Geotechnical Engineering Report

Proposed CNG Fueling Facility
3400 Service Loop Road
West Memphis, Arkansas

January 4, 2012
Terracon Project No. 35119529

Prepared for:
Clean Energy
Seal Beach, California

Prepared by:
Terracon Consultants, Inc.
Little Rock, Arkansas

January 4, 2012

Terracon

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Re: Geotechnical Engineering Report
Proposed CNG Fueling Facility
3400 Service Loop Road
West Memphis, Arkansas
Terracon Project No. 35119529

Dear Mr. Farmand:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with your request of December 12, 2011. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design of foundations for the proposed structures.

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

Sincerely,
Terracon Consultants, Inc.

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Attachment

TABLE OF CONTENTS

		Page
EXECUTIVE SUMMARY		**i**
1.0	**INTRODUCTION**	**1**
2.0	**PROJECT INFORMATION**	**1**
2.1	Project Description	1
2.2	Site Location and Description	2
3.0	**SUBSURFACE EXPLORATIONS AND CONDITIONS**	**2**
3.1	Site Geology and Published Soil Mapping	2
3.2	Typical Profile	2
3.3	Groundwater	3
4.0	**RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION**	**3**
4.1	Geotechnical Considerations	3
4.2	Preliminary Considerations for Settlement Mitigation	4
4.3	Earthwork	4
4.3.1	Compaction Requirements	5
4.3.2	Grading and Drainage	6
4.3.3	Construction Considerations	6
4.4	Foundation Recommendations	7
4.4.1	Spread Footing Design Recommendations	7
4.4.2	Spread Footing Construction Considerations	7
4.4.3	Alternate Foundation Recommendation	8
4.5	Seismic Considerations	9
4.6	Retaining Walls	10
4.6.1	Wall Foundation Design Recommendations	10
4.6.2	Lateral Earth Pressures	10
4.6.3	Construction Considerations	12
4.7	Pavement	12
4.7.1	Design Recommendations	12
4.7.2	Construction Considerations	14
5.0	**GENERAL COMMENTS**	**15**

APPENDIX A – FIELD EXPLORATION

Exhibit A-1 Site Location Plan
Exhibit A-2 Boring Location Plan
Exhibit A-3 Field Exploration Description
Exhibit A-4 Boring Log B-1

APPENDIX B – LABORATORY TESTING

Exhibit B-1 Laboratory Testing

APPENDIX C – SUPPORTING DOCUMENTS

Exhibit C-1 General Notes
Exhibit C-2 Unified Soil Classification System

EXECUTIVE SUMMARY

A geotechnical engineering report has been completed for the proposed CNG Fueling Facility at 3400 Service Loop Road in West Memphis, Arkansas. One boring was advanced to a depth of about 20 feet below existing grade to provide geotechnical information. The samples from the boring were reviewed in our laboratory. This report specifically addresses the recommendations for the proposed fueling facility.

Based on the information obtained from our exploration and testing program, the site can be developed for the proposed project if the site is prepared as recommended in this report. Of critical note, the on-site fat clay soils are considered to be moderate to highly compressible and will consolidate under the weight of new fill and foundation loads. We estimate post-construction settlement in excess of 3 inches could occur after about 9 months where 3 feet of fill is placed. Recommendations for additional study, surcharging the site and delaying construction are discussed in this report to reduce post-construction settlement to about 1 inch.

The on-site fat clay soils are also subject to shrinking and swelling with variations in moisture content. Based on the current conditions, we estimate potential movement of footings and on-grade slabs at about 2 to 3 inches. Recommendations are presented in this report to reduce the potential foundation and on-grade slab uplift movement to about 1 inch.

Additional geotechnical conclusions and recommendations are summarized in the table below.

Item	Conclusions and Recommendations
Site Conditions	
Surficial soils	Grass underlain by approximately 3 inches of topsoil underlain by overbank deposits.
Groundwater	17 feet below existing grade
Seismic Design Parameters	
IBC 2006 [1]	Site Class D, $S_1 =$ 0.426 g, $S_s =$ 1.500 g
Site Development	
Grading	Based on existing topography, we estimate cuts less than 1 foot and fills up to 3 feet
Compaction	8 inches or less loose fill thickness, 95% maximum modified Proctor dry density (ASTM D1557)
Foundations – Spread Footings	
Minimum depth for frost protection	24 inches
Minimum width	18 inches
Net allowable bearing pressure	2,000 psf

Item	Conclusions and Recommendations
Passive earth pressure coefficient (K_p)	2.8 (ultimate)
Coefficient of sliding friction	0.35 (ultimate)
Foundations – Alternative Slab-on-Grade	
Slab support	48-inch thick layer of compacted structural fill
Modulus of subgrade reaction	100 pounds per square inch per in (psi/in)
Minimum depth for frost protection	24 inches
Coefficient of sliding friction	0.35 (ultimate)
Retaining Walls	
Active	Equivalent fluid density of 40 pcf for level backfill
At-Rest	Equivalent fluid density of 60 pcf
Asphalt Concrete (AC) Pavements	
Standard duty	3 inches AC; 8 inches granular subbase course; prepared subgrade
Heavy duty	4 inches AC; 8 inches granular subbase course; prepared subgrade
Portland Cement Concrete (PCC) Pavements	
Standard duty	6 inches PCC; 4 inches granular subbase course over 24 inches low volume change cohesive fill subgrade
Heavy duty	7 inches PCC; 4 inches granular subbase course over 24 inches low volume change cohesive fill subgrade
1. Based on the Arkansas Building Code, which incorporates the provisions of the International Building Code 2006.	

This summary should be used in conjunction with the entire report for design purposes. Details are not included or fully developed in this section; the report should be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
PROPOSED CNG FUELING FACILITY
3400 SERVICE LOOP ROAD
WEST MEMPHIS, ARKANSAS

Terracon Project No. 35119529

January 4, 2012

1.0 INTRODUCTION

A geotechnical engineering report has been completed for the proposed compressed natural gas (CNG) fueling station to be located at 3400 Service Loop Road, West Memphis, Arkansas. One test boring, designated as B-1, was advanced to a depth of approximately 20 feet below the existing ground surface beneath the proposed canopy/fueling center area. The test boring log, a Site Location Plan (Exhibit A-1), and a Boring Location Plan (Exhibit A-2) 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 conditions
- groundwater conditions
- earthwork
- foundation design and construction
- slab design and construction
- seismic considerations
- retaining wall design and construction
- pavement design and construction

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site location	Appendix A, Exhibit A-2, Boring Location Plan
Proposed structures	The proposed fueling station includes a canopied dispenser area, an IMW compressor and a storage vessel within a fenced compound, and associated pavements.
Structure loads	The single cylindrical storage vessel has an estimated weight of about 7,000 pounds. The compressor weight is estimated at about 30,000 pounds.
Maximum allowable movement	Total Movement: 1 inch (assumed) Differential Movement: ½ inch (assumed)
Grading	Based on the existing site topography, we anticipate cuts of less than 1 foot and fills of about 3 feet are necessary to achieve finished grade.
Cut and fill slopes	3H:1V or shallower
Retaining walls	Not certain. No information provided at the time of this report.

2.2 Site Location and Description

Item	Description
Location	3400 Service Loop Road, West Memphis, Arkansas.
Existing improvements	The site is currently an undeveloped tract adjacent to and east of a Flying J Truck Stop.
Current ground cover	Grass, brush and small trees.
Existing topography	Generally slopes gradually downhill to the east.

3.0 SUBSURFACE EXPLORATIONS AND CONDITIONS

3.1 Site Geology and Published Soil Mapping

Formation [1]	Description [2]
Quaternary Alluvium (Stream Overbank), Qso Holocene Epoch	The deposits indicated by this notation are alluvial deposits of small streams, the overbank deposits of major streams, or older meander belt deposits of major streams. The lower contact is unconformable. The thickness is variable.

1. United States Geological Survey, 2000, The Geologic Map of Arkansas, Digital Version: U.S. Geological Survey.; http://cpg.cr.usgs.gov/pub/other-maps.html.
2. "Stratigraphic Summary of Arkansas" published by the Arkansas Geological Commission, 1998.

3.2 Typical Profile

Based on the results of the exploration and observations at the time of drilling, subsurface conditions on the project site can be generalized as follows:

Description	Approximate Depth to Bottom of Stratum (feet)	Material Encountered	Consistency / Relative Density
Stratum 1	18½	Fat clay, brown and gray	Medium stiff to stiff
Stratum 2	> 18½	Elastic silt, dark gray	Stiff

Conditions encountered at the boring location are indicated on the boring log in Appendix A of this report.

3.3 Groundwater

The borehole was observed while drilling and immediately after completion for the presence and level of groundwater. Groundwater was encountered at a depth of about 17 feet in the boring at these times. The observations represent conditions at the time of the field exploration and may not be indicative of other times, or at other locations. Groundwater conditions can change with varying seasonal weather conditions, fluctuations in the Mississippi River, and other factors. The possibility of groundwater fluctuations should be considered when developing design and construction plans for the project.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

The on-site fat clays encountered in the borings are considered to be Quaternary overbank deposits associated with the Mississippi River. As such, we consider the on-site fat clays to be moderate to highly compressible and subject to consolidation under the weight of new fill, foundations and pavements. Based on the limited laboratory testing program, assumptions made from the available information provided to us and our experience with similar soils in this region, we completed a preliminary settlement analysis and estimate in excess of 3 inches of post-construction settlement could occur under the weight of 3 feet of new fill. We estimate approximately 9 months could be required for the settlement to occur.

The on-site fat clays are subject to shrinking and swelling with variations in moisture content. Based on the subsurface conditions encountered, we estimate floor slabs and footings supported on the fat clays could potentially experience vertical movements on the order of 2 to 3 inches. To reduce potential building movement to about 1 inch, we recommend overexcavating the fat clays at least 4 feet below finished subgrade elevation and backfilling with low volume change, structural fill. The fat clays should also be overexcavated and replaced at least 2 feet below pavement subgrade elevation to reduce the effects of volume changes in the fat clays.

The recommendations presented in this report help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and at least minor cracking in the structures 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. 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 a greater thickness of low volume change fill is constructed beneath the floor slab, footings and pavements. We would be pleased to discuss other construction alternatives with you upon request.

Geotechnical engineering recommendations for the foundation system and other earth related phases of the project are outlined below. The recommendations contained in this report are based upon the results of the field and laboratory testing, and our engineering analyses based on our current understanding of the project.

4.2 Preliminary Considerations for Settlement Mitigation

We expect that the weight of the proposed structures and about 3 feet of new fill (about 450 psf uniform pressure total) will result in consolidation settlement in the underlying compressible fat clay soils in excess of 3 inches over a period of about 9 months. If the construction schedule allows, we recommend completing site grading, delaying construction about 9 months and monitoring settlement during the delay period in the structure footprint. If it is necessary to decrease the delay period, a surcharge load could be constructed above the new structural fill and then construction delayed until at least 95 percent of the settlement has occurred from the fill and surcharge placement. Using wick drains could also be considered to shorten the delay period. Settlement monitoring should be performed during this delay period. We would be pleased to discuss the use of a surcharge fill and wick drains with you in greater detail.

The settlement estimates are based on limited laboratory testing and our experience with similar soil conditions encountered at other project sites in this region. We recommend that Terracon perform additional field exploration and laboratory consolidation tests on samples of the fat clays to refine the estimated settlement amount and time.

4.3 Earthwork

Within the proposed structural area, organics and any other unsuitable materials should be stripped and removed. The native fat clays have high plasticity and are subject to shrinking and swelling with variations in moisture content. To reduce the potential for footing and on-grade slab movement associated with the proposed CNG structures and canopies, we recommend overexcavating and replacing the fat clays to a minimum depth of 4 feet below planned finished subgrade elevation with low volume change structural fill. The overexcavation should extend at least 4 feet out from the planned structure perimeter. In pavement areas where cuts or areas requiring less than 2 feet of fill are needed to reach the finished pavement subgrade elevation, the fat clays should be overexcavated and replaced to construct a minimum 2-foot thick layer of low volume change fill beneath the pavement section.

After stripping the site, completing the required overexcavation, and before placing new fill, the exposed subgrade should be proofrolled to evaluate for unstable soil conditions. Proofrolling is a very useful tool in identifying shallow areas of subgrade instability, but should be performed only after a suitable period of dry weather to avoid degrading an otherwise acceptable subgrade. The proofrolling load should be applied with a loaded tandem-axle dump truck or with similar approved construction equipment weighing at least 25 tons under the observation of the geotechnical engineer or senior technician.

Where unstable and/or unsuitable soils are identified by proofrolling, testing and visual evaluation; stabilization could include scarification, moisture conditioning, and compaction or full-depth removal and replacement with new structural fill. The appropriate method of improvement, if required, would depend on factors such as schedule, weather, the size of area to be stabilized, and the nature of the instability. More detailed recommendations can be provided during construction as the need for subgrade stabilization occurs. Performing site grading operations during warm, dry periods would help reduce the amount of subgrade stabilization required.

After proofrolling and stabilizing any unstable soils, and just prior to placing fill in areas below design grade, the top 8 inches of the subgrade should be scarified, moisture conditioned to within 0 percent to 3 percent above the material's optimum moisture content, and compacted to the density recommended in section **4.3.1 Compaction Requirements**.

Fill should meet the following material property requirements:

Fill Type [1]	USCS Classification	Acceptable Location for Placement
Imported low volume change material	CL, GC and SC LL ≤ 45 and PI ≤ 20 > 35 percent fines passing No. 200 sieve	All locations and elevations
On-site native soils [2]	CH LL > 50	> 4 feet below subgrade elevation in building areas > 2 feet below subgrade elevation in pavement areas As general fill in non-structural and landscaping areas
Well graded granular materials [3]	GW	Beneath floor slabs Constructed on low volume change fill

1. Structural 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 proposed for use as structural fill should be submitted to the geotechnical engineer for evaluation.
2. The on-site soils should not be re-used as low volume change fill because of their high plasticity.
3. Similar to AHTD Class 7 aggregate base course.

4.3.1 Compaction Requirements

Item	Description
Fill Lift Thickness	8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used
	4 to 6 inches in loose thickness when hand-guided equipment, e.g. jumping jack or plate compactor, is used
Compaction Requirements [1]	At least 95% of the material's modified Proctor maximum dry density (ASTM D 1557)
Moisture Content of Cohesive Soil	Within the range of 0 to 3 percent above the optimum moisture content value as determined by the standard Proctor test at the time of placement and compaction

Moisture Content of Granular Material (Aggregate Base) [2]	Workable moisture levels, typically within 3 percent below to 3 percent above the optimum moisture content value as determined by the standard Proctor test at the time of compaction

1. We recommend that 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.
2. Specifically, moisture levels should be maintained low enough to allow for satisfactory compaction to be achieved without the granular fill material pumping when proofrolled.

4.3.2 Grading and Drainage

Based on the site topography, we anticipate cuts less than 1 foot and fills up to about 3 feet would be necessary to reach finished grades. Paved areas should be sloped away from the facility to reduce the likelihood of water ponding near the concrete elements. Accumulation of water adjacent to on-grade slabs and footings could contribute to significant moisture increases in the subgrade soils and subsequent foundation and/or slab movement.

4.3.3 Construction Considerations

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

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, wet, or disturbed, the affected material should be removed, or these materials should be scarified, moisture conditioned, and recompacted.

As a minimum, temporary excavations should be sloped or braced as required by Occupational Health and Safety Administration (OSHA) regulations to provide stability and safe working conditions. Temporary excavations will probably be required during grading operations. The 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 observe earthwork and to perform necessary tests and observations during subgrade preparation; proofrolling; placement and compaction of controlled compacted fills; backfilling of excavations into the completed subgrade, and just prior to construction of foundations.

4.4 Foundation Recommendations

Based on constructing a minimum 4-foot thick layer of low volume change, structural fill beneath the CNG fueling facility structures as recommended in section **4.2 Earthwork**, the structures could be supported by shallow spread footings bearing on compacted structural fill. Design recommendations and construction considerations are presented in the following paragraphs and tables.

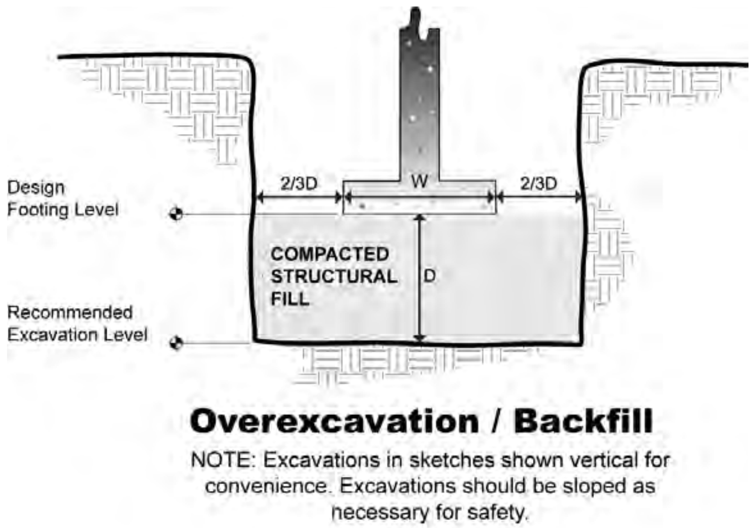
4.4.1 Spread Footing Design Recommendations

Description	Value
Net allowable bearing pressure [1]	2,000 psf
Minimum footing width	18 inches
Minimum embedment below finished grade for frost protection	24 inches
Approximate total movement [2]	3 inches
Approximate differential movement [2]	1 to 2 inches
Total unit weight (γ)	120 pcf
Passive earth pressure coefficient, K_p [3]	2.8 (ultimate)
Coefficient of sliding friction [4]	0.35 (ultimate)

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation.
2. Foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footing, the thickness of compacted fill, and the quality of the earthwork operations. Surcharging or other remedial measures would be required to reduce this value, which is expected to take at least 9 months to occur.
3. This value applies to the low volume change, structural fill placed to restore grades after undercutting. It does not apply to the existing fat clays. Passive pressure calculated with this parameter should be reduced by at least a factor of safety of 3, to reflect the amount of movement required to mobilize the passive resistance.
4. A factor of safety of at least 1.5 should be applied to the sliding resistance.

4.4.2 Spread Footing Construction Considerations

The base of foundation excavations should be free of water and loose soil prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Should the soils at bearing level become wet, disturbed, or frozen, the affected soil should be removed prior to placing concrete. The geotechnical engineer should be retained to observe and test the soil foundation bearing materials.



If unsuitable bearing soils are encountered in footing excavations, the excavations should be extended deeper to suitable soils and the footings could bear directly on these soils at the lower level. The footings could also bear on properly compacted structural fill extending down to the suitable soils. Overexcavation for compacted structural fill placement below footings should extend laterally beyond the edges of the footings at least 8 inches per foot of overexcavation depth below footing base elevation. The overexcavation should then be backfilled up to the footing base elevation with cohesive structural fill placed in lifts of 8 inches or less in loose thickness and compacted to at least 95 percent of the modified Proctor maximum dry density (ASTM D1557). The overexcavation and backfill procedure is described in the adjacent figure.

Based on groundwater being encountered at a depth of about 17 feet during drilling, temporary dewatering of groundwater will likely not be required during foundation construction. The contractor should prevent groundwater, if encountered, and surface water runoff from collecting in the excavation. Subgrade soils that become unstable because of water and/or reworking by construction activity should be replaced with compacted structural fill, as necessary.

4.4.3 Alternate Foundation Recommendation

As an alternative to spread footings, consideration may be given to supporting lightly-loaded structures on a slab-on-grade. The slab-on-grade should be underlain by at least a 48-inch thickness of compacted, low volume change structural fill constructed on stable native soils. Design recommendations for the slab-on-grade are presented in the following paragraphs.

4.4.3.1 Slab-on-Grade Design Recommendations

Description	Value
Slab support (compacted structural fill)	48-inch thick layer
Modulus of subgrade reaction	100 pounds per square inch per in (psi/in)
Minimum embedment below finished grade for frost protection [1]	24 inches
Approximate total movement [2]	3 inches
Estimated differential movement [2]	1 to 2 inches
Coefficient of sliding friction	0.35 (ultimate)

1. Air entraining admixtures should be used for concrete exposed to freezing.
2. Post-construction settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the thickness of compacted fill, and the quality of the earthwork operations. Surcharging or other remedial measures would be required to reduce this value, which is expected to take at least 9 months to occur.

4.4.3.2 Slab-on-Grade Construction Considerations

Site grading is generally accomplished early in the construction phase. However, as construction proceeds, the subgrade may be disturbed by foundation excavations, construction traffic, rainfall, etc. As a result, the slab subgrade may not be suitable for placement of structural fill and corrective action will be required.

We recommend the area underlying the slabs be rough graded and then thoroughly proofrolled with a small roller compactor operated in static mode prior to final grading and placement of any required stone base. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas previously filled or backfilled. Areas where unsuitable or unstable conditions are located should be repaired by removing and replacing the affected material with properly compacted structural fill, as necessary.

4.5 Seismic Considerations

Description	Value
Code Used	Arkansas Building Code (2006 IBC) [1]
Site Class	D [2]
Maximum considered earthquake ground motions (5 percent damping)	0.426g (S_1 – 1.0 second spectral response acceleration)
	1.500 g (S_s – 0.2 second spectral response acceleration)
Liquefaction potential in event of an earthquake	Not determined [3]

1. The Arkansas Building Code incorporates the Seismic Design Category approach from the *2006 International Building Code (IBC)*.
2. The 2006 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. The test boring extended to a maximum depth of about 20 feet. This seismic site class definition considers that similar conditions continue below the maximum depth of the subsurface exploration.
3. Boring terminated at 20 feet; the presence and condition of any granular soils below the 20-foot termination depth of our boring was not determined.

4.6 Retaining Walls

4.6.1 Wall Foundation Design Recommendations

Description	Value
Net allowable bearing pressure	2,000 psf
Bearing Stratum [1]	New structural fill
Minimum embedment below finished grade for frost protection	24 inches
Coefficient of sliding friction [2]	0.35 (ultimate)

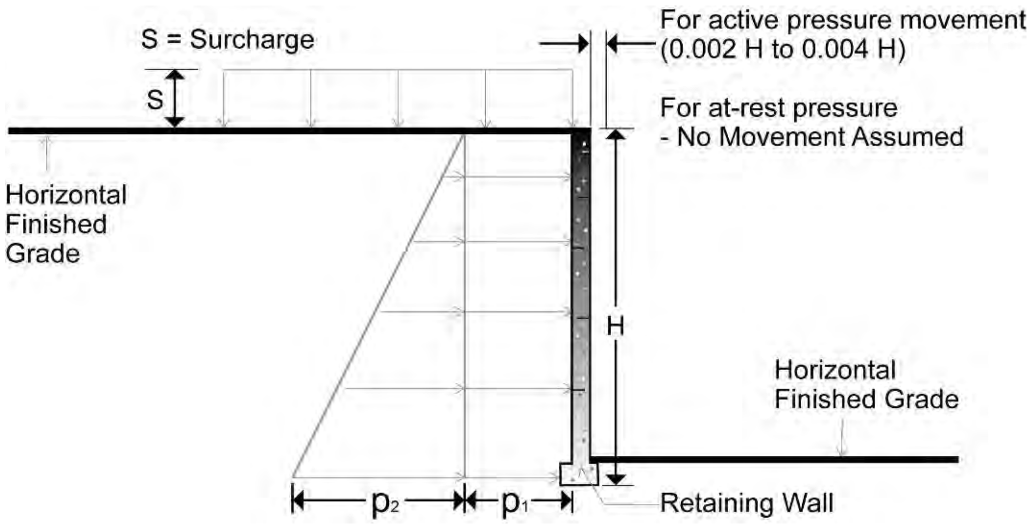
1. The foundation bearing material will depend on site grading and the location of the retaining wall. At a minimum, we recommend retaining wall foundations be designed to bear on a minimum 2-foot thick layer of low volume change, structural fill as discussed in sections 4.3 Earthwork and 4.4 Foundation Recommendations.
2. A factor of safety of at least 1.5 should be applied to the sliding resistance.

4.6.2 Lateral Earth Pressures

Walls with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to those indicated below. Earth pressures will be influenced by the structural design of the walls, wall restraint, methods of construction and the materials being restrained. Two wall restraint conditions are shown. The active case would apply to most situations of site retaining walls and foundation walls that are designed to act as free-standing retaining walls. The at-rest case should be used for those cases where walls are rigidly braced, such as sump pits and foundation walls designed as a diaphragm braced by the building frame.

Earth Pressure Coefficients/Equivalent Fluid Densities

Earth Pressure Conditions	Coefficient for Granular Backfill	Equivalent Fluid Density (pcf)	Surcharge Pressure, p_1 (psf)	Earth Pressure, p_2 (psf)
Active (K_a) [1]	0.33	40	(0.33)S	(40)H
At-Rest (K_o) [1]	0.46	55	(0.46)S	(55)H
Passive (K_p)	2.8	336		



Conditions applicable to the above parameters include:

- For active earth pressure, wall must rotate about base, with top lateral movements of about 0.002 H to 0.004 H, where H is wall height in feet.
- For passive earth pressure to develop, wall must move horizontally to mobilize resistance.
- Uniform area surcharge behind the wall, where S is surcharge pressure in psf.
- Other surcharge loads should be considered where they are located within a horizontal distance behind the wall equal to 1.5 times the height of the wall.
- Surcharge stresses due to point loads, line loads, and those of limited extent, such as compaction equipment, should be evaluated using elastic theory.
- To account for the effect of compaction equipment on the wall during construction, the lateral pressure should not be less than 200 psf, distributed uniformly over the height of the wall.
- Retained soil total unit weight up to 120 pcf.
- Backfill compacted to 95 percent of modified Proctor maximum dry density, except within 4 feet of back of wall, which should be compacted to 92 percent of modified Proctor maximum dry density with hand operated equipment.
- Loading from heavy compaction equipment not included; heavy equipment should not operate within a distance closer than the exposed height of retaining walls.
- No hydrostatic pressures acting on wall; surcharge due to water pressure may be neglected if a 2-foot wide drainage layer is placed immediately behind the wall and geotextile wrapped foundation drains are installed behind and at the base of the wall with a collection pipe leading to a reliable discharge.
- Retaining structures and foundation walls should be backfilled evenly on opposing sides to the extent practical. Temporary bracing should be

specified if walls, that are designed to be supported by other structural elements, are permitted to be backfilled before the permanent support is in place.

- No dynamic loading is considered in these recommendations.
- No safety factor included in soil parameters; lateral pressures based on the above parameters are cumulative for computing overall safety factors.
- Passive pressure should be ignored in frost zone.

Backfill placed behind the retaining wall should consist of granular soils. For the earth pressure values to be valid, this backfill must extend out from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively. To calculate the resistance to sliding, a value of 0.35 should be used as the ultimate coefficient of friction between the footing and the underlying soil.

To control hydrostatic pressure behind the retaining wall, we recommend that a 2-foot wide drainage layer be placed immediately behind the wall. The drainage layer should consist of free-draining material, such as crushed stone. Mirafi geotextile separation fabric should be placed between the crushed stone and the low volume change backfill. We also recommend that a drainage pipe be installed at the level of the wall foundation with a collection pipe leading to a reliable discharge. Weep holes may be considered in lieu of a drainage pipe where the wall is less than about 5 feet high.

4.6.3 Construction Considerations

Excavation for any retaining walls may extend into medium stiff to stiff fat clays. The contractor should be required to maintain a stable subgrade during construction. The contractor should prevent groundwater, if encountered, and surface water runoff from collecting in the excavation. Subgrade soils that become unstable because of water and/or reworking by construction activity should be replaced with compacted structural fill, as necessary.

Retaining walls designed as free-standing walls under active case earth pressures can normally be backfilled upon completion of the wall. Retaining and foundation walls designed as braced walls and at-rest earth pressure conditions should not be backfilled until the bracing in place.

4.7 Pavement

4.7.1 Design Recommendations

The proposed facility may require the removal and replacement of the existing pavement. The table below presents recommended Asphalt Concrete (AC) and Portland Cement Concrete (PCC) pavement sections for anticipated standard- and heavy-duty traffic levels. The recommended minimum pavement sections presented below are based on supporting pavements on subgrades comprised of at least 24 inches of tested and approved, structural fill. However, the design pavement sections should not be less than the pavement sections currently used at the truck stop.

Traffic Area	Asphalt Concrete Top Course (inches)	Asphalt Concrete Binder Course (inches)	Portland Cement Concrete (inches)	Granular Subbase Course (inches)	Total Thickness (inches)
AC Standard Duty	3	---	N/A	8	11
AC Heavy Duty	1.5	2.5	N/A	8	12
PCC Standard Duty	N/A	N/A	6	4	10
PCC Heavy Duty	N/A	N/A	7	4	11

Pavement designs were based on *AASHTO Guide for Design of Pavement Structures (1993)* and our experience with similar projects. The thickness of each course is a function of subgrade strength, traffic, design life, serviceability factors, and frost susceptibility. The design of pavement thickness was based on the following:

- 60,000 18-kip Equivalent Axle Loads (EALs) for standard-duty parking lot
- 100,000 18-kip EALs for heavy-duty driveways and truck access lanes
- Soil characterization of "fair", based on the encountered subsurface conditions
- Design life of 20 years

Pavements subjected to high traffic volumes and heavy trucks require thicker pavement sections. Portland cement concrete pavement is recommended for areas subjected to concentrated and repetitive loading conditions, such as the dispenser island and ingress/egress aprons. We recommend all Portland cement concrete pavement details for joint spacing, joint reinforcement, and joint sealing be prepared in accordance with American Concrete Institute (ACI 330R-08 and ACI 325R.9-91). Portland cement concrete truck pavements should be provided with mechanically reinforced joints (doweled or keyed) in accordance with ACI 330R-08.

The granular base should be compacted to at least 95 percent of the maximum dry density, as determined by ASTM D1557. The asphalt concrete should be placed in accordance with the Arkansas State Highway and Transportation Department (AHTD) *Standard Specifications for Highway Construction*, 1996 Edition. Asphalt concrete should be placed within the temperature range specified therein and compacted to between 92 and 96 percent of the theoretical mix density. Pavement components should meet the following material specifications:

Pavement Component	Specification
Asphalt Concrete Surface Course	AHTD Section 407 – Type 3
Asphalt Concrete Binder Course	AHTD Section 406 – Type 2
Granular Subbase Course	AHTD Section 303 – Class 7
Portland Cement Concrete	AHTD Section 501 Type II Portland Cement (Reinforced Concrete) f_c' = 4,000 pounds per square inch (psi)

As an alternate to aggregate base, soil cement is commonly used in the Memphis area. According to the 1993 AASHTO design approach, a 7-day unconfined compressive strength of 300 psi is required for a similar thickness of soil cement. Assuming this strength is obtained, the recommended pavement sections outlined above can be used with the corresponding thickness of cement treated base instead of granular base.

It should be noted that the AASHTO design method uses a 7-day unconfined compressive strength as the basis for the structural layer coefficient. Twenty-eight (28) day strengths would be expected to be higher, possibly as great as 50 percent higher. Therefore, we recommend that 28-day compressive strengths be expected to achieve a minimum of 450 psi. The 450 psi value correlates with minimum values used in other design procedures that incorporate the compressive strength of the soil cement base at the time of initial loading.

4.7.2 Construction Considerations

Pavement subgrades prepared early in the project should be carefully evaluated as the time for pavement construction approaches. Particular attention should be paid to high traffic areas that were rutted and disturbed, and areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by replacing the materials with properly compacted fill. When proofrolling/subgrade stabilization has been completed to the satisfaction of the geotechnical engineer, subbase may be placed.

Future performance of pavements constructed on the site will be dependent upon maintaining stable moisture content of the subgrade soil. The performance of pavements may be enhanced by reducing excess moisture that can reach the subgrade soils.

Preventative maintenance should be planned and provided for through an on-going pavement management program in order to enhance future pavement performance. Preventative maintenance activities, consisting of localized maintenance (crack sealing and patching) and global maintenance (surface sealing), are intended to slow the rate of pavement deterioration, and to preserve the pavement investment.

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 exploration performed at the indicated boring location and from other information discussed in this report. This report does not reflect variations that may occur away from the boring, across the site, or due to the modifying effects of 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 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 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.

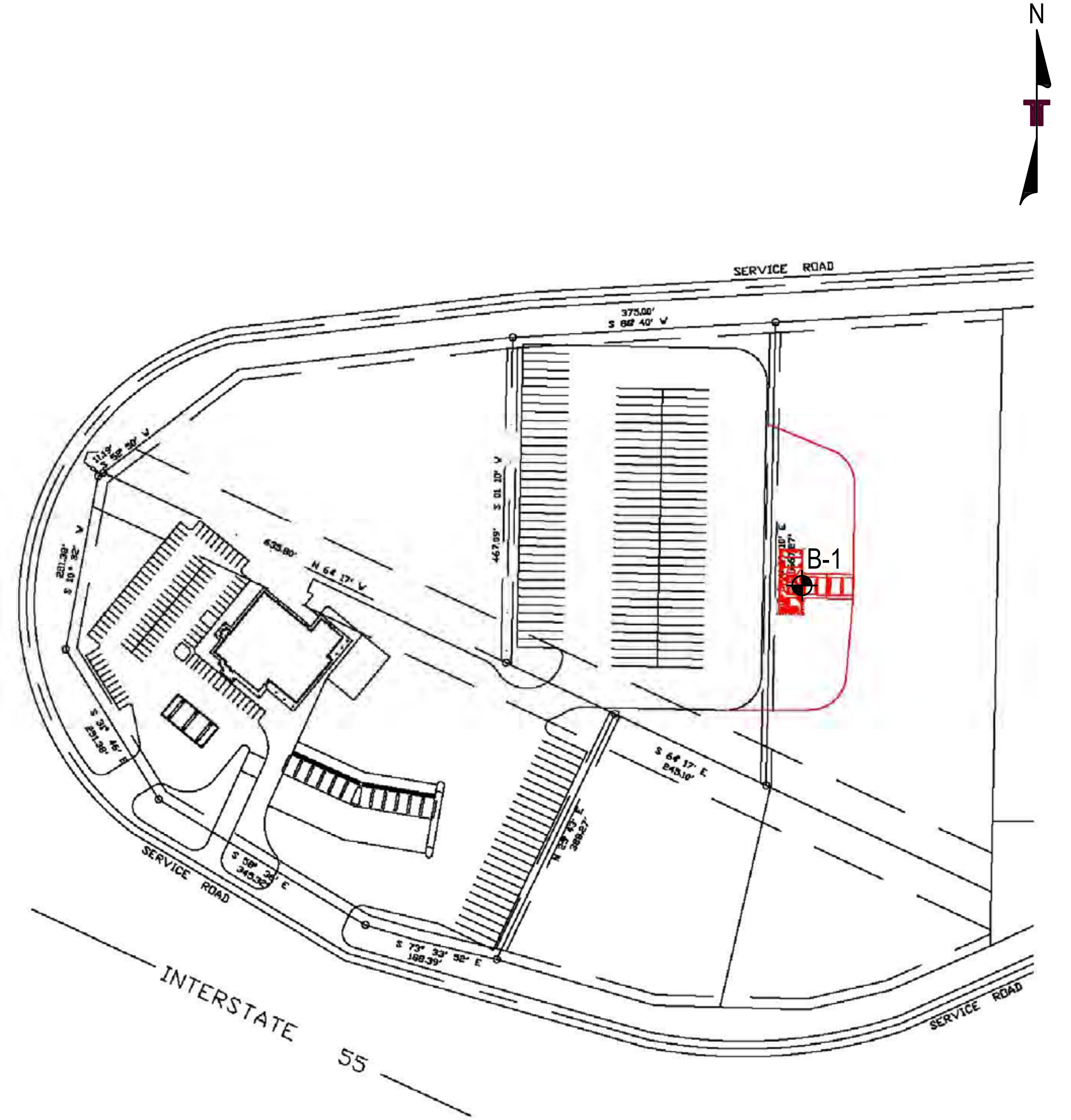
APPENDIX A

FIELD EXPLORATION

Project Mngr: SPB	Project No. 35119529	SITE LOCATION PLAN	EXHIBIT
Drawn By: PTG	Scale: N.T.S.	GEOTECHNICAL EXPLORATION	A-1
Checked By: GWF	File No. 35119529.SLP	PROPOSED CNG FUELING CENTER	
Approved By: SPB	Date: 12/29/2011	WEST MEMPHIS, ARKANSAS	

Terracon
Consulting Engineers and Scientists

25809 I-30 SOUTH BRYANT, AR 72022
PH. (501) 847-9292 FAX. (501) 847-9210



LEGEND

B-#

- BORING LOCATION

Project Mngr: SPB	Project No. 35119529
Drawn By: PTG	Scale: N.T.S.
Checked By: GWF	File No. 35119529.BLP
Approved By: SPB	Date: 12/29/2011

Terracon
Consulting Engineers and Scientists

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BORING LOCATION PLAN

GEOTECHNICAL EXPLORATION
PROPOSED CNG FUELING CENTER
WEST MEMPHIS, ARKANSAS

EXHIBIT
A-2

Field Exploration Description

Terracon drilled one boring, designated as B-1, on December 20, 2011 to a termination depth of about 20 feet below the ground surface. Terracon personnel located the boring in the field by taping distances and measuring right angle offsets using a compass from the references shown on the Boring Location Plan. The location of the boring should be considered accurate only to the degree implied by the methods used to define it.

The boring was advanced using solid stem flight augers by an all-terrain rotary drill rig, owned and operated by Keen Exploration, of Mayfield, Kentucky. Standard penetration tests were performed in the boring with an automatic hammer and four split-spoon samples were collected in the upper 10 feet and at 5-foot intervals thereafter, in general accordance with industry standards.

In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler typically the middle 12 inches of the total 24-inch penetration by means of a 140-pound safety hammer with a free fall of 30 inches is the Standard Penetration Test (SPT) resistance value “N”. This “N” value is used to estimate the consistency of cohesive soils, in-situ relative density of cohesionless soils and hardness of weathered bedrock.

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

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification.

A field log was prepared by the drill crew. The log included visual classifications of the materials encountered during drilling as well as the driller’s interpretation of the subsurface conditions between samples. The final boring log included with this report represents the engineer's interpretation of the field log and includes modifications based on laboratory observation and tests of the samples.

Our exploration services include storing the collected soil samples and making them available for inspection for 60 days from the report date. The samples will then be discarded unless requested otherwise.

LOG OF BORING NO. B-1

CLIENT: **Clean Energy Company**

SITE: **3400 Service Loop Road, West Memphis, Arkansas**

PROJECT: **Proposed CNG Fueling Facility**

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 Strength, psf	
	FAT CLAY brown and gray, medium stiff to stiff				PA						
			CH	1	SS		6	37		2500*	S-1 LL = 74 PL = 30 PI = 44
			CH	2	SS		8	48			
			CH	3	SS		9	40		2500*	S-3 LL = 89 PL = 30 PI = 59
		5			HS						
			CH	4	SS		12	40		3000*	
		10			HS						
			CH	5	SS		9	33		2500*	
		15			HS						
18.5	**ELASTIC SILT**, trace fine sand dark gray, loose		MH	6	SS		8	35			
20	BOTTOM OF BORING AT ABOUT 20 FEET	20									

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

*Hand Penetrometer
**140 lb. SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 17	WD ▼ 17	AB
WL	▼	▽	
WL	Exhibit A-4		

BORING STARTED	12-20-11		
BORING COMPLETED	12-20-11		
RIG	ATV	FOREMAN	CT
APPROVED	SPB	JOB #	35119529

Terracon

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 B. At that time, the field descriptions were confirmed or modified as necessary and a limited laboratory testing program was formulated.

The laboratory testing program consisted of performing water content tests, hand penetrometer, and Atterberg limit tests on representative soil samples. Atterberg limits tests were conducted on selected clay samples to aid in classification and to evaluate the soils' potential for volume change with variation in moisture content. A hand penetrometer was used to estimate the approximate unconfined compressive strength on representative samples of native clay. The calibrated hand penetrometer has been correlated with unconfined compression tests and provides a better estimate of soil consistency than visual examination alone. The results of all tests performed are shown on the boring log.

The laboratory test results 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 ASTM, local or other accepted standards.

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., 3" O.D., unless otherwise noted	PA:	Power Auger (Solid Stem)
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) typically the middle 12 inches of the total 24-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	BCR:	Before Casing Removal
WCI:	Wet Cave in	WD:	While Drilling	ACR:	After Casing Removal
DCI:	Dry Cave in	AB:	After Boring	N/E:	Not Encountered

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 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.

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	0 - 1	Very Soft
500 – 1,000	2 - 4	Soft
1,000 – 2,000	4 - 8	Medium Stiff
2,000 – 4,000	8 - 15	Stiff
4,000 – 8,000	15 - 30	Very Stiff
8,000+	> 30	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 50	Dense
> 50	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 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75mm)
Sand	#4 to #200 sieve (4.75 to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

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

PLASTICITY DESCRIPTION

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

UNIFIED SOIL CLASSIFICATION SYSTEM

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

[A] Based on the material passing the 3-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.

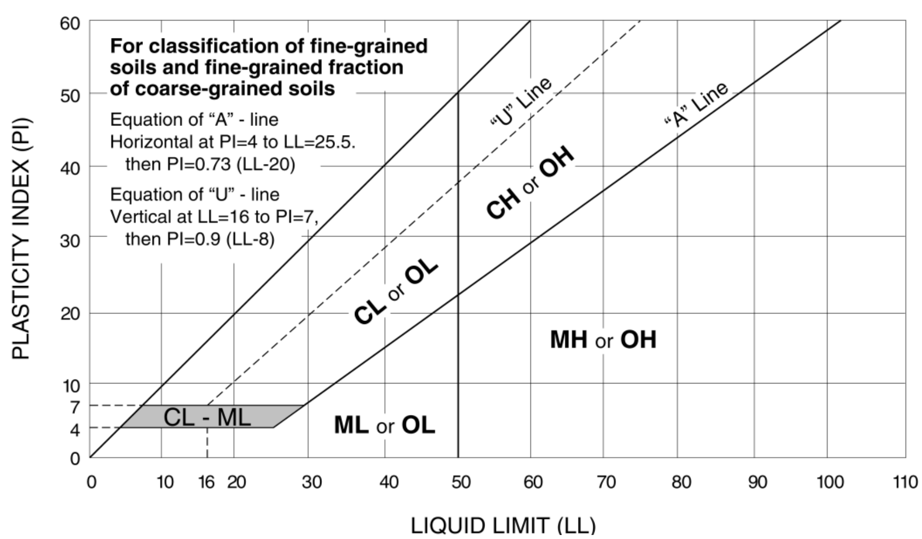

Exhibit C-2