Geotechnical Engineering Report

Proposed Building Addition

Fort Gibson National Cemetery

Fort Gibson, Oklahoma

May 14, 2012

Terracon Project No. 04125070

Prepared for:

SmithGroupJJR

Ann Arbor, Michigan

Prepared by:

Terracon Consultants, Inc.

Tulsa, Oklahoma

May 14, 2012

Terracon

SmithGroupJJR
201 Depot Street, Second Floor
Ann Arbor, Michigan 48104

Attn: Mr. Hank Byma
P: 734.662.4457
E: hank.byma@smithgroupjjr.com

Re: Geotechnical Engineering Report
Proposed Building Addition
Fort Gibson National Cemetery
Fort Gibson, Oklahoma
Terracon Project Number: 04125070

Dear Mr. Byma:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with our proposal number P04120039 dated January 30, 2012. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations and floor slabs for the proposed project.

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

Sincerely,
Terracon Consultants, Inc.
Cert. of Auth. #CA-4531 exp. 6/30/13

REGISTERED PROFESSIONAL ENGINEER
5/14/12
CONRAD S. KOEHLER
20784
OKLAHOMA

Atefeh Fathi, E.I.
Project Manager

Conrad S. Koehler, P.E.
Oklahoma No. 20784

AF:CSK:tm

Enclosures
Addressee (3 via US Mail and 1 via email)

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GEOTECHNICAL ENGINEERING REPORT
PROPOSED OFFICE BUILDING ADDITION
FORT GIBSON, OKLAHOMA

Terracon Project No. 04125070
May 14, 2012

1.0 INTRODUCTION

This geotechnical engineering report has been completed for the proposed building addition to the existing administration building in Fort Gibson National Cemetery in Fort Gibson, Oklahoma. Three borings, designated B-1, B-2, and HA-1 were performed to depths of approximately 4.5 to 15 feet below the existing ground surface. Boring HA-1 was drilled inside the existing building using a hand auger. Borings B-1 and B-2 were drilled outside the building with our drill rig. Boring logs along with a site location map and a boring location plan are included in Appendix A of this report.

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

- subsurface soil and rock conditions
- groundwater conditions
- earthwork
- floor slab subgrade preparation
- foundation design and construction

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Site layout	See Appendix A, Exhibit A-3, Boring Location Plan
Proposed development	Single-story building addition to be constructed adjacent to the west side of the existing building.
Building construction	Slab-on-grade,
Maximum structural loads	Columns: 50 kips (assumed) Walls: 3 kips per lineal foot (assumed)
Grading	The grades are unknown. However, we assume maximum fills of about 2 feet, and maximum cuts of about 1 foot will be required to develop the building addition subgrade elevation.

2.2 Site Location and Description

ITEM	DESCRIPTION
Location	Fort Gibson National Cemetery
Existing improvements	Existing administration building at the east side of the proposed building addition along with paved areas.
Current ground cover	Grass
Topography	The site generally slopes downward to the west in the proposed building addition area.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

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

Stratum	Approximate Depth to Bottom of Stratum	Material Encountered	Comments
Surface	3 inches	Topsoil	N/A
1[1]	1.5 feet	Fill: Lean clay with various amounts of gravel	N/A
2[2]	3 feet	Silt	Stiff
3[3]	13 to 15 feet	Lean clay and fat clay	Medium stiff to very stiff
4[4]	To boring termination depth of approximately 14 feet	Sandstone with shale seams	Well cemented

1- Encountered in boring B-2, only.
2- Encountered in boring B-1, only.
3- Boring B-1 terminated in this stratum.
4- Boring B-2 terminated in this stratum.

Based on visual observation and test results, the near surface clay soils classify as non-plastic silts and moderate plasticity clays. Selected samples were tested in our laboratory and had the following measured liquid limit, plastic limit, and plasticity index values:

Sample Location, Depth	Liquid Limit, (%)	Plastic Limit, (%)	Plasticity Index, (%)
Boring B-1, 0.5 – 2.0 ft.	NP	NP	NP
Boring B-2, 2.0 – 3.5 ft.	35	20	15

Conditions encountered at each boring location are indicated on the individual boring logs and included in Appendix A. Stratification boundaries on the boring logs represent the approximate location of changes in soil and rock types; in-situ, the transition between materials may be gradual.

3.2 Groundwater

The boreholes were observed while drilling and immediately after completion for the presence and level of groundwater. We did not observe groundwater during our exploration.

The groundwater level observations made during our exploration provide an indication of the groundwater conditions at the time the boring was drilled. Longer monitoring in piezometers or cased holes, sealed from the influence of surface water, would be required to evaluate long-term groundwater conditions. During some periods of the year, perched water could be present at various depths. Fluctuations in groundwater levels should be expected throughout the year depending upon variations in the amount of rainfall, runoff, evaporation, and other hydrological factors not apparent at the time the boring was performed.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

We drilled one boring along the west side and one boring along the east side of the existing building. The soil conditions encountered in boring B-1, located west of the existing building are considered more favorable for building support. The recommendations provided in this report are based on the conditions encountered in boring B-1.

Based on the results of our exploration, the proposed building addition can be supported on footings bearing in a combination of tested and approved new engineered fill, or stiff to very stiff native clays. Close observation and testing will be required during subgrade preparation for the building pad and footing construction to verify that suitable bearing materials are encountered.

We encountered silty soils to depths of about 3 feet. The near surficial silty soils are prone to strength loss and instability when wetted. If wet conditions exist during construction, silty soils will be unstable and will need to be stabilized, or removed for their full-depth.

Because of the presence of moderate plasticity clay soils, we recommend that a minimum thickness of low volume change engineered fill be constructed beneath the slab-on-grade floor. Details regarding this low-volume change zone are provided in this report in section **4.5 FLOOR SLAB**.

Recommendations regarding the design and construction of foundations and the support of floor slabs and pavements are provided below.

4.2 Earthwork

4.2.1 Site Preparation

Areas within the limits of construction should be stripped and cleared of surface vegetation, topsoil, and any other deleterious material. Surface and subsurface features from past site use should also be removed full-depth.

After stripping and completing any required cuts and over-excavations, the subgrade should be proofrolled to aid in locating soft, unstable or otherwise unsuitable soils. Proofrolling should be performed with a loaded tandem axle dump truck weighing at least 25 tons. Areas too small to proofroll, or inaccessible to proofrolling equipment, should be evaluated by the geotechnical engineer. Soft, unstable soils should be removed and replaced full-depth, if they cannot be adequately stabilized in-place.

After completing the proofrolling, and before placing any fill, the exposed subgrade should be scarified to a minimum depth of 9 inches, moisture conditioned, and compacted as recommended in section **4.2.3 Compaction Requirements**.

4.2.2 Fill Material Types

Engineered fill should meet the following material property requirements:

Fill Type [1]	USCS Classification	Acceptable Location for Placement
Low Volume Change Material [2]	CL or SC ($PI \leq 18$)	All locations and elevations
On-Site Soils	CH	Should not be placed within 24 inches of the final building subgrade, unless modified with fly ash or lime[3].
	ML	On-site silty soils should not be used as fill beneath the building unless treated with fly ash[4].

1. Controlled, compacted fill should consist of approved materials that are free of organic matter and debris and contain maximum rock size of 3 inches. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.
2. Low plasticity cohesive soil or granular soil having a plasticity index (PI) of 18 or less and containing at least 15% fines (material passing the No. 200 sieve, based on dry weight).
3. The near surface on-site fat clays generally have a PI greater than 18. The on-site clays could be used as fill within 24 inches of building subgrade, if they are effectively modified with lime or Class "C" fly ash to reduce the PI of the soil to 18 or less. We estimate a minimum of approximately 4 to 6 percent hydrated lime or 16 to 18 percent Class "C" fly ash, based on soil's compacted dry weight, would be required to reduce the PI of the on-site clays to 18 or less. However, it should be noted that only hydrated lime may effective in reducing the PI of the on-site clays with PI values in excess of about 25. The actual amounts of lime and fly ash should be determined in the field as the amount required to reduce the PI of the soil to a value of 18 or less.

Continued from page 4:

4. On-site silty soils may require treatment with fly ash to facilitate their reuse as fill. We estimate approximately 15 to 17 percent Class C fly ash, based on dry weight, could be required to treat the silty soils.

4.2.3 Compaction Requirements

The scarified and compacted subgrade and fill should be moisture conditioned and compacted using recommendations in the following table:

ITEM	DESCRIPTION
Subgrade Scarification Depth	9-inches
Fill Lift Thickness	9-inches or less in loose thickness
Compaction Requirements [1]	At least 95% of the material's maximum standard Proctor dry density (ASTM D-698)
Moisture Content	A level within -1 to +3 percent of the material's optimum moisture content

1. We recommend that engineered fill (including scarified compacted subgrade) 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.

Fill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below the bearing elevation.

The recommended moisture content should be maintained in the scarified and compacted subgrade and fills until fills are completed and footings, and floor slabs are constructed.

4.2.4 Utility Trench Backfill

Utility trenches are a common source of water infiltration and migration. All utility trenches that penetrate beneath the building addition should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate below the building. We recommend constructing an effective clay "trench plug" that extends at least 5 feet out from the face of the building exterior. The plug material should consist of clay compacted at a water content at or above the soils optimum water content. The clay fill should be placed to completely surround the utility line and be compacted in accordance with recommendations in this report.

4.2.5 Site Drainage

All grades must provide effective drainage away from the building addition during and after construction. Water permitted to pond next to the building addition can result in greater soil movements than those discussed in this report. These greater movements can result in unacceptable differential floor slab movements, cracked slabs and walls, and roof leaks. Estimated movements described in this report are based on effective drainage for the life of the structure and cannot be relied upon if effective drainage is not maintained.

Exposed ground should be sloped at a minimum 5 percent away from the building for at least 10 feet beyond the perimeter of the building. After building construction and landscaping, we recommend verifying final grades to document that effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted as necessary, as part of the structure's maintenance program.

Planters located within 10 feet of the structure should be self-contained to prevent water accessing the building and pavement subgrade soils. Sprinkler mains and spray heads should be located a minimum of 5 feet away from the building lines. Low-volume, drip style landscaped irrigation should not be used near the building. Roof runoff should be collected in drains or gutters. Roof drains and downspouts should discharge onto pavements which slope away from the building or down spouts should extend a minimum of 10 feet away from the structure.

4.2.6 Construction Considerations for Earthwork

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

The near surficial silt soils are prone to strength loss and instability when wetted. If wet conditions exist during construction, silty soils will be unstable and will need to be stabilized, or removed full-depth.

As a minimum, all temporary excavations should be sloped or braced as required by Occupational Health and Safety Administration (OSHA) regulations to provide stability and safe working conditions. The grading contractor, by his contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

The geotechnical engineer should be retained during the construction phase of the project to provide observation and testing during subgrade preparation and earthwork.

4.3 Footing Foundations

The proposed building addition can be supported on shallow footings bearing in the stiff to very stiff native clays, or tested and approved new engineering fill. A combination of observation and testing by the geotechnical engineer will be required during footing construction to verify suitable bearing materials are encountered.

4.3.1 Footing Foundation Design Recommendations

DESCRIPTION	Column	Wall
Net allowable bearing pressure[1]	2,000 psf	
Bearing material[2]	Tested and approved, engineered fill or stiff to very stiff, native clay	
Minimum width	30 inches	16 inches
Minimum embedment (depth below final adjacent grade)[3]	30 inches	
Estimated total and differential movement	< 1 inch	
Allowable passive pressure[4]	750 psf	
Coefficient of sliding friction[5]	0.30	

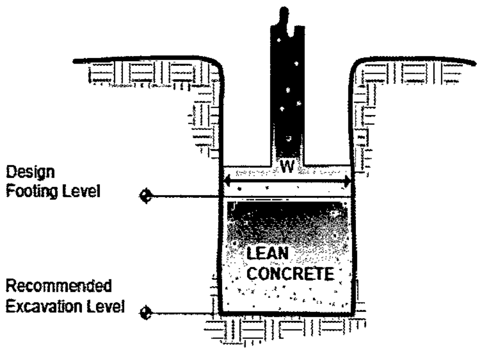
1. The net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation.
2. The recommended allowable bearing pressure is based on footings bearing in a combination of tested and approved, engineered fill or stiff to very stiff, native clay.
3. Minimum depth applies to perimeter footings and footings in unheated areas. Minimum depth will provide frost protection and reduce the potential for moisture variation below bearing level.
4. Allowable passive pressure value considers a factor of safety of about 2. Passive pressure value applies to undisturbed native clay or engineered fill. If formed footings are constructed, the space between the formed side of a footing and excavation sidewall should be cleaned of all loose material, debris, and water and backfilled with tested and approved, engineered fill material compacted to at least 95 percent of the material's standard Proctor dry density. Passive resistance should be neglected for the upper 2 feet of the soil below the final adjacent grade due to strength loss from freeze-thaw and shrink-swell.
5. Coefficient of friction value is an ultimate value and does not contain a factor of safety.

4.3.2 Construction Considerations for Footings

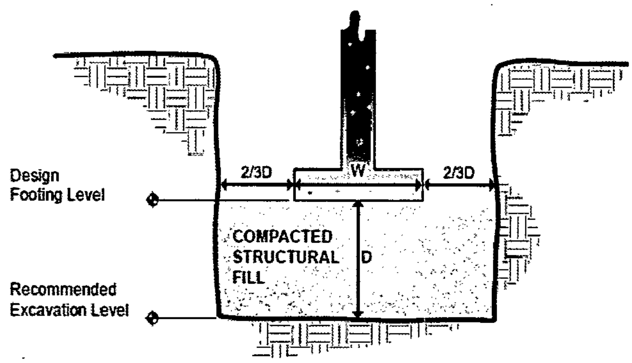
Footing excavations should be free of loose and disturbed material, debris, and water when concrete is placed. Concrete should be placed as soon as possible after excavation is completed to reduce the potential for wetting, drying, or disturbance of the bearing materials.

To evaluate that suitable bearing materials are encountered, we recommend the base of all footing foundation excavations be observed and evaluated by Terracon prior to placing reinforcing steel and concrete. The evaluation should include visual observation and hand auger probes to verify the bearing capacity of the soils encountered at the base of the foundation excavations.

If unsuitable bearing soils are encountered in foundation excavations, the excavations should be extended deeper to suitable soils and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations as shown in Figure 1. The footings could also bear on properly compacted engineered fill extending down to the suitable soils. Overexcavation 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 the bearing elevation. The overexcavation should then be backfilled up to the footing base elevation with approved engineered fill material. The overexcavation and backfill procedure is shown in Figure 2.



Lean Concrete Backfill



Overexcavation / Backfill

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

Figure 1

Figure 2

4.4 Seismic Considerations

Code Used	Site Classification
2006 International Building Code (IBC) [1]	D

1. In general accordance with the *2006 International Building Code,* Table 1613.5.2.

4.5 Floor Slab

4.5.1 Design Recommendations

ITEM	DESCRIPTION
Floor slab support	24-inch low volume change zone is required [1]

1. Because of the shrink-swell potential of the clay subgrade soils, we recommend a low volume change layer be developed below the floor slab. This layer should be at least 24 inches thick and consist of approved on-site lime modified clay or imported low volume change engineered fill having a plasticity index of 18 or less and containing at least 15% fines (material passing the No. 200 sieve, based on dry weight). Additional recommendations regarding engineered fill are presented in section **4.2.2 Material Types**.

By constructing a low volume change fill layer beneath the slab, closely controlling the moisture and density of the scarified soils and controlling the potential for moisture migration beneath the slab, the potential for floor slab movements should be reduced. However, because of the remaining thickness of moderate to high plasticity clay soils, the potential for some future movement still exists. Based on constructing a minimum 24-inch thick low plasticity fill layer beneath the floor slab, we anticipate potential slab movement could be on the order of 3/4 inch. This magnitude of slab movement could occur differentially. To further reduce the potential for slab movements, a greater thickness of low plasticity fill could be placed beneath the slab.

The use of a vapor retarder should be considered beneath concrete slabs on grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

4.5.2 Construction Considerations for Floor Slabs

We recommend that the subgrade be maintained in a relatively moist condition until the floor slab is constructed. If the subgrade should become desiccated prior to construction of the floor slab, the affected material should be removed or the materials scarified, moistened, and recompacted. Upon completion of grading operations in the building area, care should be taken to maintain the recommended subgrade moisture content and density prior to construction of the building floor slab.

4.6 Interaction between New and Existing Structures

Excavations made near existing structures should be made with care so the support of existing foundations, pavements, slabs, etc. is not adversely affected. A sufficient clear distance should be maintained between new and existing foundations to reduce the potential for overlapping bearing stresses and additional settlement of existing foundations. Connections between new and existing buildings should be designed to tolerate the anticipated differential movements.

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. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction 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

Field Exploration Description

A representative from SmithGroupJJR established the boring locations in the field.

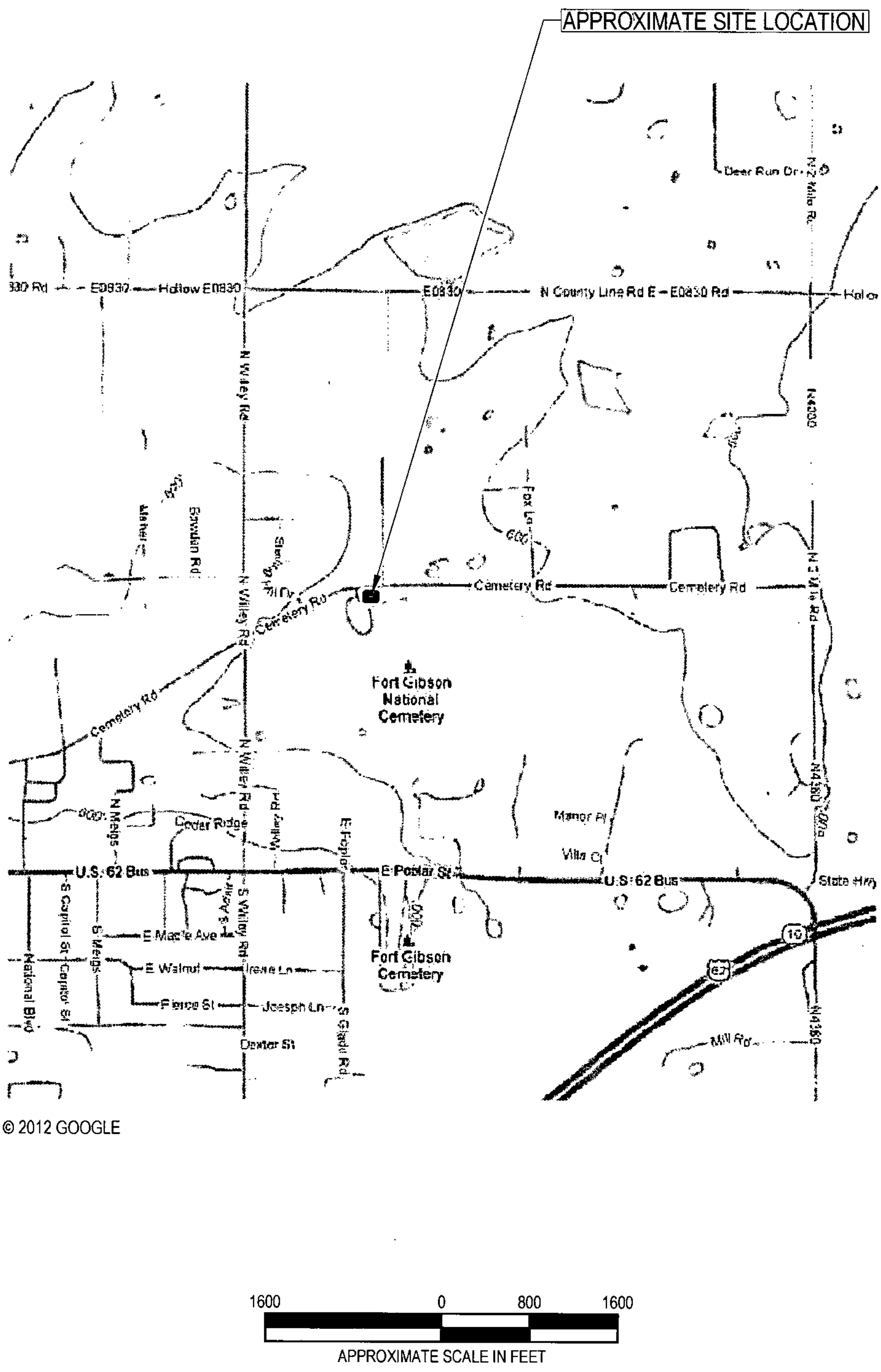
The exterior borings were drilled with an ATV-mounted rotary drill rig using continuous flight augers to advance the boreholes. Samples of the soil encountered in the borings were obtained using the split barrel sampling procedure.

In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound auto-hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in-situ relative density of cohesionless soils, consistency of cohesive soils, and hardness of weathered bedrock.

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

The interior boring was drilled by coring through the existing concrete floor slab with a core machine and collecting soil samples with a hand auger.

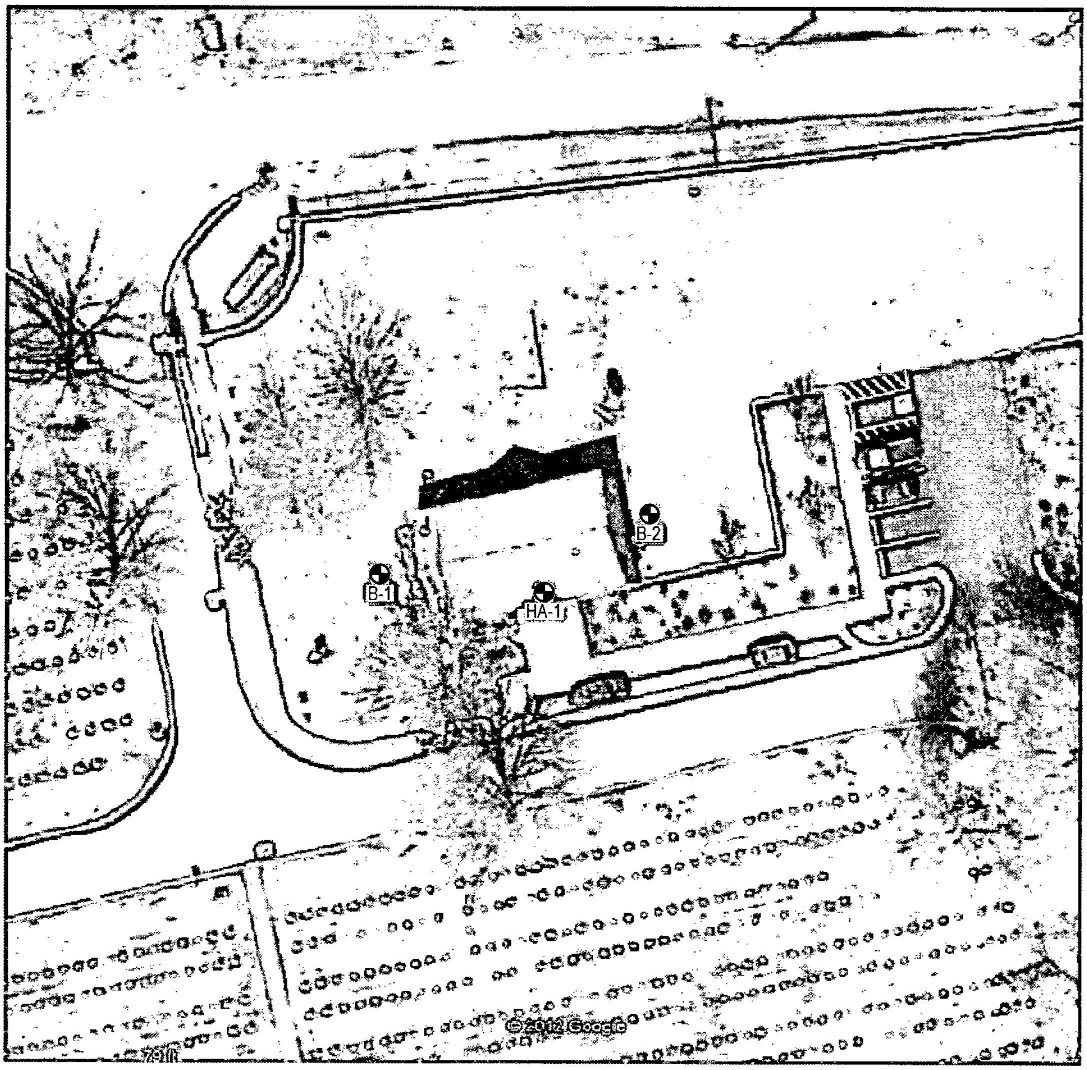
A field log of each boring was prepared by the drill crew. These logs included visual classifications of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the engineer's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



Project Mngr: AF	Project No. 04125070	**Terracon** Consulting Engineers and Scientists	SITE LOCATION MAP
Drawn By: DC	Scale: SEE BAR SCALE		GEOTECHNICAL EXPLORATION
Checked By: AF	File No. 04125070	10930 EAST 56th STREET TULSA, OKLAHOMA 74146	ADMINISTRATION BUILDING AT FORT GIBSON NATIONAL CEMETARY
Approved By: CSK	Date: MAY 2012	PH. (918) 250-0461 FAX. (918) 250-4570	FORT GIBSON, OKLAHOMA

EXHIBIT NO.

A-2



N

50 0 25 50

APPROXIMATE SCALE IN FEET

LEGEND
⊕ BORING LOCATION

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

Project Mngr: AF	Project No. 04125070	Terracon Consulting Engineers and Scientists	BORING LOCATION PLAN	EXHIBIT NO.
Drawn By: DC	Scale: SEE BAR SCALE		GEOTECHNICAL EXPLORATION	
Checked By: AF	File No. 04125070		ADMINISTRATION BUILDING AT FORT GIBSON NATIONAL CEMETARY	A-3
Approved By: CSK	Date: MAY 2012	10930 EAST 56th STREET TULSA, OKLAHOMA 74146 PH. (918) 250-0461 FAX. (918) 250-4570	FORT GIBSON, OKLAHOMA	

LOG OF BORING NO. B-1

CLIENT: SmithGroup JJR

SITE: Fort Gibson National Cementery, Fort Gibson, Oklahoma

PROJECT: Administration Building

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY, in.	SAMPLES: SPT-N BLOWS / ft.	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED COMPRESSION, psf	
	3" Topsoil **SILT** with sand, brown, stiff				PA						
			ML	1	SS	18	7	19			S-1 LL=NP PL=NP PI=NP
			ML	2	SS	18	7	21			
3	**FAT CLAY** with shale fragments, olive-brown and gray, stiff to very stiff				PA						
		5	CH	3	SS	18	13	25			
					PA						
			CH	4	SS	18	14	22			
		10			PA						
			CH	5	SS	18	29	19			
15	BOTTOM OF BORING	15									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	▽ N/E	WD	▼ N/E AB
WL	▽		▽
WL			

Terracon

BORING STARTED			4-25-12
BORING COMPLETED			4-25-12
RIG	ATV	FOREMAN	TS
APPROVED	CSK	JOB #	04125070

LOG OF BORING NO. B-2

CLIENT: SmithGroup JJR

SITE: Fort Gibson National Cementery, Fort Gibson, Oklahoma

PROJECT: Administration Building

GRAPHIC LOG (depth)	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY, in.	SAMPLES: SPT-N BLOWS / ft.	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED COMPRESSION, psf	
	3" Topsoil				PA						
1.5	Fill: **LEAN CLAY** with gravel and root hairs, brown			1	SS	18	4	17			
2.5	**LEAN CLAY** brown, medium stiff		CL	2	SS	18	4	23			S-2 LL=35 PL=20 PI=15
	FAT CLAY mottled olive-brown and reddish-brown, medium stiff to very stiff				PA						
	(with sandstone fragments below 5 feet)	5	CH	3	SS	18	14	20			
					PA						
			CH	4	SS	18	11	23			
13		10			PA						
13.7	**SANDSTONE+** with shale seams, brown, well-cemented			5	SS	1	50/2"	25			
	BOTTOM OF BORING										

+Classification estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft			
WL	∇ N/E	WD	▼ N/E AB
WL	∇		∇
WL			

Terracon

BORING STARTED	4-25-12
BORING COMPLETED	4-25-12
RIG ATV	FOREMAN TS
APPROVED CSK	JOB # 04125070

LOG OF BORING NO. HA-1

CLIENT: SmithGroup JJR

SITE: Fort Gibson National Cementery, Fort Gibson, Oklahoma

PROJECT: Administration Building

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY, in.	SAMPLES: SPT-N BLOWS / ft.	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED COMPRESSION, psf	
	6 3/4" Concrete				DB						
	3 1/2" Limestone gravel		~~CL~~	~~1~~	~~AS~~			~~11~~			
	SANDY LEAN CLAY brown		CL	2	AS			16			S-2 LL=23 PL=15 PI=8
			CL	3	AS			16			
			CL	4	AS			16			S-4 -#200=68%
	4.4		CL	5	AS			17			
	BOTTOM OF BORING										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

WATER LEVEL OBSERVATIONS, ft		
WL	▽ N/E WD	▼ N/E AB
WL	▽	▽
WL		

Terracon

BORING STARTED			4-25-12
BORING COMPLETED			4-25-12
RIG	Hand Auger	FOREMAN	TS
APPROVED	CSK	JOB #	04125070

BOREHOLE BORING LOGS-5070.GPJ 2011 TULSA.GDT 5/7/12

APPENDIX B

LABORATORY TESTING

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS) described in Appendix A. Bedrock materials were classified according to the General Notes and described using commonly accepted geotechnical terminology. The field descriptions were modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

Laboratory tests were conducted on selected soil samples. The laboratory test results are presented on the boring logs next to the respective samples. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

Selected soil samples obtained from the site were tested for the following engineering properties:

- Water content
- Atterberg limits
- Percent sassing #200 sieve

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon – 1-3/8" I.D., 2" O.D., unless otherwise noted	HS:	Hollow Stem Auger
ST:	Thin-Walled Tube - 2" O.D., unless otherwise noted	PA:	Power Auger
RS:	Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted	HA:	Hand Auger
DB:	Diamond Bit Coring - 4", N, B	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	WB:	Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL:	Water Level	WS:	While Sampling	N/E:	Not Encountered
WCI:	Wet Cave in	WD:	While Drilling		
DCI:	Dry Cave in	BCR:	Before Casing Removal		
AB:	After Boring	ACR:	After Casing Removal		

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified 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.

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	<2	Very Soft
500 – 1,000	2-3	Soft
1,001 – 2,000	4-6	Medium Stiff
2,001 – 4,000	7-12	Stiff
4,001 – 8,000	13-26	Very Stiff
8,000+	26+	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Ring Sampler (RS) Blows/Ft.	Relative Density
0 – 3	0-6	Very Loose
4 – 9	7-18	Loose
10 – 29	19-58	Medium Dense
30 – 49	59-98	Dense
50+	99+	Very Dense

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. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75 mm)
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
Modifiers	> 12

PLASTICITY DESCRIPTION

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

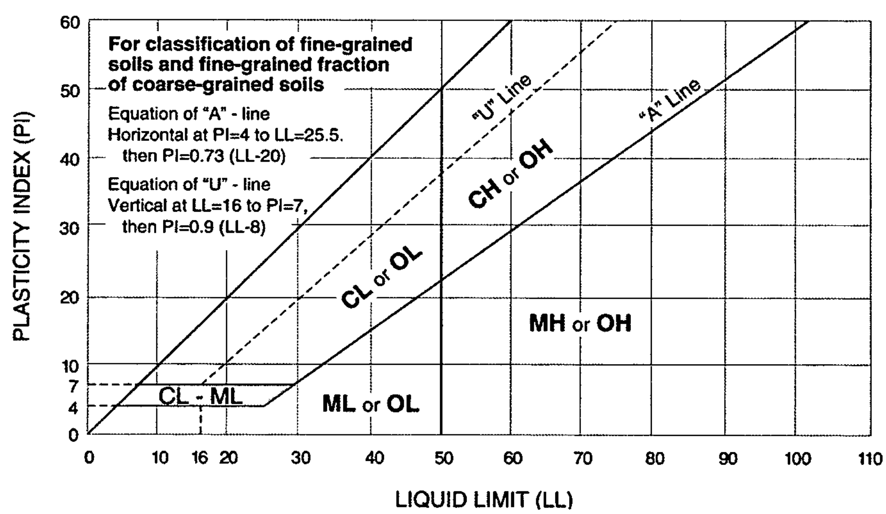
UNIFIED SOIL CLASSIFICATION SYSTEM

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

Sedimentary Rock Classification

DESCRIPTIVE ROCK CLASSIFICATION:

Sedimentary rocks are composed of cemented clay, silt and sand sized particles. The most common minerals are clay, quartz and calcite. Rock composed primarily of calcite is called limestone; rock of sand size grains is called sandstone, and rock of clay and silt size grains is called mudstone or claystone, siltstone, or shale. Modifiers such as shaly, sandy, dolomitic, calcareous, carbonaceous, etc. are used to describe various constituents. Examples: sandy shale; calcareous sandstone.

LIMESTONE	Light to dark colored, crystalline to fine-grained texture, composed of $CaCo_3$, reacts readily with HCl.
DOLOMITE	Light to dark colored, crystalline to fine-grained texture, composed of $CaMg(CO_3)_2$, harder than limestone, reacts with HCl when powdered.
CHERT	Light to dark colored, very fine-grained texture, composed of micro-crystalline quartz ($Si0_2$), brittle, breaks into angular fragments, will scratch glass.
SHALE	Very fine-grained texture, composed of consolidated silt or clay, bedded in thin layers. The unlaminated equivalent is frequently referred to as siltstone, claystone or mudstone.
SANDSTONE	Usually light colored, coarse to fine texture, composed of cemented sand size grains of quartz, feldspar, etc. Cement usually is silica but may be such minerals as calcite, iron-oxide, or some other carbonate.
CONGLOMERATE	Rounded rock fragments of variable mineralogy varying in size from near sand to boulder size but usually pebble to cobble size (½ inch to 6 inches). Cemented together with various cementing agents. Breccia is similar but composed of angular, fractured rock particles cemented together.

PHYSICAL PROPERTIES:

DEGREE OF WEATHERING

Slight	Slight decomposition of parent material on joints. May be color change.
Moderate	Some decomposition and color change throughout.
High	Rock highly decomposed, may be extremely broken.

HARDNESS AND DEGREE OF CEMENTATION

Limestone and Dolomite:

Hard	Difficult to scratch with knife.
Moderately Hard	Can be scratched easily with knife, cannot be scratched with fingernail.
Soft	Can be scratched with fingernail.

Shale, Siltstone and Claystone

Hard	Can be scratched easily with knife, cannot be scratched with fingernail.
Moderately Hard	Can be scratched with fingernail.
Soft	Can be easily dented but not molded with fingers.

Sandstone and Conglomerate

Well Cemented	Capable of scratching a knife blade.
Cemented	Can be scratched with knife.
Poorly Cemented	Can be broken apart easily with fingers.

BEDDING AND JOINT CHARACTERISTICS

Bed Thickness	Joint Spacing	Dimensions
Very Thick	Very Wide	>10′
Thick	Wide	3′ - 10′
Medium	Moderately Close	1′ - 3′
Thin	Close	2″ - 1′
Very Thin	Very Close	.4″ - 2″
Laminated	—	.1″ - .4″

Bedding Plane	A plane dividing sedimentary rocks of the same or different lithology.
Joint	Fracture in rock, generally more or less vertical or transverse to bedding, along which no appreciable movement has occurred.
Seam	Generally applies to bedding plane with an unspecified degree of weathering.

SOLUTION AND VOID CONDITIONS

Solid	Contains no voids.
Vuggy (Pitted)	Rock having small solution pits or cavities up to ½ inch diameter, frequently with a mineral lining.
Porous	Containing numerous voids, pores, or other openings, which may or may not interconnect.
Cavernous	Containing cavities or caverns, sometimes quite large.

Terracon