrel with a ball check valve in the head for venting and a hardened steel shoe for driving. A spring sample retainer is used between the shoe and the barrel to retain any loose or flowing materials. After the sampler is driven, the head and the shoe are removed and the barrel opens into two halves exposing the entire sample.

The use of a 140 lb. drive weight falling freely 30" to drive the 2" O.D. (1-3/8" I.D.) split spoon sampler a distance of one foot is known as the Standard Penetration Test. Once the sampler is lowered to the bottom of the borehole, the sampler is driven continuously for 18". The number of blows required by the 140 lb. weight to drive the sampler is recorded. Separate counts are made for the second 6" and the third 6" with the first 6" considered to be seating the sampler. An N-Value is obtained by adding the second and third 6" intervals and recorded. The N-Value correlation is shown below:

## Standard Penetration Test Diagram



### Soil Strength

#### Relative Density

Coarse Grained Soil, SAND

N-Value	Relative Density
0-4	Very Loose
5-10	Loose
11-30	Medium Dense
31-50	Dense
>50	Very Dense

#### Consistency

Fine Grained Soil, SILT or CLAY

N-Value	Relative Density
0-1	Very Soft
2-4	Soft
5-8	Medium Stiff
9-15	Stiff
16-29	Very Stiff
>29	Hard

SPT performed in accordance with ASTM D1586,  
Standard Method for Penetration Test and Split-Barrel  
Sampling of Soils.



Naturally occurring soils nearly always contain water as part of their structure. The moisture content of a soil is assumed to be the amount of water within the pore space between the soil grains which is removable by oven drying at 110°C, expressed as a percentage of the mass of dry soil. By 'dry' is meant the result of oven drying at that temperature to constant mass, usually for a period of about 12-14 hours. In non-cohesive granular soils, this procedure removes all water present.

There are several ways in which water is held in cohesive soils, which contain clay minerals existing as plate-like particles of less than 2µm across. The shape and very small size of these particles, and their chemical composition, enable them to combine with or hold on to water by several complex means as follows:

- 1) Adsorbed water is held on the surface of the particle by powerful forces of electrical attraction and virtually in a solid state. This water cannot be removed by oven drying at 110°C, and may, therefore, be considered a part of the solid soil grain.
- 2) Water which is not so tightly held and can be removed by oven drying, but not by air drying.
- 3) Capillary water, held by surface tension, generally removable by air drying.
- 4) Gravitational water, which can move within the voids between soil grains, is removable by drainage.
- 5) Chemically combined water, in the form of water of hydration within the crystal structure. Except for gypsum, and some tropical clays, this water is not generally removable by oven drying.

Moisture content is usually expressed as a percentage, always on the basis of oven-dry mass of soil. The equation for the determination of moisture content is:

$$w(\%) = \frac{m_w}{m_d} \times 100$$

where ,

$m_w$  = mass of water removed at 110°C.

$m_d$  = mass of dried soil

The following ASTM (American Society for Testing and Materials) apply to moisture content determinations:

ASTM D2216-90 Laboratory Determination of Water Content of Soil and Rock

ASTM D4959 -89 Determination of Water Content of Soil By Direct Heating Method

ASTM D4643-87 Determination of Water Content of Soil by the Microwave Oven Method

ASTM D3017-88 Water Content of Soil and Rock in Place by Nuclear Methods



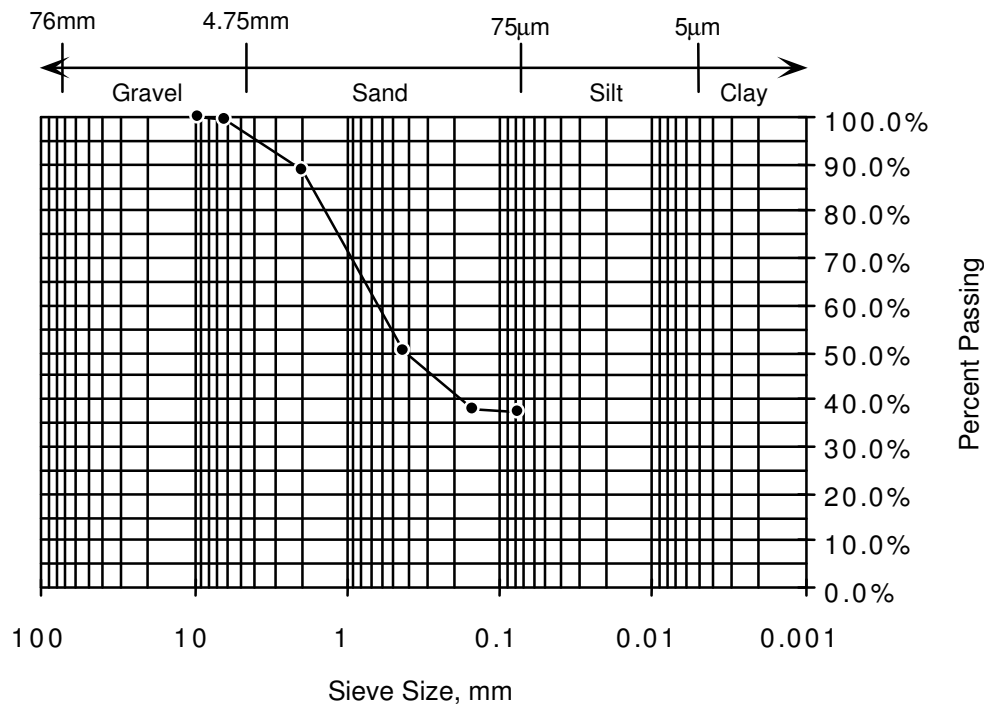
A soil consists of an assemblage of discrete particles of various shapes and sizes. The object of a particle size analysis is to group these particles into separate ranges of sizes, and so determine the relative proportions, by dry weight, of each size range.

Particle size analyses consist of two separate and quite different procedures in order to span the very wide range of particle sizes which are encountered. These are sieving and sedimentation procedures. Sieving is used for gravel and sand size (coarse) particles, which can be separated into different size ranges with a series of standard aperture openings. Sieving cannot be used for the very much smaller silt and clay size (fine) particles, so a sedimentation procedure is used instead. Measurements of the density of the suspension are made using a hydrometer.

For soils containing both coarse and fine particles, composite tests using both sieving and sedimentation methods may be used if a full particle size distribution analyses is required. Particle size testing can range from a simple sieving test on a 'clean' sand and gravel, to elaborate composite tests on clay-silt-sand-gravel mixtures.

Presentation of particle size distribution data may include a table showing the percentages, by dry weight, of particles finer than certain standard sizes and may include a graphical presentation of the percentages plotted against the particle size on a logarithmic scale. An example of the graphical presentation with respective particle sizes follows:

### Sieve Analysis



Particle size analyses are performed in accordance with ASTM D422-63, Standard Test Method for Particle-Size Analysis of Soils or ASTM C136-84, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.

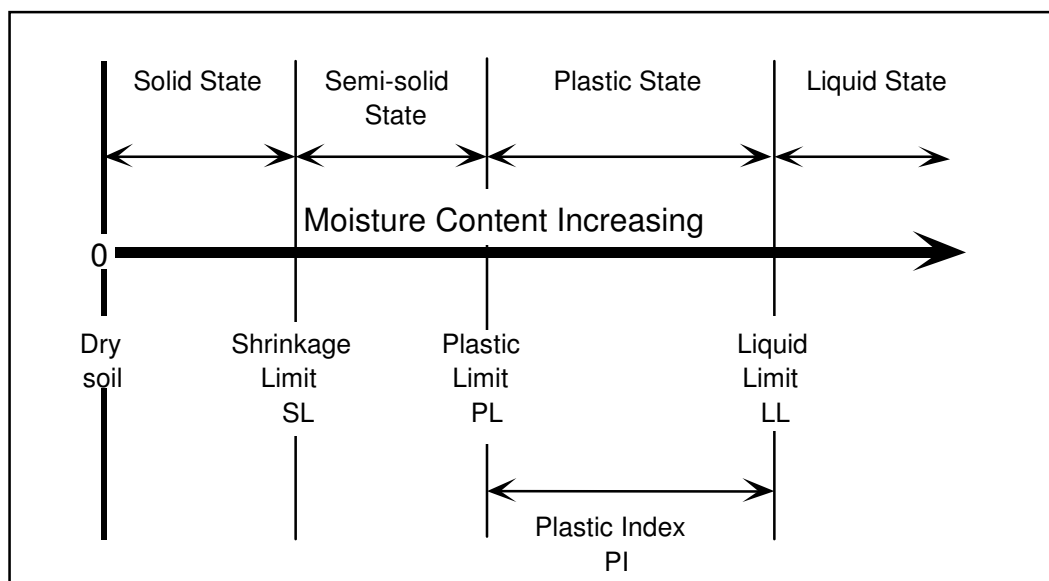


The condition of a clay soil can be altered by changing the moisture content; the softening of clay by the addition of water is a well known example. For every clay soil there is a range of moisture contents within which the clay is of a plastic consistency, and the Atterberg limits provide a means of measuring and describing the plasticity range in numerical terms.

If sufficient water is mixed with a clay, it can be made into a slurry, which behaves as a viscous liquid. This is known as the 'liquid' state. If the moisture content is gradually reduced by allowing it to dry out slowly, the clay eventually begins to hold together and to offer some resistance to deformation; this is the 'plastic' state. With further loss of water the clay shrinks and the stiffness increases until there is little plasticity left, and the clay becomes brittle; this is the 'semi-solid' state. As drying continues, the clay continues to shrink in proportion to the amount of water lost, until it reaches the minimum volume attainable by this process. Beyond that point further drying results in no further decrease in volume, and this is called the 'solid' state.

These four states, or phases, are shown diagrammatically below. The change from one phase to the next is not observable as a precise boundary, but takes place as a gradual transition. Nevertheless three arbitrary but specific boundaries have been established empirically, as indicated below, and are universally recognized. The moisture contents at these boundaries are known as the Liquid Limit (LL), Plastic Limit (PL) and the Shrinkage Limit (SL).

The moisture content range between the PL and the LL is known as the Plastic Index (PI), and is a measure of the plasticity of the clay. Cohesionless soils have no plasticity phase, so their PI is zero.



Atterberg limits are performed in accordance with ASTM D4318-84, Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils.





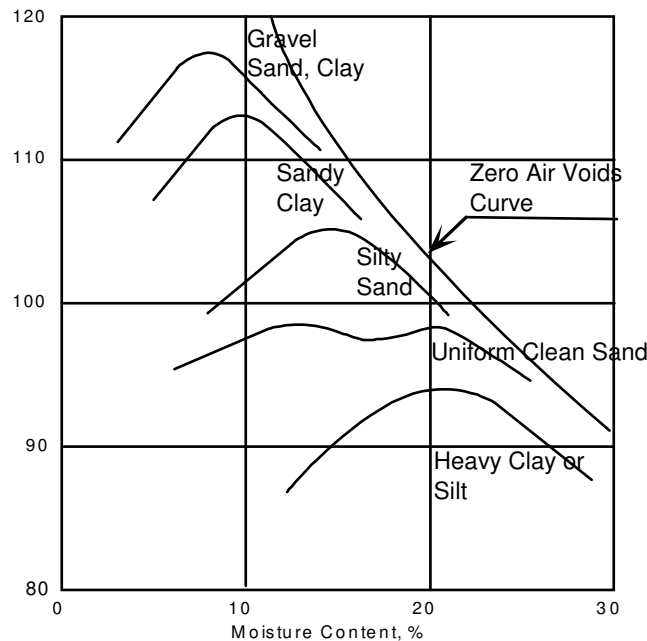
## Moisture-Density Relationships

Compaction of soil is the process by which the solid soil particles are packed more closely together by mechanical means, thus increasing the dry density. It is achieved through the reduction of air voids in the soil, with little or no reduction in the water content. The air voids cannot be eliminated altogether by compaction, but with proper control they can be reduced to a minimum. The effect of the amount of water present in a fine-grained soil on its compaction characteristics is significant.

At low moisture content the soil grains are surrounded by a thin film of water, which tends to keep the grains apart even when compacted. If the moisture content is increased, the additional water enables the grains to be more easily compacted together. Some of the air is displaced and the dry density is increased. The addition of more water, up to a certain point, enables more air to be expelled during compaction. At that point the soil grains become as closely packed together as they can be under application of a specific compactive effort. When water exceeds that required to achieve this condition, the excess water begins to displace the soil particles so that the dry density is reduced. At higher moisture contents little or no more air is expelled and the resulting dry density continues to decrease.

At each stage the compacted dry density is calculated and plotted against moisture content, a graph similar to that presented below. This graph is the 'moisture-density relationship' curve. The moisture content at which the greatest value of dry density is reached for the given amount of compaction is the optimum moisture content and the corresponding dry density is the maximum dry density.

A moisture-density relationship curve is not complete without the addition of a zero air voids line. A zero air voids line is a line (curve) showing the dry density-moisture content relation for a soil theoretically containing zero air voids. It is impossible for a point on a compaction curve to lie to the right of this line, whatever the degree of compactive effort applied.



**Compaction Curves for Typical Soils**

Compaction tests are performed in accordance with ASTM D698-91, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbs) and ASTM D1557-91, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbs).



## California Bearing Ratio

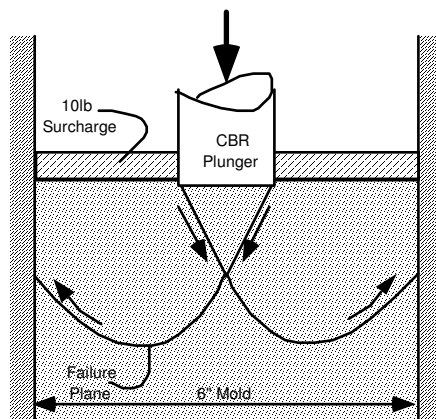
The California Bearing Ratio (CBR) test is an empirical test for estimating the bearing value of highway sub-bases and subgrades. The test follows a standardized procedure which includes pushing a plunger into the soil at a fixed rate of penetration and measuring the force required to maintain that rate. From the resulting load vs. penetration relationship, the CBR value can be derived. It is important to appreciate that this test, being of an empirical nature, is valid only for the application for which it was developed, ie. the design of pavement cross sections.

A CBR test is normally carried out on a sample of soil which reproduces as closely as possible the conditions likely to occur in the field. If the in-situ density and moisture content are known, a test specimen can be prepared to fulfill these conditions. However, specifications for road embankments and sub-bases are often worded in terms of a permitted moisture content range and acceptable density range. The CBR value for a specific soil depends upon its in place dry density and moisture content.

A typical CBR test consists of determining the moisture-density relationship for the specific soil to be tested. Once the maximum dry density and optimum moisture content are determined, the soil is compacted into a 6" diameter mold at a minimum density of 97% near the optimum moisture content. A surcharge weight equivalent to about 50psf is placed on top of the compacted sample. The sample is then submerged for a period of 4 days and allowed to swell. The sample is removed from the water bath and the penetration resistance is determined using a constant rate shear test. The load-penetration relationship is drawn as a graph and the CBR value is determined as follows:

$$\text{CBR} = \frac{\text{Force @ 0.10" Penetration}}{\text{Standard Force} = 1000\text{psi}}$$

An assumed failure mechanism beneath the CBR plunger is presented below:



CBR tests are performed in accordance with ASTM D1883, Test Method for CBR of Laboratory Compacted Soils or Virginia Test Method, VTM-8, Conducting California Bearing Ratio Tests.