Preliminary Geotechnical Engineering Report

Proposed New Southern Colorado National Cemetery
Bradley Heights Ranch, Rolling Hills Ranch, and 4 Way Ranch
El Paso County, Colorado

April 30, 2012
Project No. 23125013

Prepared for:
Department of Veteran Affairs

Prepared by:
Terracon Consultants, Inc.
Colorado Springs, Colorado

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April 30, 2012

Studley, Inc.
555 13th Street, NW
Suite 420 E
Washington, DC 20004

Attn: Ms. Samantha R. Kurtz

Re: Preliminary Geotechnical Engineering Report
Proposed New Southern Colorado National Cemetery
Bradley Heights Ranch, Rolling Hills Ranch, 4 Way Ranch
El Paso County, Colorado
Terracon Project Number: 23125013

Terracon Consultants, Inc. (Terracon) has performed preliminary geotechnical engineering services for the above referenced project. This report presents the findings of the subsurface exploration and provides preliminary geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, and pavements for the proposed project.

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

Sincerely,
Terracon Consultants, Inc.

COLORADO REGISTERED
RYAN W. FEIST
37787
PROFESSIONAL ENGINEER

Robert M. Hernandez, P.E.
Senior Staff Engineer

Ryan W. Feist, P.E.
Geotechnical Services Manager

Copies to: Addressee (1, *pdf)

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EXECUTIVE SUMMARY

A preliminary geotechnical investigation has been performed for the proposed VA national cemetery, to be located at one of three potential sites within El Paso County, Colorado. The three sites include portions of Bradley Heights Ranch, Rolling Hills Ranch, and 4 Way Ranch. Fifteen test borings were advanced to depths of approximately 9½ to 20½ feet below the existing ground surface within the general vicinity of the proposed sites (five at each site). The following geotechnical considerations were identified:

- The proposed buildings may be supported on reinforced shallow spread footings bearing on newly placed, compacted fill. Floor slabs should also bear on newly placed, compacted fill. Preliminary depths of compacted fill are site dependent and are presented in subsequent sections of this report. Proposed pavements at each of the three sites should be supported on a minimum of 12 inches of on-site or imported sand soils. On-site sand soils are considered suitable for reuse as engineered fill beneath foundations, slabs, and pavements. On-site clay soils are considered suitable for reuse at depths greater than 12 inches from pavement subgrade or within non-structural areas.

- Expansive soils and bedrock are present at the Bradley Heights and Rolling Hills sites. This report provides recommendations to help mitigate the effects of soil and bedrock shrinkage and expansion. However, even if these procedures are followed, some movement and minor cracking in the structure should be anticipated. The severity of cracking and other cosmetic damage will probably increase if any modification of the site results in excessive wetting or drying of the expansive soils and bedrock. Eliminating the risk of movement and cosmetic distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. We'd be pleased to discuss other foundation alternatives, such as drilled pier foundations, at your request.

- Groundwater was not observed within the borings at the Bradley Heights and Rolling hills sites. Relatively shallow groundwater was encountered at the 4 Way Ranch site at depths between 5½ to 12½ feet below site grade. Groundwater may cause construction difficulties during building and gravesite construction. Additional details are presented in subsequent sections of this report.

- The 2009 International Building Code, Table 1613.5.2 IBC seismic site classification for the sites is either C or D, depending on the depth to bedrock.

- Close monitoring of the construction operations discussed herein will be critical in achieving the foundation and pavement design subgrade support. We therefore recommend that Terracon be retained to monitor this portion of the work.

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

PRELIMINARY GEOTECHNICAL ENGINEERING REPORT
PROPOSED SOUTHERN COLORADO NATIONAL CEMETERY
BRADLEY HEIGHTS, ROLLING HILLS, AND 4 Way RANCHES
EL PASO COUNTY, COLORADO

Project No. 23125013
April 30, 2012

1.0 INTRODUCTION

A preliminary geotechnical investigation has been performed for the proposed VA national cemetery, to be located at one of three potential sites within El Paso County, Colorado. The three sites include portions of Bradley Heights Ranch, Rolling Hills Ranch, and 4 Way Ranch. Fifteen test borings were advanced to depths of approximately 9½ to 20½ feet below the existing ground surface within the general vicinity of the proposed sites (five at each site). Boring logs along with Boring Location Plans are included in Appendix A of this report.

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

- subsurface soil and bedrock conditions
- groundwater conditions
- foundation design and construction
- floor slab design and construction
- pavement thickness design
- earthwork
- drainage

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Site layout	See Appendix A, Boring Location Plan
Proposed Development	This proposed National Cemetery will develop gravesites for interments of both casketed and cremated remains. The first phase of development will develop approximately 50 acres to provide approximately 12,000 gravesites. The proposed project will also include entrance / access roads, an entrance area, flag/assembly area, committal shelters, an administration building/public information center with electronic gravesite locator and public restrooms, memorial walkway/donations area, grounds maintenance complex, parking, and utilities.
Finished floor elevation	We anticipate finished floor of the structures to be within three feet of existing grades

ITEM	DESCRIPTION
Maximum loads	Columns: 40 to 80 kips (assumed) Walls: 2 to 4 kips per lineal foot (assumed)
Maximum allowable movement	Total: 1 inch (assumed) Differential: ½ to ¾ of total (assumed)
Grading	Unknown. We anticipate cuts and fills up to three feet to achieve finished construction grades.
Cut and fill slopes	None anticipated.
Proposed free standing retaining walls	Not reported as part of site development.
Below grade structures	Double-depth gravesites are anticipated as part of site development.
Pavements	We anticipate pavements will be used primarily for automobile and pick-up truck traffic and consist of composite asphalt concrete and base course.

2.2 Site Location and Description

ITEM	DESCRIPTION
Location	The 200 to 300 acre properties under consideration and included in the Scope of Work (SOW) are: ■ 4 Way Ranch – located northeast of Falcon, Colorado north of Colorado State Highway 24 and east of Curtis Road ■ Rolling Hills Ranch – located southeast of Colorado Springs south of Drennan Road and South meridian Road ■ Bradley Heights – located southeast of Colorado Springs at the southwest corner of Bradley and South Marksheffel Roads
Existing improvements/topography	Each of the three sites was relatively undeveloped at the time of field exploration and being used for cattle grazing purposes. <u>4-Way</u> Bordered to the east and west by drainages. An existing drainage valley was also present running through the center of the site in a north-to-south direction. The remaining portions of the site were relatively flat. <u>Rolling Hills</u> Reportedly, the northeast portion of the site is within the 100-year floodplain. A drainage valley is oriented from northeast to sourthwest across the site. The valley slopes gently in the northeast corner of the site, then gradually becomes more pronounced and incised to the southwest. <u>Bradley Heights</u> A drainage valley is oriented in a north to south direction within the eastern portion of the site. A ridge line was also located within the central portion of the site. The remaining portions of the site sloped gently downward to the east and west from the ridgeline.

ITEM	DESCRIPTION
Current ground cover	Moderate to heavy growth of native grasses and weeds.

3.0 SUBSURFACE CONDITIONS

3.1 General and Local Geology

The project sites are located within the Colorado Piedmont section of the Great Plains physiographic province. The Colorado Piedmont, formed during the Late Tertiary and Early Quaternary time (approximately two million years ago), is a broad, erosional trench which separates the Southern Rocky Mountains from the High Plains. Structurally the site lies along the western flank of the Denver Basin. During the Late Mesozoic and Early Cenozoic periods (approximately 70 million years ago), intense tectonic activity occurred, causing the uplifting of the Front Range and associated downwarping of the Denver Basin to the east. Relatively flat uplands and broad valleys characterize the present-day topography of the Colorado Piedmont in this region.

4 Way Ranch

Surficial geologic conditions at the 4 Way Ranch site as mapped by the U.S. Geological Survey (USGS) (Cochran, 1961[1]) indicate the site is underlain by the piney creek alluvium followed by the upper part of the Dawson formation. The Piney creek alluvium is described as gravel, sand, silt, and clay of stream flood plains and lower terraces. The upper part of the Dawson formation is described as white to light gray, brownish gray, yellowish gray, and light yellowish gray, cross-bedded or massive, very arkosic sandstone with interbedded yellowish gray to greenish gray, dark brown micaceous sandstone and sandy claystone.

Information provided in the Natural Resources Conservation Service soil map surveys indicates the 4 Way Ranch site contains Columbine gravelly sandy loam type that covers approximately 139 acres or 65% of the site. In order of prevalence, this unit is followed by Stapleton sandy loams (27%), and Blakeland loamy sand (8%).

Rolling Hills

Surficial geologic conditions at the Rolling Hills site as mapped by the Colorado Geological Survey (CGS) (Madole and Thorson, 2002[2]) indicate the site is underlain by the Young alluvium

[1]Cochran, Dale M., 1961, **Geologic Map of the Falcon Quadrangle, El Paso County, Colorado**, United States Geological Survey.

[2]Madole, Richard F., and Thorson, Jon P., 2002, **Geologic Map of the Elsmere Quadrangle, El Paso County, Colorado**, Colorado Geological Survey, File Map 02-2.

one and two followed by the cone-in-cone zone of Lavington. The Young alluvium one is described as chiefly light brownish gray, grayish brown, and dark grayish brown, poorly sorted sand, silty sand, and minor pebble gravel. The Young alluvium two is decribed as similar to Young alluvium one, except the formation includes several thin beds and lenses of dark grayish brown to very dark grayish brown sediment. The cone-in-cone formation generally consists of dark gray, clayey or silty shale containing reddish brown siderite iron concretions, gray iron-stained limestone concretions, thin bentonite beds, and concretions with cone-in-one structure.

Information provided in the Natural Resources Conservation Service soil map surveys indicates the Rolling Hills Ranch site contains Manzanola clay loam soil type that covers 160 acres or 48% of the site. In order of prevalence, this unit is followed by Nelson-Tassel fine sandy loams (23%), Ustic Torrifluvents loam (19%), Ellicot loamy course sand (5%), and Vona- Unit sandy loam (5%).

Bradley Heights

Surficial geologic conditions at the Bradley Heights site as mapped by the Colorado Geological Survey (CGS) (Madole and Thorson, 2002[3]) indicate the site is underlain by the cone-in-cone zone of Lavington. The cone-in-cone formation is previously described in the Rolling Hills section of this report.

Information provided in the Natural Resources Conservation Service soil map surveys indicates the Bradley Heights site contains the Razor-Midway complex that covers approximately 193 acres or 52% of the site. In order of prevalence, this unit is followed by Nelson-Tassel fine sandy loams (20%), Stoneham Sandy loam (9%), Manzanola clay loam, 3 to 9 percent slopes (8%), Fort Collins loam (6%), Ascalon sandy loam (5%), and Manzanola clay loam, 1 to 3 percent slopes (<1%).

3.2 Typical Profile

Subsurface conditions on the project site can be generalized as shown in the tables below and on the following page:

4 Way Ranch

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Stratum 1	0 to 4 inches	Topsoil	N/A
Stratum 2	2½ to 12 feet	Sand with varying amounts of silt and clay and clay with varying amounts of sand	Sand: Loose to dense Clay: Stiff

[3]Madole, Richard F., and Thorson, Jon P., 2002, **Geologic Map of the Elsmere Quadrangle, El Paso County, Colorado**, Colorado Geological Survey, File Map 02-2.

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Stratum 3	9 to 20 feet	Sandstone with varying amounts of clay	Medium hard to very hard

Rolling Hills

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Stratum 1	0 to 4 inches	Topsoil	N/A
Stratum 2	6 to 20½ feet	Clay with varying amounts of sand and sand with varying amounts of silt and clay	Clay: Stiff to hard Sand: Loose to medium dense
Stratum 3	9½ feet (RH-5)	Claystone bedrock	Hard to very hard

Bradley Heights

Description	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency/Density
Stratum 1	0 to 4 inches	Topsoil	N/A
Stratum 2	2½ to 16 feet	Clay with varying amounts of sand	Stiff to hard
Stratum 3	10 to 20	Claystone bedrock	Medium hard to very hard

Conditions encountered at each boring location are indicated on the individual boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil; in-situ, the transition between materials may be gradual. Details for each of the borings can be found on the boring logs in Appendix A of this report.

3.3 Laboratory Test Results

Selected laboratory test results for each site are listed below. Remaining laboratory test results have been included in Appendix B of this report.

4 Way Ranch

Laboratory test results indicate that the sand soil samples tested at the 4 Way Ranch site exhibit low compression at in-situ water contents. When elevated in water content, the sand soils tested exhibit non-expansion potential and low to moderate compression at increased loading.

Rolling Hills

Laboratory test results indicate that the clay and sand soil samples tested at the Rolling Hills site exhibit low compression at in-situ water contents. When elevated in water content, the clay soils tested exhibit moderate to high expansion potential and low to moderate compression at

increased loading. The sand soils tested at elevated water contests exhibit non-expansion potential and low to moderate compression at increased loading. It is our opinion that the on-site claystone bedrock should be considered to have high to very high expansive potential.

Bradley Heights

Laboratory test results indicate that the clay soil samples tested at the Bradley Heights site exhibit low compression at in-situ water contents. When elevated in water content, the clay soils tested exhibit low expansion potential and moderate compression at increased loading. It is our opinion that the on-site claystone bedrock should be considered to have high to very high expansive potential.

3.4 Groundwater

Groundwater was not encountered in the borings at any of the three sites at the time of field exploration. When checked approximately 1½ weeks after drilling, groundwater was not observed at the Bradley Heights and Rolling Hills sites. The following table lists the depth to groundwater at the 4 Way Ranch site when checked approximately 1½ weeks after drilling.

Groundwater Depths at 4 Way Ranch Site

Boring No.	Depth to Groundwater When Checked on 4/25/12
4W-1	5½ feet
4W-2	Not Observed
4W-3	12½ feet
4W-4	10 feet
4W-5	7½ feet

These observations represent groundwater conditions at the time of the field exploration, and may not be indicative of other times, or at other locations. Groundwater levels can be expected to fluctuate with varying seasonal and weather conditions.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project. Fluctuations in groundwater levels can best be determined by implementation of a groundwater monitoring plan. Such a plan would include installation of groundwater monitoring wells and periodic measurement of groundwater levels over a sufficient period of time.

4.0 PRELIMINARY RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on the results of our field investigation, laboratory testing program and geotechnical analyses, development of the sites are considered feasible from a geotechnical viewpoint provided that the conclusions and considerations provided herein are incorporated into the design and construction of the project.

Expansive soils and bedrock are present at the Bradley Heights and Rolling Hills sites. This report provides recommendations to help mitigate the effects of soil and bedrock shrinkage and expansion. However, even if these procedures are followed, some movement and minor cracking in the structure should be anticipated. The severity of cracking and other cosmetic damage will probably increase if any modification of the site results in excessive wetting or drying of the expansive soils and bedrock. Eliminating the risk of movement and cosmetic distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. We'd be pleased to discuss other foundation alternatives, such as drilled pier foundations, at your request.

Relatively shallow groundwater was encountered at the 4 Way Ranch site at depths of approximately 5½ to 12½ feet below site grade. Relatively shallow groundwater may limit the potential locations of gravesites. In addition, groundwater may cause difficulties during construction of foundations and proposed utilities depending on the depths. Dewatering of foundation excavations and utility trenches may be required during construction should foundations be constructed near the groundwater table. The individual contractor(s) should be made responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottom.

Preliminary geotechnical engineering recommendations for foundation systems and other earth connected phases of the project are outlined herein. The recommendations contained in this report are based upon the results of data presented herein, engineering analyses, and our current understanding of the proposed project.

4.2 Earthwork

4.2.1 Site Preparation

Prior to placing any fill, all vegetation and any otherwise unsuitable material should be removed from the proposed floor slab, foundation, and pavement areas. The subgrade should also be proof-rolled where possible or probed with a metal T-probe to aid in locating loose, soft, or otherwise undesirable areas. Proof-rolling can be performed with a loaded tandem axle dump truck. Unacceptable soil should be removed or mitigated in place prior to placing fill.

Although evidence of underground facilities was not observed during the site reconnaissance, such features could be encountered during construction. If unexpected underground facilities are encountered, such features should be removed and the excavation benched to expose firm, approved materials prior to backfill placement and/or construction.

4.2.2 Material Types

Engineered fill should meet the following material property requirements:

Fill Type [1]	USCS Classification	Acceptable Location for Placement
On-Site Soils	SC, SM, SW-SM, CL, CH	The on-site sand soils at all three sites are considered acceptable for use as engineered fill beneath foundations, slabs, and pavements. On-site clay soils at all three sites may be reused at depths greater than 12 inches from pavement subgrade and within non-structural areas. Clay soils are not considered suitable for support of slabs-on-grade or building foundations.
Imported Soils	Varies	Imported soils meeting the gradation outlined herein can be considered acceptable for use as engineered fill beneath foundations and slabs.

1. Controlled, compacted fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.

Imported soils (if required) should conform to the following:

Gradation	Percent finer by weight (ASTM C136)
3”	100
No. 4 Sieve	50-100
No. 200 Sieve	35 (max)

- Liquid Limit……....30 (max)
- Plastic Limit……...10 (max)
- Maximum Expansive Potential (%)……..1.5*

*Measured on a sample compacted to approximately 95 percent of the ASTM D698 maximum dry density at optimum water content. The sample is confined under a 100 psf surcharge and submerged.

4.2.3 Compaction Requirements

Material Type and Location	Per ASTM D698		
	Minimum Compaction Requirement (%)	Range of Water Contents	
		Minimum	Maximum
Beneath foundations and slabs:	95	-2%	+3%
Beneath pavements:	95	-2%	+3%
12 inches directly below pavements:	98	-2%	+3%
	Per ASTM D1557		
Aggregate base (beneath slabs)	95	-3%	+3%
Aggregate base (beneath pavements)	98	-3%	+3%

1. Engineered fill materials should be placed in horizontal, loose lifts not exceeding 8 inches in thickness and should be thoroughly compacted. Where light compaction equipment is used, as is customary within a few feet of retaining walls and in utility trenches, the lift thickness may need to be reduced to achieve the desired degree of compaction. Soils removed which will be used as engineered fill should be protected to aid in preventing an increase in moisture content due to rain.
2. We recommend that engineered fill be tested for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.

4.2.4 Grading and Drainage

All grades must be adjusted to provide positive drainage away from structures during construction and maintained throughout the life of the proposed project. Exposed ground should be sloped at a minimum of 10 percent grade for at least 10 feet beyond the perimeter of the building, where possible. Where possible, asphalt pavement or concrete flatwork should be sloped at a minimum of 2 percent beyond the building perimeter. Where ADA or other requirements or existing site features limit the gradient, slopes on the order of ½ to 1 percent minimum are considered acceptable.

4.3 Foundation Systems

4.3.1 Preliminary Spread Footing Design Recommendations

We recommend spread-footing foundations bear on newly placed, compacted fill. Additional preliminary design recommendations are presented below and on the following pages:

DESCRIPTION	Column	Wall
Net allowable bearing pressure [1]	2,000 to 3,000 psf	2,000 to 3,000 psf

DESCRIPTION	Column	Wall
Minimum dimensions	24 inches	16 inches
Minimum embedment below finished grade for frost protection [2]	30 inches	30 inches
Approximate total movement [3]	1 inch	1 inch
Estimated differential movement [3]	½ to ¾ of total between columns	½ to ¾ of total over 40 feet

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. Assumes fill or unsuitable soils, if encountered, will be undercut and replaced with engineered fill.
2. For exterior foundations beneath continuously heated structures, depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure. The minimum depth for interior footings in continuously heated structures is 12 inches below finished grade.
3. The foundation movement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of compacted fill, the quality of the earthwork operations, and maintaining uniform soil water content throughout the life of the structure. The estimated movements are based on maintaining uniform soil water content during the life of the structure. Additional foundation movements could occur if water from any source infiltrates the foundation soils; therefore, proper drainage and irrigation practices should be incorporated into the design and operation of the facility. Failure to maintain soil water content and positive drainage will nullify the movement estimates provided above.

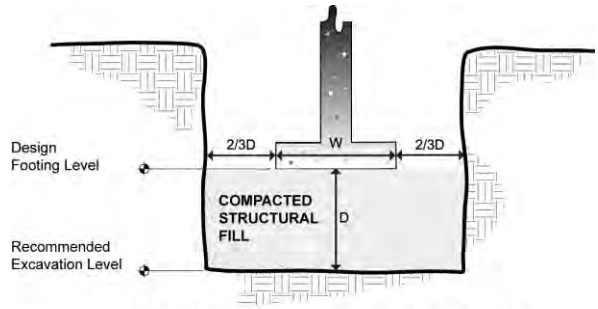
The table below lists the preliminary recommended over-excavation requirements beneath foundations for each site. The following numbers can be refined once the structure locations are known and the final geotechnical exploration is complete.

Site Location	Potential Over-Excavation Beneath Foundations Depending on Encountered Soils	Minimum Recommended Separation Between Bottom of Foundations and Claystone Bedrock
4 Way Ranch	1 to 2 feet (sand soils) 2 to 4 feet (clay soils)	N/A
Rolling Hills	1 to 2 feet (sand soils) 5 to 7 feet (clay soils)	5 to 7 feet
Bradley Heights	3 to 5 feet (clay soils)	5 to 7 feet

4.3.2 Construction Considerations

The base of all foundation excavations should be free of water and loose soil and rock prior to placing concrete. If unsuitable soils are encountered at the base of the over-excavation, supplemental recommendations will be required, such as additional removal and replacement. Over-excavation for compacted backfill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing base elevation.

Fill should be placed in lifts of 8 inches or less in loose thickness and compacted to at least 95 percent of the material's maximum dry density (ASTM D698). Compactive effort should be in accordance with recommendations provided in the **EARTHWORK** section of this report. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Should the soils at bearing level become excessively dry, disturbed or saturated, or frozen, the affected soil should be removed prior to placing concrete. It is recommended that a construction testing laboratory be retained to observe and test the soil foundation bearing materials.



Overexcavation / Backfill

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

4.4 Seismic Considerations

Code Used	Site Classification
2009 International Building Code (IBC) [1]	C[2] (bedrock within 20 feet of ground surface) D[2] (bedrock greater than 20 feet from ground surface)
Mapped Spectral Acceleration for Short Periods, S_s [2]	0.185
Mapped Spectral Acceleration for a 1-second period, S_1 [2]	0.059

1. In general accordance with the *2009 International Building Code,* Table 1613.5.2. The 2009 International Building Code (IBC) requires a site soil profile determination extending a depth of 100 feet for seismic site classification. The current scope requested does not include the required 100 foot soil profile determination as borings for this project extended to a maximum depth of approximately 25½ feet. Additional exploration to deeper depths could be performed to confirm the conditions below the current depth of exploration. Alternatively, a geophysical exploration could be utilized in order to attempt to justify a higher seismic site class.
2. In general accordance with the Pikes Peak Regional Building Code

4.5 Floor Slab

4.5.1 Preliminary Design Recommendations

The table on the following page lists the preliminary recommended over-excavation requirements beneath slabs for each site. The following numbers can be refined once the building locations are known and once final geotechnical exploration is complete.

Site Location	Potential Over-Excavation Beneath Slabs Depending on Encountered Soils
4 Way Ranch	1 to 2 feet (sand soils) 2 to 4 feet (clay soils)
Rolling Hills	1 to 2 feet (sand soils) 5 to 7 feet (clay soils)
Bradley Heights	3 to 5 feet (clay soils)

1. We recommend subgrades be maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become desiccated prior to construction of floor slabs, the affected material should be removed or the materials scarified, moistened, and recompacted. Upon completion of grading operations in the building areas, care should be taken to maintain the recommended subgrade moisture content and density prior to construction of the building floor slabs.
2. The floor slab design should include a capillary break, comprised of a minimum of 4 inches of free-draining, compacted, granular material. Free-draining granular material should have less than 5 percent fines (material passing the #200 sieve). Other design considerations such as cold temperatures and condensation development could warrant more extensive design provisions.

Where appropriate, saw-cut control joints should be placed in the slab to help control the location and extent of cracking. The use of a vapor retarder should be used directly beneath concrete slabs on grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

4.6 Pavements

4.6.1 Subgrade Preparation

On most project sites, the site grading is accomplished relatively early in the construction phase. Fills are placed and compacted in a uniform manner. However, as construction proceeds, excavations are made into these areas, rainfall and surface water saturates some areas, heavy traffic from concrete trucks and other delivery vehicles disturbs the subgrade and many surface irregularities are filled in with loose soils to improve trafficability temporarily. As a result, the pavement subgrades, initially prepared early in the project, should be carefully evaluated as the time for pavement construction approaches.

We recommend the moisture content and density of the top 12 inches of the subgrade be evaluated and the pavement subgrades be proofrolled within one day prior to commencement of actual paving operations. Areas not in compliance with the required ranges of moisture or density should be moisture conditioned and recompacted. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and

replacing the materials with properly compacted fills. If a significant precipitation event occurs after the evaluation or if the surface becomes disturbed, the subgrade should be reviewed by qualified personnel immediately prior to paving. The subgrade should be in its finished form at the time of the final review.

After proofrolling and repairing deep subgrade deficiencies, the entire subgrade should be scarified and developed as recommended in the **Earthwork** section this report to provide a uniform subgrade for pavement construction. Areas that appear severely desiccated following site stripping may require further undercutting and moisture conditioning. If a significant precipitation event occurs after the evaluation or if the surface becomes disturbed, the subgrade should be reviewed by qualified personnel immediately prior to paving. The subgrade should be in its finished form at the time of the final review.

4.6.2 Preliminary Design Considerations

Design of pavements for the project has been based on the procedures outlined in the National Asphalt Pavement Association (NAPA) Information Series 109 (IS-109). Equivalent single-axle loads (ESALs) for the proposed parking area were not available at the time of report preparation. We have based our pavement thickness design on the following NAPA design traffic classes:

- **Traffic Class I** – Parking stalls, parking lots for autos and pickup trucks and 18-kip equivalent single axle loads (ESAL's) up to 7,000.

- **Traffic Class II** – Traffic consisting of autos, home delivery trucks, trash pickup, occasional moving vans, and ESAL's up to 27,000.

In addition to the flexible pavement design analyses, a preliminary rigid pavement design analysis was completed, based upon American Concrete Institute (ACI) 330R-01; Guide for Design and Construction of Concrete Parking Lots. A modulus of rupture of 650 psi (working stress 488 psi) was used for pavement concrete.

As part of our design, we recommend all pavement sections be supported on a minimum of 12 inches of on-site or approved imported sand soils. Based on the borings performed on each of the three sites, it is anticipated that import sand soils will be required for the Bradley Heights site. The use of on-site sand soils and/or imported soils may be required depending on where the roads are located at the Rolling Hills and 4 Way Ranch sites. We anticipate the soils at pavement subgrade will have an estimated design class of "medium" according to Table B of NAPA IS-109.

We suggest the following pavement sections be considered at a minimum:

Traffic Classification	Alternative	Asphalt Concrete (in.)	Portland Cement Concrete (in.)	Base Course (in.)	Minimum amount of compacted on-site sand soils or imported soils (in.)
Traffic Class I/II	A	4	---	4	12
	B	---	5	4	

Each alternative should be investigated with respect to current material availability and economic conditions. A minimum of 7 inches of rigid concrete pavement followed by 4 inches of aggregate base course is recommended at the location of dumpsters where trash trucks park and load.

4.7 Exterior Slabs

Exterior slabs-on-grade, exterior architectural features, and utilities founded in backfill may experience some movement due to the volume change of the material. In areas of clay, we recommend slabs be supported on sand soils as described in the earthwork section of this report. Additional recommendations to reduce potential movement are as follows:

- minimizing moisture increases in the backfill
- controlling moisture-density during placement of backfill
- using designs which allow vertical movement between the exterior features and adjoining structural elements
- placing effective control joints on relatively close centers

4.8 Corrosion and Soil Nutrient Considerations

The table on the following page lists the results of laboratory soluble sulfate, soluble chloride, electrical resistivity, and pH testing. These values may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

Boring	Soluble Sulfate (Percent)	Soluble Chloride (Percent)	Electrical Resistivity (ohm.cm)	pH
4W5	0.010	0.0004	1,319	7.2
RH-4	0.129	0.0016	679	7.2
BH-5	0.925	0.0018	556	7.3

Results of soluble sulfate testing indicate that samples of the on-site soils tested at the 4 Way Ranch site possess negligible sulfate concentrations when classified in accordance with Table 4.3.1 of the ACI Design Manual. Samples of soils tested at the Rolling Hills Ranch Site possess moderate sulfate concentrations. Samples of soils tested at the Bradley Heights site possess

severe sulfate concentrations. Concrete should be designed in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 4.

Topsoil at each of the three sites is considered negligible. The use of imported soils for topsoil will likely be required depending on the intended use. In general, soil nutrient test results from the 4 Way Ranch and Bradley Heights site indicate that 3 to 4 cubic yards per 1,000 square feet of low salt compost may be beneficial. Results from the Rolling Hills ranch site indicate that yield reduction is likely due to high salts. Additional recommendations regarding soil nutrient requirements are presented in Appendix B of this report.

5.0 GENERAL COMMENTS

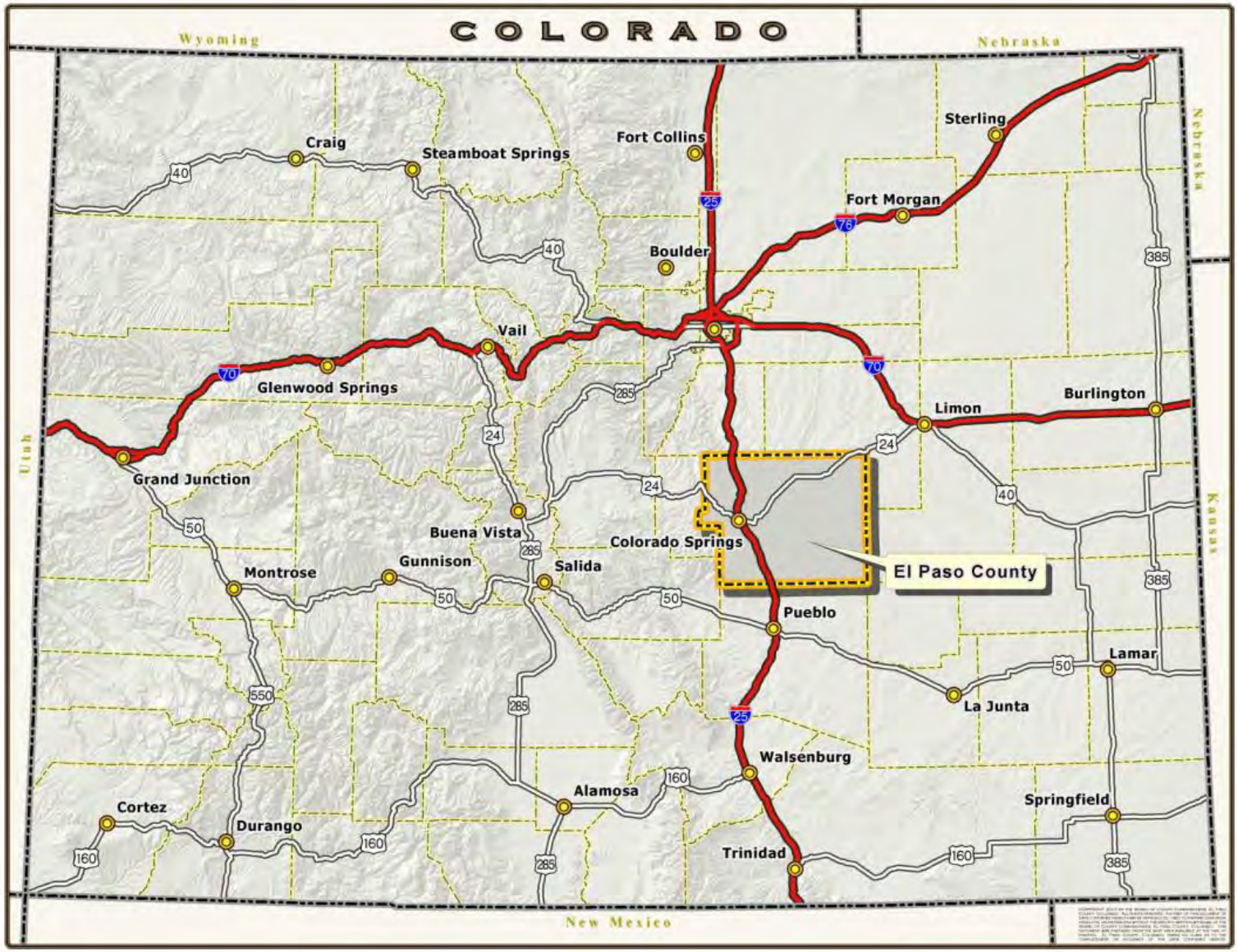
Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. The analysis and recommendations presented in this report are based upon the data obtained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

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

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

APPENDIX A

FIELD EXPLORATION



N

BASE DRAWING OBTAINED FROM EL PASO COUNTY GIS

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

Project Manager: DKT	Project No. 23125013
Drawn by: DKT	Scale: N.T.S.
Checked by: RWF	File Name: Fig 1
Approved by: RWF	Date: 4/16/2012

Terracon
Consulting Engineers & Scientists
4172 Center Park Drive Colorado Springs, CO 80916
PH. (719) 597-2116 FAX. (719) 597-2117

COLORADO STATE MAP

PROPOSED VA NATIONAL CEMETARY SITES
EL PASO COUNTY, COLORADO

Exhibit

A-1

N

BASE DRAWING OBTAINED FROM EL PASO COUNTY GIS

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

Project Manager: DKT	Project No. 23125013
Drawn by: DKT	Scale: N.T.S.
Checked by: RWF	File Name: Fig 2
Approved by: RWF	Date: 4/16/2012

Terracon
Consulting Engineers & Scientists
4172 Center Park Drive Colorado Springs, CO 80916
PH. (719) 597-2116 FAX. (719) 597-2117

EL PASO COUNTY MAP

● APPROXIMATE SITE LOCATION
PROPOSED VA NATIONAL CEMETARY SITES
EL PASO COUNTY, COLORADO

Exhibit

A-2

N

Indicates Boring Location

BASE DRAWING OBTAINED FROM GOOGLE EARTH
DIAGRAM IS FOR GENERAL LOCATION
ONLY, AND IS NOT INTENDED FOR
CONSTRUCTION PURPOSES

Project Manager: DKT	Project No. 23125013
Drawn by: DKT	Scale: N.T.S.
Checked by: RWF	File Name: Fig 3
Approved by: RWF	Date: 4/16/2012

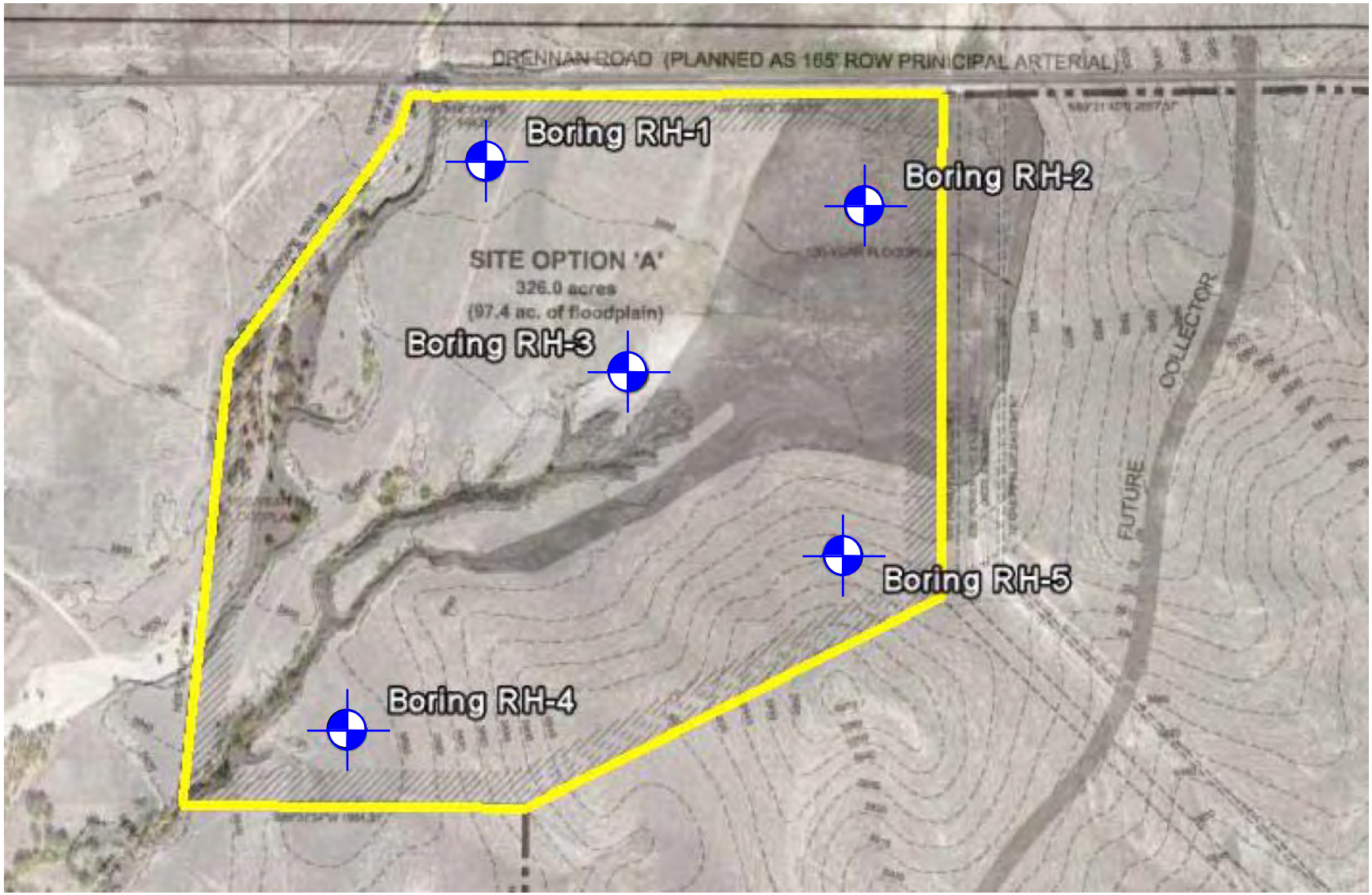
Terracon
Consulting Engineers & Scientists
4172 Center Park Drive Colorado Springs, CO 80916
PH. (719) 597-2116 FAX. (719) 597-2117

BORING LOCATION PLAN

4 WAY RANCH
NORTH OF HIGHWAY 24 AND CURTIS RD
FALCON, COLORADO

Exhibit

A-3



N

Indicates Boring Location.

BASE DRAWING OBTAINED FROM LAI DESIGN GROUP AND GOOGLE EARTH. DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager: DKT	Project No. 23125013
Drawn by: DKT	Scale: N.T.S.
Checked by: RWF	File Name: Fig 4
Approved by: RWF	Date: 4/16/2012

Terracon
Consulting Engineers & Scientists
4172 Center Park Drive Colorado Springs, CO 80916
PH. (719) 597-2116 FAX. (719) 597-2117

BORING LOCATION PLAN

ROLLING HILLS RANCH
SW OF BRADLEY RD AND MOCKINGBIRD LN
COLORADO SPRINGS, COLORADO

Exhibit

A-4

N

Indicates Boring Location

BASE DRAWING OBTAINED FROM CLASSIC CONSULTING AND GOOGLE EARTH

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

Project Manager: DKT	Project No. 23125013
Drawn by: DKT	Scale: N.T.S.
Checked by: RWF	File Name: Fig 5
Approved by: RWF	Date: 4/16/2012

Terracon
Consulting Engineers & Scientists
4172 Center Park Drive Colorado Springs, CO 80916
PH. (719) 597-2116 FAX. (719) 597-2117

BORING LOCATION PLAN

BRADLEY HEIGHTS
SW OF BRADLEY RD AND MARKSHEFFEL RD
COLORADO SPRINGS, COLORADO

Exhibit

A-5

Field Exploration Description

Fifteen test borings (five at each site) were advanced in the vicinity of the three potential national cemetery sites between April 12 and April 13, 2012, to depths of approximately 9½ to 20½ feet below existing site grade at the approximate locations shown on the Boring Location Plans, Exhibits A-3, A-4, and A-5. The borings were advanced with a truck-mounted drilling rig, utilizing 4-inch diameter solid-stem auger.

The borings were located in the field using a handheld GPS (typical horizontal accuracy within 20 feet) unit referencing latitude and longitude coordinates from Google Earth. The accuracy of the boring locations should only be assumed to the level implied by the methods used.

Lithologic logs of the borings were recorded by the Terracon field representative during drilling operations. At selected intervals, samples of the subsurface materials were taken by driving split-spoon and ring barrel samplers. Representative bulk samples of subsurface materials were also obtained.

Penetration resistance measurements were obtained by driving the split-spoon and ring barrel samplers into the subsurface materials with a 140-pound hammer falling 30 inches. The penetration resistance value is a useful index to the consistency, relative density or hardness of the materials encountered.

An automatic SPT hammer was used to advance the samplers in the borings. A greater efficiency is typically achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. Published correlations between the barrel blow counts, SPT values, and soil properties are based on the lower efficiency cathead and rope method. This higher efficiency affects the standard penetration resistance blow count value by increasing the penetration per hammer blow over what would be obtained using the cathead and rope method. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

Groundwater measurements were made in the borings at the time of site exploration and about one to two weeks after drilling. Borings were backfilled with auger cuttings subsequent to final groundwater readings. Some settlement of the backfill should be anticipated.

BORING LOG NO. 4W-1

PROJECT: 4 Way Ranch VA

CLIENT: Studley, Inc.
Washington, DC

SITE: North of Curtis Road and U.S. Highway 24
El Paso County, Colorado

LOCATION See Exhibit A-3

DEPTH	GRAPHIC LOG	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILTY SAND (SM), light brown, loose to medium dense									
					10	6-11 N=17	2	110		
					10	11-44 N=55	10	125	NP	16
		5	▽							
7.5					10	35-50 N=85	12	123		
	CLAYEY SANDSTONE, light brown, medium hard to hard									
10.0					10	35-50/5" N=85/11"	11	121		
	Boring Terminated at 10 Feet	10								

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed during drilling.

▽ *Water observed on 4/25/12*

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/13/2012 | Boring Completed: 4/13/2012

Drill Rig: CME-55 | Driller: Precision Sampling

Project No.: 23125013 | Exhibit A-7

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-FW.GPJ TERRACON2012.GDT 4/30/12

BORING LOG NO. 4W-2

PROJECT: 4 Way Ranch VA

CLIENT: Studley, Inc.
Washington, DC

SITE: North of Curtis Road and U.S. Highway 24
El Paso County, Colorado

LOCATION See Exhibit A-3

DEPTH		DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	CLAYEY SAND, brown, medium dense									
2.5	**CLAYEY SANDSTONE**, light brown to light gray, medium hard to very hard				10	17-50 N=67	4	120		
		5			10	35-50/3" N=85/9"	12	120		
	with iron staining at 7 feet.				10	32-50/5" N=82/11"	11	123		
9.0	***Boring Terminated at 9 Feet***				3	N=50/3"	8	101		

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed during drilling.

No water observed on 4/25/12

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/13/2012 | Boring Completed: 4/13/2012

Drill Rig: CME-55 | Driller: Precision Sampling

Project No.: 23125013 | Exhibit A-8

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-FW.GPJ TERRACON2012.GDT 4/30/12

BORING LOG NO. 4W-3

PROJECT: 4 Way Ranch VA

CLIENT: Studley, Inc.
Washington, DC

SITE: North of Curtis Road and U.S. Highway 24
El Paso County, Colorado

LOCATION See Exhibit A-3

DEPTH	Description	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	CLAYEY SAND (SC), brown, medium dense						
3.0		10	10-16 N=26	7	100		
	WELL GRADED SAND WITH SILT (SW-SM), light brown, medium dense						
5.0		10	19-37 N=56	2	116		
	CLAYEY SAND (SC), brown to yellow-brown, medium dense						
8.0		10	20-30 N=50	10	121		
	CLAYEY SANDSTONE, light brown to light gray, very hard						
		8	40-50/3" N=90/9"	10	125		
15.5		17	21-39-49 N=88	14			
	Boring Terminated at 15.5 Feet						

DEPTH (ft): 5, 10, 15

WATER LEVEL OBSERVATIONS

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed during drilling.

Water observed on 4/25/12

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/13/2012	Boring Completed: 4/13/2012
Drill Rig: CME-55	Driller: Precision Sampling
Project No.: 23125013	Exhibit A-9

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-FW.GPJ TERRACON2012.GDT 4/30/12

BORING LOG NO. 4W-4

PROJECT: 4 Way Ranch VA

CLIENT: Studley, Inc.
Washington, DC

SITE: North of Curtis Road and U.S. Highway 24
El Paso County, Colorado

LOCATION See Exhibit A-3

DEPTH	Description	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SANDY LEAN CLAY (CL), light brown, stiff						
		10	7-12 N=19	8	95	29-20-9	59
3.0	**WELL GRADED SAND WITH SILT (SW-SM)**, light brown, medium dense						
		10	17-40 N=57	2	124		
5.0	**CLAYEY SANDSTONE**, light gray, hard						
		9	44-50/4" N=94/10"	9	120		
		9	40-50/4" N=90/10"	10	128		
		10	25-50/5" N=75/11"	13	114		
15.0	***Boring Terminated at 15 Feet***						

DEPTH (ft): 5, 10, 15

WATER LEVEL OBSERVATIONS

SAMPLE TYPE

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed during drilling.

Water observed on 4/25/12

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/13/2012 | Boring Completed: 4/13/2012

Drill Rig: CME-55 | Driller: Precision Sampling

Project No.: 23125013 | Exhibit A-10

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-FW.GPJ TERRACON2012.GDT 4/30/12

BORING LOG NO. 4W-5

PROJECT: 4 Way Ranch VA

CLIENT: Studley, Inc.
Washington, DC

SITE: North of Curtis Road and U.S. Highway 24
El Paso County, Colorado

LOCATION See Exhibit A-3

DEPTH	Description	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILTY SAND (SM), light brown, medium dense						
		10	11-22 N=33	5	117		
		10	11-15 N=26	2	110		
5							
6.0	**CLAYEY SAND (SC)**, light brown, medium dense						
		10	10-14 N=24	15	115		
9.0	**SANDY LEAN CLAY (CL)**, light brown, stiff						
		10	5-13 N=18	23	104		
10							
12.0	**CLAYEY SANDSTONE**, light gray, very hard						
		5	N=50/5"	12	112		
15							
20.0		6	20-50/5" N=50/5"	8			
20	***Boring Terminated at 20 Feet***						

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed during drilling.

Water observed on 4/25/12

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/13/2012 | Boring Completed: 4/13/2012

Drill Rig: CME-55 | Driller: Precision Sampling

Project No.: 23125013 | Exhibit A-11

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-FW.GPJ TERRACON2012.GDT 4/30/12

BORING LOG NO. RH-1

PROJECT: Rolling Hills VA

CLIENT: Studley, Inc.
Washington, DC

SITE: SE of Marksheffel Road and Drennan Road
El Paso County, Colorado

LOCATION See Exhibit A-4

DEPTH	GRAPHIC LOG	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	FAT CLAY WITH SAND (CH), brown, stiff to very stiff, with calcium deposits and rootlets.									
					8	9-14 N=23	21	78		
					8	7-9 N=16	17	71	56-29-27	78
		5								
					8	5-8 N=13	21	70		
					8	6-9 N=15	19	72		
		10								
12.0	**SILTY SAND (SM)**, light brown, medium dense									
					8	9-12 N=21	6	99		
		15								
20.5		20			14	6-9-10 N=19	3			
	Boring Terminated at 20.5 Feet									

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed on 4/25/12

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/13/2012 | Boring Completed: 4/13/2012

Drill Rig: CME-55 | Driller: Precision Sampling

Project No.: 23125013 | Exhibit A-12

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-RH.GPJ TERRACON2012.GDT 4/30/12

BORING LOG NO. RH-2

PROJECT: Rolling Hills VA

CLIENT: Studley, Inc.
Washington, DC

SITE: SE of Marksheffel Road and Drennan Road
El Paso County, Colorado

LOCATION See Exhibit A-4

DEPTH	GRAPHIC LOG	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILTY SAND (SM), light brown, loose									
3.0					7	5-9 N=14	5	98		
	CLAYEY SAND (SC), light brown, loose									
					10	7-9 N=16	10	89		
6.0		5								
	SILTY SAND (SM), light brown, loose									
8.0					8	6-10 N=16	9	94		
	SANDY LEAN CLAY (CL), brown, very stiff, with calcium deposits.									
					8	19-22 N=41	15	108		
		10								
					8	8-12 N=20	12	101		
		15								
20.5		20			17	7-11-13 N=24	33			
	Boring Terminated at 20.5 Feet									

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed on 4/25/12

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/12/2012 | Boring Completed: 4/12/2012

Drill Rig: CME-55 | Driller: Precision Sampling

Project No.: 23125013 | Exhibit A-13

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-RH.GPJ TERRACON2012.GDT 4/30/12

BORING LOG NO. RH-3

PROJECT: Rolling Hills VA

CLIENT: Studley, Inc.
Washington, DC

SITE: SE of Marksheffel Road and Drennan Road
El Paso County, Colorado

LOCATION See Exhibit A-4

DEPTH	GRAPHIC LOG	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	FAT CLAY (CH), dark brown, hard									
3.0					10	15-31 N=46	25	95		
	SILTY SAND (SM), light brown, loose									
5.0					10	6-10 N=16	6	83		
	FAT CLAY WITH SAND (CH), light brown, stiff, with calcium deposits.	5								
8.0					6	8-8 N=16	11	86		
	SILTY SAND (SM), light brown, medium dense									
10.0					6	9-10 N=19	11	79		
	Boring Terminated at 10 Feet	10								

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed on 4/25/12

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/12/2012 | Boring Completed: 4/12/2012

Drill Rig: CME-55 | Driller: Precision Sampling

Project No.: 23125013 | Exhibit A-14

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-RH.GPJ TERRACON2012.GDT 4/30/12

BORING LOG NO. RH-4

PROJECT: Rolling Hills VA

CLIENT: Studley, Inc.
Washington, DC

SITE: SE of Marksheffel Road and Drennan Road
El Paso County, Colorado

LOCATION See Exhibit A-4

GRAPHIC LOG	DEPTH	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	FAT CLAY WITH SAND (CH), brown, very stiff to hard, with rootlets at 2 feet.									
					8	7-17 N=24	12	82		
					8	15-30 N=45	20	99		
		5								
					11	15-27 N=42	22	96		
					11	15-40 N=55	19	104		
		10								
		15			11	10-20 N=30	24	93		
	20.5	20			16	6-9-12 N=21	19			
	Boring Terminated at 20.5 Feet									

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed on 4/25/12

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/13/2012 | Boring Completed: 4/13/2012

Drill Rig: CME-55 | Driller: Precision Sampling

Project No.: 23125013 | Exhibit A-15

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-RH.GPJ TERRACON2012.GDT 4/30/12

BORING LOG NO. RH-5

PROJECT: Rolling Hills VA

CLIENT: Studley, Inc.
Washington, DC

SITE: SE of Marksheffel Road and Drennan Road
El Paso County, Colorado

LOCATION See Exhibit A-4

DEPTH	GRAPHIC LOG	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILTY CLAYEY SAND (SC-SM), light brown, loose to medium dense, with rootlets at 2 feet.									
					10	3-8 N=11	8	100		
	rootlets not observed below 4 feet.				10	8-20 N=28	5	105	23-16-7	39
6.0		5								
	CLAYSTONE, brown, hard to very hard, with iron staining									
					5	N=50/6"	12	106		
9.5					4	N=50/5"	14	107		
	Boring Terminated at 9.5 Feet									

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed on 4/25/12

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/12/2012
Boring Completed: 4/12/2012
Drill Rig: CME-55
Driller: Precision Sampling
Project No.: 23125013
Exhibit A-16

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-RH.GPJ TERRACON2012.GDT 4/30/12

BORING LOG NO. BH-1

PROJECT: Bradley Heights VA

CLIENT: Studley, Inc.
Washington, DC

SITE: Southwest of Marksheffel Rd. and Bradley Rd.
El Paso County, Colorado

LOCATION See Exhibit A-5

DEPTH	GRAPHIC LOG	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	LEAN CLAY WITH SAND (CL), brown, very stiff, with calcium deposits and rootlets.									
					6	11-15 N=26	7	95		
	rootlets not observed below 4 feet.				8	10-16 N=26	9	90	43-19-24	81
		5								
					8	11-27 N=38	10	112		
					8	8-12 N=20	9	105		
		10								
	color change to light brown to light gray, with iron staining at 14 feet.				6	10-20 N=30	11	106		
16.0		15								
	CLAYSTONE, brown to dark brown, very hard									
20.0					14	31-50/5" N=50/5"	13			
	Boring Terminated at 20 Feet	20								

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with soil cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed on 4/24/12.

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/12/2012	Boring Completed: 4/12/2012
Drill Rig: CME-55	Driller: Precision Sampling
Project No.: 23125013	Exhibit A-17

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-BH.GPJ TERRACON2012.GDT 4/30/12

BORING LOG NO. BH-2

PROJECT: Bradley Heights VA

CLIENT: Studley, Inc.
Washington, DC

SITE: Southwest of Marksheffel Rd. and Bradley Rd.
El Paso County, Colorado

LOCATION See Exhibit A-5

DEPTH	Description	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	LEAN CLAY WITH SAND (CL), brown, stiff, with calcium deposits.									
					7	7-11 N=18	8	94		
					7	6-10 N=16	11	99		
6.0		5								
	WEATHERED CLAYSTONE, brown to dark brown, medium hard									
					11	25-44 N=69	13	114		
9.0										
	CLAYSTONE, brown to dark brown, hard, with iron staining				7	30-50/3" N=80/9"	12	118		
		10								
15.0					6	20-50/4" N=70/10"	12	117		
	Boring Terminated at 15 Feet	15								

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with soil cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed on 4/24/12.

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/12/2012 | Boring Completed: 4/12/2012

Drill Rig: CME-55 | Driller: Precision Sampling

Project No.: 23125013 | Exhibit A-18

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-BH.GPJ TERRACON2012.GDT 4/30/12

BORING LOG NO. BH-3

PROJECT: Bradley Heights VA

CLIENT: Studley, Inc.
Washington, DC

SITE: Southwest of Marksheffel Rd. and Bradley Rd.
El Paso County, Colorado

LOCATION See Exhibit A-5

DEPTH	Description	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	LEAN CLAY WITH SAND (CL), light brown to brown, very stiff, with calcium deposits and rootlets.						
		10	9-14 N=23	7	91		
	rootlets not observed below 4 feet.	6	11-26 N=37	10	110		
6.0	**WEATHERED CLAYSTONE**, light brown, medium hard to hard, with iron staining.						
		7	15-35 N=50	10	112		
10.0		7	25-50/5" N=75/11"	11	118		
	Boring Terminated at 10 Feet						

DEPTH (ft): 5, 10

GRAPHIC LOG

WATER LEVEL OBSERVATIONS

SAMPLE TYPE

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with soil cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed on 4/24/12.

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/12/2012 | Boring Completed: 4/12/2012

Drill Rig: CME-55 | Driller: Precision Sampling

Project No.: 23125013 | Exhibit A-19

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-BH.GPJ TERRACON2012.GDT 4/30/12

BORING LOG NO. BH-4

PROJECT: Bradley Heights VA

CLIENT: Studley, Inc.
Washington, DC

SITE: Southwest of Marksheffel Rd. and Bradley Rd.
El Paso County, Colorado

LOCATION See Exhibit A-5

DEPTH	Description	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	LEAN CLAY WITH SAND (CL), brown, very stiff to hard, with calcium deposits.									
					8	25-40 N=65	12	108		
		5			10	14-23 N=37	9	101	37-18-19	78
6.0	**WEATHERED CLAYSTONE**, brown to dark brown, medium hard, with iron staining.									
					10	20-35 N=55	11	111		
10.0		10			11	35-43 N=78	14	108		
	Boring Terminated at 10 Feet									

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with soil cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed on 4/24/12.

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/12/2012 | Boring Completed: 4/12/2012

Drill Rig: CME-55 | Driller: Precision Sampling

Project No.: 23125013 | Exhibit A-20

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-BH.GPJ TERRACON2012.GDT 4/30/12

BORING LOG NO. BH-5

PROJECT: Bradley Heights VA

CLIENT: Studley, Inc.
Washington, DC

SITE: Southwest of Marksheffel Rd. and Bradley Rd.
El Paso County, Colorado

LOCATION See Exhibit A-5

DEPTH	Description	DEPTH (ft)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (%)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	LEAN CLAY WITH SAND (CL), light brown, very stiff									
2.5	**WEATHERED CLAYSTONE**, brown, medium hard				10	25-45 N=70	9	119		
		5			10	20-42 N=62	10	119		
6.0	**CLAYSTONE**, brown, gray, and dark gray, hard, with iron staining and gypsum deposits				10	40-50/4" N=90/10"	11	120		
		10			10	25-50/4" N=75/10"	10	119		
15.0		15			10	30-50/4" N=80/10"	15	111		
	Boring Terminated at 15 Feet									

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

Hammer Type: Automatic

Advancement Method:
4-inch solid-stem

Abandonment Method:
Backfilled with soil cuttings

See Exhibit A-6 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water observed on 4/24/12.

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

Boring Started: 4/12/2012	Boring Completed: 4/12/2012
Drill Rig: CME-55	Driller: Precision Sampling
Project No.: 23125013	Exhibit A-21

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TERRACON SMART LOG-NO WELL 23125013-BH.GPJ TERRACON2012.GDT 4/30/12

APPENDIX B

LABORATORY TESTING

Laboratory Testing

Samples retrieved during the field exploration were returned to the laboratory for observation by the project geotechnical engineer. An applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials. The field descriptions were confirmed or modified as necessary, and were classified in general accordance with the Unified Soil Classification System described in Appendix C.

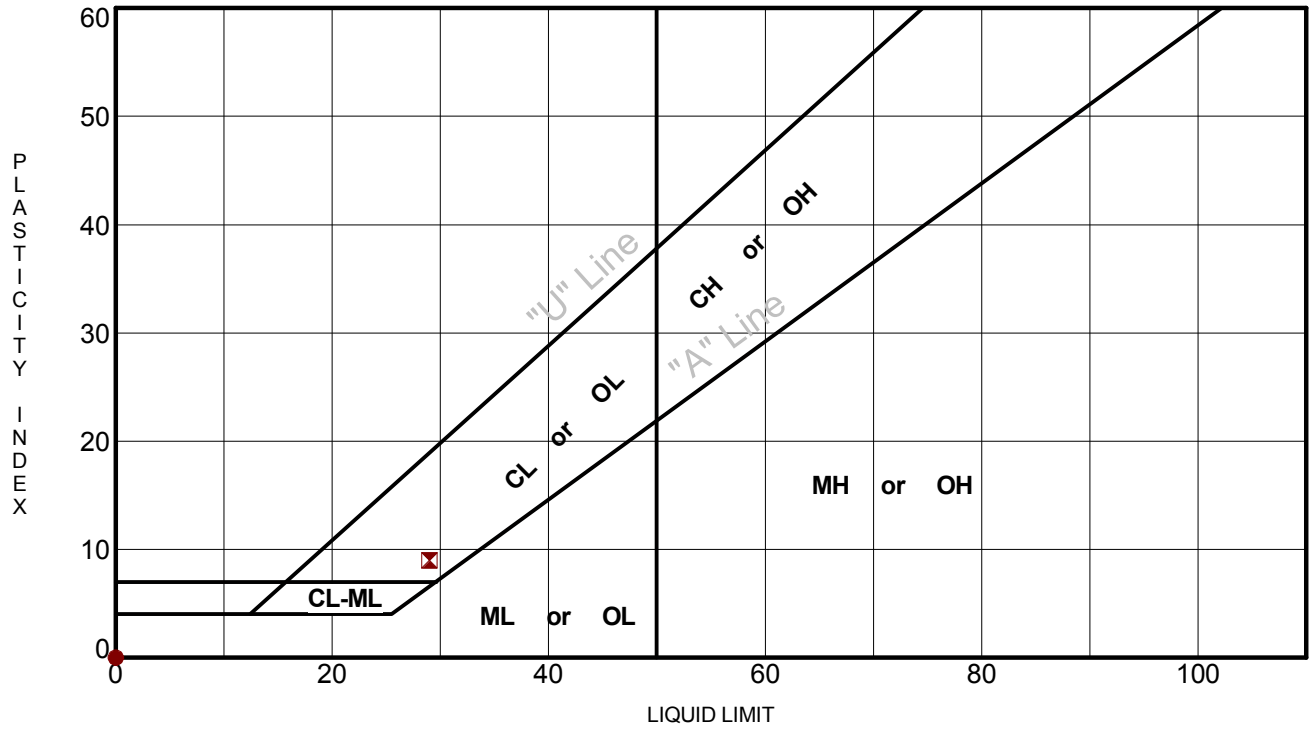
Laboratory test results are presented on the Logs of Borings and in Appendix B, and were used for the geotechnical engineering analyses, and the development of foundation and earthwork recommendations. Laboratory tests were performed in general accordance with the applicable Terracon test standards.

Selected soil and/or bedrock samples were tested for the following engineering properties:

- Water content
- Dry density
- Consolidation/expansion
- Grain size
- Plasticity index
- Electrical resistivity
- pH
- Water soluble sulfate content
- Water soluble chloride content
- Topsoil nutrient testing

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
● 4W-1	4.0	NP	NP	NP	16	SM	SILTY SAND
⧗ 4W-4	2.0	29	20	9	59	CL	SANDY LEAN CLAY

PROJECT: 4 Way Ranch VA

SITE: North of Curtis Road and U.S. Highway 24
El Paso County, Colorado

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

PROJECT NUMBER: 23125013

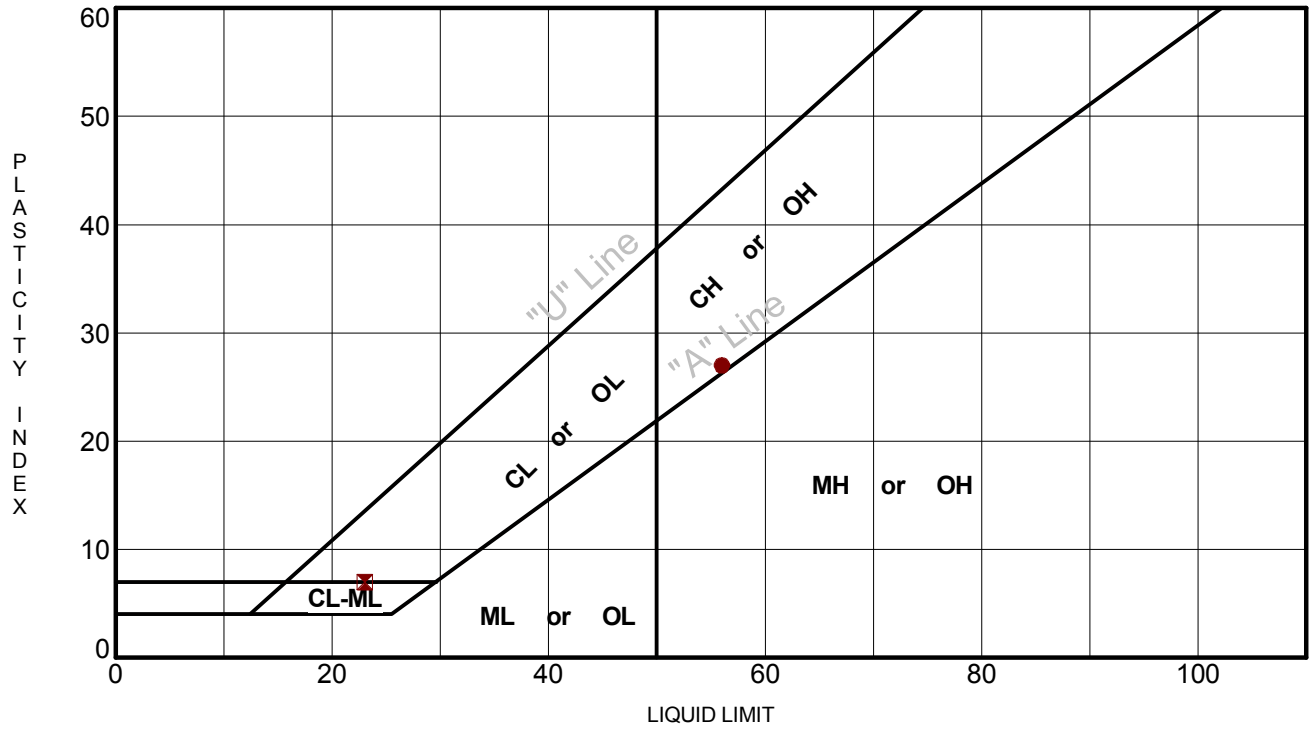
CLIENT: Studley, Inc.
Washington, DC

EXHIBIT: B-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS 23125013-FW.GPJ TERRACON2012.GDT 4/30/12

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
● RH-1	4.0	56	29	27	78	CH	FAT CLAY with SAND
⧗ RH-5	4.0	23	16	7	39	SC-SM	SILTY, CLAYEY SAND

PROJECT: Rolling Hills VA
SITE: SE of Marksheffel Road and Drennan Road
El Paso County, Colorado

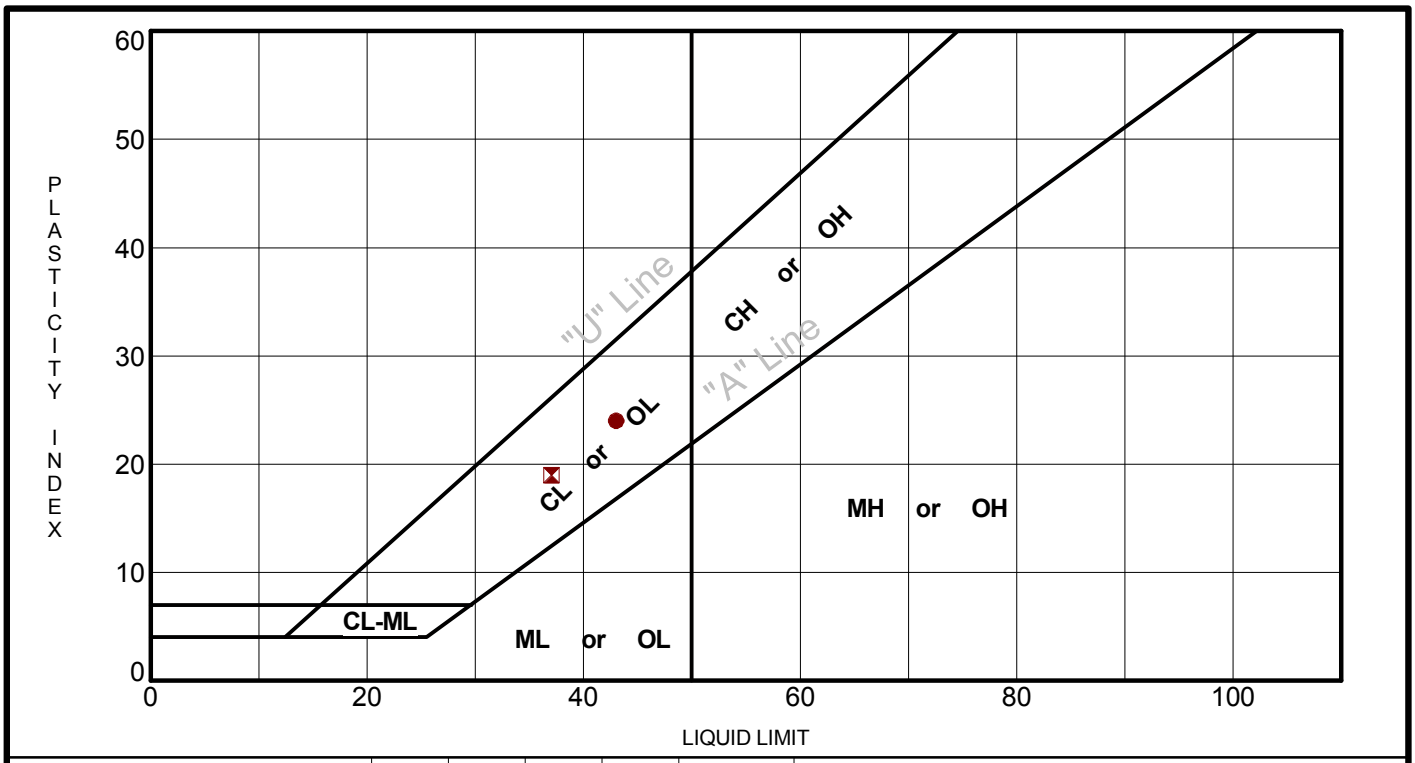
Terracon
4172 Center Park Drive
Colorado Springs, Colorado

PROJECT NUMBER: 23125013
CLIENT: Studley, Inc.
Washington, DC
EXHIBIT: B-3

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS 23125013-RH.GPJ TERRACON2012.GDT 4/30/12

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID	Depth	LL	PL	PI	Fines	USCS	Description
● BH-1	4.0	43	19	24	81	CL	LEAN CLAY with SAND
⊠ BH-4	4.0	37	18	19	78	CL	LEAN CLAY with SAND(CL)

PROJECT: Bradley Heights VA
SITE: Southwest of Marksheffel Rd. and Bradley Rd.
El Paso County, Colorado

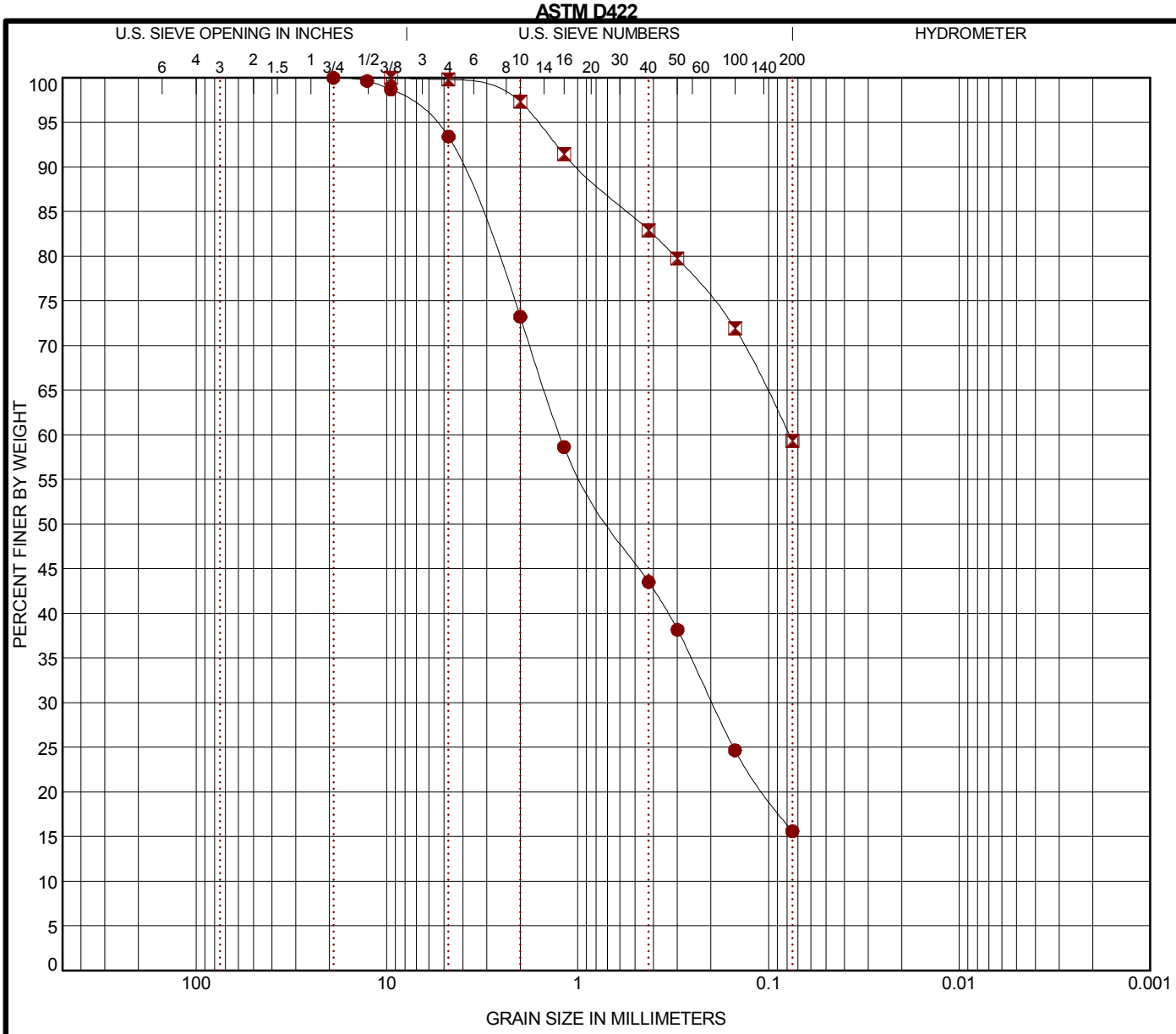
Terracon
4172 Center Park Drive
Colorado Springs, Colorado

PROJECT NUMBER: 23125013
CLIENT: Studley, Inc.
Washington, DC
EXHIBIT: B-4

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS 23125013-BH.GPJ TERRACON2012.GDT 4/30/12

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		USCS Classification	LL	PL	PI	Cc	Cu
●	4W-1	4.0	SILTY SAND(SM)	NP	NP	NP		
⊠	4W-4	2.0	SANDY LEAN CLAY(CL)	29	20	9		

	Specimen Identification		D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	4W-1	4.0	19.05	1.239	0.197		6.6	77.8	15.6	
⊠	4W-4	2.0	9.525	0.078			0.2	40.5	59.3	

PROJECT: 4 Way Ranch VA

SITE: North of Curtis Road and U.S. Highway 24
El Paso County, Colorado

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

PROJECT NUMBER: 23125013

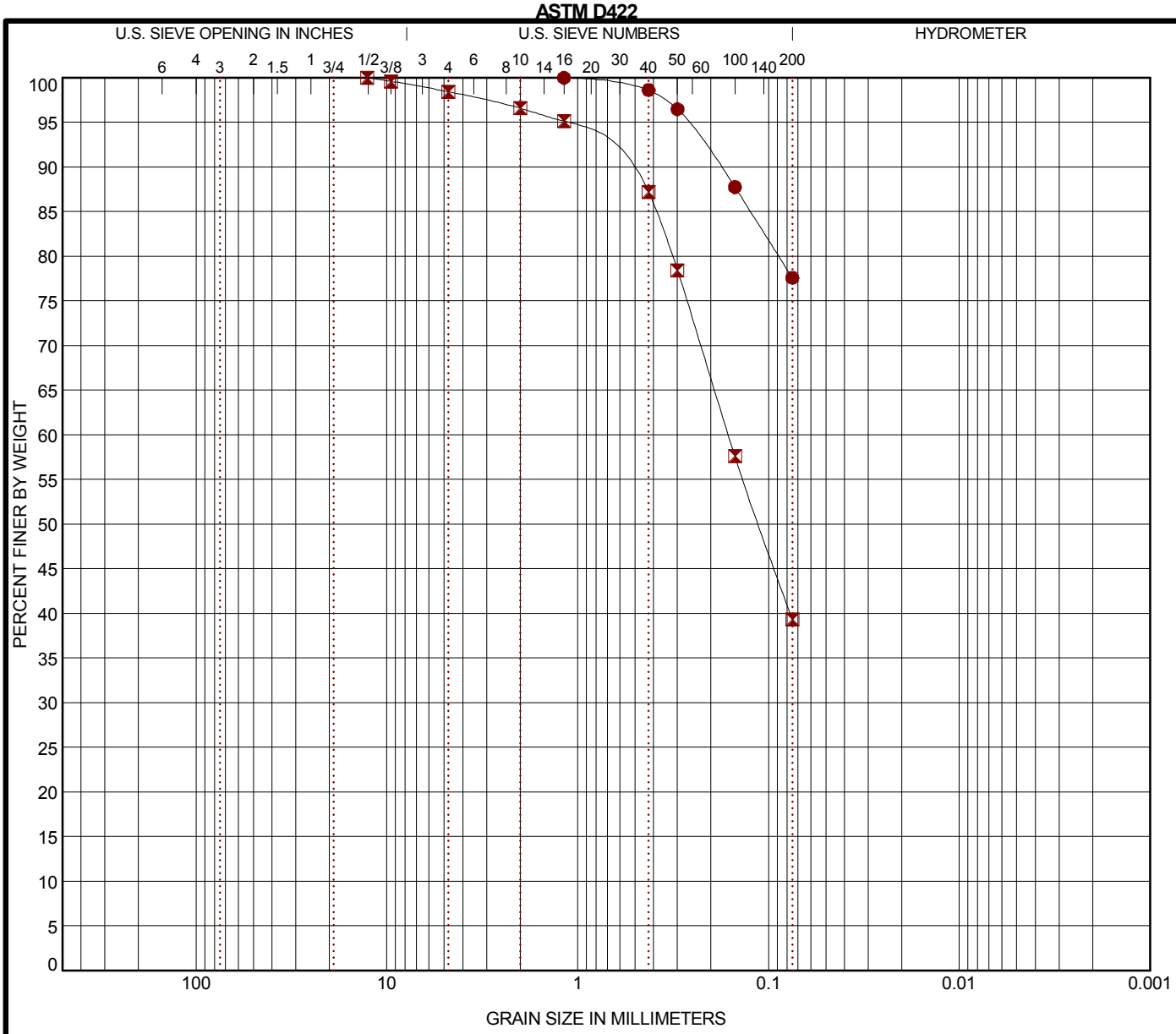
CLIENT: Studley, Inc.
Washington, DC

EXHIBIT: B-1

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 23125013-FW.GPJ TERRACON2012.GDT 4/30/12

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		USCS Classification	LL	PL	PI	Cc	Cu
●	RH-1	4.0	FAT CLAY with SAND(CH)	56	29	27		
⊠	RH-5	4.0	SILTY, CLAYEY SAND(SC-SM)	23	16	7		

	Specimen Identification		D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	RH-1	4.0	1.18				0.0	22.4	77.6	
⊠	RH-5	4.0	12.7	0.162			1.6	59.1	39.4	

PROJECT: Rolling Hills VA
SITE: SE of Marksheffel Road and Drennan Road
El Paso County, Colorado

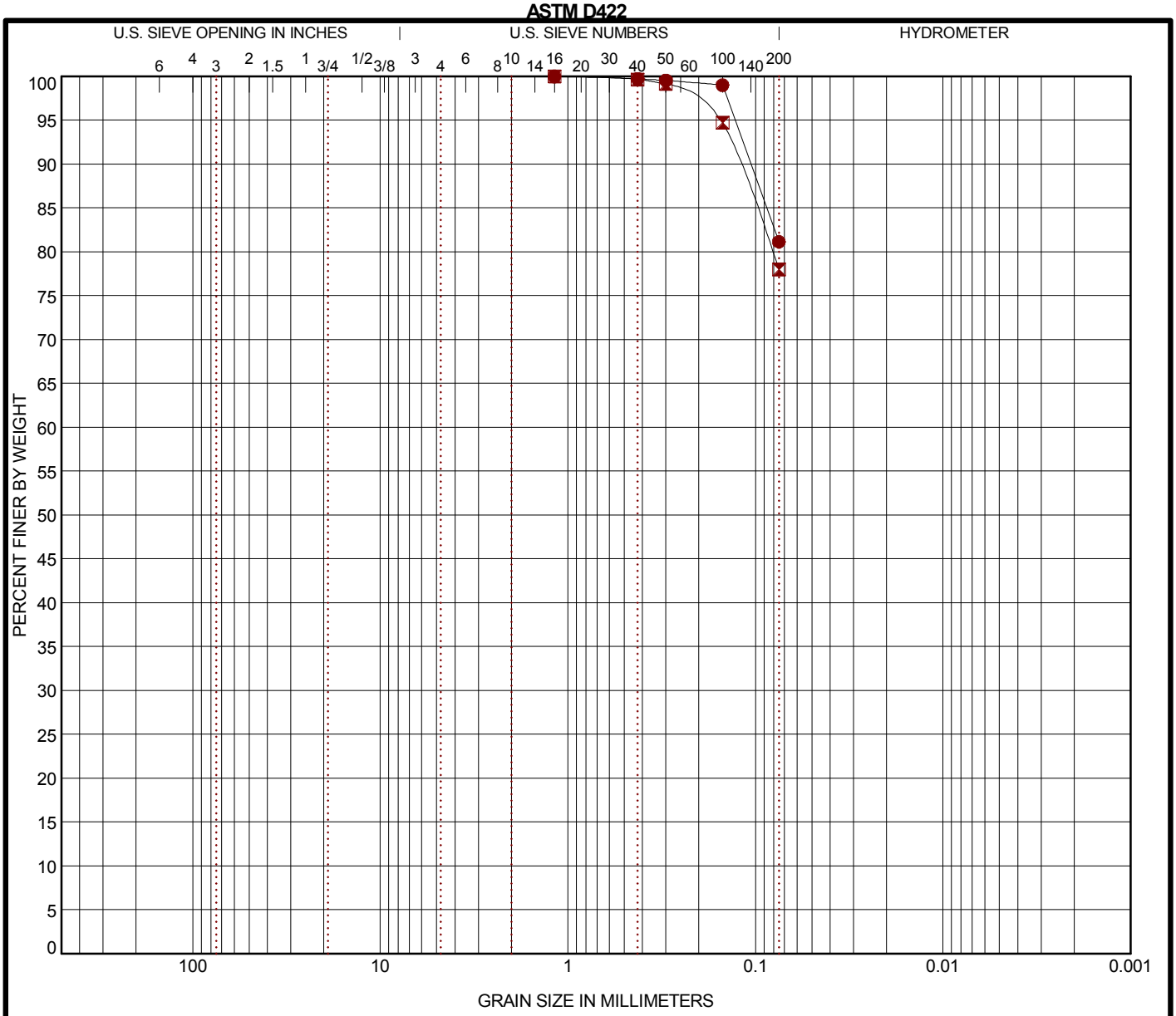
Terracon
4172 Center Park Drive
Colorado Springs, Colorado

PROJECT NUMBER: 23125013
CLIENT: Studley, Inc.
Washington, DC
EXHIBIT: B-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 23125013-RH.GPJ TERRACON2012.GDT 4/30/12

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		USCS Classification	LL	PL	PI	Cc	Cu
●	BH-1	4.0	LEAN CLAY with SAND(CL)	43	19	24		
⊠	BH-4	4.0	LEAN CLAY with SAND(CL)	37	18	19		

	Specimen Identification		D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Clay
●	BH-1	4.0	1.18				0.0	18.8	81.2	
⊠	BH-4	4.0	1.18				0.0	22.0	78.0	

PROJECT: Bradley Heights VA
SITE: Southwest of Marksheffel Rd. and Bradley Rd.
El Paso County, Colorado

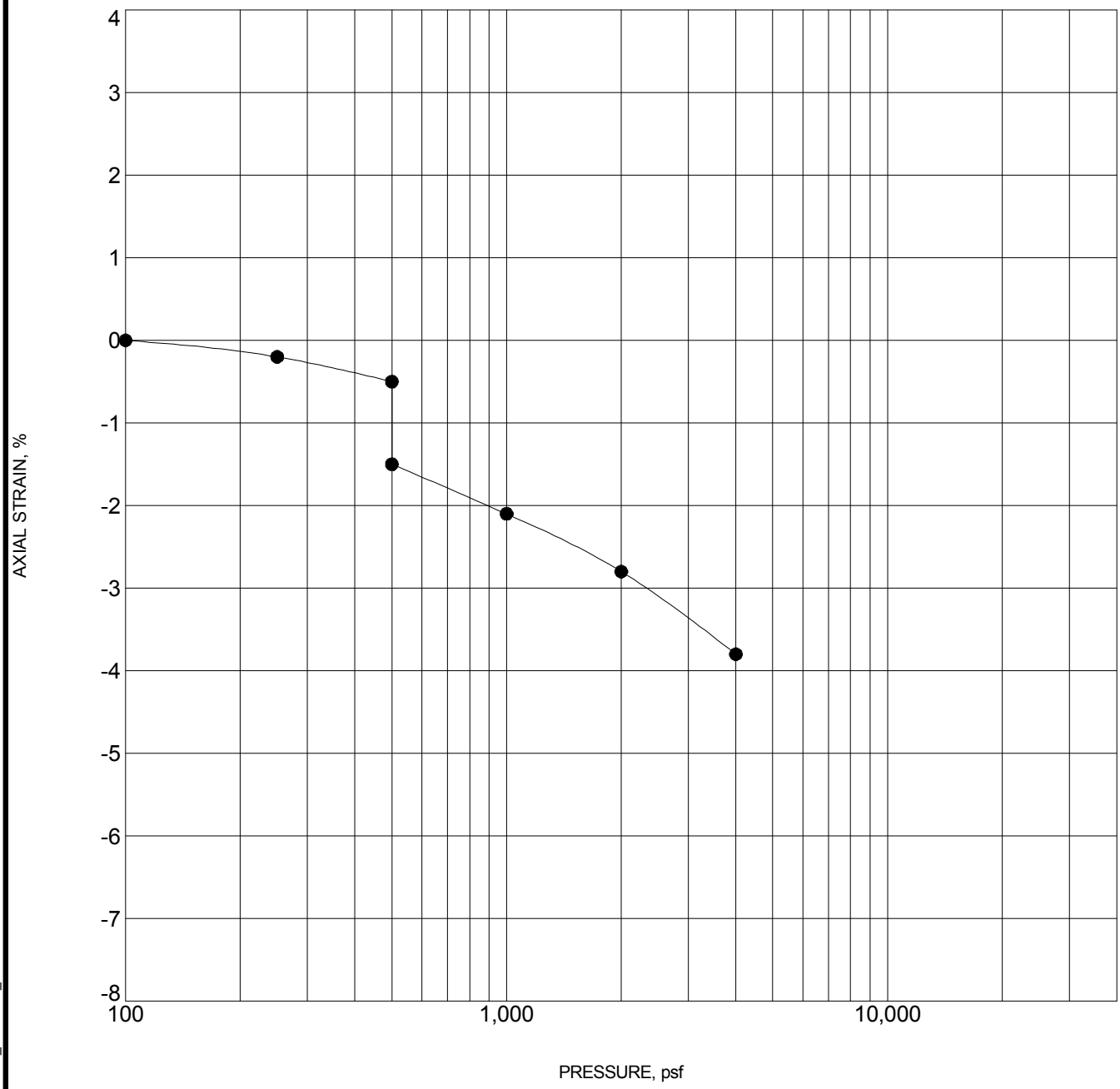
Terracon
4172 Center Park Drive
Colorado Springs, Colorado

PROJECT NUMBER: 23125013
CLIENT: Studley, Inc.
Washington, DC
EXHIBIT: B-7

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 23125013-BH.GPJ TERRACON2012.GDT 4/30/12

SWELL CONSOLIDATION TEST

ASTM



Specimen Identification			Classification	γ_d, pcf	WC, %
●	4W-1	2.0 ft	SILTY SAND(SM)	110	2

NOTES: Sample inundated with water at 500 pounds per square foot (psf.)

PROJECT: 4 Way Ranch VA
SITE: North of Curtis Road and U.S. Highway 24
El Paso County, Colorado

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

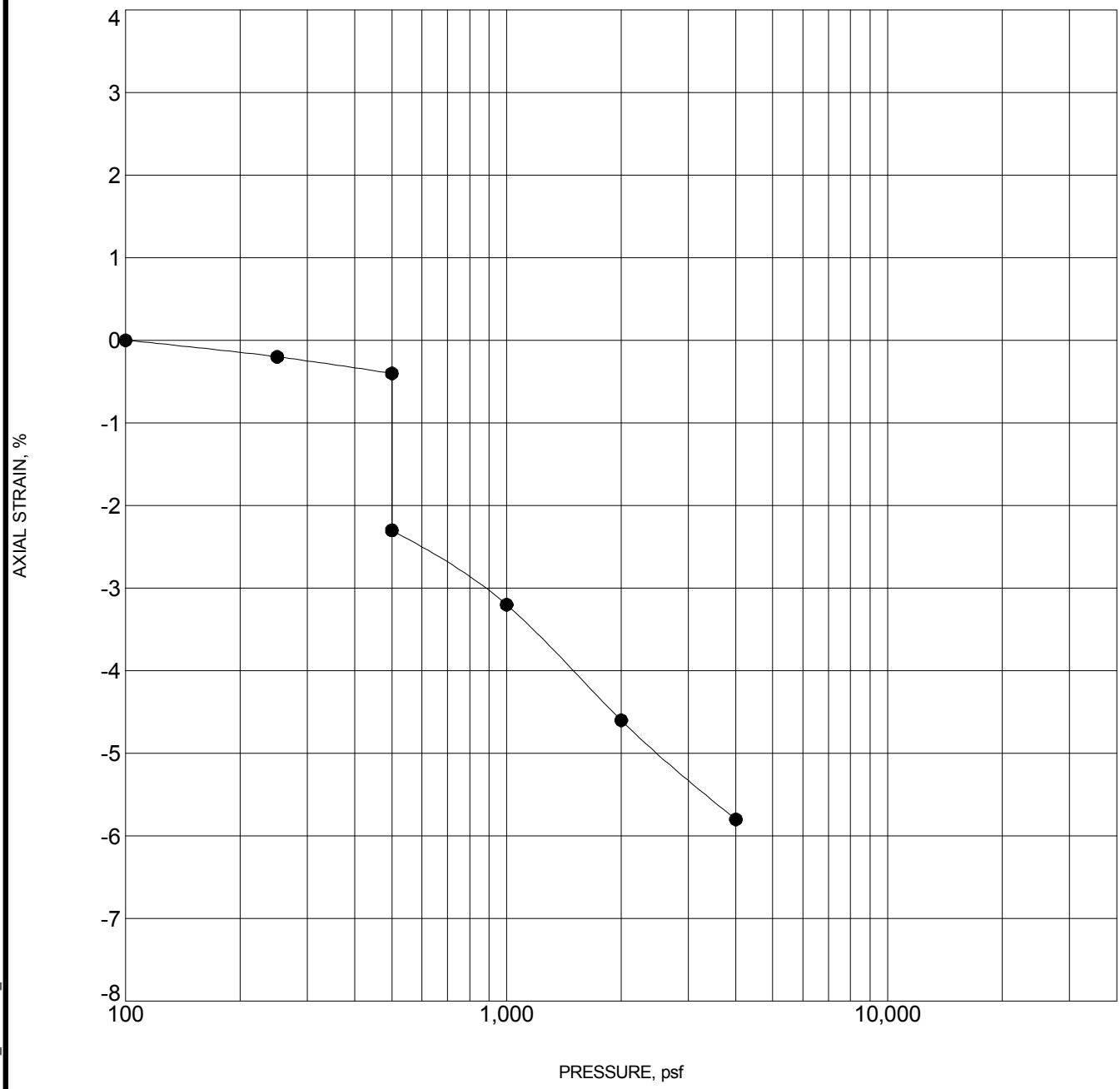
PROJECT NUMBER: 23125013
CLIENT: Studley, Inc.
Washington, DC

EXHIBIT: B-8

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS 23125013-FW.GPJ TERRACON2012.GDT 4/30/12

SWELL CONSOLIDATION TEST

ASTM



Specimen Identification			Classification	γ_d, pcf	WC, %
●	4W-4	4.0 ft	WELL-GRADED SAND with SILT(SW-SM)	124	2

NOTES: Sample inundated with water at 500 pounds per square foot (psf.)

PROJECT: 4 Way Ranch VA
SITE: North of Curtis Road and U.S. Highway 24
El Paso County, Colorado

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

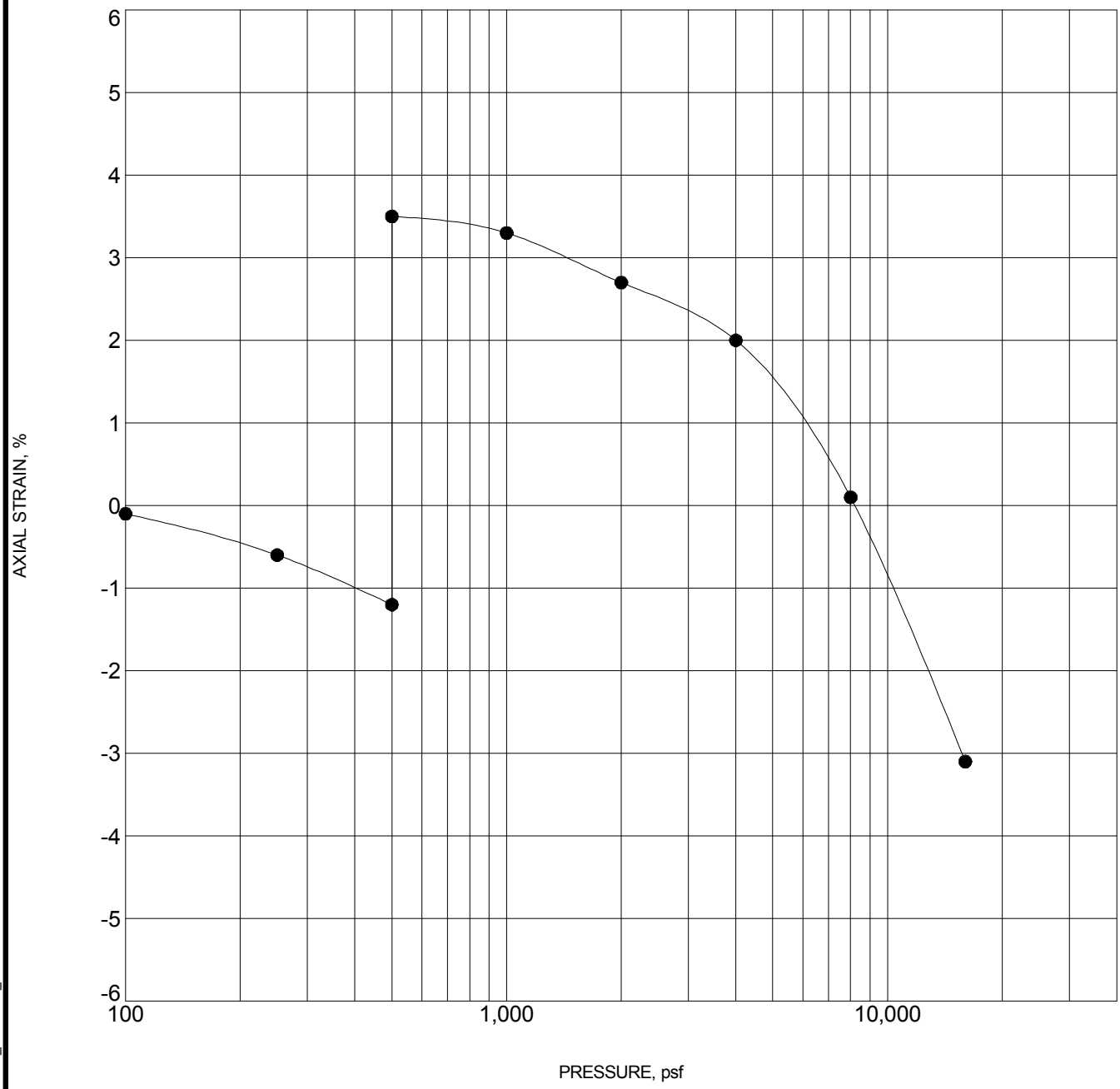
PROJECT NUMBER: 23125013
CLIENT: Studley, Inc.
Washington, DC

EXHIBIT: B-9

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS 23125013-FW.GPJ TERRACON2012.GDT 4/30/12

SWELL CONSOLIDATION TEST

ASTM



Specimen Identification			Classification	γ_d, pcf	WC, %
●	RH-3	2.0 ft	FAT CLAY(CH)	95	25

NOTES: Sample inundated with water at 500 pounds per square foot (psf.)

PROJECT: Rolling Hills VA
SITE: SE of Marksheffel Road and Drennan Road
El Paso County, Colorado

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

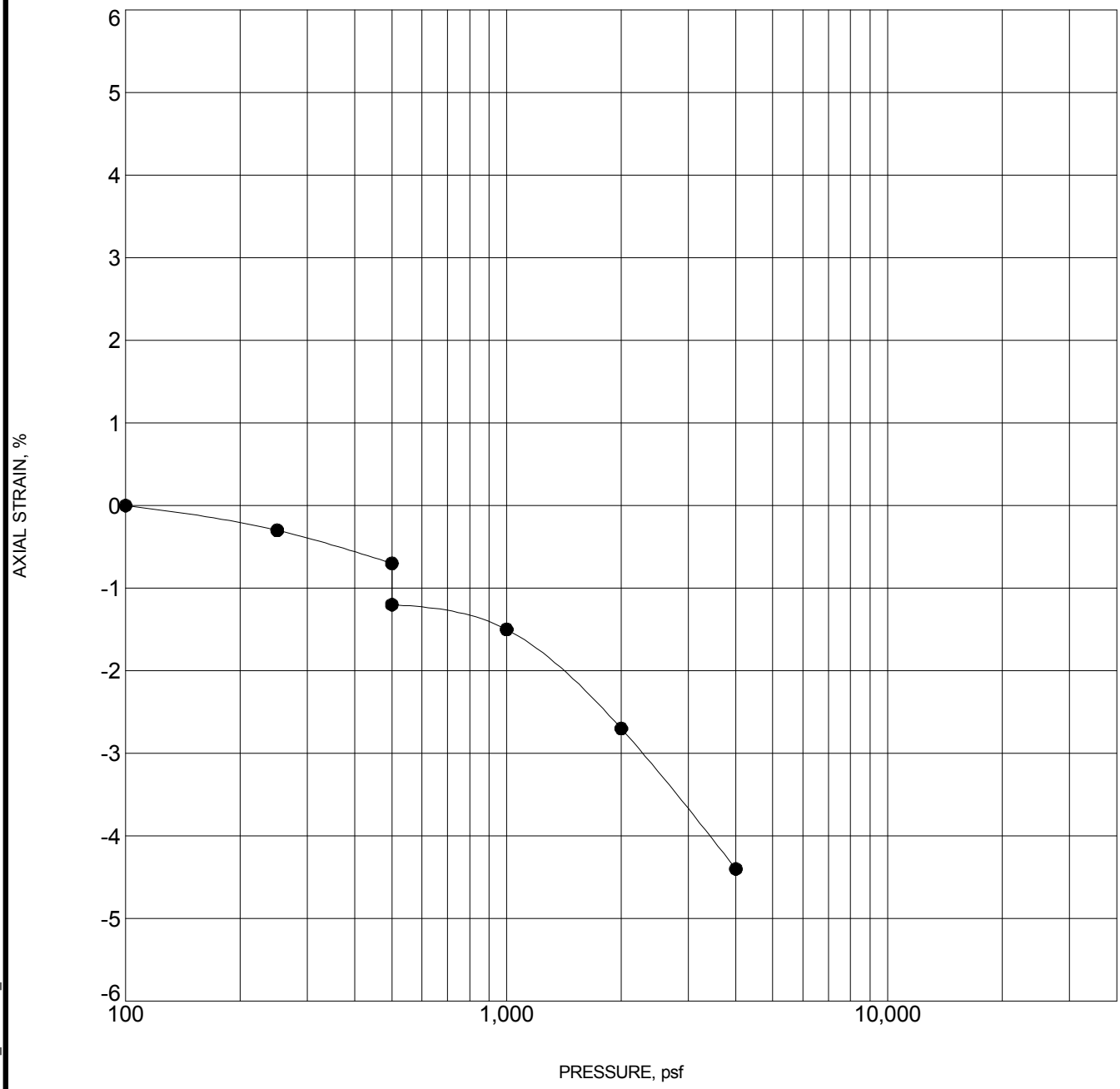
PROJECT NUMBER: 23125013
CLIENT: Studley, Inc.
Washington, DC

EXHIBIT: B-10

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS 23125013-RH.GPJ TERRACON2012.GDT 4/30/12

SWELL CONSOLIDATION TEST

ASTM



Specimen Identification			Classification	γ_d, pcf	WC, %
●	RH-5	2.0 ft	SILTY CLAYEY SAND(SC-SM)	100	8

NOTES: Sample inundated with water at 500 pounds per square foot (psf.)

PROJECT: Rolling Hills VA
SITE: SE of Marksheffel Road and Drennan Road
El Paso County, Colorado

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

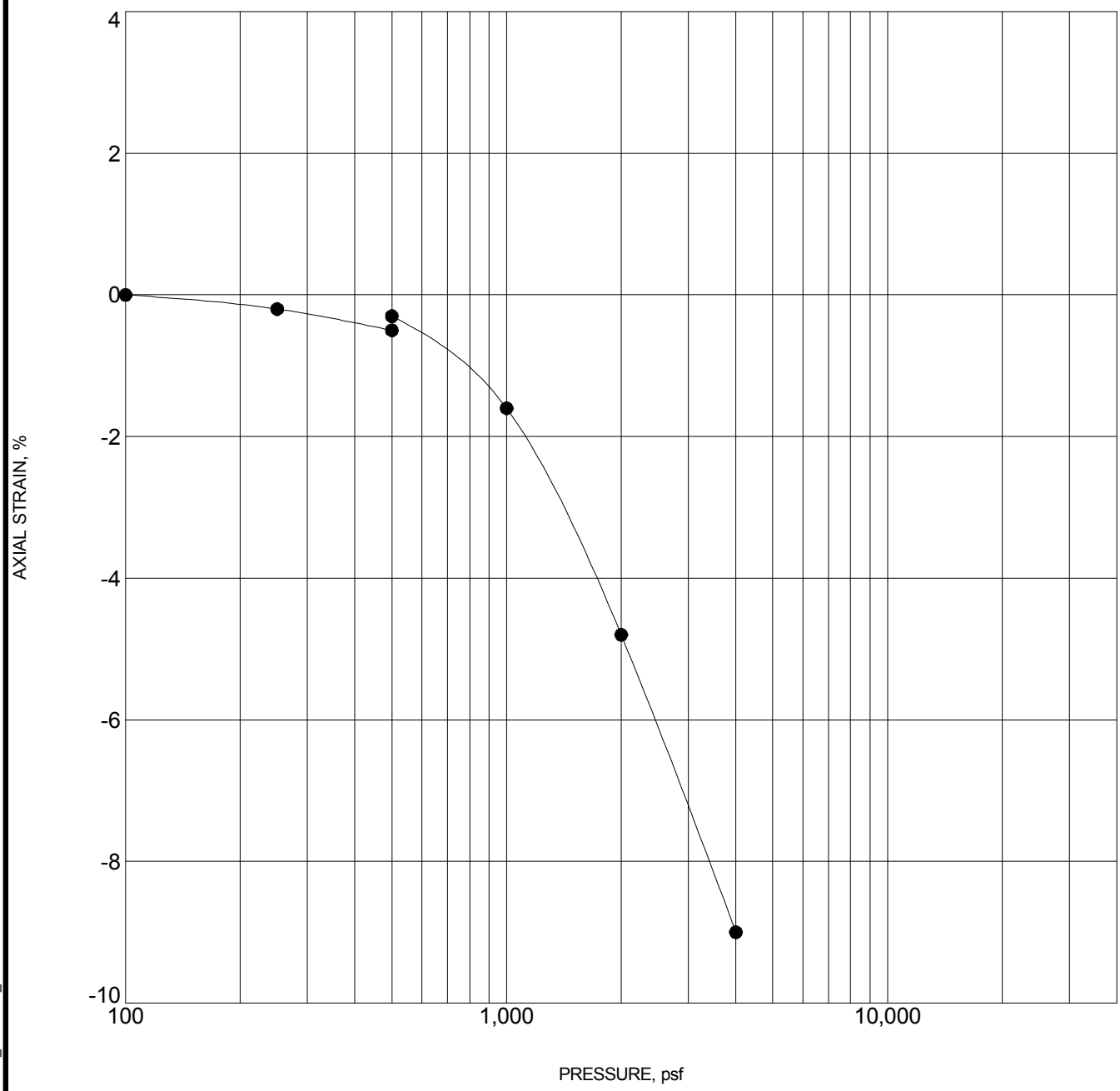
PROJECT NUMBER: 23125013
CLIENT: Studley, Inc.
Washington, DC

EXHIBIT: B-11

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS 23125013-RH.GPJ TERRACON2012.GDT 4/30/12

SWELL CONSOLIDATION TEST

ASTM



Specimen Identification			Classification	γ_d, pcf	WC, %
●	BH-2	2.0 ft	LEAN CLAY with SAND(CL)	94	8

NOTES: Sample inundated with water at 500 pounds per square foot (psf.)

PROJECT: Bradley Heights VA
SITE: Southwest of Marksheffel Rd. and Bradley Rd.
El Paso County, Colorado

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

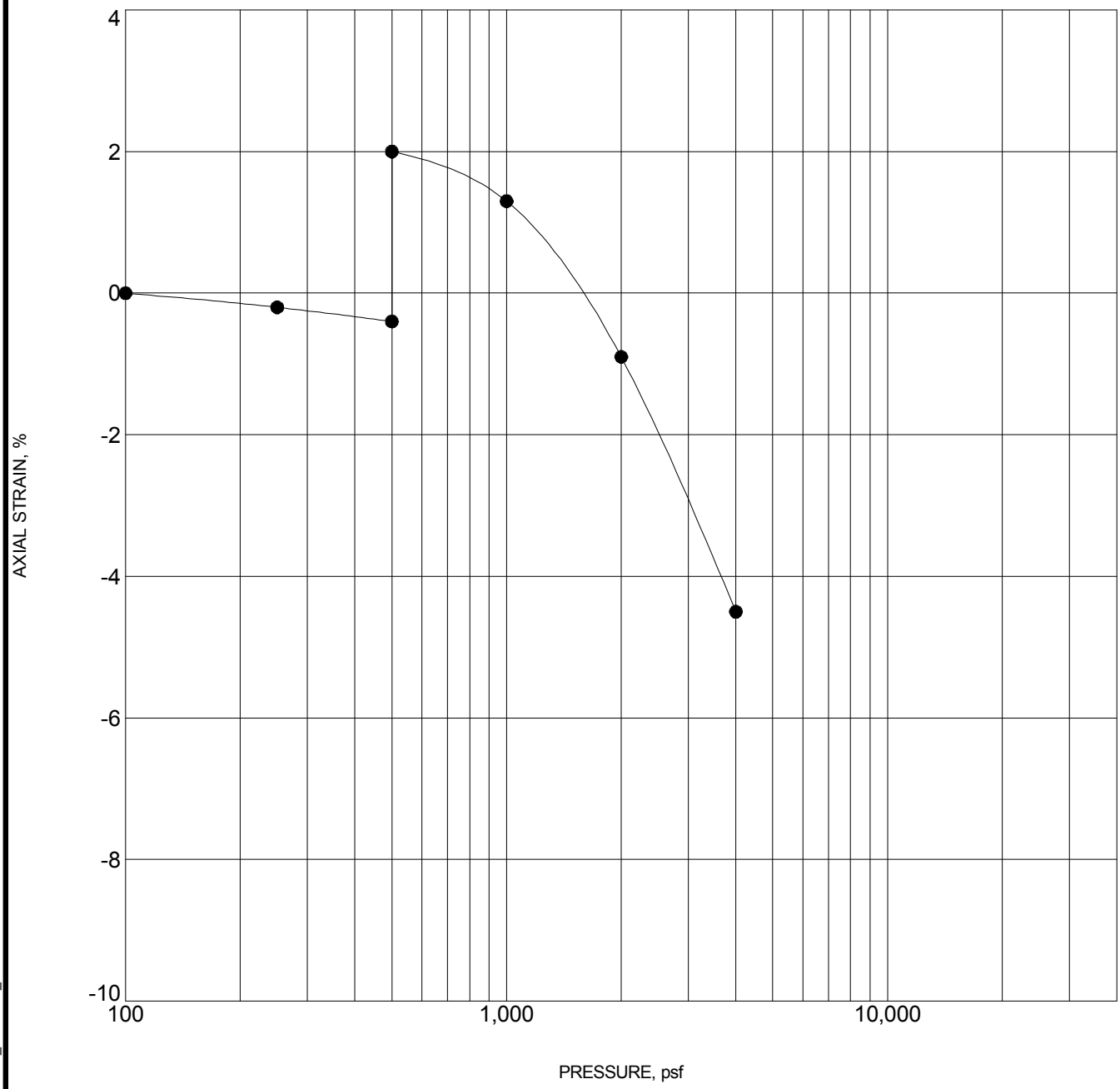
PROJECT NUMBER: 23125013
CLIENT: Studley, Inc.
Washington, DC

EXHIBIT: B-12

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS 23125013-BH.GPJ TERRACON2012.GDT 4/30/12

SWELL CONSOLIDATION TEST

ASTM



Specimen Identification			Classification	γ_d, pcf	WC, %
●	BH-4	4.0 ft	LEAN CLAY with SAND(CL)	101	9

NOTES: Sample inundated with water at 500 pounds per square foot (psf.)

PROJECT: Bradley Heights VA
SITE: Southwest of Marksheffel Rd. and Bradley Rd.
El Paso County, Colorado

Terracon
4172 Center Park Drive
Colorado Springs, Colorado

PROJECT NUMBER: 23125013
CLIENT: Studley, Inc.
Washington, DC

EXHIBIT: B-13

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. TC_CONSOL_STRAIN-USCS 23125013-BH.GPJ TERRACON2012.GDT 4/30/12

Colorado Analytical Laboratories, Inc.

Analytical Results

TASK NO: 120417013

Report To: Ryan Feist
Company: Terracon, Inc. - Colo Springs
4172 Center Park Drive
Colo. Springs CO 80916

Bill To: Ryan Feist
Company: Terracon, Inc. - Colo Springs
4172 Center Park Drive
Colo. Springs CO 80916

Task No.: 120417013
Client PO:
Client Project: Fourway Ranch VA Cemetary 23125013

Date Received: 4/17/12
Date Reported: 4/27/12
Matrix: Soil - Geotech

Customer Sample ID FW 5 (1-10)
Sample Date/Time:
Lab Number: 120417013-03

Test	Result	Method
Chloride - Water Soluble	**0.0004 %**	AASHTO T291-91/ ASTM D4327
pH	**7.2 units**	AASHTO T289-91
Resistivity	**1319 ohm.cm**	AASHTO T288-91
Sulfate - Water Soluble	**0.010 %**	AASHTO T290-91/ ASTM D4327

Abbreviations/ References:

AASHTO - American Association of State Highway and Transportation Officials.
ASTM - American Society for Testing and Materials.
ASA - American Society of Agronomy.
DIPRA - Ductile Iron Pipe Research Association Handbook of Ductile Iron Pipe.

DATA APPROVED FOR RELEASE BY

240 South Main Street / Brighton, CO 80601-0507 / 303-659-2313
Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

Colorado Analytical Laboratories, Inc.

Analytical Results

TASK NO: 120417012

Report To: Ryan Feist
Company: Terracon, Inc. - Colo Springs
4172 Center Park Drive
Colo. Springs CO 80916

Bill To: Ryan Feist
Company: Terracon, Inc. - Colo Springs
4172 Center Park Drive
Colo. Springs CO 80916

Task No.: 120417012
Client PO:
Client Project: Rolling Hills VA Cemetary 23125013

Date Received: 4/17/12
Date Reported: 4/27/12
Matrix: Soil - Geotech

Customer Sample ID RH 4 (1-10)
Sample Date/Time:
Lab Number: 120417012-03

Test	Result	Method
Chloride - Water Soluble	**0.0016 %**	AASHTO T291-91/ ASTM D4327
pH	**7.2 units**	AASHTO T289-91
Resistivity	**679 ohm.cm**	AASHTO T288-91
Sulfate - Water Soluble	**0.129 %**	AASHTO T290-91/ ASTM D4327

Abbreviations/ References:

AASHTO - American Association of State Highway and Transportation Officials.
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ASA - American Society of Agronomy.
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Colorado Analytical Laboratories, Inc.

Analytical Results

TASK NO: 120417014

Report To: Ryan Feist
Company: Terracon, Inc. - Colo Springs
4172 Center Park Drive
Colo. Springs CO 80916

Bill To: Ryan Feist
Company: Terracon, Inc. - Colo Springs
4172 Center Park Drive
Colo. Springs CO 80916

Task No.: 120417014
Client PO:
Client Project: Bradley Heights VA Cemetary 23125013

Date Received: 4/17/12
Date Reported: 4/27/12
Matrix: Soil - Geotech

Customer Sample ID BH 5 (1-10)
Sample Date/Time:
Lab Number: 120417014-03

Test	Result	Method
Chloride - Water Soluble	**0.0018 %**	AASHTO T291-91/ ASTM D4327
pH	**7.3 units**	AASHTO T289-91
Resistivity	**556 ohm.cm**	AASHTO T288-91
Sulfate - Water Soluble	**0.925 %**	AASHTO T290-91/ ASTM D4327

Abbreviations/ References:

AASHTO - American Association of State Highway and Transportation Officials.
ASTM - American Society for Testing and Materials.
ASA - American Society of Agronomy.
DIPRA - Ductile Iron Pipe Research Association Handbook of Ductile Iron Pipe.

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Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

Colorado Analytical Laboratories, Inc.

Soil Nutrient Laboratory Report

Lab No.: *120417013-01* **Date Rec:** *4/17/12* **Reported:** *4/27/12*	**Report To:** Ryan Feist	**Company:** Terracon, Inc. - Colo Springs 4172 Center Park Drive Colo. Springs CO 80916

Sample ID: *FW 2 (2)*

Project: *Fourway Ranch VA Cemetary*

Laboratory Results:

	Sample Result	Low----------Ave----------High
Field Texture (EST)	Sandy Loam	
pH (units)	8.5	**********
Salts (MMHOS/CM)	0.7	**********
CEC Est. (MEQ/100G)	6.0	******
Lime (Qual.)	High	**********
Organic Matter (%)	0.4	***
Organic N (lbs/acre)	10.5	*****
Sodium (meq/100g Soil)	0.62	**********
Available Nutrients (ppm)		
Nitrate Nitrogen	0.8	
Phosphorus	1.5	*
Potassium	30.8	*****
Calcium	1353.7	**********
Magnesium	83.0	******
Sulfur	29.7	**********
Boron	0.3	
Zinc	12.7	**********
Iron	2.4	**********
Manganese	1.3	**********
Copper	15.9	**********

Note: Average Values are for Colorado Soils

Fertilizer Recommendations

General Landscape

Nitrogen:	*130 lbs/Acre*
Phosphorus - P2O5:	*80 lbs/Acre*
Potassium - K2O:	*15 lbs/Acre*
Sulfur SO4-S:	*10 lbs/Acre*
Lime:	*0 lbs/Acre*

**To convert recommendations to lbs/1000 sq. ft. divide by 40.*

Comments

Split Nitrogen Recommendations 2 to 3 Times Throughout the Growing Season.

3 to 4 Cubic Yards/ 1000 sq. ft. of Low Salt Compost May Be Beneficial.

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Colorado Analytical Laboratories, Inc.

Soil Nutrient Laboratory Report

Lab No.: *120417013-02* **Date Rec:** *4/17/12* **Reported:** *4/27/12*	**Report To:** Ryan Feist	**Company:** Terracon, Inc. - Colo Springs 4172 Center Park Drive Colo. Springs CO 80916

Sample ID: *FW 3 (2)*

Project: *Fourway Ranch VA Cemetary*

Laboratory Results:

	Sample Result	Low----------Ave----------High
Field Texture (EST)	Sandy Loam	
pH (units)	8.0	**********
Salts (MMHOS/CM)	0.8	**********
CEC Est. (MEQ/100G)	7.4	********
Lime (Qual.)	Medium	**********
Organic Matter (%)	1.1	**********
Organic N (lbs/acre)	32.6	**********
Sodium (meq/100g Soil)	0.37	********
Available Nutrients (ppm)		
Nitrate Nitrogen	7.7	*******
Phosphorus	1.8	*
Potassium	86.2	**********
Calcium	1910.9	**********
Magnesium	75.2	*****
Sulfur	18.1	**********
Boron	0.2	
Zinc	6.9	**********
Iron	2.1	**********
Manganese	1.0	**********
Copper	5.4	**********

Note: Average Values are for Colorado Soils

Fertilizer Recommendations

General Landscape

Nitrogen:	*120 lbs/Acre*
Phosphorus - P2O5:	*80 lbs/Acre*
Potassium - K2O:	*0 lbs/Acre*
Sulfur SO4-S:	*30 lbs/Acre*
Lime:	*0 lbs/Acre*

**To convert recommendations to lbs/1000 sq. ft. divide by 40.*

Comments ***Split Nitrogen Recommendations 2 to 3 Times Throughout the Growing Season.***

3 to 4 Cubic Yards/ 1000 sq. ft. of Low Salt Compost May Be Beneficial.

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Colorado Analytical Laboratories, Inc.

Soil Nutrient Laboratory Report

Lab No.: *120417012-01* **Date Rec:** *4/17/12* **Reported:** *4/27/12*	**Report To:** Ryan Feist	**Company:** Terracon, Inc. - Colo Springs 4172 Center Park Drive Colo. Springs CO 80916

Sample ID: *RH 1 (2)*

Project: *Rolling Hills VA Cemetary*

Laboratory Results:

	Sample Result	Low----------Ave----------High
Field Texture (EST)	Silt Loam	
pH (units)	7.1	**********
Salts (MMHOS/CM)	2.4	**********
CEC Est. (MEQ/100G)	18.4	**********
Lime (Qual.)	Low	
Organic Matter (%)	4.8	**********
Organic N (lbs/acre)	144.0	**********
Sodium (meq/100g Soil)	1.40	**********
Available Nutrients (ppm)		
Nitrate Nitrogen	8.4	********
Phosphorus	5.8	*****
Potassium	160.9	**********
Calcium	7422.8	**********
Magnesium	324.3	**********
Sulfur	68.4	**********
Boron	0.3	
Zinc	7.6	**********
Iron	8.6	**********
Manganese	2.1	**********
Copper	3.4	**********

Note: Average Values are for Colorado Soils

Fertilizer Recommendations

General Landscape

Nitrogen:	*120 lbs/Acre*
Phosphorus - P2O5:	*80 lbs/Acre*
Potassium - K2O:	*0 lbs/Acre*
Sulfur SO4-S:	*0 lbs/Acre*
Lime:	*0 lbs/Acre*

**To convert recommendations to lbs/1000 sq. ft. divide by 40.*

Comments ***Split Nitrogen Recommendations 2 to 3 Times Throughout the Growing Season.***

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Colorado Analytical Laboratories, Inc.

Soil Nutrient Laboratory Report

Lab No.: *120417012-02* **Date Rec:** *4/17/12* **Reported:** *4/27/12*	**Report To:** Ryan Feist	**Company:** Terracon, Inc. - Colo Springs 4172 Center Park Drive Colo. Springs CO 80916

Sample ID: *RH 4 (2)*

Project: *Rolling Hills VA Cemetary*

Laboratory Results:

	Sample Result	Low----------Ave----------High
Field Texture (EST)	Silt Loam	
pH (units)	7.1	**********
Salts (MMHOS/CM)	6.9	**********
CEC Est. (MEQ/100G)	16.3	**********
Lime (Qual.)	Low	
Organic Matter (%)	3.7	**********
Organic N (lbs/acre)	111.6	**********
Sodium (meq/100g Soil)	2.36	**********
Available Nutrients (ppm)		
Nitrate Nitrogen	22.8	**********
Phosphorus	23.1	**********
Potassium	250.8	**********
Calcium	10061.1	**********
Magnesium	754.0	**********
Sulfur	2268.0	**********
Boron	0.4	
Zinc	4.6	**********
Iron	12.1	**********
Manganese	1.5	**********
Copper	2.8	**********

Note: Average Values are for Colorado Soils

Fertilizer Recommendations

General Landscape

Nitrogen:	*90 lbs/Acre*
Phosphorus - P2O5:	*40 lbs/Acre*
Potassium - K2O:	*0 lbs/Acre*
Sulfur SO4-S:	*0 lbs/Acre*
Lime:	*0 lbs/Acre*

**To convert recommendations to lbs/1000 sq. ft. divide by 40.*

Comments

Split Nitrogen Recommendations 2 to 3 Times Throughout the Growing Season.

Yield Reduction Likely Due To High Salts.

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Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

Colorado Analytical Laboratories, Inc.

Soil Nutrient Laboratory Report

Lab No.: *120417014-01* **Date Rec:** *4/17/12* **Reported:** *4/27/12*	**Report To:** Ryan Feist	**Company:** Terracon, Inc. - Colo Springs 4172 Center Park Drive Colo. Springs CO 80916

Sample ID: *BH 1 (2)*

Project: *Bradley Heights VA Cemetary*

Laboratory Results:

	Sample Result	Low----------Ave----------High
Field Texture (EST)	Silt Loam	
pH (units)	8.3	**********
Salts (MMHOS/CM)	0.8	**********
CEC Est. (MEQ/100G)	11.5	**********
Lime (Qual.)	Medium	**********
Organic Matter (%)	1.3	**********
Organic N (lbs/acre)	40.2	**********
Sodium (meq/100g Soil)	0.28	******
Available Nutrients (ppm)		
Nitrate Nitrogen	1.2	
Phosphorus	3.3	**
Potassium	102.8	**********
Calcium	3796.4	**********
Magnesium	858.5	**********
Sulfur	10.1	**********
Boron	0.4	*
Zinc	5.4	**********
Iron	1.9	**********
Manganese	1.7	**********
Copper	11.5	**********

Note: Average Values are for Colorado Soils

Fertilizer Recommendations

General Landscape

Nitrogen:	*130 lbs/Acre*
Phosphorus - P2O5:	*80 lbs/Acre*
Potassium - K2O:	*0 lbs/Acre*
Sulfur SO4-S:	*40 lbs/Acre*
Lime:	*0 lbs/Acre*

**To convert recommendations to lbs/1000 sq. ft. divide by 40.*

Comments

Split Nitrogen Recommendations 2 to 3 Times Throughout the Growing Season.

3 to 4 Cubic Yards/ 1000 sq. ft. of Low Salt Compost May Be Beneficial.

240 South Main Street / Brighton, CO 80601-0507 / 303-659-2313
Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

Colorado Analytical Laboratories, Inc.

Soil Nutrient Laboratory Report

Lab No.: *120417014-02* **Date Rec:** *4/17/12* **Reported:** *4/27/12*	**Report To:** Ryan Feist	**Company:** Terracon, Inc. - Colo Springs 4172 Center Park Drive Colo. Springs CO 80916

Sample ID: *BH 4 (2)*

Project: *Bradley Heights VA Cemetary*

Laboratory Results:

	Sample Result	Low----------Ave----------High
Field Texture (EST)	Silt Clay Loam	
pH (units)	8.4	**********
Salts (MMHOS/CM)	1.8	**********
CEC Est. (MEQ/100G)	21.9	**********
Lime (Qual.)	High	**********
Organic Matter (%)	2.5	**********
Organic N (lbs/acre)	75.2	**********
Sodium (meq/100g Soil)	2.69	**********
Available Nutrients (ppm)		
Nitrate Nitrogen	1.4	
Phosphorus	2.1	*
Potassium	165.6	**********
Calcium	4431.8	**********
Magnesium	1335.1	**********
Sulfur	100.5	**********
Boron	5.5	**********
Zinc	33.7	**********
Iron	4.9	**********
Manganese	2.3	**********
Copper	22.8	**********

Note: Average Values are for Colorado Soils

Fertilizer Recommendations

General Landscape

Nitrogen:	*130 lbs/Acre*
Phosphorus - P2O5:	*80 lbs/Acre*
Potassium - K2O:	*0 lbs/Acre*
Sulfur SO4-S:	*0 lbs/Acre*
Lime:	*0 lbs/Acre*

**To convert recommendations to lbs/1000 sq. ft. divide by 40.*

Comments

Split Nitrogen Recommendations 2 to 3 Times Throughout the Growing Season.

Yield Reduction Likely Due to High Boron.

240 South Main Street / Brighton, CO 80601-0507 / 303-659-2313
Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

APPENDIX C

SUPPORTING DOCUMENTS

EXPLANATION OF BORING LOG INFORMATION

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

- Auger
- Split Spoon
- Shelby Tube
- Macro Core
- Ring Sampler
- Rock Core
- Grab Sample
- No Recovery

WATER LEVEL

- Water Initially Encountered
- Water Level After a Specified Period of Time
- Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

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

LOCATION AND ELEVATION NOTES

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

STENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength, Qu, tsf	Standard Penetration or N-Value Blows/Ft.	Ring Sampler Blows/Ft.
Very Loose	0 - 3	0 - 6	Very Soft	less than 0.25	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	0.25 to 0.50	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	0.50 to 1.00	5 - 7	5 - 9
Dense	30 - 50	59 - 98	Stiff	1.00 to 2.00	8 - 14	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	2.00 to 4.00	15 - 30	19 - 42
			Hard	above 4.00	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

GRAIN SIZE TERMINOLOGY

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

RELATIVE PROPORTIONS OF FINES

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

PLASTICITY DESCRIPTION

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

Terracon

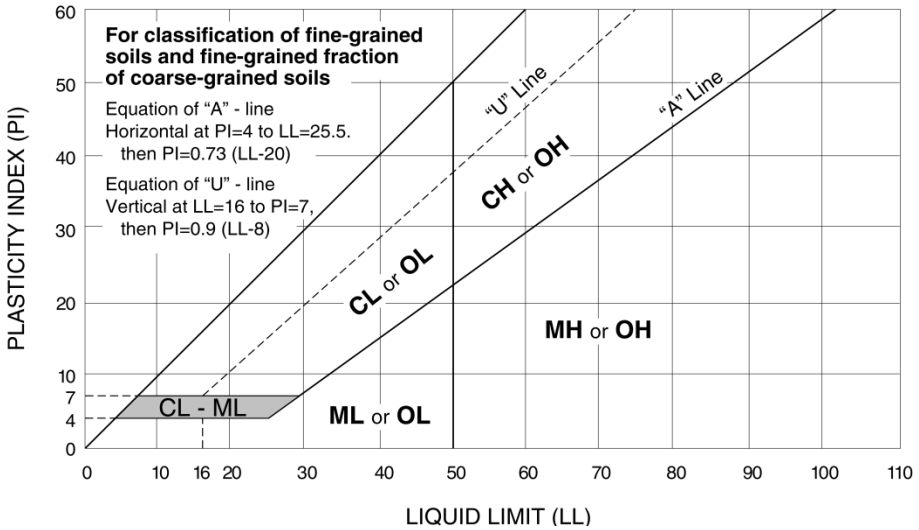
UNIFIED SOIL CLASSIFICATION SYSTEM

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

[A] Based on the material passing the 3-in. (75-mm) sieve
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

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

[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.



GENERAL NOTES

Description of Rock Properties

WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" not discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock [a]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

a. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD)		Joint Openness Descriptors	
RQD, as a percentage	Diagnostic description	Openness	Descriptor
Exceeding 90	Excellent	No Visible Separation	Tight
90 – 75	Good	Less than 1/32 in.	Slightly Open
75 – 50	Fair	1/32 to 1/8 in.	Moderately Open
50 – 25	Poor	1/8 to 3/8 in.	Open
Less than 25	Very poor	3/8 in. to 0.1 ft.	Moderately Wide
		Greater than 0.1 ft.	Wide

a. RQD (given as a percentage) = length of core in pieces 4 in. and longer/length of run.

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976.
U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.

Exhibit C-3