Geotechnical Engineering Report

Embankment Soil Survey
Interstate 35 over Waterloo Road Interchange
Oklahoma and Logan Counties, Oklahoma
Job Piece No. 29843(04)
Engineering Contract No. EC-1500N
January 25, 2019
Terracon Project No. 03185252

Prepared for:
Garver
Tulsa, Oklahoma

Prepared by:
Terracon Consultants, Inc.
Oklahoma City, Oklahoma

terracon.com
Terracon

Environmental ▪ Facilities ▪ Geotechnical ▪ Materials

January 25, 2019

Garver
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Tulsa, Oklahoma 74136

Attn: Ms. Jenny Sallee
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Re: Geotechnical Engineering Report
Embankment Soil Survey
Interstate 35 over Waterloo Road Interchange
Oklahoma and Logan Counties, Oklahoma
Job Piece No. 29843(04)
Engineering Contract No. EC-1500N
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Dear Ms. Sallee:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. The scope of our services was outlined in the Geotechnical Scope of Work Revision 2 (Terracon Proposal No. P03165261) dated August 16, 2016.

We appreciate the opportunity to work with you on this project. If you have any questions regarding this report, or if we may be of further service in other ways, please let us know.

Sincerely,
Terracon Consultants, Inc.
Cert. Of Auth. #CA-4531 exp. 6/30/19

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for: Diana Vargas-Suaza, E.I.
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Amber Hame for
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Senior Staff Engineer

Norman Tan, P.E.
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NORMAN TAN
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Copies to: Addressee (1 via email)

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INTERSTATE 35 OVER WATERLOO ROAD INTERCHANGE
OKLAHOMA AND LOGAN COUNTIES, OKLAHOMA
JOB PIECE NO. 29843(04)
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1.0 INTRODUCTION

This report presents the results of our geotechnical engineering services performed for the proposed approach embankments for the new Interstate 35 over Waterloo Road bridge, Ramp B embankment and embankment of the new alignment of Industrial Boulevard in Oklahoma and Logan Counties, Oklahoma as shown in Exhibits A-1 to A-3 Site Location Plan and Boring Location Plans. We understand that embankments with fill heights up to 10 to 20 feet will be required for this project.

Subsurface explorations were performed for the following embankment section:

Stations	Maximum Embankment Fill Height (feet)	Number of Borings	Number of CPT Soundings
135+00 to 138+00 and 140+12 to 143+52[1]	12 to 15	3 (EB-1 to EB-3)	3
135+00 to 138+00[2]	20	1 (EB-4)	1
12+00 to 16+00[3]	17	1 (EB-5)	1

1 Approach embankment of I-35 over Waterloo Road
2 Ramp B embankment
3 Embankment on new Industrial Boulevard alignment

The borings were advanced to depths ranging from approximately 34 to 79 feet in the embankment borings. The cone penetrometer soundings (CPTU) were terminated at about 10.4 to 76 feet. The results of the borings and CPTU soundings and diagrams showing their approximate locations 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
- earthwork
- slope stability analysis
- groundwater conditions
- embankment design and construction
- settlement analysis

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site layout	See Appendix A, Exhibit A-2 (Boring Location Plan).
Proposed Grading	We understand the project includes the reconstruction and widening of the existing I-35 over Waterloo Road bridges on its existing alignment. The existing embankments will be widened and raised. Based on the grading plans and information provided to us by client, the new abutment embankments will have fill heights of up to 15 feet. We also understand that Ramp B will be widened and fill heights of about 20 feet will be placed for the new embankment. Industrial Boulevard will be realigned and fill embankments up to 17 feet will be constructed on the new alignment. The embankments will be constructed between the approximate stations outlined in the table above. We also understand that the new embankments will be constructed with maximum side slopes of 3 horizontal to 1 vertical (3H:1V).

2.2 Site Location and Description

Item	Description
Location	The project is located on I-35 over Waterloo Road Interchange in Oklahoma and Logan Counties, Oklahoma.
Current ground cover	Vegetation and pavements.

3.0 SUBSURFACE CONDITIONS

3.1 Site Geology

Based on information published in the Oklahoma Department of Transportation manual, *“Engineering Classification of Geologic Materials: Division Four”*, the geology of the project site consists of the Garber Unit of Permian Age.

This unit consists of a series of red clay shales, red sandy shales, and massive commonly cross-bedded lenticular sandstones.

The total thickness of the unit is about 400 feet in Oklahoma County, it thickens to about 600 feet in Garfield County and continues to thicken northward to the state line.

3.2 Typical Profile

The conditions encountered in the subsurface exploration are shown on the CPT sounding and boring logs in Appendix A and are briefly described below. The stratification lines shown on the CPT soundings and boring logs represent the approximate boundary between soil and rock types; in-situ, the transition between materials may be gradual and indistinct. Classification of bedrock materials was made from disturbed samples. Petrographic analysis may reveal other rock types. Details for each of the borings can be found on the boring logs included in Appendix A of this report. Based on the results of the borings, subsurface conditions on the project site can be generalized as follows:

Description	Approximate Depth to Bottom of Stratum (feet)	Material Encountered	Consistency/Density
Stratum 1	8.5 to 9.5	Fill: Sands with varying amounts of clay and clays with varying amounts of sand with varying amount of asphalt fragments or gravel	N/A
Stratum 2	24.5 to 74	Lean clay with varying amounts of sand	Soft to very stiff
		Sand with varying amounts of clay and silt	Very loose to dense
Stratum 3	Boring termination depths	Weathered shale and weathered sandstone	Poorly cemented to well cemented and Soft to moderately hard

Laboratory tests were conducted on selected soil and rock samples. Atterberg limits test results on the overburden soils indicate the soils to be non-plastic to low plasticity clays with liquid limits of less than 29; plastic limits of less than 15 and plasticity indices of less than 15. Sieve analysis tests were also performed on selected overburden soil samples indicating a percent of fines of varying from 23 to 46 percent in the sands and of 60 to 81 percent in the clays.

The test results are presented on the boring logs in Appendix A and in the laboratory results in Appendix B.

3.3 Groundwater

The borings were monitored while drilling, immediately and at least 24 hours after completing the drilling operations for the presence and level of groundwater. As reported in the lower left corner of the boring logs, groundwater was encountered in the borings at the following depths.

Boring No.	Water Level While Drilling Depth (ft.) / Elevation (ft.)	Water Level After Drilling Depth (ft.) / Elevation (ft.)	24 Hour Water Level Depth (ft.) / Elevation (ft.)
EB-1	34/1077	31/1080	Not measured[1]
EB-2	33/1074.6	33/1074.6	33/1074.6
EB-3	28/1079.1	33/1074.1	17/1090.1
EB-4	19/1080.0	34/1065.0	Not measured[1]
EB-5[1]	21/1066.0	N/A[2]	Dry Cave in at 9/1078.0

[1] Borings EB-1 and EB-4 were located on roadway and were backfilled immediately after completion

[2] Groundwater was not measured after boring completion due to water introduction

The groundwater level observations made during our exploration provide an indication of the groundwater conditions for the short duration that the borings were allowed to remain open. However, this does not necessarily mean that the water levels summarized above are stable groundwater levels. Long-term monitoring with observation wells, sealed from the influence of surface water, would be required to accurately define the potential range of groundwater conditions at this site. Fluctuations in the groundwater level should be expected due to seasonal variations in the amount of rainfall, runoff, and other factors not apparent at the time the borings were drilled. The possibility of groundwater level fluctuations and the presence of perched water should be considered when designing and developing the construction plans for the project.

4.0 EMBANKMENT SLOPE STABILITY AND SETTLEMENT ANALYSIS

4.1 Geotechnical Considerations

Based on the information and drawings provided to us by the Client, we understand that maximum embankment fills of approximately 15 to 20 feet will be necessary for the new embankments. It is anticipated that fill materials will consist of a mixture of locally available clays and sands.

Recommendations regarding design and construction of embankments, as well as settlement and slope stability analyses are provided below.

4.2 Site Preparation

The recommendations presented below apply to general site preparation for the embankment areas. Areas to be graded should be stripped of all trees, surface vegetation, pavements, topsoil, organic containing soils, and any other deleterious materials. The topsoil and organic containing soils should be removed from the construction area and either wasted from the site or stockpiled for use as topsoil. Additionally, all trees and major root systems, any existing roadway or structures should be removed from the site. Excavations resulting from the removal of trees and root systems, any existing roadway or structures should be cleaned of all loose material and water and properly backfilled as recommended in the following sections of this report.

After stripping and completing any required cuts, and before placing any fill, the exposed subgrade should be proofrolled with a fully-loaded dump truck, scraper, or other rubber-tired construction equipment weighing at least 25 tons to evaluate the presence of any low strength, unstable soils. Any low strength, unstable soils identified by the proofrolling should be overexcavated and replaced with approved materials listed in the following section **4.3 Material Types**.

Areas which pass the proofroll and appear sufficiently stable should be scarified to a depth of at least 8 inches and moisture conditioned to a level within 2 percent of the material's optimum moisture content, determined in accordance with the standard Proctor procedure, AASHTO T-99. The scarified zone should then be compacted to at least 95 percent of the material's maximum laboratory dry density determined in accordance with AASHTO T-99.

It is critical that the earthwork be performed in strict conformance with the geotechnical recommendations.

4.3 Material Types

Based on the proposed grading for the project, it is anticipated that fill materials will consist of mixtures of sands with varying amounts of clay and silt and lean clay with varying amounts of sand. Fill materials should meet the following material property requirements:

Fill Type[1]	USCS Classification	Acceptable Location for Placement
On-Site Soils[2]	SM, SC, SC-SM, CL	All locations and elevations
Select Fill Material[3]	CL or SC (PI ≤ 18) and (>15% Pass #200)	All locations and elevations

[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

Fill Type[1]	USCS Classification	Acceptable Location for Placement

should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.

[2] It should be noted that some of the on-site soils appear to have relatively high sand contents. Soils with high sand contents are likely to become unstable with minor changes in moisture contents and/or repeated construction traffic. Close moisture control during compaction operations will be required to reduce the possibility that the soils will pump or become unstable. Depending on the gradation of the soils, the fill soils used for construction of the new embankments may be susceptible to surface erosion and the use of vegetative cover and or other erosion control may be required to reduce the possibility of sloughing and/or erosion of the surface soils.

[3] Some of the on-site soils appear suitable for use as select fill materials. However, this should be verified during construction by further testing.

4.4 Compaction Requirements

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

Item	Description
Subgrade Scarification Depth	8-inches
Fill Lift Thickness	8-inches or less in loose thickness
Compaction Requirements[1]	At least 95% of the materials maximum standard Proctor dry density (AASHTO T-99).
Moisture Content	**On-Site Soils (Overburden soils) or Select Fill Materials**: SM, SC, CL, SC-SM: A level within 2 percent of the material's optimum moisture content, determined in accordance with AASHTO T-99, the standard Proctor procedure.

[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.

The fill material should be placed on a relatively level surface. Existing subgrade slopes of greater than about 4H:1V should be continuously benched to avoid placing fill on a sloped surface. The benches should be of sufficient width for easy access to dumping and compaction equipment.

4.5 Embankment Design and Construction Recommendations

We understand that maximum embankment fills of approximately 15 to 20 feet will be necessary between stations outlined in the table from section **1.0 Introduction**. For estimating embankment quantities, the contract documents should include a provision for overbuilding the embankment by 2 to 13 inches to accommodate the anticipated settlement following construction.

Based on the results of analyses, it is recommended that during the construction of the proposed embankments, the settlement of the subsurface materials be continuously monitored during construction and for a period of 1 to 3 months after construction of the fill materials to evaluate the measured settlement amount with respect to the estimated settlement amount. The settlement of the embankment can be monitored through the installation of settlement plates. The contractor should install the settlement plates approximately 1 foot below the existing surface at the toe of the existing embankment. We recommend at least three sets (three vertical cross sections within each embankment) of settlement instrumentation be installed at locations where the largest settlement is anticipated.

The construction documents should require the contractor to install and assess settlement plates as construction progresses. For estimating embankment quantities the contract documents should include a provision for overbuilding the embankment as recommended above to accommodate the anticipated settlement following construction. This estimate can be refined based on the analysis of the settlement data. The settlement plates should continue to be monitored throughout and following completion of fill placement, and until primary construction settlements are complete.

Final grading and paving of the roadway at the top of the embankments should not be performed until settlements are complete. Estimates of time for the majority of settlement to occur are provided below, but the ultimate decision of when it is appropriate to proceed with final grading and paving should be based on the results of the monitoring.

4.6 Settlement Analysis

Embankment settlement is mainly caused by foundation soil consolidation due to the weight of the new embankment fill and by consolidation of the embankment material due to its own weight. Based on the proposed grading for the project, we anticipate the embankment fill will consist of clayey/silty sands or lean clays with sand.

Estimated settlement of the new embankment fill soils due to its own weight was based upon the typical value of compression for low plasticity inorganic soils as presented in the Naval Facilities Engineering Command, Foundation and Earth Structures, Design Manual 7.02, Chapter 2, Table 1. The settlement of the new fill soils will be on the order of approximately 3/4 to 1 ¾ inches due to its own weight. Our settlement analysis of the embankment soils assumes that the soils and construction procedures discussed in this report are utilized.

Estimated settlement of the embankment foundation soils and/or existing embankment fill was based upon the results of the electronic piezocone penetrometer (CPTU) test data, visual classification of the soils, relative consistency of the soil, laboratory test results, available correlations, and our experience with similar soils. The CPTU soundings were advanced to cone refusal.

The estimated settlements of the new embankment fill and the embankment foundation soils and/or existing embankment fill are presented in the following table:

Embankment	Embankment Borings	Approx. Fill Height (feet)	Approx. Settlement of New Embankment Fill (inches)[1,2]	Approx. Settlement of Foundation Soils (inches)	Approx. Maximum Total Settlement (inches) [3]
I-35 North Embankment	**CPT-1 / EB-1**	11	¾ to 1	¾ to 1 ¼	2 ¼
I-35 North Embankment	**CPT-2 / EB-2 & CPT-3 / EB-3**	15	1 to 1 ¼	3 ½ to 4	5 ¼
Ramp B	**CPT-4 / EB-4**	20	1 ½ to 1 ¾	10 ¾ to 11 ¼	13
Industrial	**CPT 5 / EB-5**	17	1 ¼ to 1 ½	8 ½ to 9	10 ½

[1] Approximate settlement within the new embankment fill depends on the fill material used.
[2] Approximate settlement within the new embankment fill
[3] Approximate maximum settlement within existing embankment and foundation soils

Based on our experience on projects of similar size and scope and upon empirical data, it is our opinion that the estimated time to achieve post construction primary settlement of the foundation soils to less than 1 inch for the proposed embankments in these areas is anticipated to be about 1 to 3 months after fill placement.

4.7 Slope Stability Analysis

Slope stability analyses of the embankments were performed for critical cross-sections using the computer program SLOPE/W 2016, version 8.16, by Geo-Slope International. The slope stability analyses were conducted using the Morgenstern-Price methodology using a search routine and non-linear failure surface optimization to identify non-linear critical failure surfaces.

We modeled the proposed embankment as non plastic to low plasticity sands and low plasticity clays with sand material having maximum side slopes of 3 horizontal to 1 vertical.

Based on our analyses of the laboratory tests, available correlations, and our experience with similar soils, we utilized the shear strength parameters of soils shown in the tables below to perform the slope stability analyses. Effective shear strength parameters (c’ and ϕ’) are based on drained conditions to account for long-term stability and total shear strength parameters (c and ϕ) are based on undrained conditions is to account for short-term stability.

I-35 South Embankment- Shear Strength Parameters of Soils (Using Borings EB-1 and EB-4)

Material	Consistency /Relative Density	Bottom Elevation of Soil Layer (feet)	Total Unit Weight (pcf)	Effective Shear Strength Parameters		Total Shear Strength Parameters	
				Cohesion c (psf)	Friction Angle, ϕ (deg.)	Cohesion c' (psf)	Friction Angle, ϕ' (deg.)
New Embankment Fill (SC-SM or CL)	--	--	125	1,500	0	0	28
Existing Fill-Silty Sand (SM)	--	1107.5	125	0	31	0	31
Existing Fill-Sandy Lean Clay (CL)	--	1102.5	125	1,500	0	0	28
Sandy Lean Clay (CL)	Very Stiff	1097.5	120	2,000	0	0	28
Clayey Sand (SC)	Medium Dense	1092.5	120	0	30	0	30
Silty Sand (SM)	Dense	1086.5	120	0	32	0	32
Clayey Sand (SC)	Medium Dense	1075.5	120	0	31	0	31
	Loose	1070.5	120	0	27	0	27
Lean to Fat Clay with Sand (CL-CH)	Stiff	1065.5	120	2,000	0	50	26
Lean Clay with Sand to Sandy Lean Clay (CL)	Soft to Stiff	1045.5	120	900	0	0	27
Silty Clayey Sand (SC-SM)	Loose	1035.5	120	0	27	0	27
Sandy Lean Clay (CL)	Soft to Medium Stiff	1025	120	750	0	0	27

I-35 North Embankment- Shear Strength Parameters of Soils (Using Borings EB-2 and EB-3)

Material	Consistency /Relative Density	Bottom Elevation of Soil Layer (feet)	Total Unit Weight (pcf)	Effective Shear Strength Parameters		Total Shear Strength Parameters	
				Cohesion c (psf)	Friction Angle, ϕ (deg.)	Cohesion c' (psf)	Friction Angle, ϕ' (deg.)
New Embankment Fill (SC or CL)	--	--	125	1,500	0	0	28
Existing Fill- Clayey Sand	--	1104	125	0	31	0	31
Existing Fill- Lean Clay with Sand	--	1099	125	1,500	0	0	28
Lean Clay with Sand (CL)	Medium Stiff	1094	120	1,500	0	0	27
Silty Clayey Sand (SC-SM)	Medium Dense	1089	120	0	33	0	33
Lean Clay with Sand (CL)	Stiff	1084	120	1,500	0	0	27
Silty Sand (SM)	Loose	1074	120	0	27	0	27
Sandy Lean Clay	Soft	1069	120	700	0	0	27
	Stiff	1059	120	2,000	0	0	28

Ramp B Embankment- Shear Strength Parameters of Soils (Using Boring EB-4)

Material	Consistency /Relative Density	Bottom Elevation of Soil Layer (feet)	Total Unit Weight (pcf)	Effective Shear Strength Parameters		Total Shear Strength Parameters	
				Cohesion c (psf)	Friction Angle, ϕ (deg.)	Cohesion c’ (psf)	Friction Angle, ϕ’ (deg.)
New Embankment Fill (SC or CL)	--	--	125	1,500	0	0	28
Silty Clayey Sand (SC-SM)	Medium Dense to Dense	1086	120	0	32	0	32
Clayey Sand (SC)	Medium Dense	1075	120	0	31	0	31
	Loose	1070.5	120	0	27	0	27
Lean to Fat Clay with Sand (CL-CH)	Stiff	1065.5	120	2,000	0	50	26
Lean Clay with Sand to Sandy Lean Clay (CL)	Soft to Stiff	1045.5	120	900	0	0	27
Silty Clayey Sand (SC-SM)	Loose	1035.5	120	0	27	0	27
Sandy Lean Clay	Soft to Medium Stiff	1025	120	750	0	0	27

Industrial Road Embankment- Shear Strength Parameters of Soils (Using Boring EB-5)

Material	Consistency /Relative Density	Bottom Elevation of Soil Layer (feet)	Total Unit Weight (pcf)	Effective Shear Strength Parameters		Total Shear Strength Parameters	
				Cohesion c (psf)	Friction Angle, ϕ (deg.)	Cohesion c' (psf)	Friction Angle, ϕ' (deg.)
New Embankment Fill (SC or CL)	--	--	125	1,500	0	0	28
Existing Fill- Clayey Sand	--	1079	125	0	29	0	29
Silty Sand (SM)	Loose	1073	120	0	27	0	27
	Medium Dense	1068	120	0	29	0	29
	Very Loose	1063	120	0	27	0	27
Clayey Sand (SC)	Very Loose	1053	120	0	27	0	27
Sandy Lean Clay (CL)	Soft	1037	120	400	0	0	27

A global stability analysis evaluates the ratio of resisting to driving forces, and this ratio is referred to as the factor of safety. The magnitudes of these forces are dependent upon the slope geometry, soil characteristics (texture, density, shear strength, and moisture content), surcharge loading, and groundwater conditions. A factor of safety of 1.0 indicates that these forces are in equilibrium and failure is imminent. A factor of safety greater than 1.0 indicates that there is a margin of safety against failure. The closer the factor of safety is to 1.0, the probability of movement increases. The degree of risk or the magnitude of the factor of safety, which is considered acceptable, is generally established by industry standards and is dependent upon many factors such as variability of the soil conditions, groundwater conditions, surcharge loading, and cost of repair. Minimum factors of safety of 1.3 and 1.5 for global stability are generally considered acceptable for short-term and long-term stability conditions, respectively. The results of the slope stability analyses are summarized in the following table:

Embankment	**Analyzed Station**	**Factor of Safety (FOS)**	
		Short-Term	**Long-Term**
I-35 South Embankment	138+00	1.5 (Exhibit C-1)	1.6 (Exhibit C-2)
I-35 South Embankment	140+54.83	1.7	1.5

Embankment	Analyzed Station	Factor of Safety (FOS)	
		Short-Term	Long-Term
		(Exhibit C-3)	(Exhibit C-4)
Ramp B	136+90.69	2.9 (Exhibit C-5)	1.7 (Exhibit C-6)
Industrial	12+50	3.1 (Exhibit C-7)	1.6 (Exhibit C-8)

See Exhibits C-1 to C-8 for the graphical outputs of the slope stability analyses. Based on our analyses, we recommend that embankment slopes be 3H:1V or flatter.

4.8 Erosion and Drainage Considerations

Embankments constructed with cohesionless materials are more susceptible to erosion and scour due to water flow over the embankment face than cut faces that expose clays and rock. We recommended that embankment slopes be armored and/or well vegetated (with appropriate grass cover) to assist in reducing the influence of water that may flow over the face of the slope, regardless of material type. Vegetation can be established by either sodding, hydroseeding or seeding over at least 8 inches of topsoil. Water should be channeled away from the slope face to reduce the possibility of erosion due to water flow.

5.0 GENERAL COMMENTS

The results presented in this report are based upon the data obtained from the borings performed at the indicated locations. This report does not reflect variations that may occur between borings, 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 of this project does not include either specifically or by implication any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential of such contamination, 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 expressed or implied, are intended or made. In the event that any 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 Consultants, Inc. reviews the changes, and either verifies or modifies the conclusions of this report in writing.

APPENDIX A

FIELD EXPLORATION

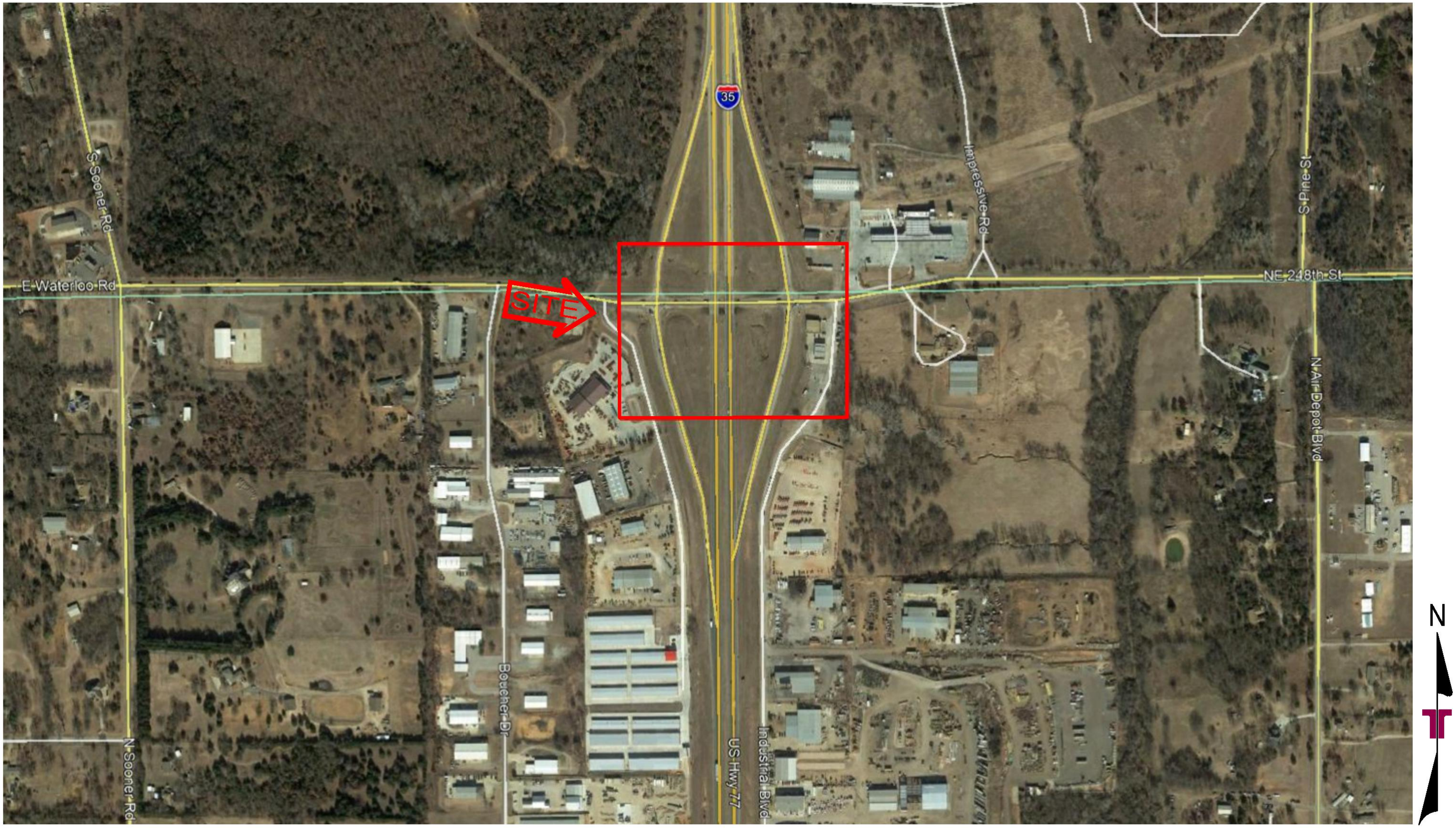

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

Project Mngr: DCVS	Project No. 03185252
Drawn By: CAN	Scale: NTS
Checked By: DCVS	File No. 03185252 (A1-A3)
Approved By: NKT	Date: DEC 2018

Terracon
Consulting Engineers and Scientists
4701 N STILES AVE OKLAHOMA CITY, OKLAHOMA 73105
PH. (405) 525-0453 FAX. (405) 557-0549

SITE LOCATION PLAN

EMBANKMENT SURVEY
INTERSTATE 35 OVER WATERLOO ROAD INTERCHANGE
LOGAN AND OKLAHOMA COUNTIES, OKLAHOMA

EXHIBIT
A1

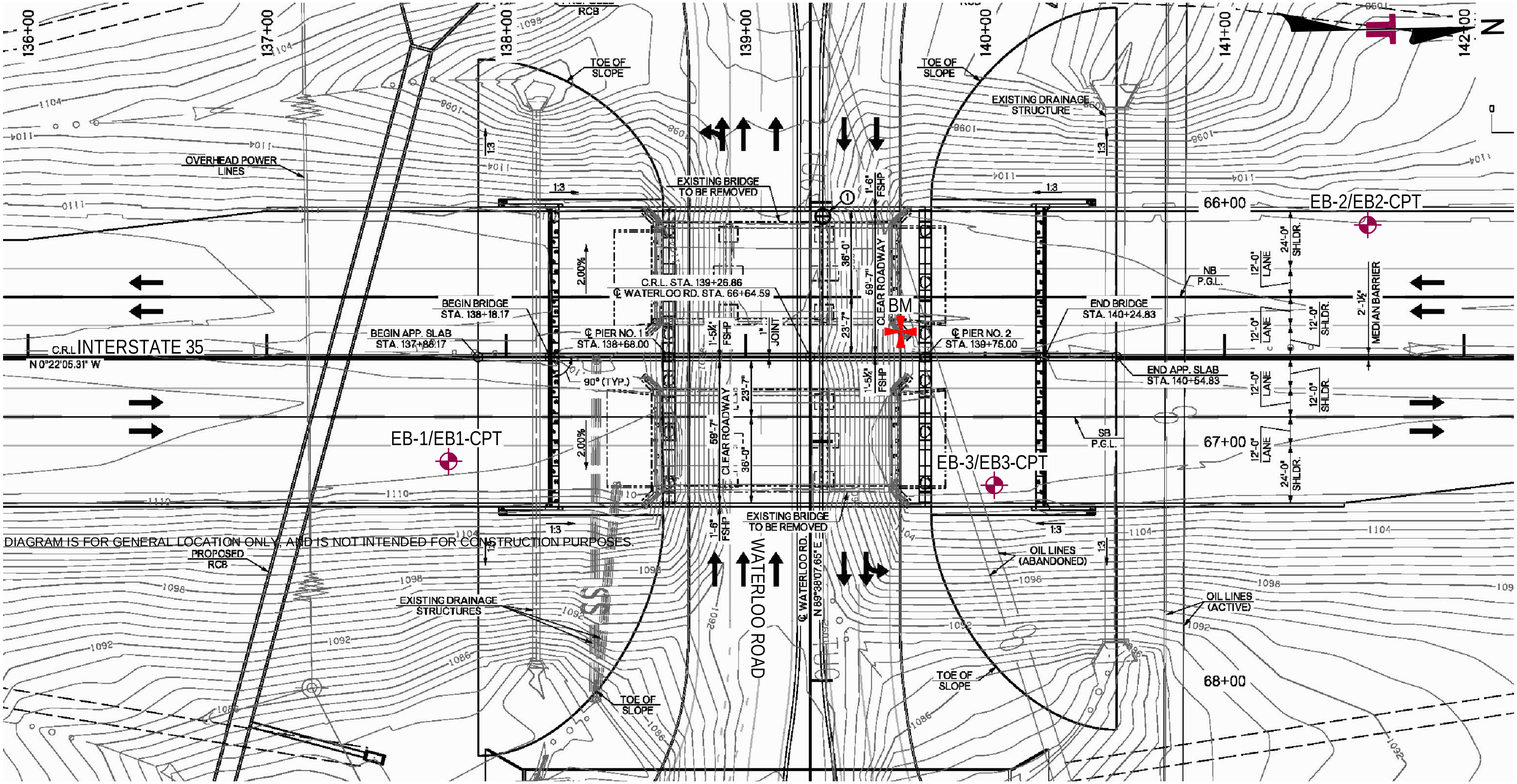

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

BORING NO.	STATION NO.*	OFFSET (FT.)*	ELEV. (FT.)
EB-1/EB1-CPT	137+76	43 RT.	1111.0
EB-2/EB2-CPT	141+60	56 LT.	1107.6
EB-3/EB3-CPT	140+04	53 RT.	1107.1

BM: CIRCLED "X"
MARK ON WING WALL
ELEV.: 1110.4 FT

***BASED ON I-35 CRL**

LEGEND

⌖ BORING LOCATION

Project Mngr: DCVS	Project No. 03185252
Drawn By: CAN	Scale: NTS
Checked By: DCVS	File No. 03185252 (A1-A3)
Approved By: NKT	Date: DEC 2018

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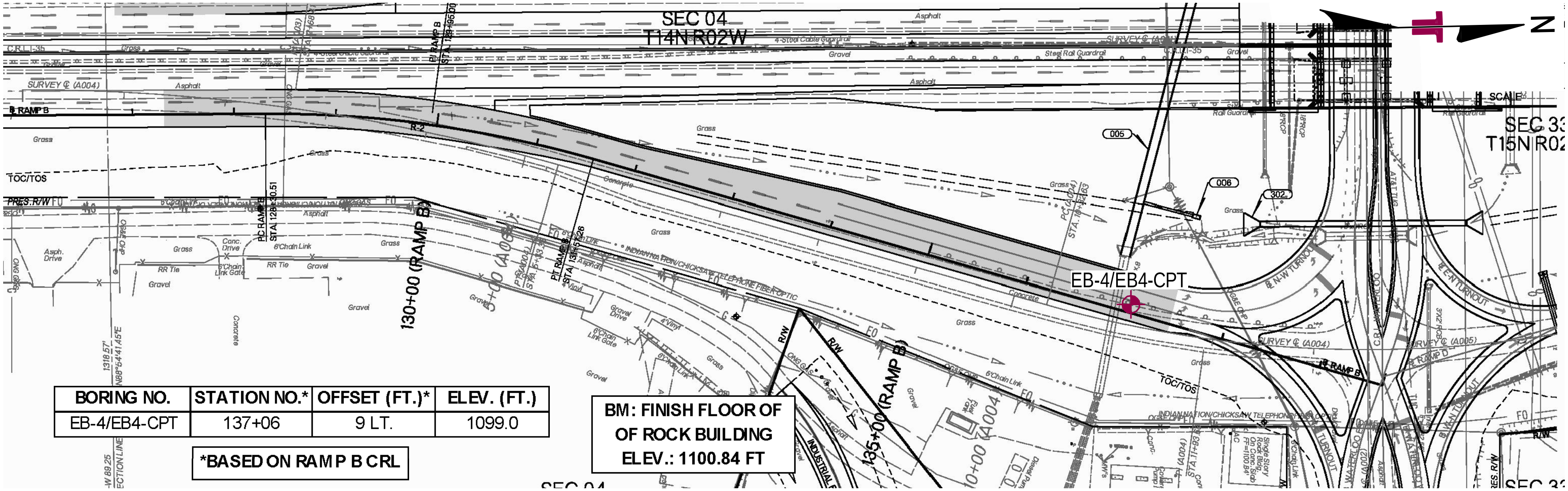
BORING LOCATION PLAN
EMBANKMENT SURVEY
INTERSTATE 35 OVER WATERLOO ROAD INTERCHANGE
LOGAN AND OKLAHOMA COUNTIES, OKLAHOMA

EXHIBIT
A2

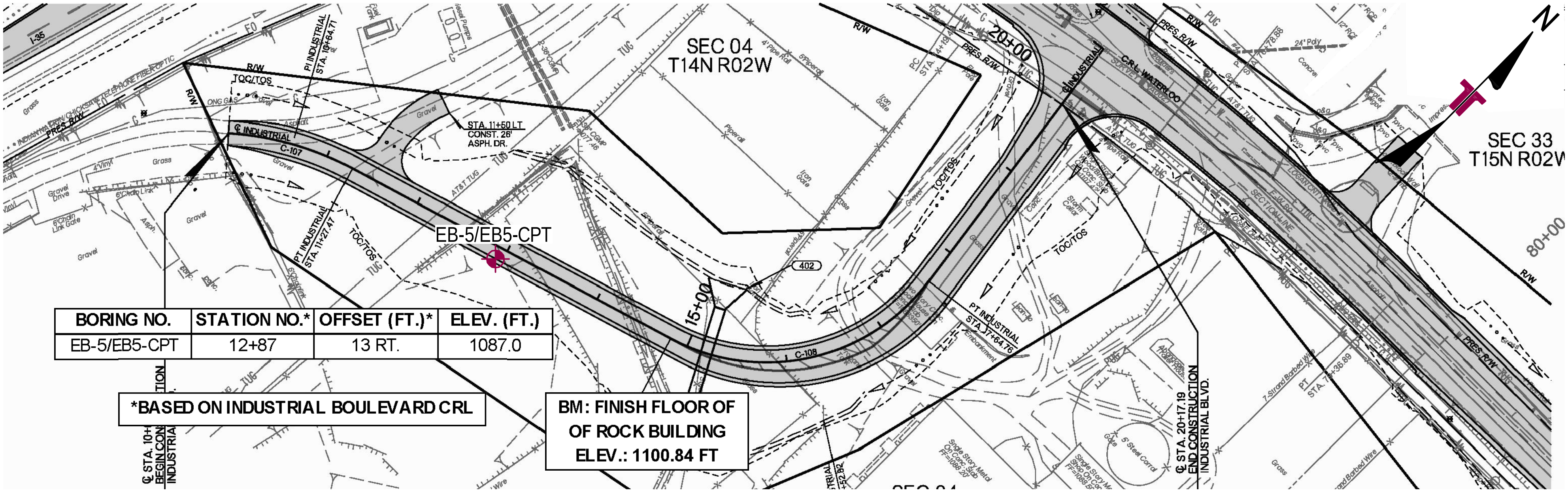


BORING NO.	STATION NO.*	OFFSET (FT.)*	ELEV. (FT.)
EB-4/EB4-CPT	137+06	9 LT.	1099.0

***BASED ON RAMP B CRL**

BM: FINISH FLOOR OF
OF ROCK BUILDING
ELEV.: 1100.84 FT

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



BORING NO.	STATION NO.*	OFFSET (FT.)*	ELEV. (FT.)
EB-5/EB5-CPT	12+87	13 RT.	1087.0

***BASED ON INDUSTRIAL BOULEVARD CRL**

BM: FINISH FLOOR OF
OF ROCK BUILDING
ELEV.: 1100.84 FT

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

LEGEND

⌖ BORING LOCATION

Project Mngr: DCVS	Project No. 03185252
Drawn By: CAN	Scale: NTS
Checked By: DCVS	File No. 03185252 (A1-A3)
Approved By: NKT	Date: DEC 2018

Terracon
Consulting Engineers and Scientists
4701 N STILES AVE OKLAHOMA CITY, OKLAHOMA 73105
PH. (405) 525-0453 FAX. (405) 557-0549

BORING LOCATION PLAN

EMBANKMENT SURVEY
INTERSTATE 35 OVER WATERLOO ROAD INTERCHANGE
LOGAN AND OKLAHOMA COUNTIES, OKLAHOMA

EXHIBIT
A3

Field Exploration Description

Terracon personnel located the borings in the field by taping distances and estimating right angles based on information from the site plan provided by Garver. Terracon determined the approximate ground surface elevations at the borings using an engineer's level. These elevations were referenced to the following bench mark:

Description	Elevation (ft.)
Circled X on NE Bridge Wingwall- Southbound	1110.4

Based on the benchmark, the ground surface elevations at the boring locations ranged from 1092.5 to 1111 feet. The elevations shown on the logs have been rounded to the nearest 0.1 foot. The boring locations and elevations should be considered accurate only to the degree implied by the methods used to define them.

A truck mounted, rotary drill rig equipped with continuous flight augers was used to advance the boreholes. Representative samples were obtained by the split-barrel sampling procedures. Bulk samples were collected from auger cuttings from borings EB-1, EB-2, EB-4 and EB-5.

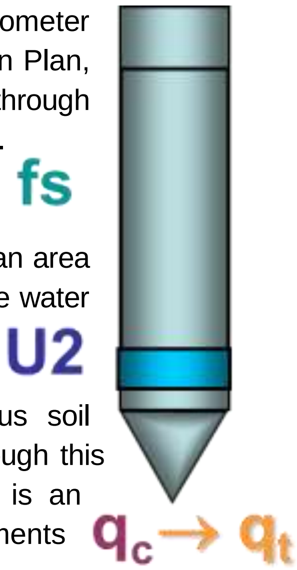
The split-barrel sampling procedure uses a standard 2-inch O.D. split-barrel sampling spoon that is driven into the bottom of the boring with a 140-pound drive hammer falling 30 inches. The number of blows required to advance the sampling spoon the last 12 inches, or less, of a typical 18-inch sampling interval or portion thereof, is recorded as the standard penetration resistance value, N. The N value is used to estimate the in-situ relative density of cohesionless soils and, to a lesser degree of accuracy, the consistency of cohesive soils and the hardness of sedimentary bedrock. The sampling depths, penetration distances, and the N values are reported on the boring logs. The samples were tagged for identification, sealed to reduce moisture loss and returned to the laboratory for further examination, testing and classification.

An automatic Standard Penetration Test (SPT) drive hammer was used to advance the split-barrel sampler. The automatic drive hammer achieves a greater mechanical efficiency when compared to a conventional safety drive hammer operated with a cathead and rope. We considered this higher efficiency in our interpretation and analysis of the subsurface information provided with this report.

Field logs were prepared as part of the drilling operations. These boring logs included visual classifications of the materials encountered during drilling and the field personnel's interpretation of the subsurface conditions between samples. The final boring logs included with this report may include modifications based on observations and tests of the samples in the laboratory.

As required by the Oklahoma Water Resources Board, any borings deeper than 20 feet, or borings which encounter groundwater or contaminated materials must be grouted or plugged in accordance with Oklahoma State statutes. One boring log must also be submitted to the Oklahoma Water Resources Board for each 10 acres of project site area. Terracon grouted the borings and submitted a log in order to comply with the Oklahoma Water Resources Board requirements.

Five soundings were performed with a piezometric electronic cone penetrometer (CPTU) at the approximate locations shown on the attached Boring Location Plan, Exhibits A-2 and A-3. The CPT hydraulically pushes an instrumented cone through the soil while nearly continuous readings are recorded to a portable computer. The cone is equipped with electronic load cells to measure tip resistance and sleeve resistance and a pressure transducer to measure the generated ambient pore pressure. The face of the cone has an apex angle of 60° and an area of 10 cm^2. Digital data representing the tip resistance, friction resistance, pore water pressure, and probe inclination angle are recorded about every 2 centimeters while advancing through the ground at a rate between 1 1/2 and 2 1/2 centimeters per second. These measurements are correlated to various soil properties used for geotechnical design. No soil samples are gathered through this subsurface investigation technique. It should be noted that the soil type is an interpretation based on empirical correlation rather than direct measurements and should be evaluated accordingly.



CPT testing is conducted in general accordance with ASTM D5778 "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils."

Upon completion, the data collected were downloaded and processed by the project engineer.

BORING LOG NO. EB-1

PROJECT: **Embankment Soil Survey**
1-35 over Waterloo Road Interchange

CLIENT: **Garver, LLC**
Tulsa, Oklahoma

SITE: **Interstate 35 and Waterloo Road**
Oklahoma & Logan Counties, Oklahoma

LOCATION See exhibits A-2 & A-3

Latitude: 35.7246° Longitude: -97.4161°

Station: 137+76 Offset: 43' RT from CRL

Approximate Surface Elev.: 1111.0 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▩	**FILL - SILTY SAND**, weak red (10R 4/3) with clay seams red (7.5R 4/6)				☒	17	7-7-4 N=11			16			
	3.5	1107.5+/-											
▩	**FILL - SANDY LEAN CLAY**, brown (7.5YR 5/4)		5		☒	15	3-4-7 N=11			18		24-15-9	68
	8.5	1102.5+/-											
▨	**SANDY LEAN CLAY (CL)**, weak red (10R 4/4) with dark brown (7.5YR 3/2), very stiff		10		☒	18	7-9-10 N=19			15			
	13.5	1097.5+/-											
▨	**CLAYEY SAND (SC)**, reddish brown (2.5YR 4/4) and weak red (10R 4/4), medium dense		15		☒	16	9-6-12 N=18			15		21-13-8	47
	18.5	1092.5+/-											
░	**SILTY SAND (SM)**, with clay seams, reddish brown 5YR 4/4) and reddish brown (5YR 4/4), medium dense		20		☒	14	10-12-13 N=25			17			
					☒	15	7-12-50/3"			13			
	24.5	1086.5+/-											
⁘	**WEATHERED SILTY SANDSTONE**, red (2.5YR 5/6) and light red (2.5YR 6/6), cemented		25										
	-red (10R 4/6), well cemented below 28.5'				☒	1	50/2"			6			
			30										

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

Surface Cover: Approx. 4" of Asphalt Concrete Pavement

WATER LEVEL OBSERVATIONS

∇ *34' While drilling*
∇ *31' After boring*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-21-2018	Boring Completed: 11-21-2018
Drill Rig: 747	Driller: R. Peters
Project No.: 03185252	Exhibit: A-5

BORING LOG NO. EB-1

PROJECT: Embankment Soil Survey
1-35 over Waterloo Road Interchange

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

CLIENT: Garver, LLC
Tulsa, Oklahoma

LOCATION See exhibits A-2 & A-3

Latitude: 35.7246° Longitude: -97.4161°

Station: 137+76 Offset: 43' RT from CRL

Approximate Surface Elev.: 1111.0 (Ft.) +/-

GRAPHIC LOG	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	WEATHERED SILTY SANDSTONE, red (2.5YR 5/6) and light red (2.5YR 6/6), cemented *(continued)*		▽									
	33.5 — 1077.5+/-											
	34.0 **WEATHERED SHALE**, light grayish green (GLEY 1 8/1) and red (10R 4/6), moderately hard — 1077+/-		▽	⋈	3	50/3"			10			
	Boring Terminated at 34 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *34' While drilling*

▽ *31' After boring*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-21-2018	Boring Completed: 11-21-2018
Drill Rig: 747	Driller: R. Peters
Project No.: 03185252	Exhibit: A-5

BORING LOG NO. EB-2

Page 1 of 2

PROJECT: Embankment Soil Survey
1-35 over Waterloo Road Interchange

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

CLIENT: Garver, LLC
Tulsa, Oklahoma

LOCATION See exhibits A-2 & A-3

Latitude: 35.7257° Longitude: -97.4165°

Station: 141+60 Offset: 56' LT from CRL

Approximate Surface Elev.: 1107.6 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▩	**FILL - SILTY SAND WITH CLAY POCKETS** , with asphalt and gravel fragments, reddish brown (2.5YR 4/4) and red (7.5R 4/6)				☒	10	8-8-5 N=13			10			
	3.5	1104+/-											
▩	**FILL - CLAYEY SAND** , red (10R 5/6)		5		☒	9	6-9-12 N=21			17		22-10-12	46
	8.5	1099+/-											
▨	**LEAN CLAY WITH SAND (CL)**, weak red (10R 4/4). trace light greenish gray (GLEY1 8/1), medium stiff		10		☒	11	3-4-4 N=8			17		21-13-8	74
	13.5	1094+/-											
▨	**SILTY CLAYEY SAND (SC-SM)**, reddish brown (2.5YR 4/4) with dark brown (7.5YR 3/2), medium dense		15		☒	10	8-14-15 N=29			16			
	18.5	1089+/-											
▨	**LEAN CLAY WITH SAND (CL)**, weak red (10R 4/4). trace light greenish gray (GLEY1 8/1), stiff		20		☒	16	5-5-7 N=12			14		27-14-13	81
	23.5	1084+/-											
▨	**SILTY SAND (SM)**, dark reddish brown (5YR 3/3), loose		25		☒	13	2-2-2 N=4			9			
▨	-yellowish red (5YR 5/6) below 28.5'		30		☒	12	2-3-4 N=7			11			

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass

WATER LEVEL OBSERVATIONS

▽ *33' While drilling*
▽ *33' After boring*
▼ *33' After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-19-2018	Boring Completed: 11-19-2018
Drill Rig: 747	Driller: R. Peters
Project No.: 03185252	Exhibit: A-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 03185252 EMBANKMENT SURVEY - I-35 OVER WATERLOO ROAD PHASE II.GPJ MODELLAYER.GPJ 1/1/19

BORING LOG NO. EB-2

Page 2 of 2

PROJECT: Embankment Soil Survey
1-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

LOCATION See exhibits A-2 & A-3

Latitude: 35.7257° Longitude: -97.4165°

Station: 141+60 Offset: 56' LT from CRL

Approximate Surface Elev.: 1107.6 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
SILTY SAND (SM), dark reddish brown (5YR 3/3), loose *(continued)*			▼									
33.5	1074+/-											
SANDY LEAN CLAY (CL), reddish brown (5YR 4/4), soft to medium stiff		35		☒	18	1-1-3 N=4			21			
-red (10R 4/6) and reddish brown (5YR 4/4) below 38.5' -very stiff below 39.5'		40		☒	18	0-6-12 N=18			21			
-red (10R 4/6), stiff below 43.5'		45		☒	12	3-8-7 N=15			17			
48.5	1059+/-											
WEATHERED SHALE WITH SAND SEAMS, pale red (5R 6/2) and red (10R 4/6), moderately hard		50		☒	3	50/3"			20			
53.5	1054+/-											
+WEATHERED SANDSTONE, weak red (5R 5/4) and pale red (5R 6/2), well cemented				☒	2	50/2"			17			
54.0	1053.5+/-											

Boring Terminated at 54 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *33' While drilling*
▽ *33' After boring*
▼ *33' After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-19-2018	Boring Completed: 11-19-2018
Drill Rig: 747	Driller: R. Peters
Project No.: 03185252	Exhibit: A-6

BORING LOG NO. EB-3

PROJECT: Embankment Soil Survey
1-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

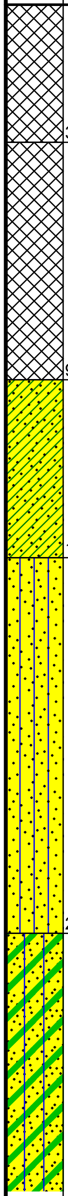
SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

LOCATION See exhibits A-2 & A-3

Latitude: 35.7255° Longitude: -97.4161°

Station: 140+04 Offset: 53' RT from CRL

Approximate Surface Elev.: 1107.1 (Ft.) +/-



DEPTH / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
FILL - CLAYEY SAND WITH ASPHALT AND GRAVEL FRAGMENTS, reddish brown (2.5YR 4/4) and dark reddish brown (2.5YR 3/4)			☒	12	12-10-9 N=19			9			
3.5 — 1103.5+/-											
FILL - LEAN CLAY WITH SAND, weak red (10R 4/4) and red (10R 5/6)	5		☒	10	5-6-10 N=16			15		23-13-10	74
-yellowish red (5YR 4/6) and brown (7.5YR 4/4) below 8.5'			☒	18	5-6-7 N=13			19			
9.5 — 1097.5+/-	10										
SANDY LEAN CLAY (CL), yellowish red (5YR 4/6) and brown (7.5YR 4/4), stiff											
14.0 — 1093+/-			☒	18	10-12-11 N=23			17			
SILTY SAND (SM), reddish brown (2.5YR 4/4) and red (2.5YR 5/6), medium dense	15	▼									
-dense below 18.5'	20		☒	14	13-17-16 N=33			16			
23.5 — 1083.5+/-											
SILTY CLAYEY SAND (SC-SM), dark reddish brown (2.5YR 3/3) and black (2.5YR 2.5/1), loose	25		☒	18	1-2-3 N=5			14		19-12-7	44
		▽									
-trace clay, reddish brown (2.5YR 4/4) below 28.5'	30		☒	18	3-3-4 N=7			12			

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

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass

WATER LEVEL OBSERVATIONS

▽ *28' While drilling*

▽ *33' After boring*

▼ *17' After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-19-2018	Boring Completed: 11-19-2018
Drill Rig: 747	Driller: R. Peters
Project No.: 03185252	Exhibit: A-7

BORING LOG NO. EB-3

Page 2 of 2

PROJECT: **Embankment Soil Survey**
1-35 over Waterloo Road Interchange

SITE: **Interstate 35 and Waterloo Road**
Oklahoma & Logan Counties, Oklahoma

CLIENT: **Garver, LLC**
Tulsa, Oklahoma

LOCATION See exhibits A-2 & A-3

Latitude: 35.7255° Longitude: -97.4161°

Station: 140+04 Offset: 53' RT from CRL

Approximate Surface Elev.: 1107.1 (Ft.) +/-

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		SILTY CLAYEY SAND (SC-SM), dark reddish brown (2.5YR 3/3) and black (2.5YR 2.5/1), loose *(continued)*			▽									
	33.5		1073.5+/-											
		SANDY LEAN CLAY (CL), reddish brown (2.5YR 4/4), medium stiff		35		☒	14	3-3-3 N=6			17			
		-weak red (10R 4/4), very stiff at 38.5'		40		☒	18	3-20-3 N=23			20			
	43.5		1063.5+/-											
		LEAN CLAY (CL), red (10R 5/8) and dark red (7.5R 3/6), very stiff				☒	17	6-20-50/5"			12			
	44.5		1062.5+/-	45										
		+WEATHERED SHALE, weak red (7.5R 5/4) and light greenish gray (GLEY1 8/1), soft												
		-with sand, red (10R 5/6), trace light greenish gray (GLEY1 8/1), moderately hard below 48.5'				☒		50/4"			16			
	49.0		1058+/-											
		Boring Terminated at 49 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

- ▽ *28' While drilling*
- ▽ *33' After boring*
- ▼ *17' After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-19-2018	Boring Completed: 11-19-2018
Drill Rig: 747	Driller: R. Peters
Project No.: 03185252	Exhibit: A-7

BORING LOG NO. EB-4

PROJECT: Embankment Soil Survey
1-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

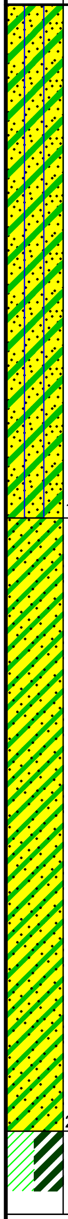
SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

LOCATION See exhibits A-2 & A-3

Latitude: 35.7244° Longitude: -97.4155°

Station: 137+06 Offset: 9' LT from CL Ramp B

Approximate Surface Elev.: 1099.0 (Ft.) +/-



DEPTH	DESCRIPTION	ELEVATION (Ft.)
	SILTY CLAYEY SAND (SC-SM), red (10R 4/6) with dark reddish gray (2.5YR 3/1), medium dense	
	-reddish brown (2.5YR 4/4), dense below 3.5'	
	-with clay seams, red (10R 4/6) with reddish brown (2.5YR 4/4), medium dense below 8.5'	
13.0		1086+/-
	CLAYEY SAND (SC), weak red (7.5R 4/4) and red (7.5R 4/6), medium dense	
	-red (7.5R 5/6) with pale red (7.5R 6/4) below 18.5'	
	-dark reddish gray (10R 3/1), loose below 23.5'	
28.5		1070.5+/-
	LEAN TO FAT CLAY WITH SAND (CL-CH), reddish brown (2.5YR 4/4), stiff	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		☒	15	8-13-13 N=26			14		20-13-7	37
5		☒	14	14-15-22 N=37			17			
10		☒	11	7-12-15 N=27			19			
15		☒	16	7-11-11 N=22			14			
20	▽	☒	12	7-10-11 N=21			20		20-10-10	29
25		☒	15	2-2-3 N=5			17			
30		☒	18	5-6-7 N=13			18			

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

Surface Cover: Approx. 5" of Portland Cement Concrete and Grass

WATER LEVEL OBSERVATIONS

▽ *19' While drilling*

▼ *34' After boring*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-20-2018	Boring Completed: 11-20-2018
Drill Rig: 747	Driller: R. Peters
Project No.: 03185252	Exhibit: A-8

BORING LOG NO. EB-4

PROJECT: Embankment Soil Survey
1-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

LOCATION See exhibits A-2 & A-3

Latitude: 35.7244° Longitude: -97.4155°

Station: 137+06 Offset: 9' LT from CL Ramp B

Approximate Surface Elev.: 1099.0 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**LEAN TO FAT CLAY WITH SAND (CL-CH)**, reddish brown (2.5YR 4/4), stiff *(continued)*												
	33.5	1065.5+/-											
▨	**SANDY LEAN CLAY (CL)**, red (2.5YR 4/6), soft		35	▽	☒	18	0-2-2 N=4			19			
	-medium stiff below 38.5'		40		☒	14	2-3-4 N=7			23			
	43.5	1055.5+/-											
▨	**LEAN CLAY WITH SAND (CL)**, red (2.5YR 4/6), soft		45		☒	18	1-1-2 N=3			26		29-15-14	71
	-stiff below 48.5'		50		☒	14	4-5-4 N=9			20			
	53.5	1045.5+/-											
▨	**SILTY CLAYEY SAND (CL-ML)**, red (2.5YR 5/6), loose		55		☒	9	1-2-3 N=5			21			
			60		☒	10	3-4-5 N=9			20			

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

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *19' While drilling*

▽ *34' After boring*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-20-2018	Boring Completed: 11-20-2018
Drill Rig: 747	Driller: R. Peters
Project No.: 03185252	Exhibit: A-8

BORING LOG NO. EB-4

PROJECT: Embankment Soil Survey
1-35 over Waterloo Road Interchange

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

CLIENT: Garver, LLC
Tulsa, Oklahoma

LOCATION See exhibits A-2 & A-3

Latitude: 35.7244° Longitude: -97.4155°

Station: 137+06 Offset: 9' LT from CL Ramp B

Approximate Surface Elev.: 1099.0 (Ft.) +/-

GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨		**SILTY CLAYEY SAND (CL-ML)**, red (2.5YR 5/6), loose *(continued)*												
	63.5		1035.5+/-											
▨		**SANDY LEAN CLAY (CL)**, dark reddish brown (2.5YR 3/3), medium stiff		65		☒	18	0-2-3 N=5			24			
▨		-red (2.5YR 5/6) and dark reddish brown (2.5YR 3/3), soft below 68'		70		☒	7	0-0-2 N=2			21			
	74.0		1025+/-			☒	12	17-50/6"			20			
⁙		**WEATHERED SILTY SANDSTONE**, red (2.5YR 5/6) trace grayish brown (10YR 5/2), poorly cemented		75										
⁙	79.0	-light red (2.5YR 6/6), well cemented below 78.5'	1020+/-			☒	2	50/2"			20			
		Boring Terminated at 79 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *19' While drilling*

▽ *34' After boring*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-20-2018	Boring Completed: 11-20-2018
Drill Rig: 747	Driller: R. Peters
Project No.: 03185252	Exhibit: A-8

BORING LOG NO. EB-5

PROJECT: Embankment Soil Survey
1-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

LOCATION See exhibits A-2 & A-3

Latitude: 35.7238° Longitude: -97.4143°

Station: 12+87 Offset: 13' RT from CRL

Approximate Surface Elev.: 1087.0 (Ft.) +/-

DEPTH	Description	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	FILL - CLAYEY SAND WITH GRAVEL, dusky red (10R 3/4)				☒	16	4-5-7 N=12			10			
2.0	**FILL - SILTY SAND**, dusky red (10R 3/4)	1085+/-	5		☒	10	5-4-5 N=9			6			
8.5	**SILTY SAND (SM)**, dark reddish brown (2.5YR 3/3), loose	1078.5+/-	10	▨	☒	18	4-2-3 N=5			5		NP	28
	-dark reddish brown (5YR 4/4) and yellowish red (5YR 5/6), medium dense below 13.5'		15		☒	10	5-5-5 N=10			8			
	-red (2.5YR 4/6), very loose below 18.5'		20	▽	☒	4	1-1-2 N=3			14			
23.5	**CLAYEY SAND (SC)**, reddish brown (2.5YR 4/4), very loose	1063.5+/-	25		☒	18	0-1-1 N=2			20		26-14-12	32
28.5	**SILTY CLAYEY SAND (CL-ML)**, red (2.5YR 4/6), very loose	1058.5+/-	30		☒	18	0-0-2 N=2			21			

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger 0' - 33.5'
Rock Bit - 33.5' - 54'

Abandonment Method:
Boring backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

Surface Cover: Bare Soils

WATER LEVEL OBSERVATIONS

▽ *21' While drilling*

▨ *Dry Cave In at 9'*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-27-2018	Boring Completed: 11-27-2018
Drill Rig: 747	Driller: R. Peters
Project No.: 03185252	Exhibit: A-9

BORING LOG NO. EB-5

PROJECT: **Embankment Soil Survey**
1-35 over Waterloo Road Interchange

SITE: **Interstate 35 and Waterloo Road**
Oklahoma & Logan Counties, Oklahoma

CLIENT: **Garver, LLC**
Tulsa, Oklahoma

LOCATION See exhibits A-2 & A-3

Latitude: 35.7238° Longitude: -97.4143°

Station: 12+87 Offset: 13' RT from CRL

Approximate Surface Elev.: 1087.0 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	LABORATORY HP (psf)	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	SILTY CLAYEY SAND (CL-ML), red (2.5YR 4/6), very loose *(continued)*												
	33.5	1053.5+/-											
	SANDY LEAN CLAY (CL), reddish brown (2.5YR 4/4) and red (10R 4/6), soft		35		☒	14	0-0-2 N=2			24		27-12-15	60
			40		☒		0-1-1 N=2			26			
	-dark brown (7.5YR 3/2) and reddish brown (5YR 4/3) below 43.5'		45		☒	18	2-1-2 N=3			20			
	-weak red (10R 4/4) below 48'				☒	18	2-3-50/4"						
	49.5	1037.5+/-											
	WEATHERED SILTY SANDSTONE, red (10R 5/6), cemented		50										
	54.0 -well cemented below 53.5'	1033+/-			☒		50/2"						
	Boring Terminated at 54 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.
+Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
Power Auger 0' - 33.5'
Rock Bit - 33.5' - 54'

Abandonment Method:
Boring backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS
▽ *21' While drilling*
▨ *Dry Cave In at 9'*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-27-2018	Boring Completed: 11-27-2018
Drill Rig: 747	Driller: R. Peters
Project No.: 03185252	Exhibit: A-9

CPT LOG NO. EB1-CPT

PROJECT: Embankment Soil Survey
1-35 over Waterloo Road Interchange

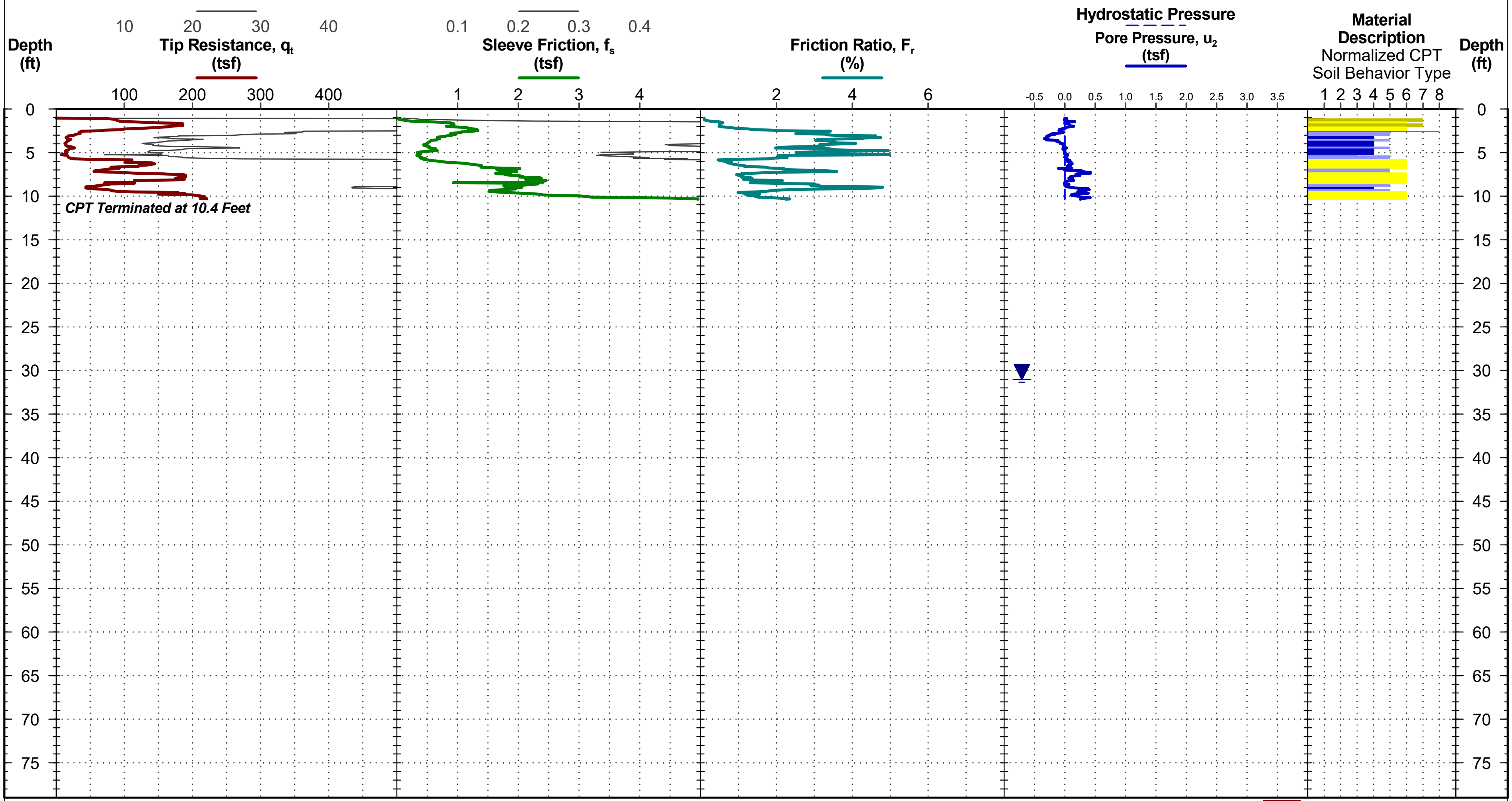
CLIENT: Garver, LLC
Tulsa, Oklahoma

TEST LOCATION: See exhibits A-2 & A-3

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

Latitude: 35.7246°
Longitude: -97.4161°

Station: 137+76
Offset: 43' RT from CRL



See Exhibit A-4 for description of field procedures.
See Appendix D for explanation of symbols and abbreviations.

CPT sensor calibration reports available upon request.

- 1 Sensitive, fine grained
- 2 Organic soils - clay
- 3 Clay - silty clay to clay
- 4 Silt mixtures - clayey silt to silty clay
- 5 Sand mixtures - silty sand to sandy silt
- 6 Sands - clean sand to silty sand
- 7 Gravelly sand to dense sand
- 8 Very stiff sand to clayey sand
- 9 Very stiff fine grained

WATER LEVEL OBSERVATION

▼ 31 ft estimated water depth
(used in normalizations and correlations; see Appendix D)

Probe no. 5037 with net area ratio of 0.832
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 8/28/2017
Tip and sleeve areas of 10 cm^2 and 150 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
4701 N Stiles Ave
Oklahoma City, OK

CPT Started: 11/21/2018	CPT Completed: 11/21/2018
Rig: 747	Operator: APS
Project No.: 03185252	Exhibit: A-10

CPT LOG NO. EB2-CPT

Page 1 of 1

PROJECT: Embankment Soil Survey
1-35 over Waterloo Road Interchange

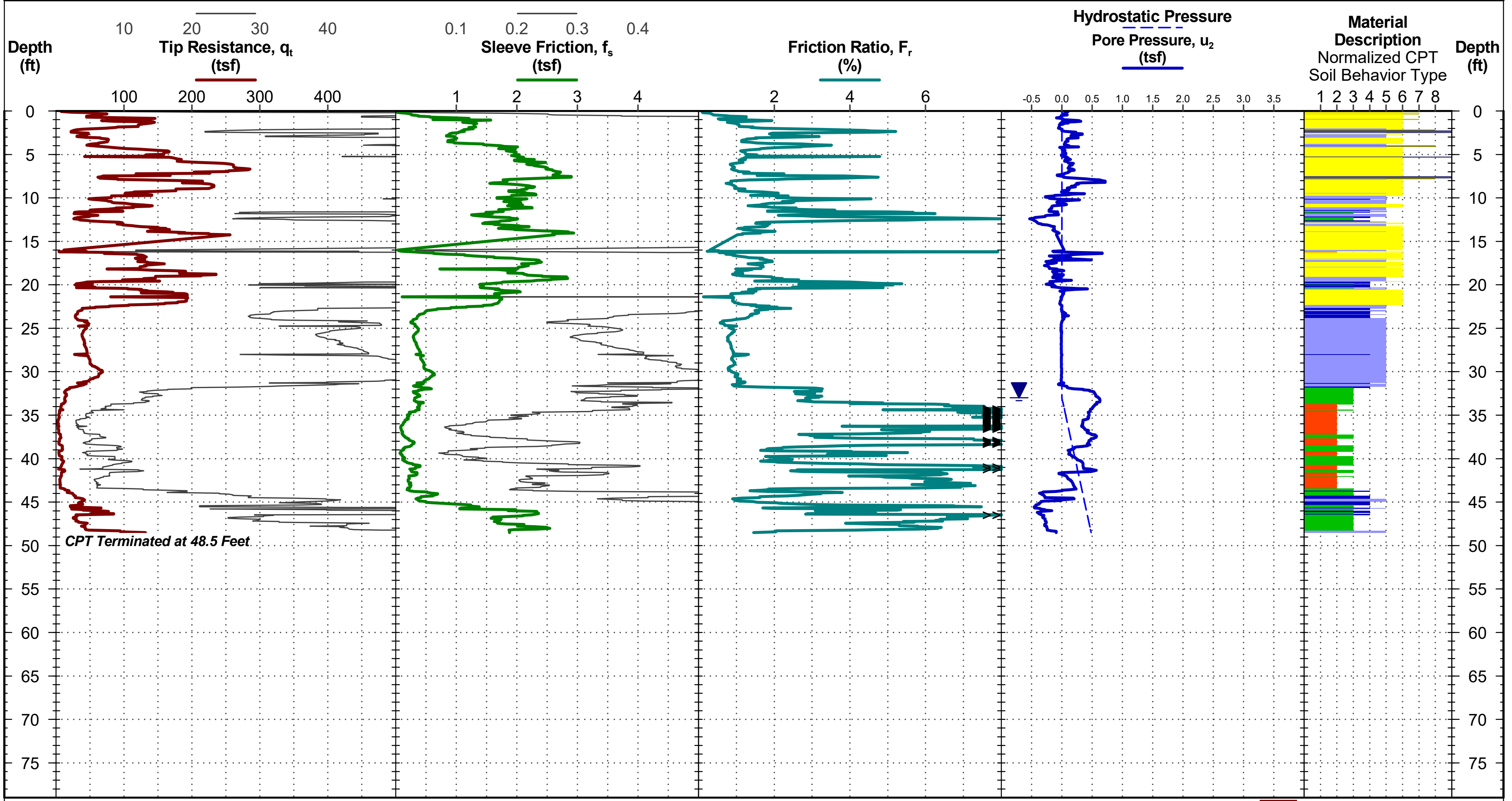
CLIENT: Garver, LLC
Tulsa, Oklahoma

TEST LOCATION: See exhibits A-2 & A-3

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

Latitude: 35.7257° -
Longitude: 97.4165°

Station: 141+60
Offset: 56' LT from CRL



See Exhibit A-4 for description of field procedures.
See Appendix D for explanation of symbols and abbreviations.

CPT sensor calibration reports available upon request.

- 🟥 1 Sensitive, fine grained
- 🟧 2 Organic soils - clay
- 🟩 3 Clay - silty clay to clay
- 🟦 4 Silt mixtures - clayey silt to silty clay
- 🟪 5 Sand mixtures - silty sand to sandy silt
- 🟨 6 Sands - clean sand to silty sand
- 🟨 7 Gravelly sand to dense sand
- 🟫 8 Very stiff sand to clayey sand
- ⬛ 9 Very stiff fine grained

WATER LEVEL OBSERVATION

▼ 33 ft estimated water depth
(used in normalizations and correlations; see Appendix D)

Probe no. 5037 with net area ratio of 0.832
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 8/28/2017
Tip and sleeve areas of 10 cm^2 and 150 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
4701 N Stiles Ave
Oklahoma City, OK

CPT Started: 11/21/2018	CPT Completed: 11/21/2018
Rig: 747	Operator: APS
Project No.: 03185252	Exhibit: A-11

CPT LOG NO. EB3-CPT

Page 1 of 1

PROJECT: Embankment Soil Survey
1-35 over Waterloo Road Interchange

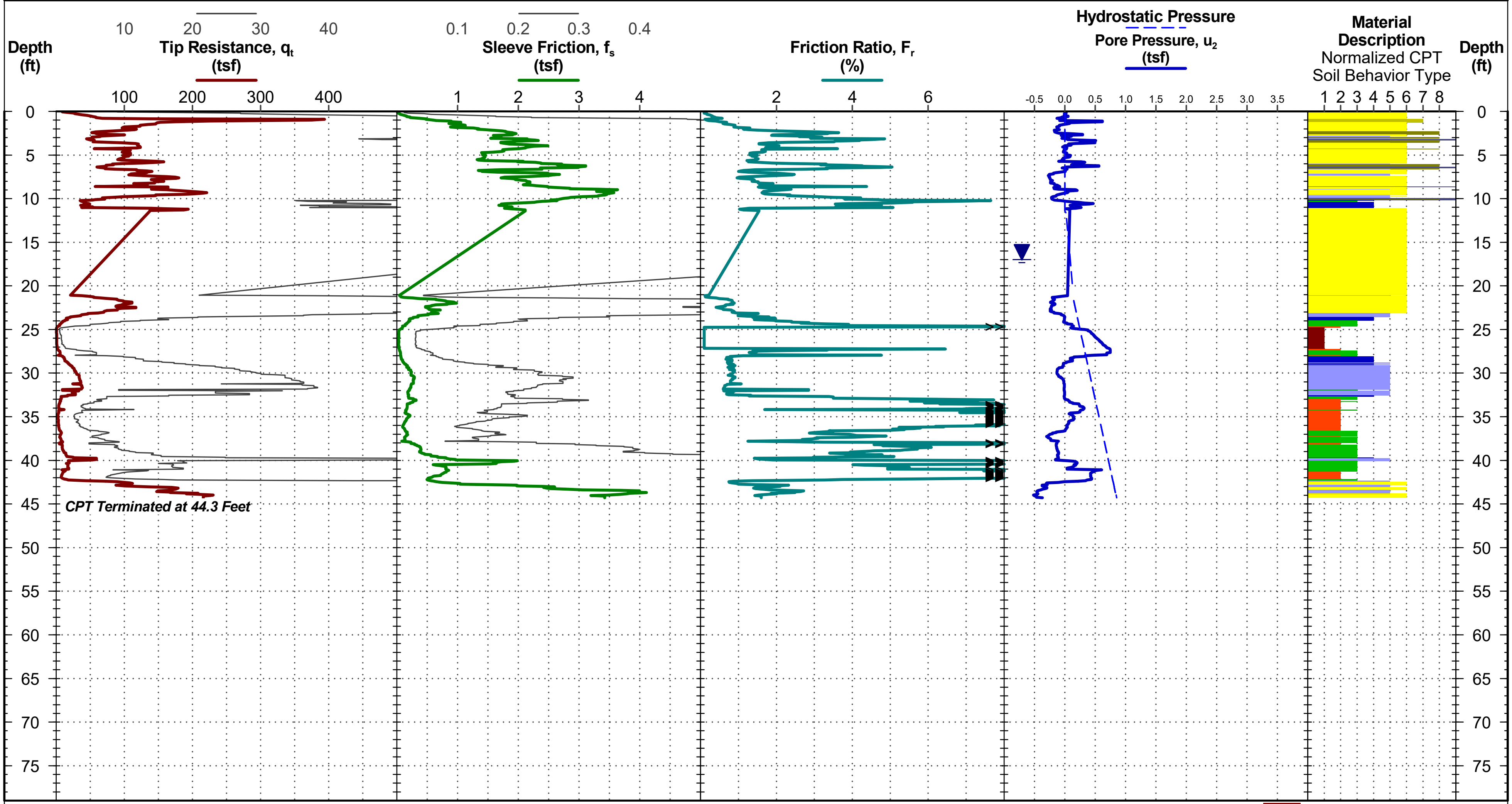
CLIENT: Garver, LLC
Tulsa, Oklahoma

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

TEST LOCATION: See exhibits A-2 & A-3

Latitude: 35.7255°
Longitude: -97.4161°

Station: 140+04
Offset: 53' RT from CRL



See Exhibit A-4 for description of field procedures.
See Appendix D for explanation of symbols and abbreviations.

CPT sensor calibration reports available upon request.

- 1 Sensitive, fine grained
- 2 Organic soils - clay
- 3 Clay - silty clay to clay
- 4 Silt mixtures - clayey silt to silty clay
- 5 Sand mixtures - silty sand to sandy silt
- 6 Sands - clean sand to silty sand
- 7 Gravelly sand to dense sand
- 8 Very stiff sand to clayey sand
- 9 Very stiff fine grained

WATER LEVEL OBSERVATION

▼ 17 ft estimated water depth
(used in normalizations and correlations; see Appendix D)

Probe no. 5037 with net area ratio of 0.832
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 8/28/2017
Tip and sleeve areas of 10 cm^2 and 150 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
4701 N Stiles Ave
Oklahoma City, OK

CPT Started: 11/21/2018	CPT Completed: 11/21/2018
Rig: 747	Operator: APS
Project No.: 03185252	Exhibit: A-12

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. CPT REPORT 03185252 EMBANKMENT SURVEY - I-35 OVER WATERLOO ROAD PHASE II.GPJ TERRACON_DATATEMPLATE.G

CPT LOG NO. EB4-CPT

PROJECT: Embankment Soil Survey
1-35 over Waterloo Road Interchange

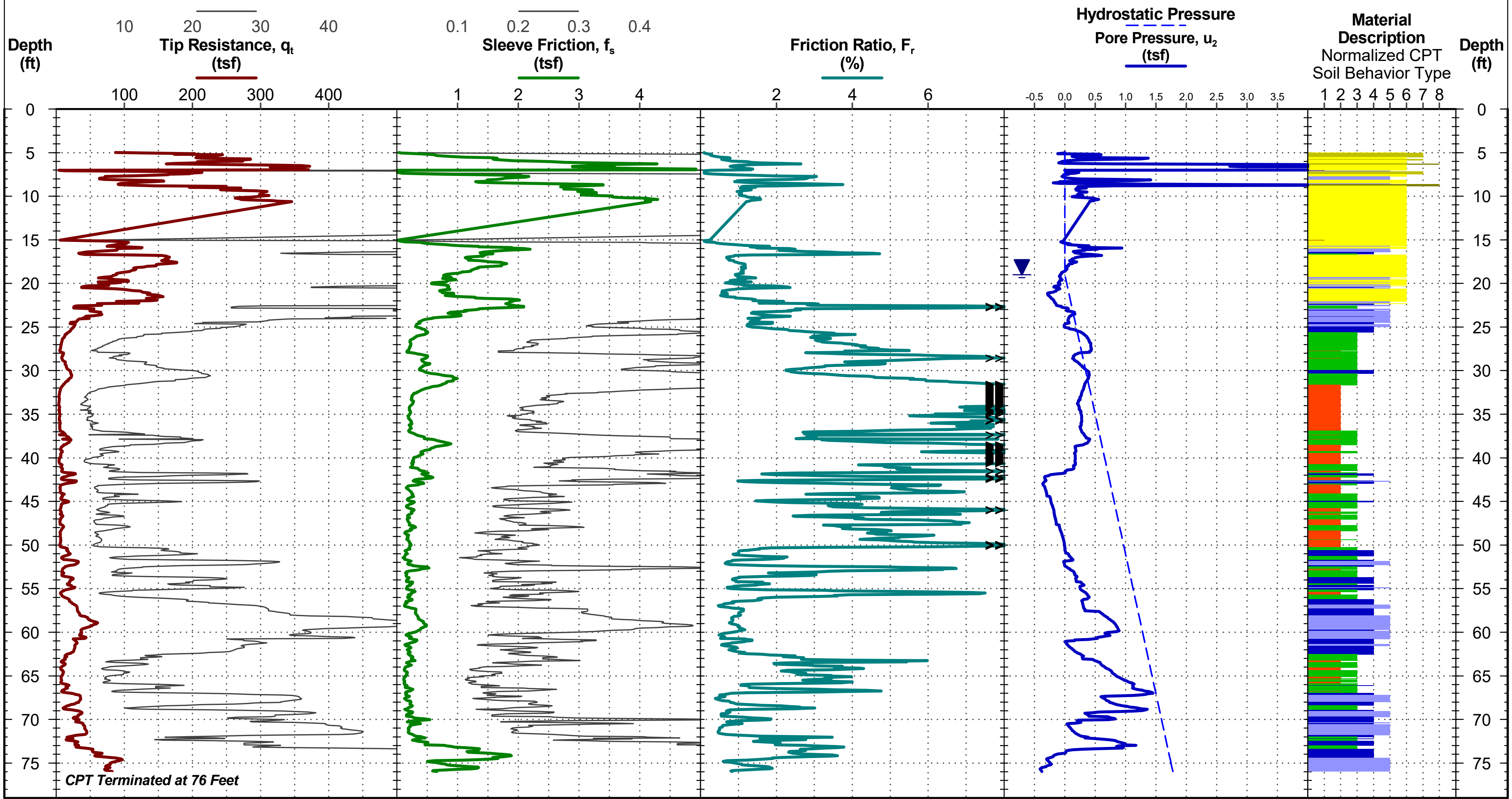
CLIENT: Garver, LLC
Tulsa, Oklahoma

TEST LOCATION: See exhibits A-2 & A-3

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

Latitude: 35.7244°
Longitude: -97.4155°

Station: 137+06
Offset: 9' LT from CL Ramp B



See Exhibit A-4 for description of field procedures.
See Appendix D for explanation of symbols and abbreviations.

CPT sensor calibration reports available upon request.

- 🟫 1 Sensitive, fine grained
- 🟥 2 Organic soils - clay
- 🟩 3 Clay - silty clay to clay
- 🟦 4 Silt mixtures - clayey silt to silty clay
- 🟪 5 Sand mixtures - silty sand to sandy silt
- 🟨 6 Sands - clean sand to silty sand
- 🟨 7 Gravelly sand to dense sand
- 🟫 8 Very stiff sand to clayey sand
- ⬛ 9 Very stiff fine grained

WATER LEVEL OBSERVATION

▼ 19 ft estimated water depth
(used in normalizations and correlations; see Appendix D)

Probe no. 5037 with net area ratio of 0.832
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 8/28/2017
Tip and sleeve areas of 10 cm^2 and 150 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
4701 N Stiles Ave
Oklahoma City, OK

CPT Started: 11/20/2018
Rig: 747
Project No.: 03185252

CPT Completed: 11/20/2018
Operator: APS
Exhibit: A-13

CPT LOG NO. EB5-CPT

Page 1 of 1

PROJECT: Embankment Soil Survey
1-35 over Waterloo Road Interchange

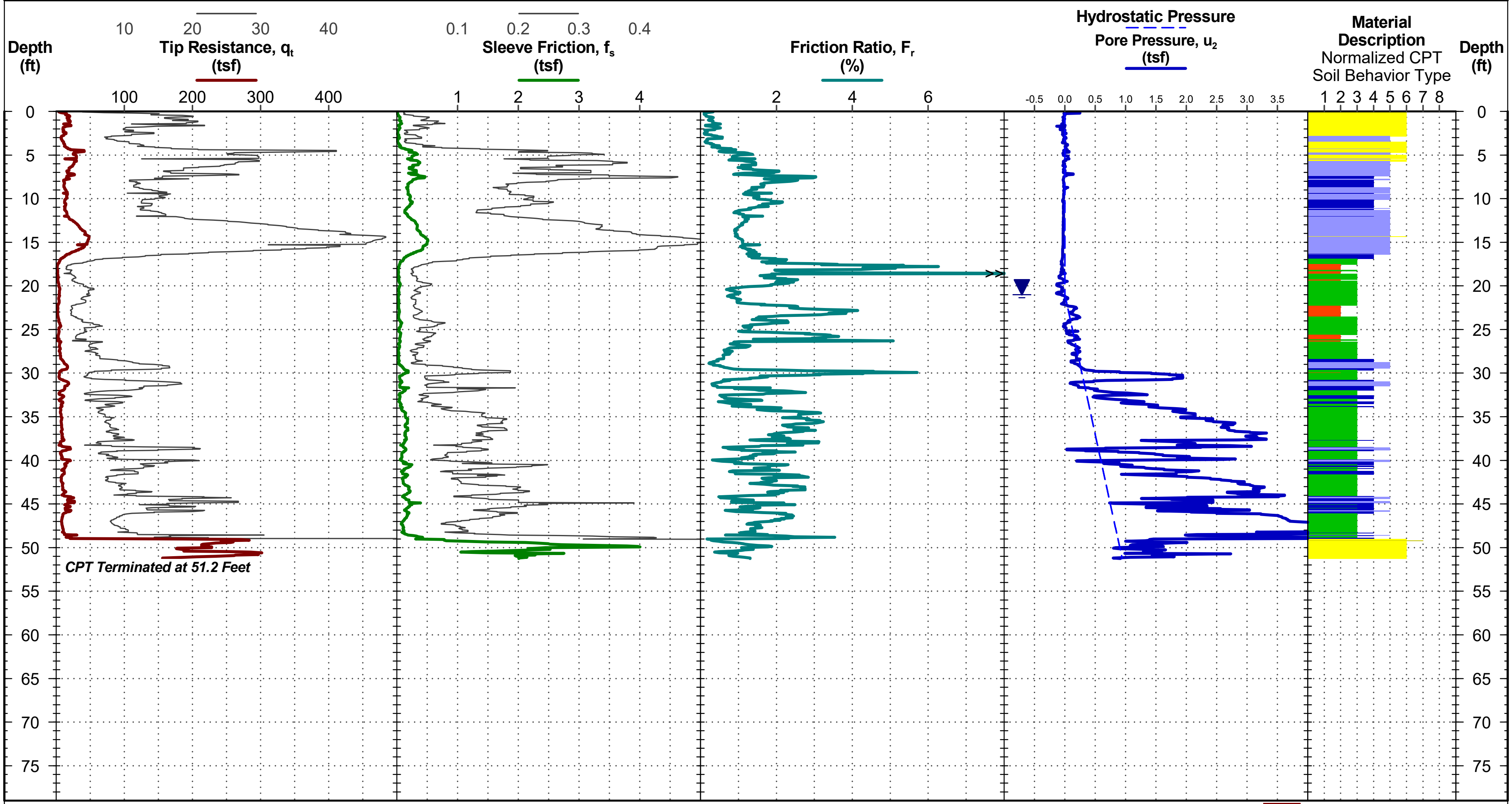
CLIENT: Garver, LLC
Tulsa, Oklahoma

TEST LOCATION: See exhibits A-2 & A-3

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

Latitude: 35.7238°
Longitude: -97.4143°

Station: 12+87
Offset: 13' RT from CRL



CPT Terminated at 51.2 Feet

See Exhibit A-4 for description of field procedures.
See Appendix D for explanation of symbols and abbreviations.

CPT sensor calibration reports available upon request.

- 🟥 1 Sensitive, fine grained
- 🟧 2 Organic soils - clay
- 🟩 3 Clay - silty clay to clay
- 🟦 4 Silt mixtures - clayey silt to silty clay
- 🟪 5 Sand mixtures - silty sand to sandy silt
- 🟨 6 Sands - clean sand to silty sand
- 🟨 7 Gravelly sand to dense sand
- 🟫 8 Very stiff sand to clayey sand
- ⬛ 9 Very stiff fine grained

WATER LEVEL OBSERVATION

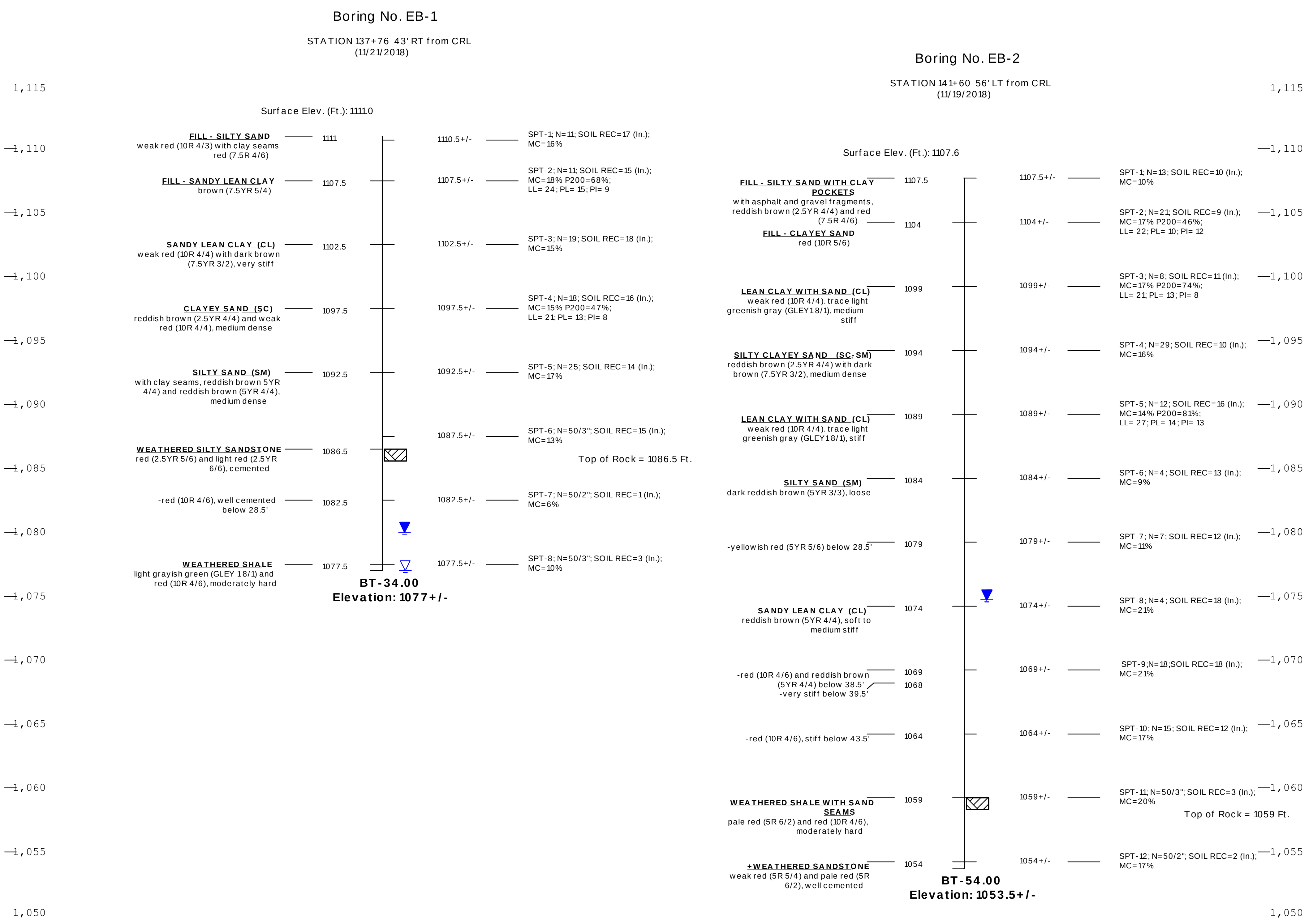
▼ 21 ft estimated water depth
(used in normalizations and correlations; see Appendix D)

Probe no. 5037 with net area ratio of 0.832
U2 pore pressure transducer location
Manufactured by Geotech A.B.; calibrated 8/28/2017
Tip and sleeve areas of 10 cm^2 and 150 cm^2
Ring friction reducer with O.D. of 1.875 in

Terracon
4701 N Stiles Ave
Oklahoma City, OK

CPT Started: 11/28/2018	CPT Completed: 11/28/2018
Rig: 747	Operator: APS
Project No.: 03185252	Exhibit: A-14

REVISIONS		
REV. NO.	DESCRIPTION	DATE



Boring No. EB-1

STATION 137+76 43' RT from CRL
(11/21/2018)

Surface Elev. (Ft.): 1111.0

FILL - SILTY SAND weak red (10R 4/3) with clay seams red (7.5R 4/6)	1111	1110.5+/-	SPT-1; N=11; SOIL REC=17 (In.); MC=16%
FILL - SANDY LEAN CLAY brown (7.5YR 5/4)	1107.5	1107.5+/-	SPT-2; N=11; SOIL REC=15 (In.); MC=18% P200=68%; LL= 24; PL= 15; PI= 9
SANDY LEAN CLAY (CL) weak red (10R 4/4) with dark brown (7.5YR 3/2), very stiff	1102.5	1102.5+/-	SPT-3; N=19; SOIL REC=18 (In.); MC=15%
CLAYEY SAND (SC) reddish brown (2.5YR 4/4) and weak red (10R 4/4), medium dense	1097.5	1097.5+/-	SPT-4; N=18; SOIL REC=16 (In.); MC=15% P200=47%; LL= 21; PL= 13; PI= 8
SILTY SAND (SM) with clay seams, reddish brown 5YR 4/4) and reddish brown (5YR 4/4), medium dense	1092.5	1092.5+/-	SPT-5; N=25; SOIL REC=14 (In.); MC=17%
		1087.5+/-	SPT-6; N=50/3"; SOIL REC=15 (In.); MC=13%
WEATHERED SILTY SANDSTONE red (2.5YR 5/6) and light red (2.5YR 6/6), cemented	1086.5		
-red (10R 4/6), well cemented below 28.5'	1082.5	1082.5+/-	SPT-7; N=50/2"; SOIL REC=1 (In.); MC=6%
WEATHERED SHALE light grayish green (GLEY 1 8/1) and red (10R 4/6), moderately hard	1077.5	1077.5+/-	SPT-8; N=50/3"; SOIL REC=3 (In.); MC=10%

Top of Rock = 1086.5 Ft.

BT-34.00
Elevation: 1077+/-

Boring No. EB-2

STATION 141+60 56' LT from CRL
(11/19/2018)

Surface Elev. (Ft.): 1107.6

FILL - SILTY SAND WITH CLAY POCKETS with asphalt and gravel fragments, reddish brown (2.5YR 4/4) and red (7.5R 4/6)	1107.5	1107.5+/-	SPT-1; N=13; SOIL REC=10 (In.); MC=10%
FILL - CLAYEY SAND red (10R 5/6)	1104	1104+/-	SPT-2; N=21; SOIL REC=9 (In.); MC=17% P200=46%; LL= 22; PL= 10; PI= 12
LEAN CLAY WITH SAND (CL) weak red (10R 4/4). trace light greenish gray (GLEY1 8/1), medium stiff	1099	1099+/-	SPT-3; N=8; SOIL REC=11 (In.); MC=17% P200=74%; LL= 21; PL= 13; PI= 8
SILTY CLAYEY SAND (SC-SM) reddish brown (2.5YR 4/4) with dark brown (7.5YR 3/2), medium dense	1094	1094+/-	SPT-4; N=29; SOIL REC=10 (In.); MC=16%
LEAN CLAY WITH SAND (CL) weak red (10R 4/4). trace light greenish gray (GLEY1 8/1), stiff	1089	1089+/-	SPT-5; N=12; SOIL REC=16 (In.); MC=14% P200=81%; LL= 27; PL= 14; PI= 13
SILTY SAND (SM) dark reddish brown (5YR 3/3), loose	1084	1084+/-	SPT-6; N=4; SOIL REC=13 (In.); MC=9%
-yellowish red (5YR 5/6) below 28.5'	1079	1079+/-	SPT-7; N=7; SOIL REC=12 (In.); MC=11%
SANDY LEAN CLAY (CL) reddish brown (5YR 4/4), soft to medium stiff	1074	1074+/-	SPT-8; N=4; SOIL REC=18 (In.); MC=21%
-red (10R 4/6) and reddish brown (5YR 4/4) below 38.5'	1069	1069+/-	SPT-9;N=18;SOIL REC=18 (In.); MC=21%
-very stiff below 39.5'	1068		
-red (10R 4/6), stiff below 43.5'	1064	1064+/-	SPT-10; N=15; SOIL REC=12 (In.); MC=17%
WEATHERED SHALE WITH SAND SEAMS pale red (5R 6/2) and red (10R 4/6), moderately hard	1059	1059+/-	SPT-11; N=50/3"; SOIL REC=3 (In.); MC=20%
+WEATHERED SANDSTONE weak red (5R 5/4) and pale red (5R 6/2), well cemented	1054	1054+/-	SPT-12; N=50/2"; SOIL REC=2 (In.); MC=17%

Top of Rock = 1059 Ft.

BT-54.00
Elevation: 1053.5+/-

LEGEND

DCD = DIAMOND CORE DRILLING, ASTM D2113-83
SPT = STANDARD PENETRATION TEST, ASTM D1586
SS = SPLIT SPOON SAMPLER
N = NUMBER OF BLOWS PER 12 INCHES
MC = MOISTURE CONTENT
LL = LIQUID LIMIT (NV=NO VALUE)
PI = PLASTICITY INDEX (NP=NO PLASTICITY)
#200 = PERCENT PASSING #200 SIEVE
UCS = UNCONFINED COMPRESSIVE STRENGTH
TCP = TEXAS CONE PENETROMETER
WCI = WET CAVE IN
▽ = WATER LEVEL WHILE DRILLING OR SAMPLING
▼ = WATER LEVEL AFTER DRILLING
▼ = WATER LEVEL 24 HOURS AFTER DRILLING
▨ = TOP OF ROCK

NOTE: WATER LEVEL ELEVATIONS SHOWN WERE OBTAINED AT THE TIME THE BORINGS WERE DRILLED AND MAY FLUCTUATE THROUGHOUT THE YEAR.

NOTE: "SS" DENOTES STANDARD PENETRATION TEST, AASHTO D1586-84. "TCP" DENOTES TEXAS CONE PENETRATION TEST.

* NOTE: TOP OF ROCK LINE SHOWN FOR ESTIMATING PURPOSES ONLY.

** NOTE: WATER LEVEL ELEVATION SHOWN WERE OBTAINED AT THE TIME THE BORINGS WERE DRILLED AND MAY FLUCTUATE THROUGHOUT THE YEAR.

*** NOTE: ROCK CLASSIFICATION IS BASED ON DRILLING CHARACTERISTICS AND VISUAL OBSERVATION OF ROCK CORE SAMPLES. PETROGRAPHIC ANALYSIS OF THIN SECTIONS OF THE ROCK CORE SAMPLES MAY REVEAL OTHER TYPES.

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Terracon

OKLAHOMA AND LOGAN COUNTIES

SUBSURFACE PROFILE
(SHEET 1 OF 3)

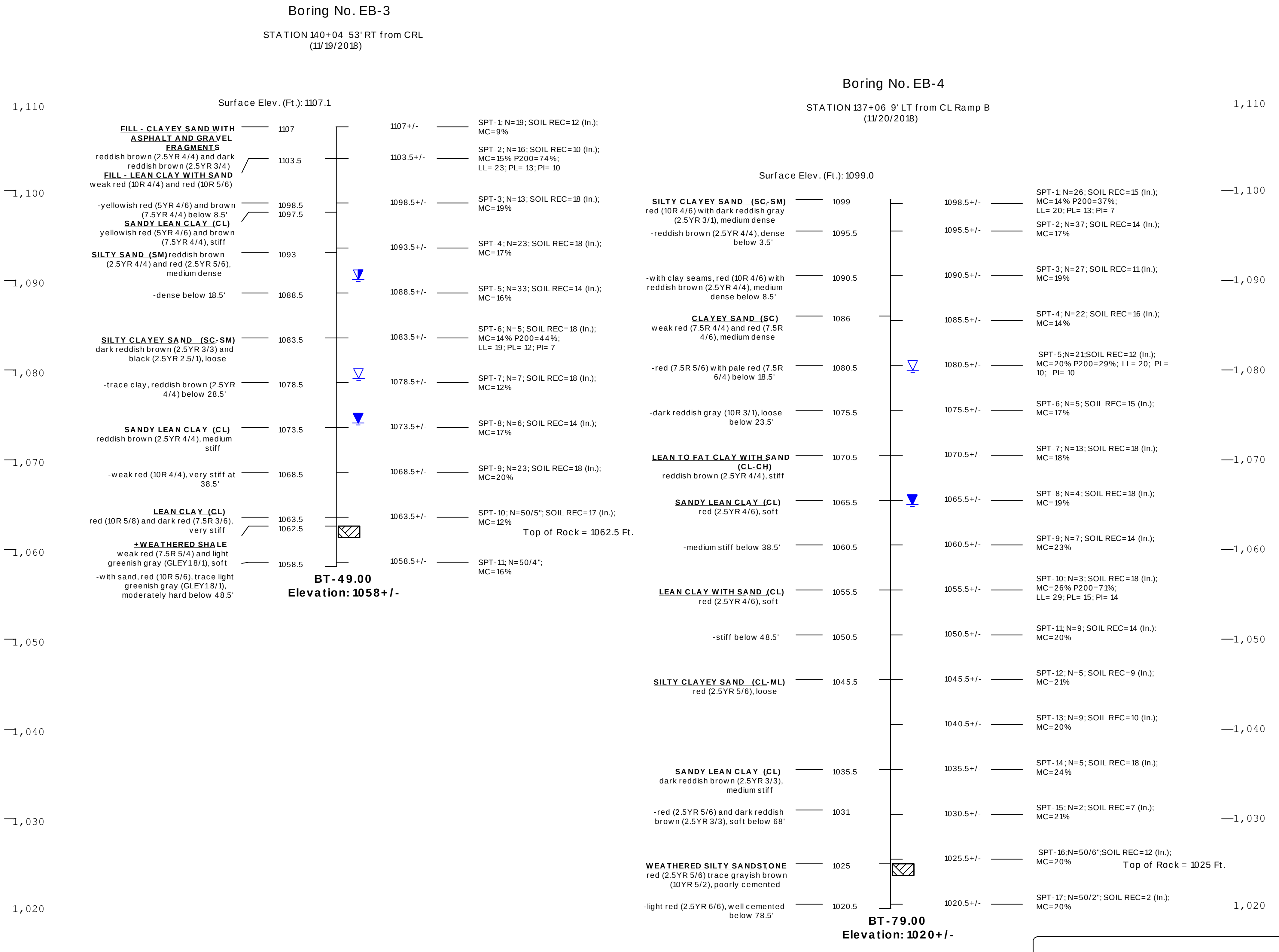
Design	XX	X/XX
Detail	XX	X/XX
Check	XX	X/XX

Squad: XXXXXXX
Engr.: XXXXXXXX

STATE OF OKLAHOMA
DEPARTMENT OF TRANSPORTATION
JOB PIECE NO. 29843(04)
SHEET NO XXX

Exhibit A-15

REVISIONS		
REV. NO.	DESCRIPTION	DATE



Boring No. EB-3

STATION 140+04 53' RT from CRL
(11/19/2018)

Surface Elev. (Ft.): 1107.1

FILL - CLAYEY SAND WITH ASPHALT AND GRAVEL FRAGMENTS reddish brown (2.5YR 4/4) and dark reddish brown (2.5YR 3/4)	1107	1107+/-	SPT-1; N=19; SOIL REC=12 (In.); MC=9%
FILL - LEAN CLAY WITH SAND weak red (10R 4/4) and red (10R 5/6)	1103.5	1103.5+/-	SPT-2; N=16; SOIL REC=10 (In.); MC=15% P200=74%; LL= 23; PL= 13; PI= 10
-yellowish red (5YR 4/6) and brown (7.5YR 4/4) below 8.5'	1098.5	1098.5+/-	SPT-3; N=13; SOIL REC=18 (In.); MC=19%
SANDY LEAN CLAY (CL) yellowish red (5YR 4/6) and brown (7.5YR 4/4), stiff	1097.5		
SILTY SAND (SM) reddish brown (2.5YR 4/4) and red (2.5YR 5/6), medium dense	1093	1093.5+/-	SPT-4; N=23; SOIL REC=18 (In.); MC=17%
-dense below 18.5'	1088.5	1088.5+/-	SPT-5; N=33; SOIL REC=14 (In.); MC=16%
SILTY CLAYEY SAND (SC-SM) dark reddish brown (2.5YR 3/3) and black (2.5YR 2.5/1), loose	1083.5	1083.5+/-	SPT-6; N=5; SOIL REC=18 (In.); MC=14% P200=44%; LL= 19; PL= 12; PI= 7
-trace clay, reddish brown (2.5YR 4/4) below 28.5'	1078.5	1078.5+/-	SPT-7; N=7; SOIL REC=18 (In.); MC=12%
SANDY LEAN CLAY (CL) reddish brown (2.5YR 4/4), medium stiff	1073.5	1073.5+/-	SPT-8; N=6; SOIL REC=14 (In.); MC=17%
-weak red (10R 4/4), very stiff at 38.5'	1068.5	1068.5+/-	SPT-9; N=23; SOIL REC=18 (In.); MC=20%
LEAN CLAY (CL) red (10R 5/8) and dark red (7.5R 3/6), very stiff	1063.5	1063.5+/-	SPT-10; N=50/5"; SOIL REC=17 (In.); MC=12%
+WEATHERED SHALE weak red (7.5R 5/4) and light greenish gray (GLEY1 8/1), soft	1062.5		Top of Rock = 1062.5 Ft.
-with sand, red (10R 5/6), trace light greenish gray (GLEY1 8/1), moderately hard below 48.5'	1058.5	1058.5+/-	SPT-11; N=50/4"; MC=16%

BT-49.00
Elevation: 1058+/-

Boring No. EB-4

STATION 137+06 9' LT from CL Ramp B
(11/20/2018)

Surface Elev. (Ft.): 1099.0

SILTY CLAYEY SAND (SC-SM) red (10R 4/6) with dark reddish gray (2.5YR 3/1), medium dense	1099	1098.5+/-	SPT-1; N=26; SOIL REC=15 (In.); MC=14% P200=37%; LL= 20; PL= 13; PI= 7
-reddish brown (2.5YR 4/4), dense below 3.5'	1095.5	1095.5+/-	SPT-2; N=37; SOIL REC=14 (In.); MC=17%
-with clay seams, red (10R 4/6) with reddish brown (2.5YR 4/4), medium dense below 8.5'	1090.5	1090.5+/-	SPT-3; N=27; SOIL REC=11 (In.); MC=19%
CLAYEY SAND (SC) weak red (7.5R 4/4) and red (7.5R 4/6), medium dense	1086	1085.5+/-	SPT-4; N=22; SOIL REC=16 (In.); MC=14%
-red (7.5R 5/6) with pale red (7.5R 6/4) below 18.5'	1080.5	1080.5+/-	SPT-5;N=21;SOIL REC=12 (In.); MC=20% P200=29%; LL= 20; PL= 10; PI= 10
-dark reddish gray (10R 3/1), loose below 23.5'	1075.5	1075.5+/-	SPT-6; N=5; SOIL REC=15 (In.); MC=17%
LEAN TO FAT CLAY WITH SAND (CL-CH) reddish brown (2.5YR 4/4), stiff	1070.5	1070.5+/-	SPT-7; N=13; SOIL REC=18 (In.); MC=18%
SANDY LEAN CLAY (CL) red (2.5YR 4/6), soft	1065.5	1065.5+/-	SPT-8; N=4; SOIL REC=18 (In.); MC=19%
-medium stiff below 38.5'	1060.5	1060.5+/-	SPT-9; N=7; SOIL REC=14 (In.); MC=23%
LEAN CLAY WITH SAND (CL) red (2.5YR 4/6), soft	1055.5	1055.5+/-	SPT-10; N=3; SOIL REC=18 (In.); MC=26% P200=71%; LL= 29; PL= 15; PI= 14
-stiff below 48.5'	1050.5	1050.5+/-	SPT-11; N=9; SOIL REC=14 (In.): MC=20%
SILTY CLAYEY SAND (CL-ML) red (2.5YR 5/6), loose	1045.5	1045.5+/-	SPT-12; N=5; SOIL REC=9 (In.); MC=21%
		1040.5+/-	SPT-13; N=9; SOIL REC=10 (In.); MC=20%
SANDY LEAN CLAY (CL) dark reddish brown (2.5YR 3/3), medium stiff	1035.5	1035.5+/-	SPT-14; N=5; SOIL REC=18 (In.); MC=24%
-red (2.5YR 5/6) and dark reddish brown (2.5YR 3/3), soft below 68'	1031	1030.5+/-	SPT-15; N=2; SOIL REC=7 (In.); MC=21%
WEATHERED SILTY SANDSTONE red (2.5YR 5/6) trace grayish brown (10YR 5/2), poorly cemented	1025	1025.5+/-	SPT-16;N=50/6";SOIL REC=12 (In.); MC=20% Top of Rock = 1025 Ft.
-light red (2.5YR 6/6), well cemented below 78.5'	1020.5	1020.5+/-	SPT-17; N=50/2"; SOIL REC=2 (In.); MC=20%

BT-79.00
Elevation: 1020+/-

LEGEND

DCD = DIAMOND CORE DRILLING, ASTM D2113-83
SPT = STANDARD PENETRATION TEST, ASTM D1586
SS = SPLIT SPOON SAMPLER
N = NUMBER OF BLOWS PER 12 INCHES
MC = MOISTURE CONTENT
LL = LIQUID LIMIT (NV=NO VALUE)
PI = PLASTICITY INDEX (NP=NO PLASTICITY)
#200 = PERCENT PASSING #200 SIEVE
UCS = UNCONFINED COMPRESSIVE STRENGTH
TCP = TEXAS CONE PENETROMETER
WCI = WET CAVE IN
∇ = WATER LEVEL WHILE DRILLING OR SAMPLING
▼ = WATER LEVEL AFTER DRILLING
▼ = WATER LEVEL 24 HOURS AFTER DRILLING
▨ = TOP OF ROCK

NOTE: WATER LEVEL ELEVATIONS SHOWN WERE OBTAINED AT THE TIME THE BORINGS WERE DRILLED AND MAY FLUCTUATE THROUGHOUT THE YEAR.

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Terracon

OKLAHOMA AND LOGAN COUNTIES

SUBSURFACE PROFILE
(SHEET 2 OF 3)

Design	XX	X/XX
Detail	XX	X/XX
Check	XX	X/XX

Squad: XXXXXXX
Engr.: XXXXXXXX

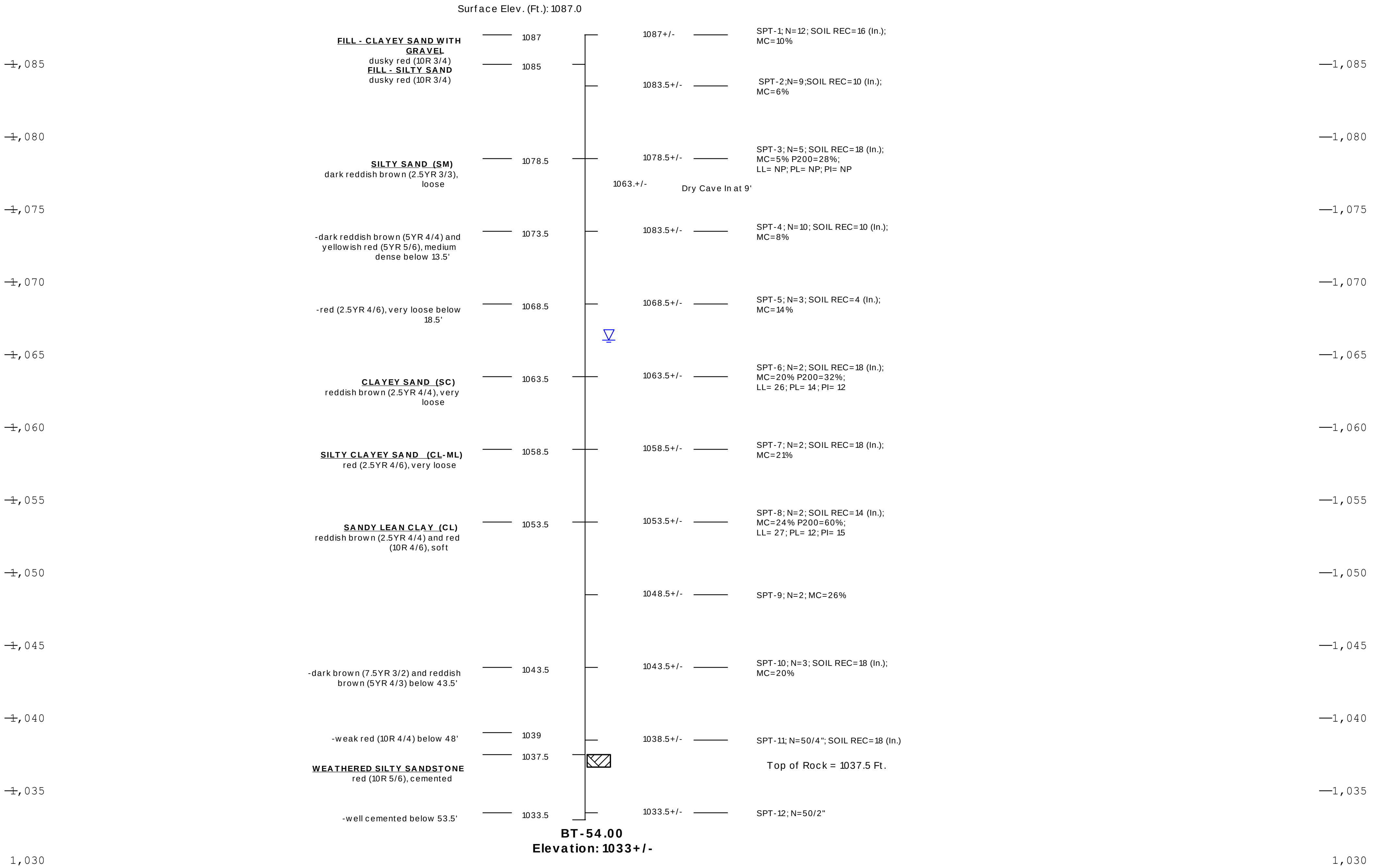
STATE OF OKLAHOMA
DEPARTMENT OF TRANSPORTATION
JOB PIECE NO. 29843(04)
SHEET NO XXX

Exhibit A-16

REVISIONS		
REV. NO.	DESCRIPTION	DATE

Boring No. EB-5

STATION 12+87 13' RT from CRL
(11/27/2018)



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Terracon

OKLAHOMA AND LOGAN COUNTIES

SUBSURFACE PROFILE
(SHEET 3 OF 3)

Design	XX	X/XX
Detail	XX	X/XX
Check	XX	X/XX

Squad: XXXXXXX
Engr.: XXXXXXXX

STATE OF OKLAHOMA
DEPARTMENT OF TRANSPORTATION
JOB PIECE NO. 29843(04)
SHEET NO XXX

Exhibit A-17

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 D. Samples of bedrock were classified in accordance with the general notes for Sedimentary Rock Classification. At that time, the field descriptions were confirmed or 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 and bedrock samples and the test results are presented in this appendix. The laboratory test results were used for the geotechnical engineering, slope stability and settlement analyses. Laboratory tests were performed in general accordance with the applicable ASTM and AASHTO, local or other accepted standards.

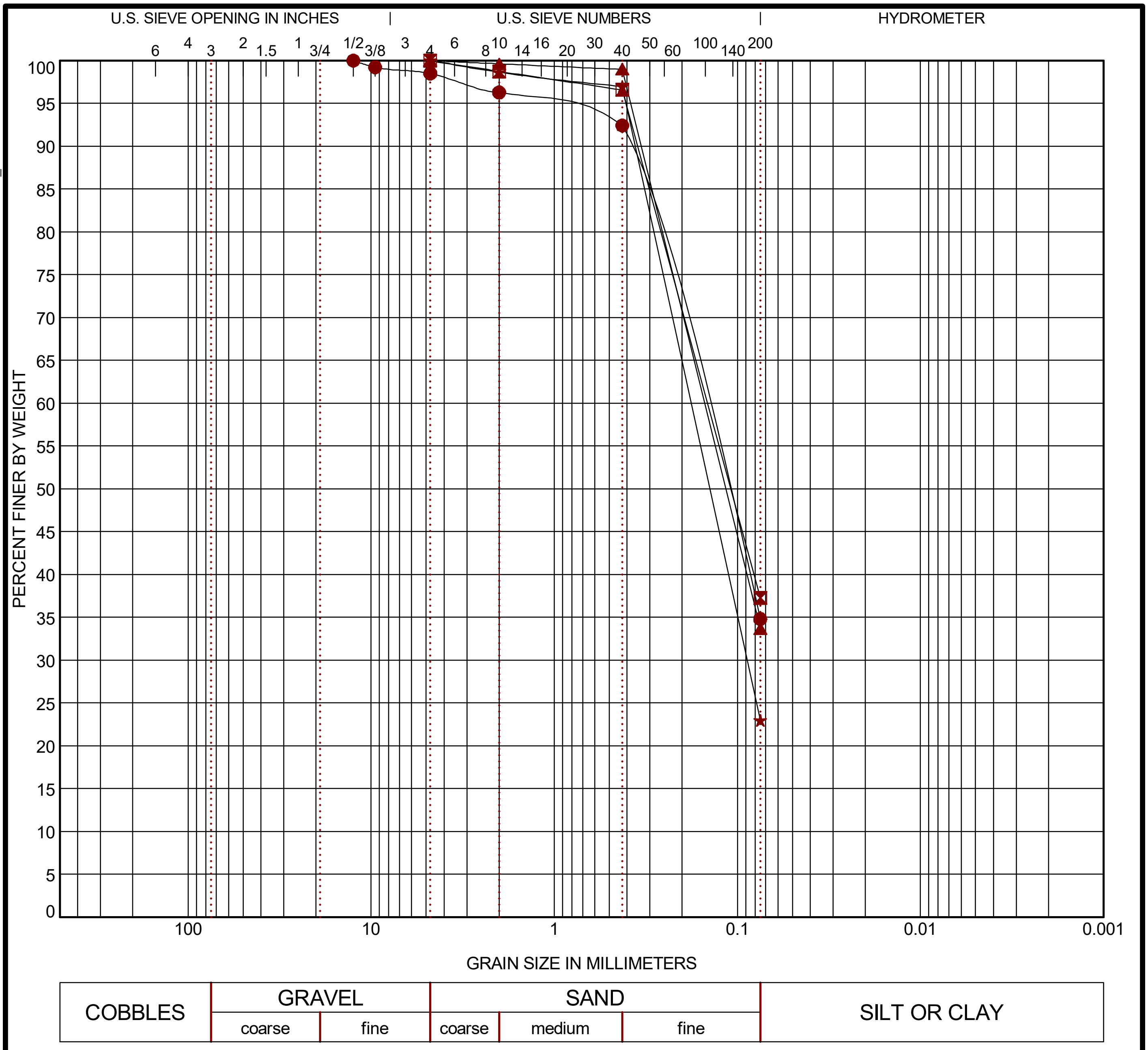
Selected soil and bedrock samples obtained from the site were tested for the following engineering properties:

- Visual Classification (ASTM D2488)
- In-situ Water Content (AASHTO T 265)
- Sieve Analysis (AASHTO T88)
- Atterberg Limits (AASHTO T 89 and T90)
- Moisture Density Relationship (AASHTO T-99)
- Direct Shear Test (ASTM D3080)

Procedural standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	Bulk EB-1	1 - 5	SILTY, CLAYEY SAND (SC-SM)	A-2-4 (0)		20	14	6		
☒	Bulk EB-2	1 - 5	SILTY SAND (SM)	A-4 (0)		NP	NP	NP		
▲	Bulk EB-4	1 - 5	SILTY SAND (SM)	A-2-4 (0)		NP	NP	NP		
★	Bulk EB-5	1 - 5	SILTY SAND (SM)	A-2-4 (0)		NP	NP	NP		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	Bulk EB-1	1 - 5	12.5	0.16			1.5	63.7		34.8	
☒	Bulk EB-2	1 - 5	4.75	0.146			0.0	62.7		37.3	
▲	Bulk EB-4	1 - 5	4.75	0.151			0.0	66.3		33.7	
★	Bulk EB-5	1 - 5	4.75	0.179	0.088		0.0	77.0		23.0	

PROJECT: Embankment Survey
1-35 over Waterloo Road Interchange

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

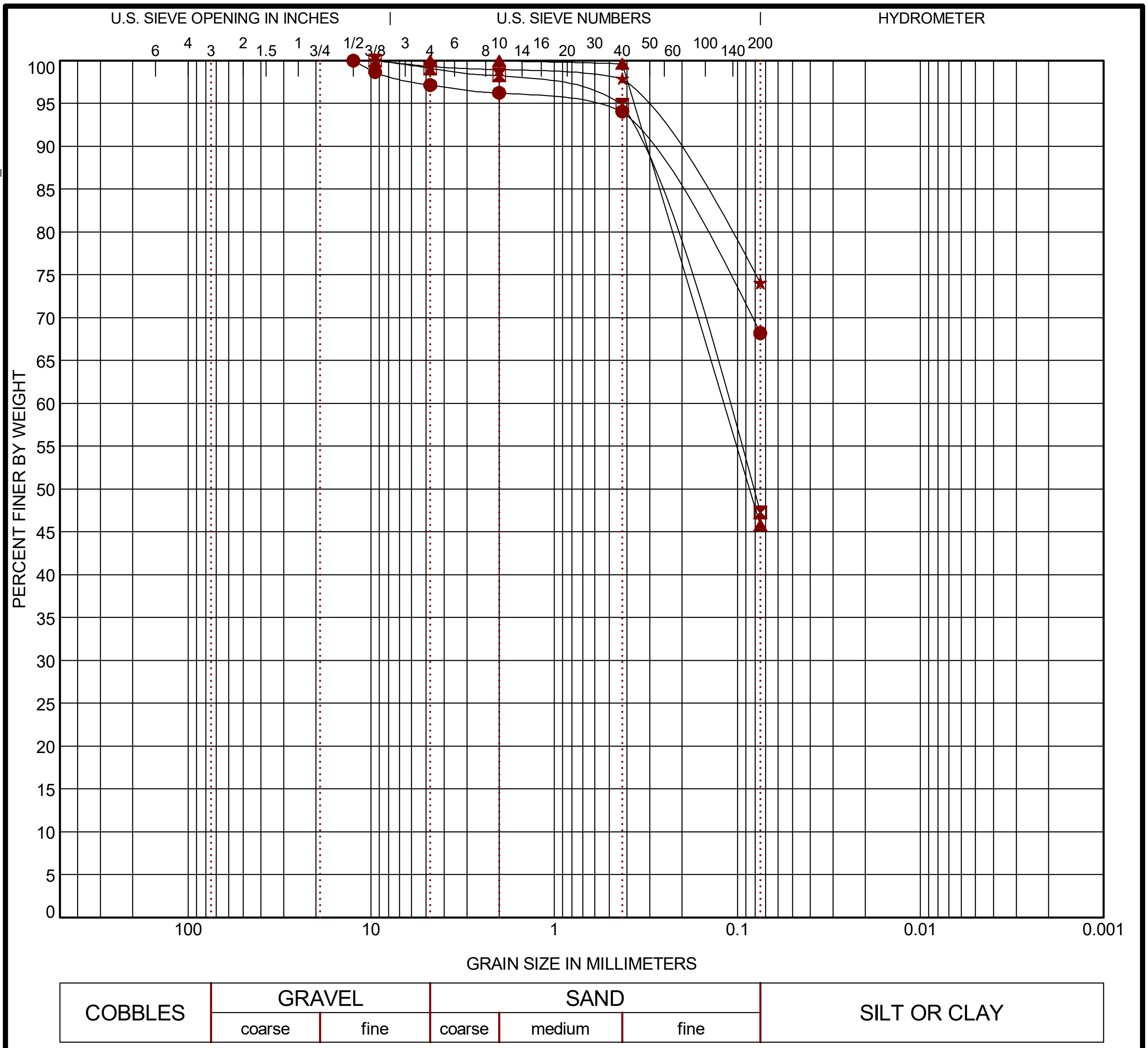
PROJECT NUMBER: 03185252

CLIENT: Garver, LLC
Tulsa, Oklahoma

EXHIBIT: B-2

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	EB-1	3.5 - 5	SANDY LEAN CLAY (CL)	A-4 (3)	18	24	15	9		
☒	EB-1	13.5 - 15	CLAYEY SAND (SC)	A-4 (1)	15	21	13	8		
▲	EB-2	3.5 - 5	CLAYEY SAND (SC)	A-6 (2)	17	22	10	12		
★	EB-2	8.5 - 10	LEAN CLAY with SAND (CL)	A-4 (3)	17	21	13	8		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	EB-1	3.5 - 5	12.5				2.8	29.0		68.2	
☒	EB-1	13.5 - 15	9.5	0.119			0.9	51.8		47.3	
▲	EB-2	3.5 - 5	4.75	0.119			0.0	54.2		45.8	
★	EB-2	8.5 - 10	9.5				0.7	25.2		74.1	

PROJECT: Embankment Survey
1-35 over Waterloo Road Interchange

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03185252

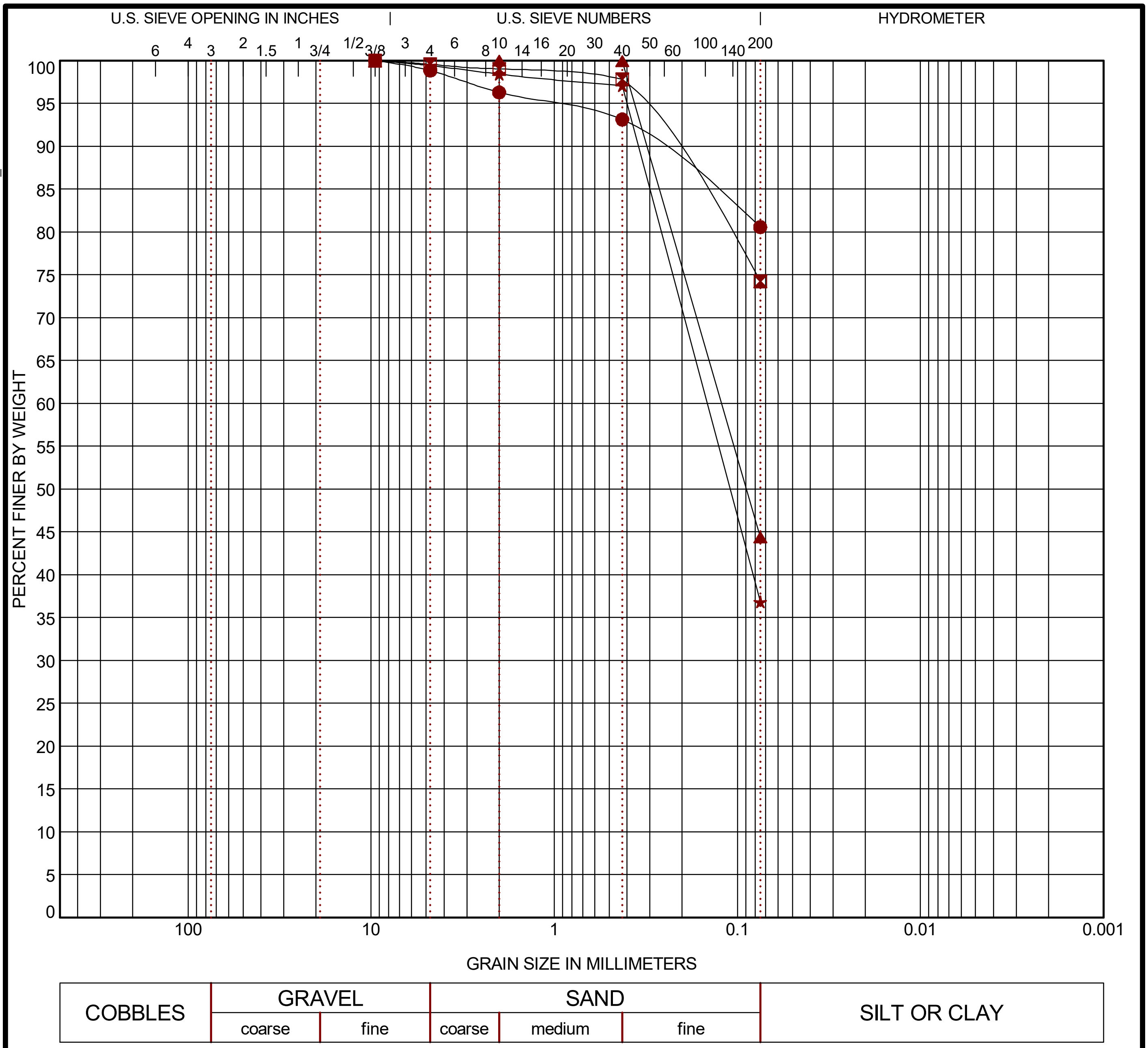
CLIENT: Garver, LLC
Tulsa, Oklahoma

EXHIBIT: B-3

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO DESC COMBINED 03185252 EMBANKMENT SURVEY - I-35 OVER WATERLOO ROAD PHASE II.GPJ TERRACON_DATATEMPLATE.GDT 1/7/19

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	EB-2	18.5 - 20	LEAN CLAY with SAND (CL)	A-6 (8)	14	27	14	13		
☒	EB-3	3.5 - 5	LEAN CLAY with SAND (CL)	A-4 (4)	15	23	13	10		
▲	EB-3	23.5 - 25	SILTY, CLAYEY SAND (SC-SM)	A-4 (0)	14	19	12	7		
★	EB-4	0.4 - 1.9	SILTY, CLAYEY SAND (SC-SM)	A-4 (0)	14	20	13	7		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	EB-2	18.5 - 20	9.5				1.2	18.3		80.6	
☒	EB-3	3.5 - 5	9.5				0.4	25.3		74.2	
▲	EB-3	23.5 - 25	2	0.122			0.0	55.6		44.4	
★	EB-4	0.4 - 1.9	9.5	0.146			0.6	62.6		36.8	

PROJECT: Embankment Survey
1-35 over Waterloo Road Interchange

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03185252

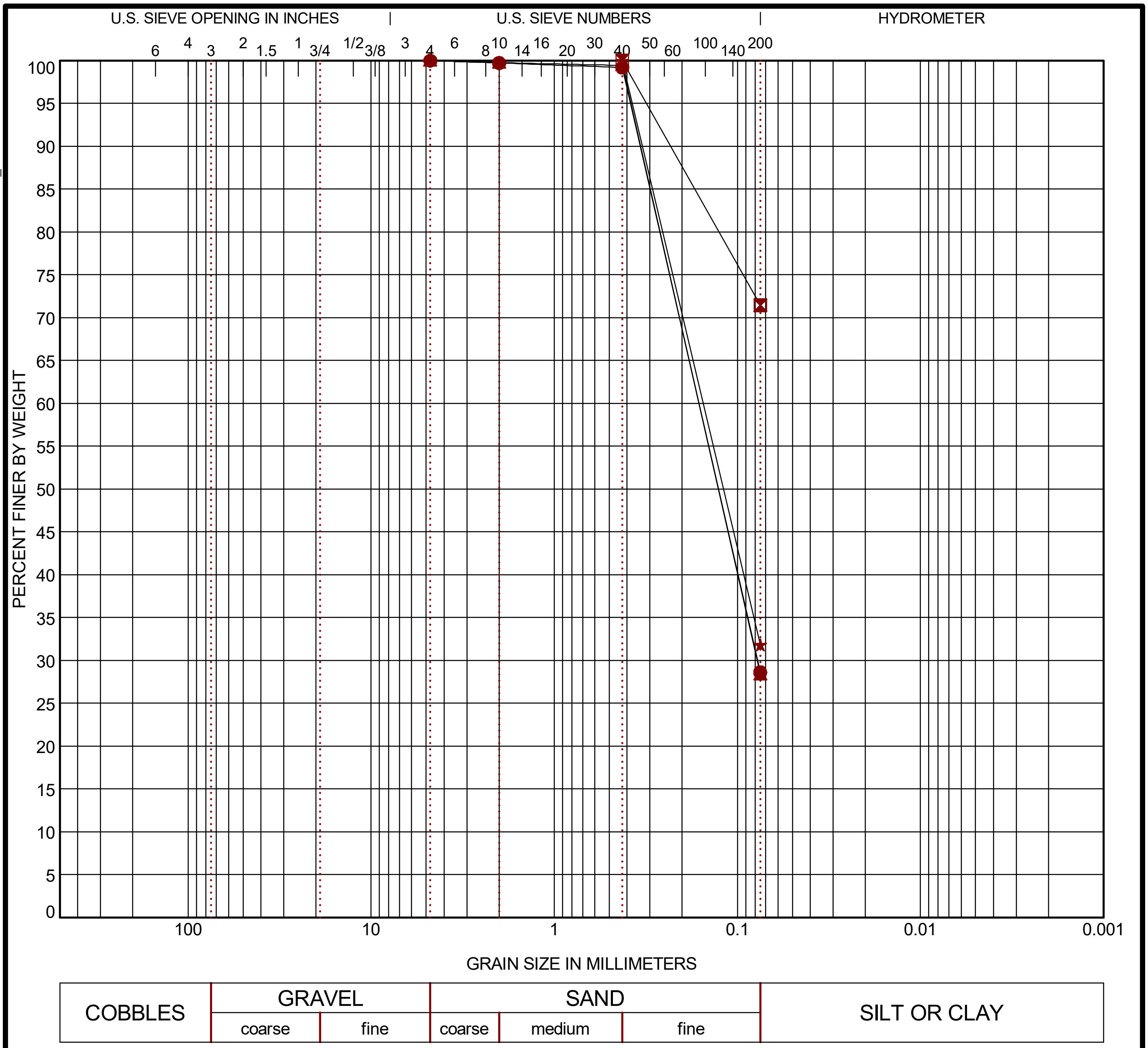
CLIENT: Garver, LLC
Tulsa, Oklahoma

EXHIBIT: B-4

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO DESC COMBINED 03185252 EMBANKMENT SURVEY - I-35 OVER WATERLOO ROAD PHASE II.GPJ TERRACON_DATATEMPLATE.GDT 1/7/19

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	EB-4	18.5 - 20	CLAYEY SAND (SC)	A-2-4 (0)	20	20	10	10		
☒	EB-4	43.5 - 45	LEAN CLAY with SAND (CL)	A-6 (7)	26	29	15	14		
▲	EB-5	8.5 - 10	SILTY SAND (SM)	A-2-4 (0)	5	NP	NP	NP		
★	EB-5	23.5 - 25	CLAYEY SAND (SC)	A-2-6 (0)	20	26	14	12		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	EB-4	18.5 - 20	4.75	0.162	0.078		0.0	71.4		28.6	
☒	EB-4	43.5 - 45	0.425				0.0	28.6		71.4	
▲	EB-5	8.5 - 10	4.75	0.162	0.078		0.0	71.6		28.4	
★	EB-5	23.5 - 25	0.425	0.154				68.1		31.8	

PROJECT: Embankment Survey
1-35 over Waterloo Road Interchange

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

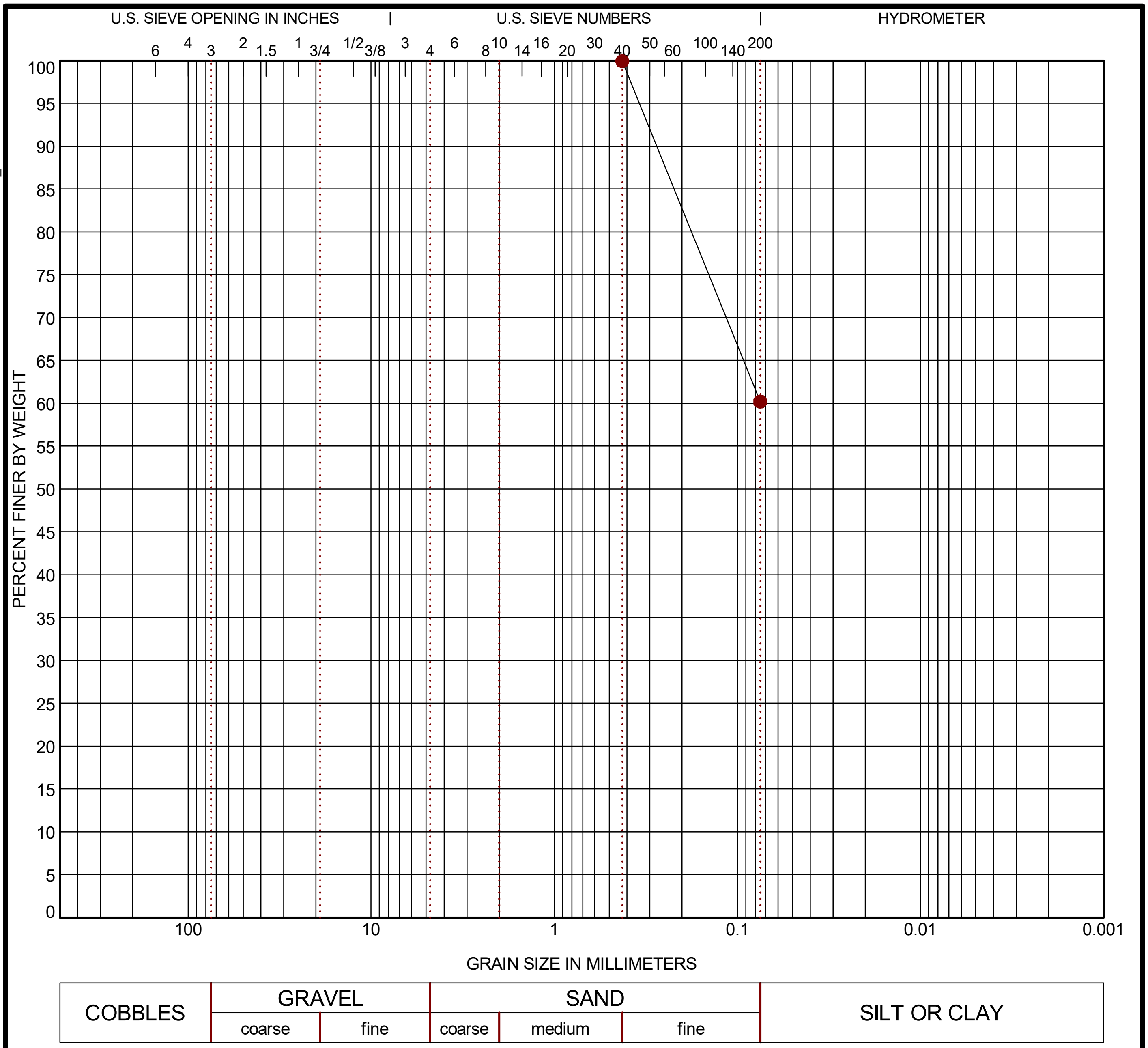
PROJECT NUMBER: 03185252

CLIENT: Garver, LLC
Tulsa, Oklahoma

EXHIBIT: B-5

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	EB-5	33.5 - 35	SANDY LEAN CLAY (CL)	A-6 (6)	24	27	12	15		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	EB-5	33.5 - 35	0.425					39.7		60.2	

PROJECT: Embankment Survey
1-35 over Waterloo Road Interchange

SITE: Interstate 35 and Waterloo Road
Oklahoma & Logan Counties, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03185252

CLIENT: Garver, LLC
Tulsa, Oklahoma

EXHIBIT: B-6

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO DESC COMBINED 03185252 EMBANKMENT SURVEY - I-35 OVER WATERLOO ROAD PHASE II.GPJ TERRACON_DATATEMPLATE.GDT 1/7/19

Terracon

Laboratory Compaction Characteristics of Soil

4701 North Stiles Ave.
Oklahoma City, OK 73105
(405) 525 0453

Client Name: Garver, LLC
Project Name: Embankment Survey
Location: Interstate 35 over Waterloo Road Interchange
Oklahoma and Logan Counties, Oklahoma

Source Material: Bulk EB-1 (1.0-5.0')
Sample Description: Silty, clayey sand, weak red (10R 4/3) and
brown (7.5YR 5/4)
Material Designation: lab 785 Sample date: 11/21/18
Test Method: Method A
Test Procedure: AASHTO T-99
Sample Preparation: Dry
Rammer: X Mechanical ____ Manual

Project No.: 03185252 Date: 12/07/18

TEST RESULTS

Maximum Dry Unit Wt.: 118.7 pcf
Optimum Water Content: 13.3 %

Liquid Limit: 20 Plastic Limit: 14
Plasticity Index: 6
% passing # 200 sieve: 35
AASHTO Class. A-2-4(0) USCS: SC-SM
Reviewed by: DCVS

Zero air voids for specific gravity of 2.70

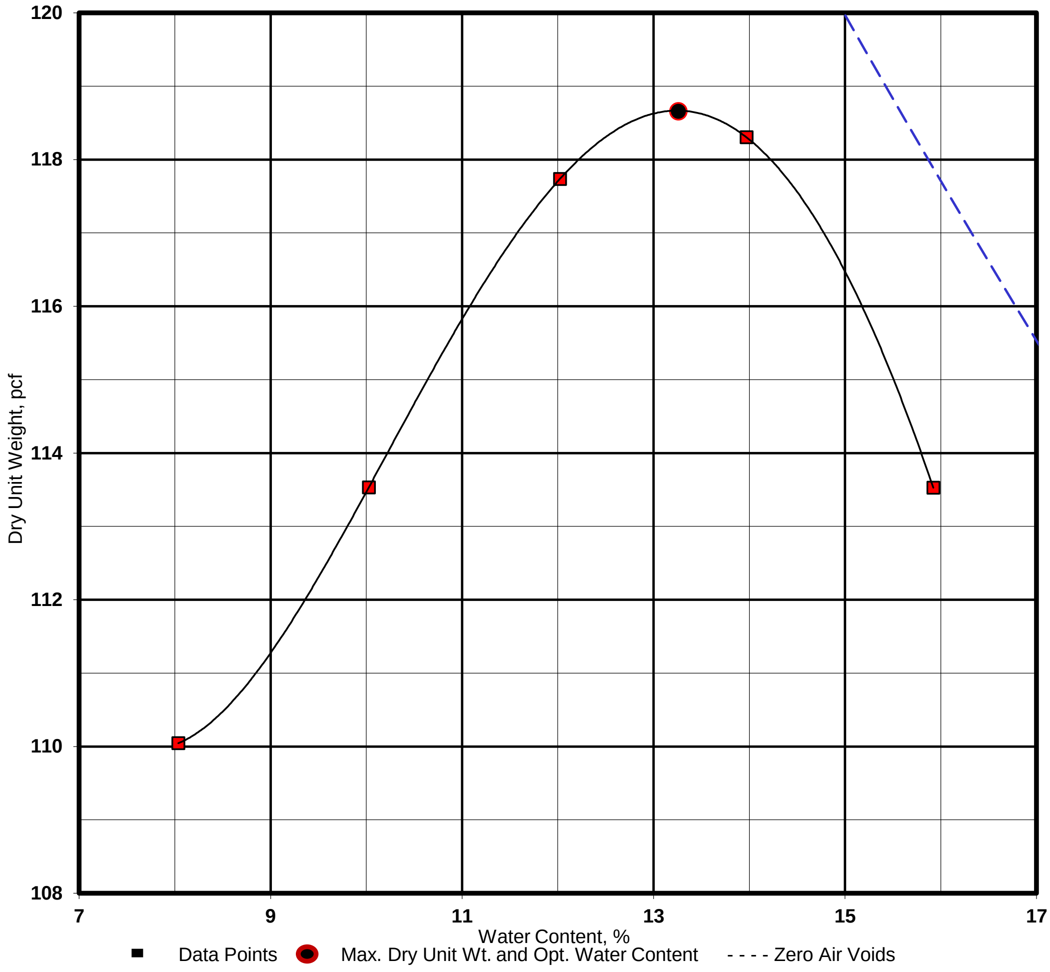


Exhibit B-7

Terracon

Laboratory Compaction Characteristics of Soil

4701 North Stiles Ave.
Oklahoma City, OK 73105
(405) 525 0453

Client Name: Garver, LLC

Project Name: Embankment Survey

Location: Interstate 35 over Waterloo Road Interchange
Oklahoma and Logan Counties, Oklahoma

Project No.: 03185252 Date: 12/07/18

TEST RESULTS

Maximum Dry Unit Wt.: 114.9 pcf

Optimum Water Content: 12.2 %

Source Material: Bulk EB-2 (1.0-5.0')

Sample Description: Silty Sand, reddish-brown (2.5YR 4/4) and red (7.5YR 4/6) and red (10R 5/6)

Material Designation: lab 786 Sample date: 11/19/18

Test Method: Method A

Test Procedure: AASHTO T-99

Sample Preparation: Dry

Rammer: X Mechanical ____ Manual

Liquid Limit: NP Plastic Limit: NP

Plasticity Index: NP

% passing # 200 sieve: 37

AASHTO Class. A-4(0) USCS: SM

Reviewed by: DCVS

Zero air voids for specific gravity of 2.70

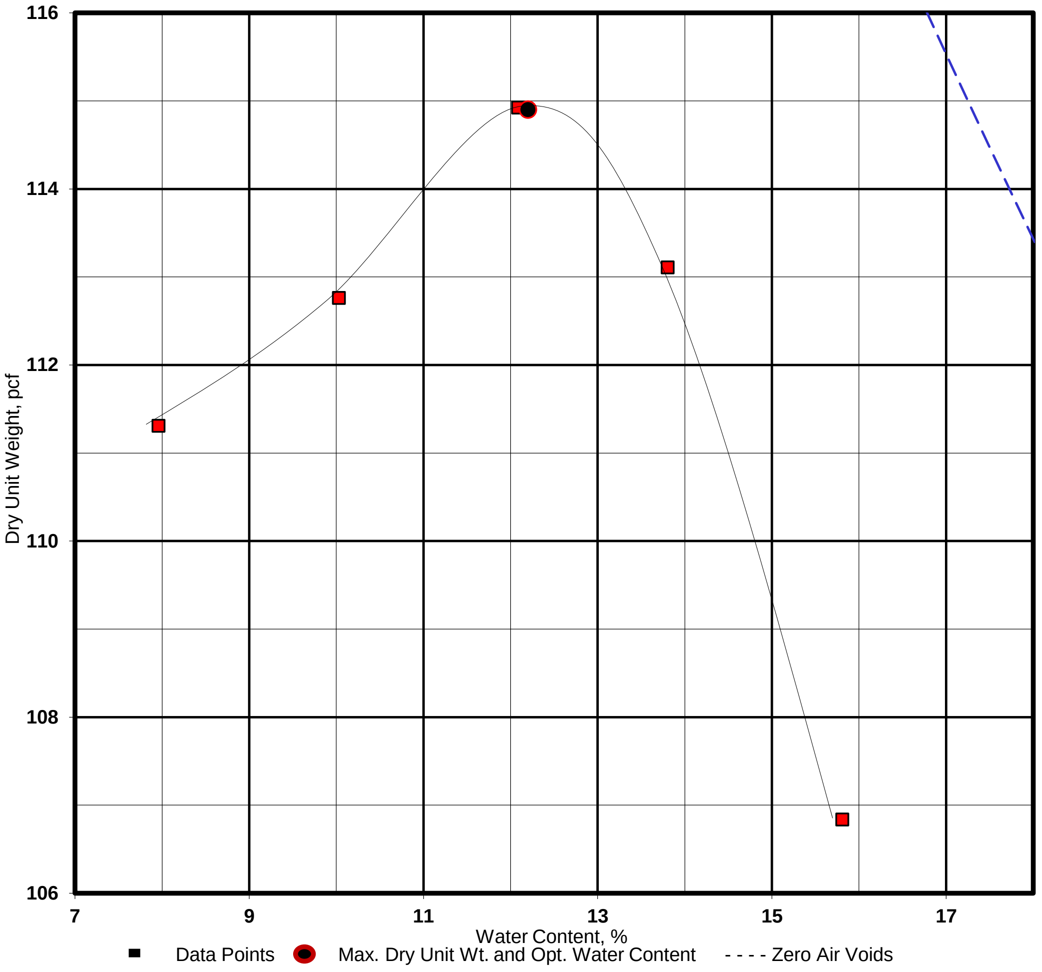


Exhibit B-8

Laboratory Compaction Characteristics of Soil

4701 North Stiles Ave.
Oklahoma City, OK 73105
(405) 525 0453

Client Name: Garver, LLC
Project Name: Embankment Survey
Location: Interstate 35 over Waterloo Road Interchange
Oklahoma and Logan Counties, Oklahoma

Project No.: 03185252 Date: 12/07/18

TEST RESULTS

Maximum Dry Unit Wt.: 115.2 pcf
Optimum Water Content: 12.7 %

Source Material: Bulk EB-4 (1.0-5.0')
Sample Description: Silty sand, red (10R 4/6) with dark reddish-gray (2.5YR 3/1)
Material Designation: lab 787 Sample date: 11/20/18
Test Method: Method A
Test Procedure: AASHTO T-99
Sample Preparation: Dry
Rammer: X Mechanical ____ Manual

Liquid Limit: NP Plastic Limit: NP
Plasticity Index: NP
% passing # 200 sieve: 34
AASHTO Class. A-2-4(0) USCS: SM
Reviewed by: DCVS

Zero air voids for specific gravity of 2.70

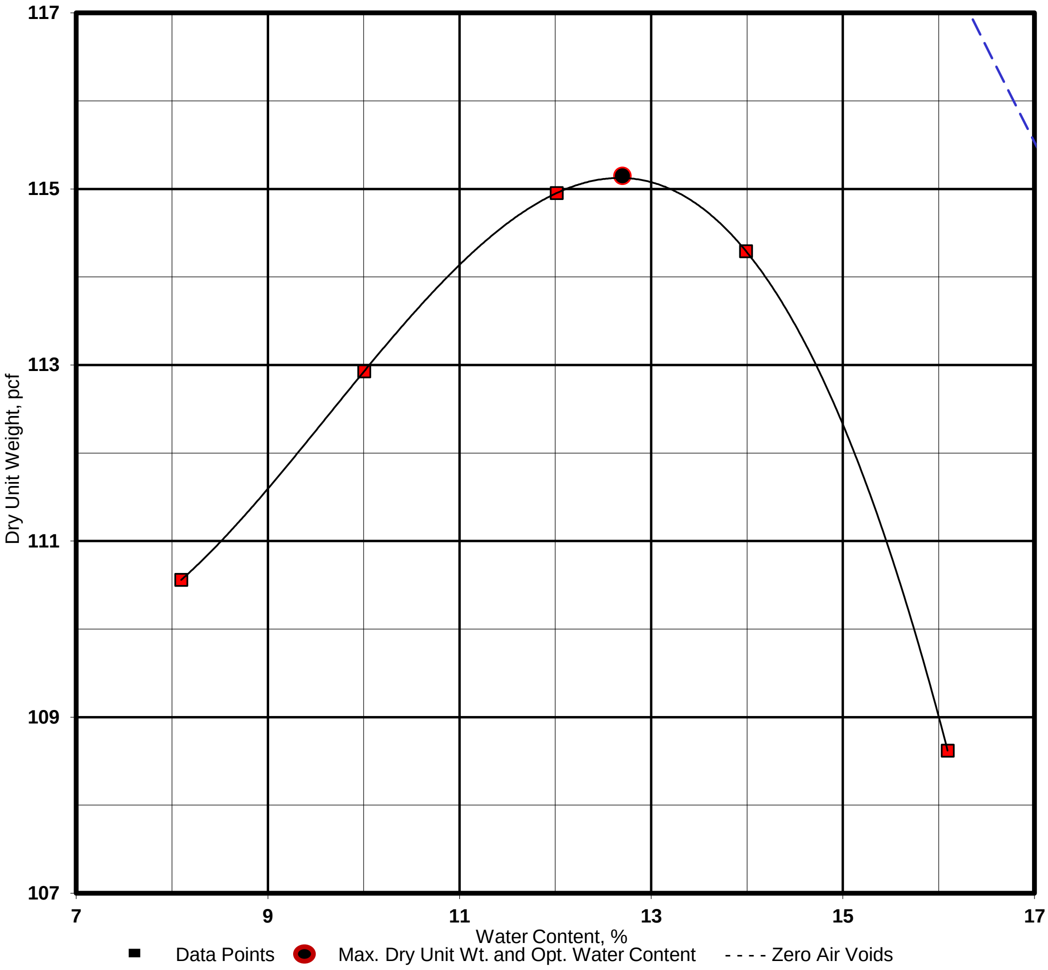


Exhibit B-9

Terracon

Laboratory Compaction Characteristics of Soil

4701 North Stiles Ave.
Oklahoma City, OK 73105
(405) 525 0453

Client Name: Garver, LLC

Project Name: Embankment Survey

Location: Interstate 35 over Waterloo Road Interchange
Oklahoma and Logan Counties, Oklahoma

Project No.: 03185252 Date: 12/07/18

TEST RESULTS

Maximum Dry Unit Wt.: 112.1 pcf

Optimum Water Content: 12.9 %

Source Material: Bulk EB-5 (1.0-5.0')

Sample Description: Silty sand, dusky red (10R 3/4)

Material Designation: lab 788 Sample date: 11/27/18

Test Method: Method A

Test Procedure: AASHTO T-99

Sample Preparation: Dry

Rammer: X Mechanical ___ Manual

Liquid Limit: NP Plastic Limit: NP

Plasticity Index: NP

% passing # 200 sieve: 23

AASHTO Class. A-2-4(0) USCS: SM

Reviewed by: DCVS

Zero air voids for specific gravity of 2.70

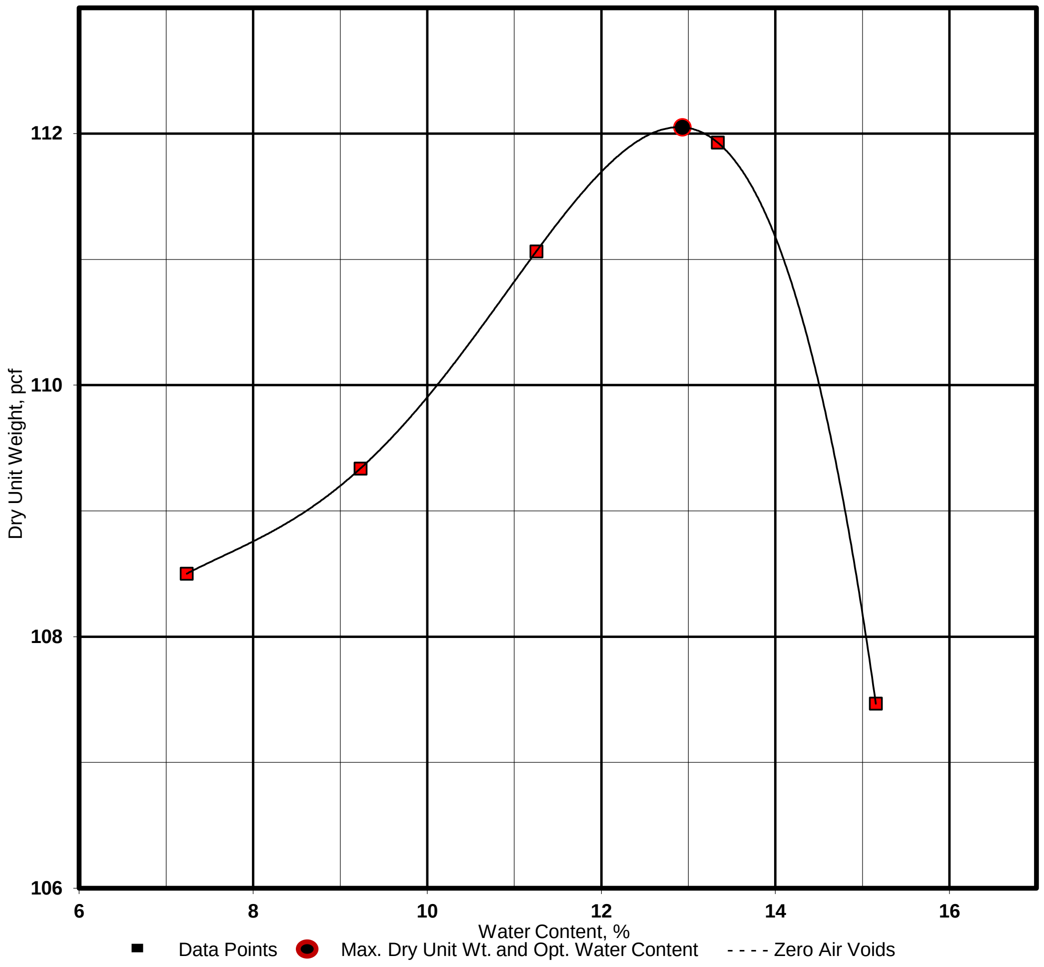
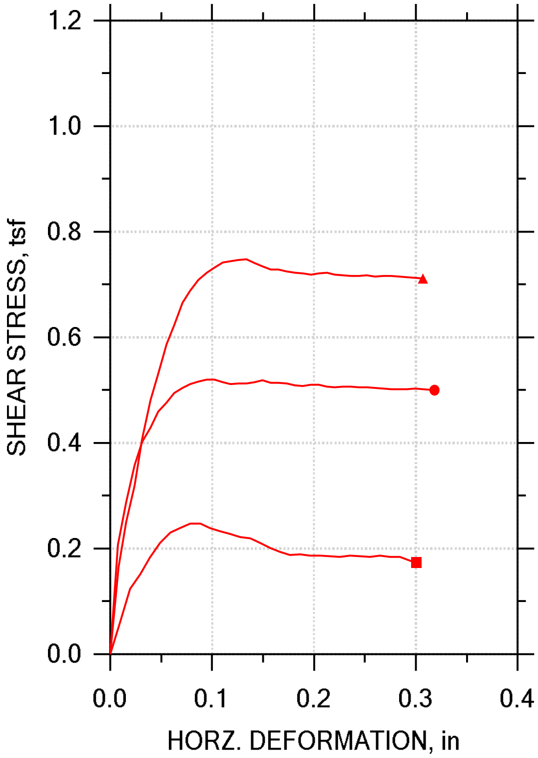
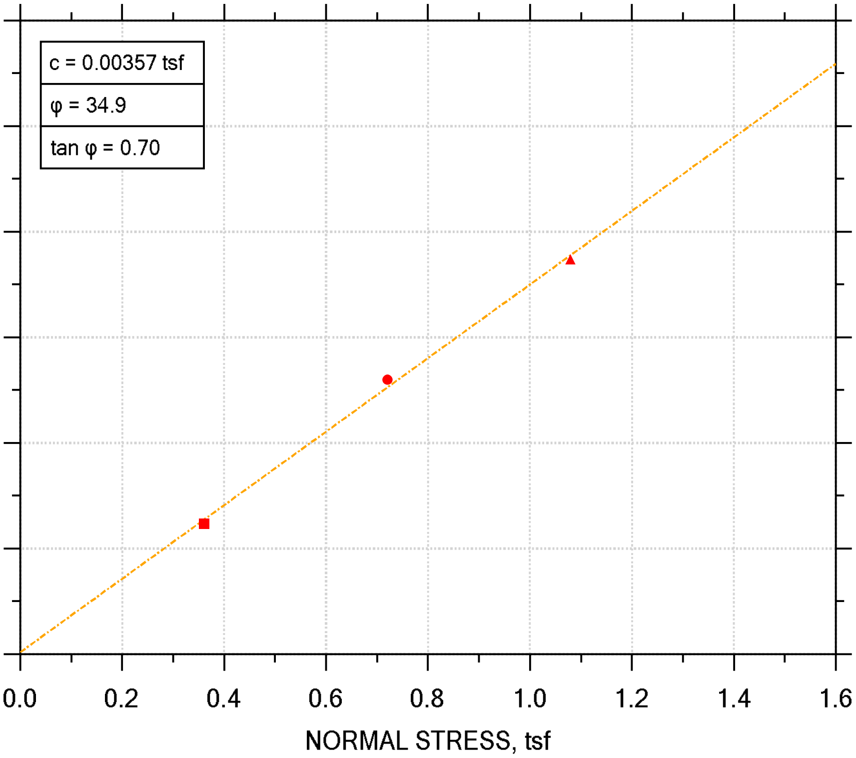


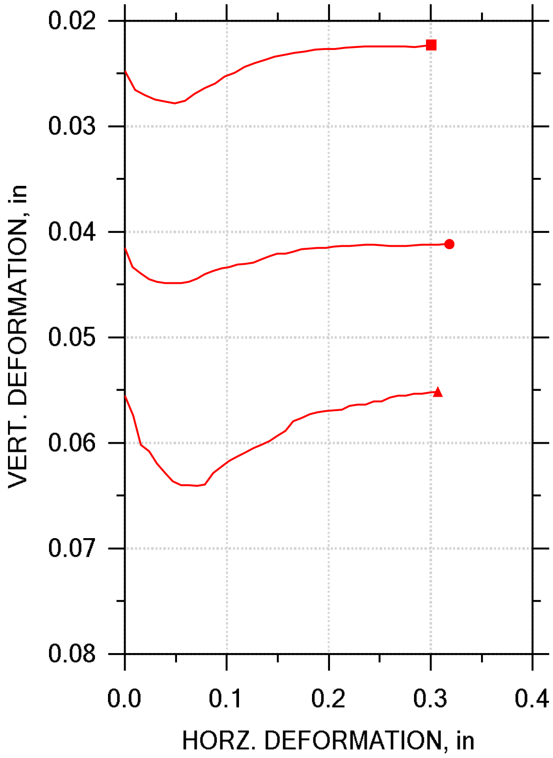
Exhibit B-10

DIRECT SHEAR TEST OF SOILS UNDER CONSOLIDATED DRAINED CONDITIONS ASTM D3080

Terracon
Consulting Engineers & Scientists







Symbol		■	●	▲	
Test No.		5.0 PSI	10.0 PSI	15.0 PSI	
Sample No.		S-1	S-1	S-1	
Shape		Circular	Circular	Circular	
Initial	Dimension, in	2.5024	2.5028	2.5008	
	Area, in²	4.918	4.9196	4.9118	
	Height, in	1.1543	1.1535	1.155	
	Water Content, %	13.52	13.37	13.19	
	Dry Density, pcf	112.3	112.2	112.5	
	Saturation, %	75.64	74.71	74.32	
	Void Ratio	0.47351	0.47426	0.47038	
Consol. Height, in		1.1296	1.112	1.0995	
Consol. Void Ratio		0.44194	0.42121	0.39972	
Final	Water Content, %	16.57	15.99	15.24	
	Dry Density, pcf	114.5	116.4	118.2	
	Saturation, %	98.66	100.50	100.91	
	Void Ratio	0.44507	0.42164	0.4002	
Normal Stress, tsf		0.35984	0.72029	1.0793	
Max. Shear Stress, tsf		0.24697	0.51982	0.74809	
Ult. Shear Stress, tsf		0.17384	0.50009	0.71143	
Time to Failure, min		371.85	556.41	445.79	
Disp. Rate, in/min		0.00017323	0.00017323	0.00030315	
Estimated Specific Gravity		2.65	2.65	2.65	
Liquid Limit		20	20	20	
Plastic Limit		14	14	14	
Plasticity Index		6	6	6	

Project: EMBANKMENT SURVEY-I-35 AND WATERLOO RD INTERCHANGE

Location: I-35 AND WATERLOO RD INTERCHANGE, OKLAHOMA CITY, OK

Project No.: 03185252

Boring No.: Bulk EB-1 Depth: 1.0'-5.0'

Sample Type: RECONSTITUTED

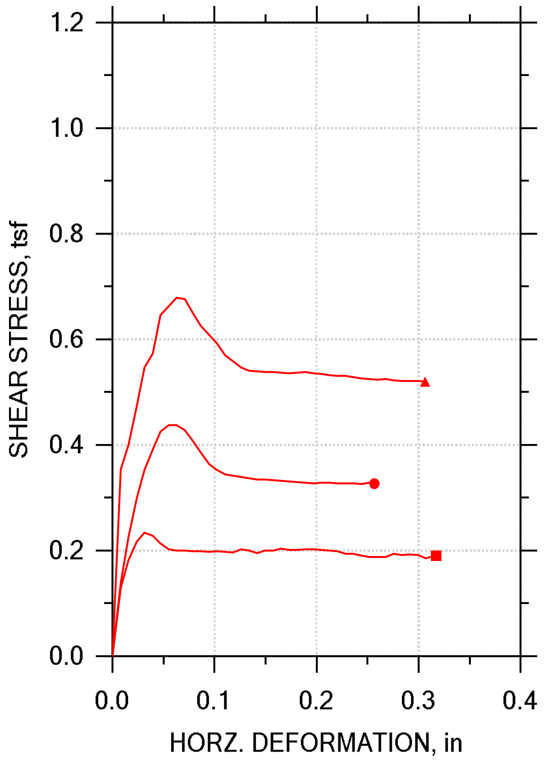
Description: SILTY, CLAYEY SAND, WEAK RED (10R 4/3) AND BROWN (7.5YR 5/4)

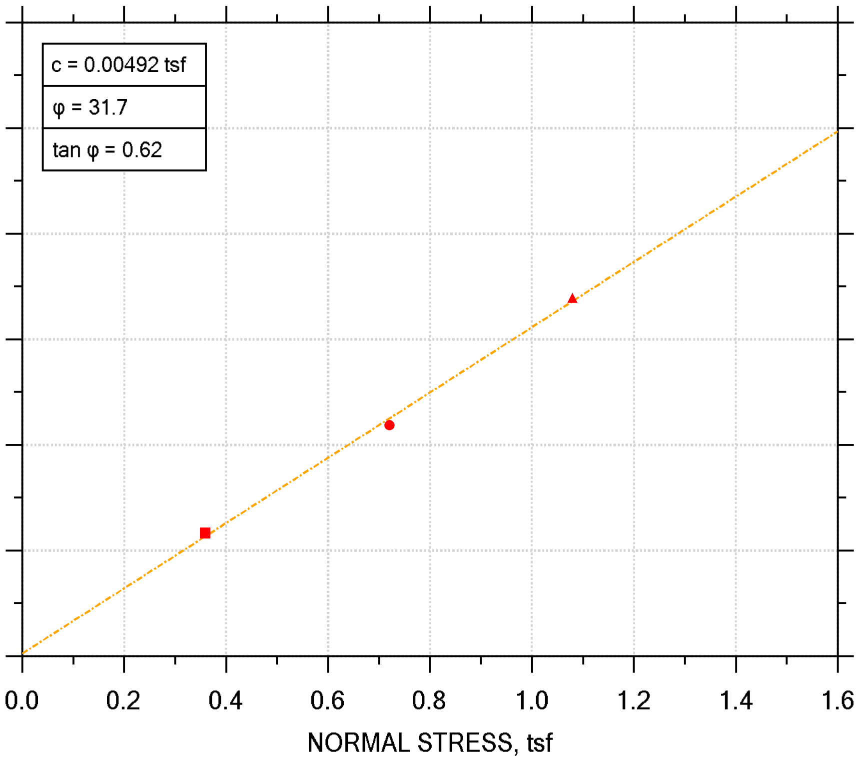
Remarks: TEST PERFORMED AS PER ASTM 3080 SPECIMEN RECONSTITUTED TO 95.0% SPD @ OMC

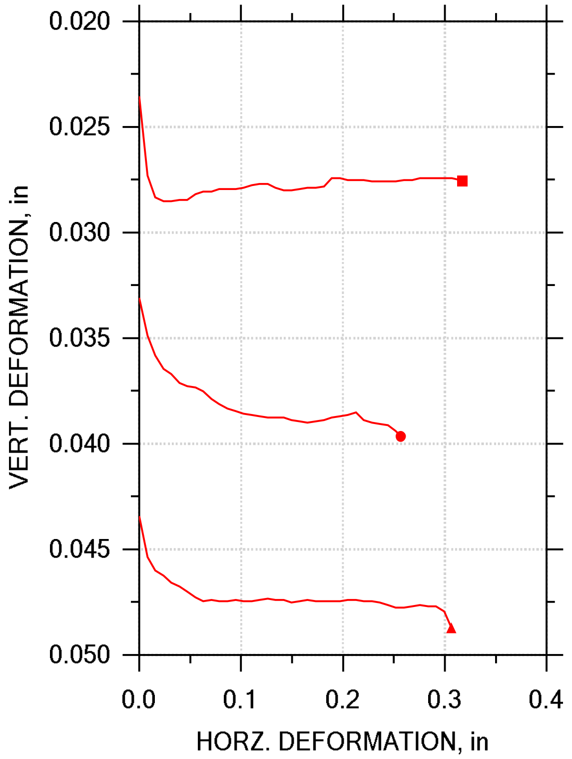
Exhibit B-11

DIRECT SHEAR TEST OF SOILS UNDER CONSOLIDATED DRAINED CONDITIONS ASTM D3080

Terracon
Consulting Engineers & Scientists







Symbol		■	●	▲	
Test No.		5.0 PSI	10.0 PSI	15.0 PSI	
Sample No.		S-1	S-1	S-1	
Shape		Circular	Circular	Circular	
Initial	Dimension, in	2.5016	2.5012	2.502	
	Area, in²	4.9149	4.9134	4.9165	
	Height, in	1.1563	1.1547	1.1567	
	Water Content, %	12.79	12.75	12.79	
	Dry Density, pcf	109.3	109.6	109.2	
	Saturation, %	66.02	66.28	65.80	
	Void Ratio	0.51351	0.50985	0.51516	
Consol. Height, in		1.1328	1.1216	1.1133	
Consol. Void Ratio		0.4827	0.46658	0.45828	
Final	Water Content, %	17.57	16.87	17.13	
	Dry Density, pcf	112.0	113.5	114.0	
	Saturation, %	97.52	97.61	100.57	
	Void Ratio	0.47743	0.45802	0.45135	
Normal Stress, tsf		0.35928	0.72037	1.0799	
Max. Shear Stress, tsf		0.23338	0.43747	0.67885	
Ult. Shear Stress, tsf		0.18998	0.32686	0.51982	
Time to Failure, min		194.66	367.19	232.07	
Disp. Rate, in/min		0.00017323	0.00017323	0.00030512	
Estimated Specific Gravity		2.65	2.65	2.65	
Liquid Limit		NP	NP	NP	
Plastic Limit		NP	NP	NP	
Plasticity Index		NP	NP	NP	

Project: EMBANKMENT SURVEY-I-35 AND WATERLOO RD INTERCHANGE

Location: I-35 AND WATERLOO RD INTERCHANGE, OKLAHOMA CITY, OK

Project No.: 03185252

Boring No.: BULK EB-4 Depth: 1.0'-5.0'

Sample Type: RECONSTITUTED

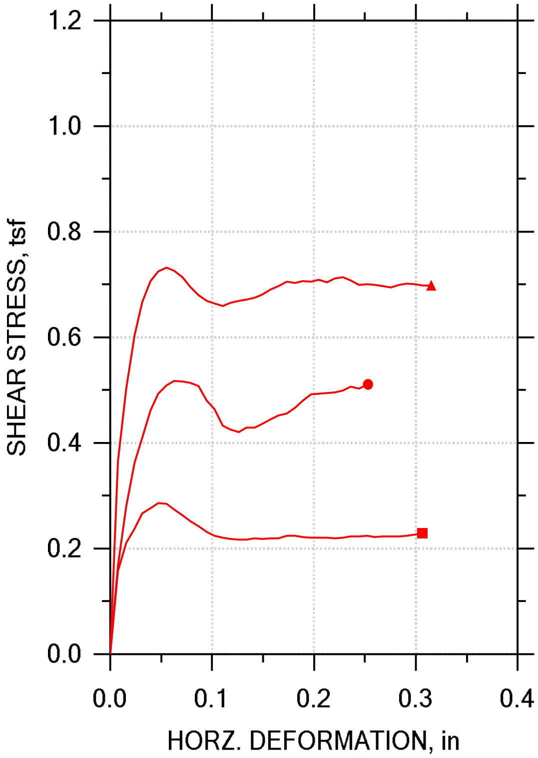
Description: SILTY SAND, RED (10R 4/6) WITH DARK REDDISH-GRAY (2.5YR 3/1)

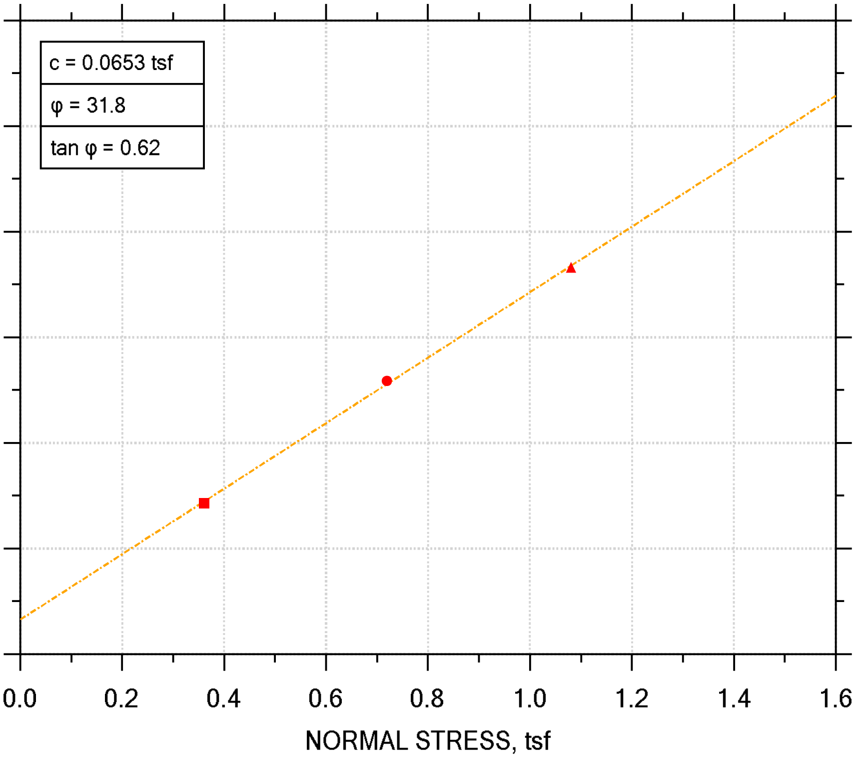
Remarks: TEST PERFORMED AS PER ASTM D3080. SPECIMEN RECONSTITUTED TO 95.0% SPD @ OMC

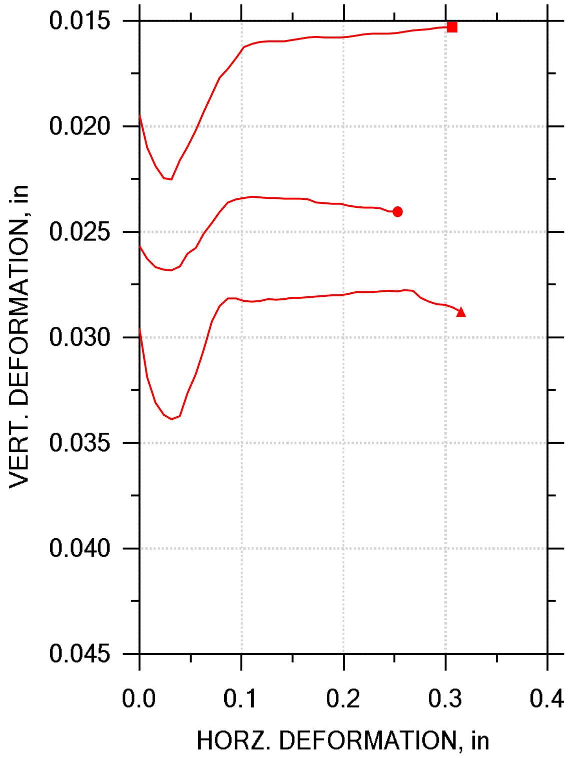
Exhibit B-12

DIRECT SHEAR TEST OF SOILS UNDER CONSOLIDATED DRAINED CONDITIONS ASTM D3080

Terracon
Consulting Engineers & Scientists







Symbol		■	●	▲	
Test No.		5.0 PSI	10.0 PSI	15.0 PSI	
Sample No.		S-1	S-1	S-1	
Shape		Circular	Circular	Circular	
Initial	Dimension, in	2.5004	2.5016	2.5008	
	Area, in²	4.9103	4.9149	4.9118	
	Height, in	1.1571	1.1559	1.1555	
	Water Content, %	12.42	12.79	12.87	
	Dry Density, pcf	106.9	106.6	106.6	
	Saturation, %	60.10	61.49	61.84	
	Void Ratio	0.54779	0.55138	0.55157	
Consol. Height, in		1.1376	1.1302	1.1259	
Consol. Void Ratio		0.52177	0.51693	0.51185	
Final	Water Content, %	19.43	19.66	19.01	
	Dry Density, pcf	108.3	108.9	109.3	
	Saturation, %	97.65	100.38	98.21	
	Void Ratio	0.52731	0.519	0.51293	
Normal Stress, tsf		0.36037	0.71961	1.0803	
Max. Shear Stress, tsf		0.28589	0.51756	0.73248	
Ult. Shear Stress, tsf		0.22893	0.51094	0.69847	
Time to Failure, min		180.92	369.46	332.99	
Disp. Rate, in/min		0.00030512	0.00017323	0.00017323	
Estimated Specific Gravity		2.65	2.65	2.65	
Liquid Limit		NP	NP	NP	
Plastic Limit		NP	NP	NP	
Plasticity Index		NP	NP	NP	

Project: EMBANKMENT SURVEY-I-35 AND WATERLOO RD INTERCHANGE

Location: I-35 AND WATERLOO RD INTERCHANGE, OKLAHOMA CITY, OK

Project No.: 03185252

Boring No.: BULK EB-5 Depth: 1.0'-5.0'

Sample Type: RECONSTITUTED

Description: SILTY SAND, DUSKY RED (10R 3/4)

Remarks: TEST PERFORMED AS PER ASTM D3080. SPECIMEN RECONSTITUTED TO 95.0% SPD @ OMC

Exhibit B-13

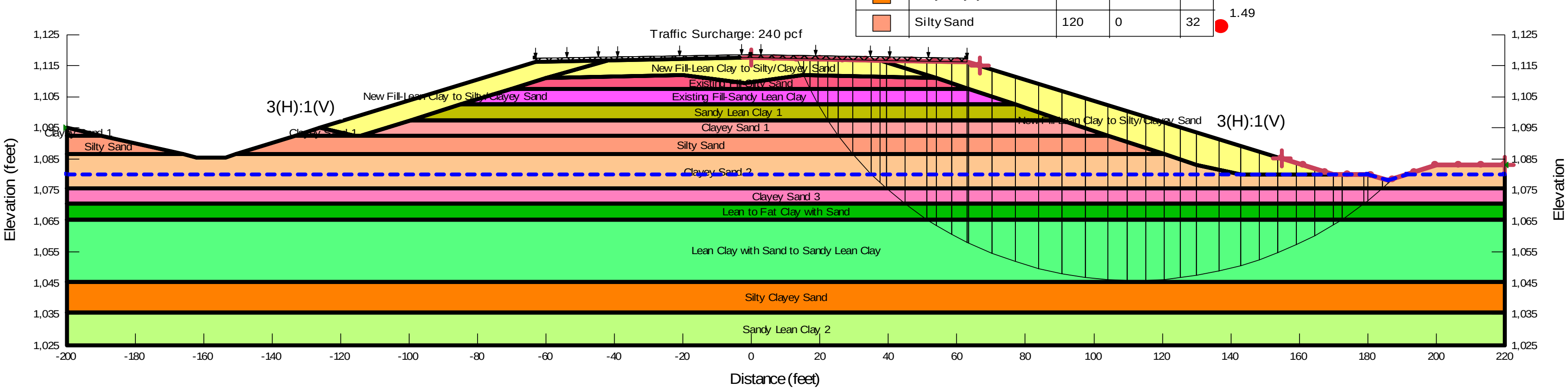
APPENDIX C

MISCELLANEOUS

I-35 SOUTH EMBANKMENT - SLOPE STABILITY ANALYSIS AT STATION 138+00 (SHORT-TERM CONDITION)

Project: Embankment Survey I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185252
File Name: Station 138+00-Short Term.gsz
Created By: Khatri, Deep K
Date: 1/10/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟥	Clayey Sand 1	120	0	30
🟧	Clayey Sand 2	120	0	31
🟪	Clayey Sand 3	120	0	27
🟪	Existing Fill-Sandy Lean Clay	125	1,500	0
🟥	Existing Fill-Silty Sand	125	0	31
🟩	Lean Clay with Sand to Sandy Lean Clay	120	900	0
🟩	Lean to Fat Clay with Sand	120	2,000	0
🟨	New Fill-Lean Clay to Silty/Clayey Sand	125	1,500	0
🟨	Sandy Lean Clay 1	120	2,000	0
🟩	Sandy Lean Clay 2	120	750	0
🟧	Silty Clayey Sand	120	0	27
🟧	Silty Sand	120	0	32

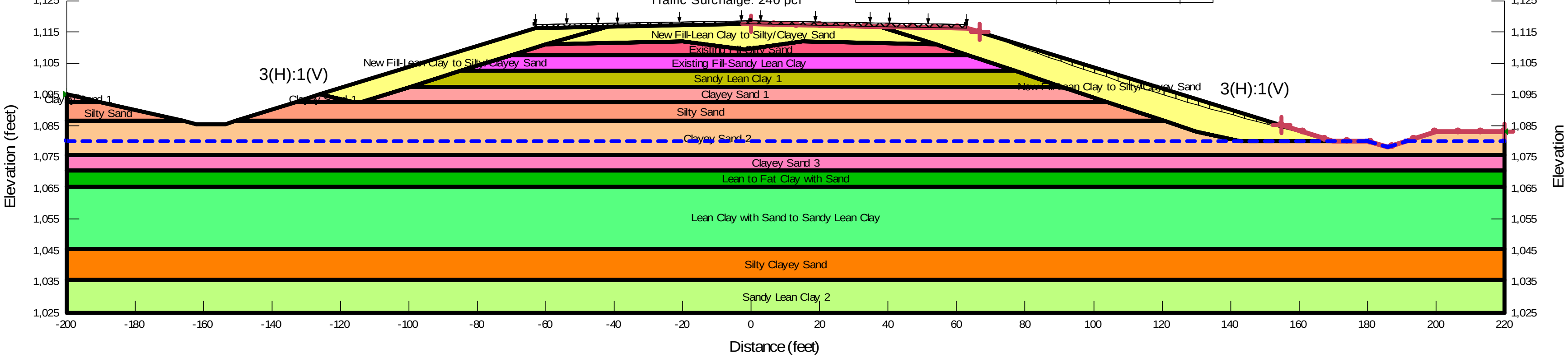


Drawn by:	Exhibit C-1
DKK	
Reviewed by:	Global Slope Stabiltiy Analysis
NKT	Embankment Soil Survey – I-35 over Waterloo Road Interchange Oklahoma and Logan Counties, Oklahoma
Scale:	
As Shown	Terracon
Terracon Project No.	
03185252	

I-35 SOUTH EMBANKMENT - SLOPE STABILITY ANALYSIS AT STATION 138+00 (LONG-TERM CONDITION)

Project: Embankment Survey I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185252
File Name: Station 138+00.gsz
Created By: Khatri, Deep K
Date: 1/10/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟥	Clayey Sand 1	120	0	30
🟧	Clayey Sand 2	120	0	31
🟪	Clayey Sand 3	120	0	27
🟪	Existing Fill-Sandy Lean Clay	125	0	28
🟥	Existing Fill-Silty Sand	125	0	31
🟩	Lean Clay with Sand to Sandy Lean Clay	120	0	27
🟩	Lean to Fat Clay with Sand	120	50	26
🟨	New Fill-Lean Clay to Silty/Clayey Sand	125	0	28
🟨	Sandy Lean Clay 1	120	0	28
🟩	Sandy Lean Clay 2	120	0	27
🟧	Silty Clayey Sand	120	0	27
🟧	Silty Sand	120	0	32

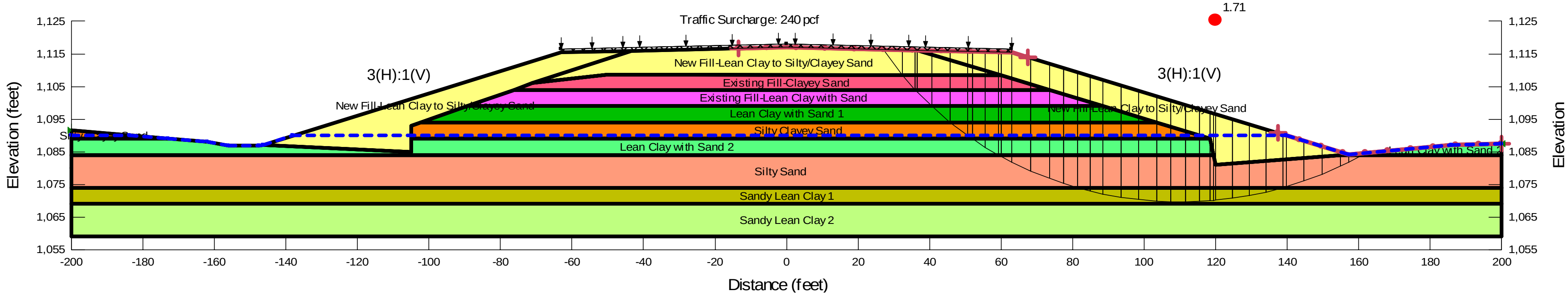


Drawn by:	Exhibit C-2
DKK	
Reviewed by:	Global Slope Stabiltiy Analysis
NKT	Embankment Soil Survey – I-35 over Waterloo Road Interchange Oklahoma and Logan Counties, Oklahoma
Scale:	
As Shown	Terracon
Terracon Project No.	
03185252	

I-35 NORTH EMBANKMENT - SLOPE STABILITY ANALYSIS AT STATION 140+54.83 (SHORT-TERM CONDITION)

Project: Embankment Survey I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185252
File Name: Station 140+54.83 - Short Term.gsz
Created By: Khatri, Deep K
Date: 1/10/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟥	Existing Fill-Clayey Sand	125	0	31
🟪	Existing Fill-Lean Clay with Sand	125	1,500	0
🟩	Lean Clay with Sand 1	120	1,500	0
🟩	Lean Clay with Sand 2	120	1,500	0
🟨	New Fill-Lean Clay to Silty/Clayey Sand	125	1,500	0
🟫	Sandy Lean Clay 1	120	700	0
🟩	Sandy Lean Clay 2	120	2,000	0
🟧	Silty Clayey Sand	120	0	33
🟧	Silty Sand	120	0	27

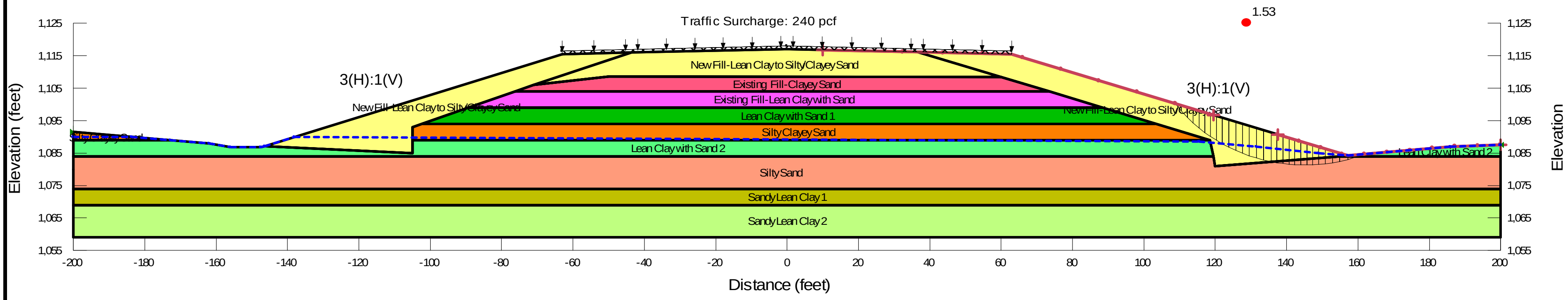


Drawn by:	Exhibit C-3
DKK	
Reviewed by:	Global Slope Stabiltiy Analysis
NKT	Embankment Soil Survey – I-35 over Waterloo Road Interchange Oklahoma and Logan Counties, Oklahoma
Scale:	
As Shown	Terracon
Terracon Project No.	
03185252	

I-35 NORTH EMBANKMENT - SLOPE STABILITY ANALYSIS AT STATION 140+54.83 (LONG-TERM CONDITION)

Project: Embankment Survey I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185252
File Name: Station 140+54.83.gsz
Created By: Khatri, Deep K
Date: 1/23/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟥	Existing Fill-Clayey Sand	125	0	31
🟪	Existing Fill-Lean Clay with Sand	125	0	28
🟩	Lean Clay with Sand 1	120	0	27
🟩	Lean Clay with Sand 2	120	0	27
🟨	New Fill-Lean Clay to Silty/Clayey Sand	125	0	28
🟩	Sandy Lean Clay 1	120	0	27
🟩	Sandy Lean Clay 2	120	0	28
🟧	Silty Clayey Sand	120	0	33
🟧	Silty Sand	120	0	27



Drawn by:
DKK
Reviewed by:
NKT
Scale:
As Shown
Terracon Project No.
03185252

Exhibit C-4

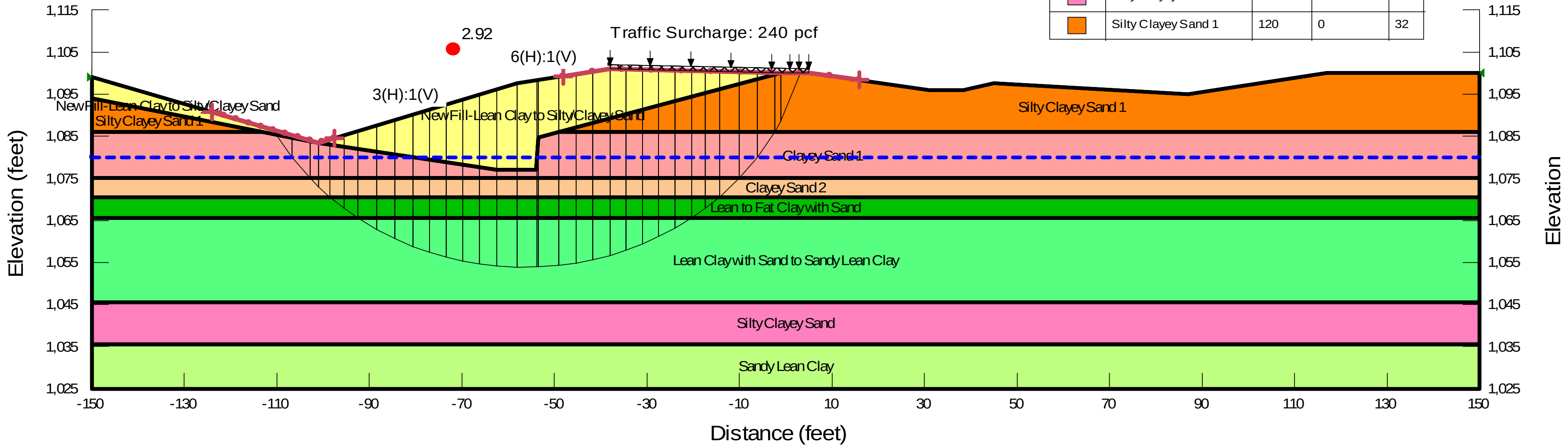
Global Slope Stabiltiy Analysis
Embankment Soil Survey – I-35 over Waterloo Road Interchange
Oklahoma and Logan Counties, Oklahoma

Terracon

RAMP B - SLOPE STABILITY ANALYSIS AT STATION 136+90.69 (SHORT-TERM CONDITION)

Project: Embankment Survey I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185252
File Name: Station 136+90.69 - Short Term.gsz
Created By: Khatri, Deep K
Date: 1/10/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟥	Clayey Sand 1	120	0	31
🟧	Clayey Sand 2	120	0	27
🟩	Lean Clay with Sand to Sandy Lean Clay	120	900	0
🟩	Lean to Fat Clay with Sand	120	2,000	0
🟨	New Fill-Lean Clay to Silty/Clayey Sand	125	1,500	0
🟩	Sandy Lean Clay	120	750	0
🟪	Silty Clayey Sand	120	0	27
🟧	Silty Clayey Sand 1	120	0	32

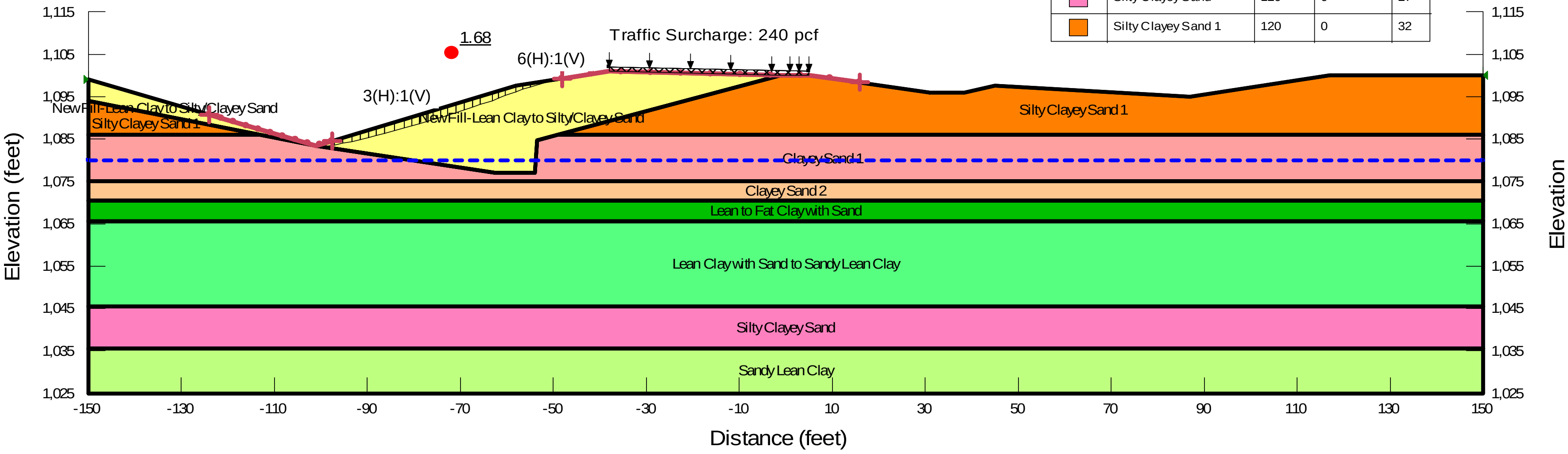


Drawn by:	Exhibit C-5
DKK	
Reviewed by:	Global Slope Stabiltiy Analysis
NKT	Embankment Soil Survey – I-35 over Waterloo Road Interchange
Scale:	Oklahoma and Logan Counties, Oklahoma
As Shown	Terracon
Terracon Project No.	
03185252	

RAMP B - SLOPE STABILITY ANALYSIS AT STATION 136+90.69 (LONG-TERM CONDITION)

Project: Embankment Survey I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185252
File Name: Station 136+90.69.gsz
Created By: Khatri, Deep K
Date: 1/10/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟥	Clayey Sand 1	120	0	31
🟧	Clayey Sand 2	120	0	27
🟩	Lean Clay with Sand to Sandy Lean Clay	120	0	27
🟩	Lean to Fat Clay with Sand	120	50	26
🟨	New Fill-Lean Clay to Silty/Clayey Sand	125	0	28
🟩	Sandy Lean Clay	120	0	27
🟪	Silty Clayey Sand	120	0	27
🟧	Silty Clayey Sand 1	120	0	32

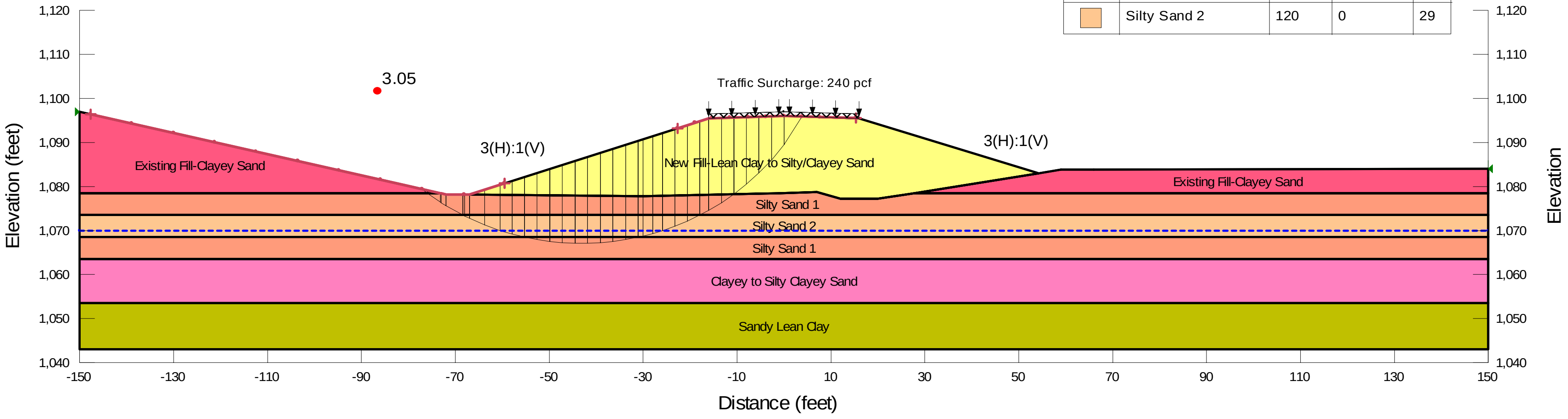


Drawn by:	Exhibit C-6
DKK	
Reviewed by:	Global Slope Stabiltiy Analysis
NKT	Embankment Soil Survey – I-35 over Waterloo Road Interchange Oklahoma and Logan Counties, Oklahoma
Scale:	
As Shown	Terracon
Terracon Project No.	
03185252	

INDUSTRIAL - SLOPE STABILITY ANALYSIS AT STATION 12+50 (SHORT-TERM CONDITION)

Project: Embankment Survey I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185252
File Name: Station 12+50 - Short Term (Updated).gsz
Created By: Khatri, Deep K
Date: 1/24/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟪	Clayey to Silty Clayey Sand	120	0	27
🟥	Existing Fill-Clayey Sand	125	0	29
🟨	New Fill-Lean Clay to Silty/Clayey Sand	125	1,500	0
🟩	Sandy Lean Clay	120	400	0
🟧	Silty Sand 1	120	0	27
🟧	Silty Sand 2	120	0	29



Drawn by:
DKK
Reviewed by:
NKT
Scale:
As Shown
Terracon Project No.
03185252

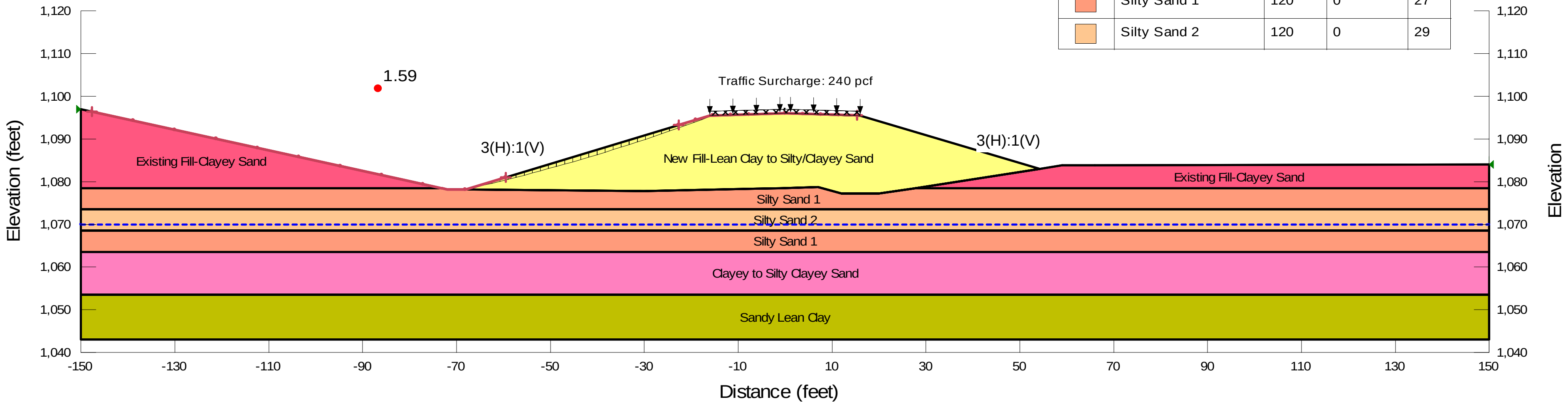
Exhibit C-7

Global Slope Stabiltiy Analysis
Embankment Soil Survey – I-35 over Waterloo Road Interchange
Oklahoma and Logan Counties, Oklahoma

INDUSTRIAL - SLOPE STABILITY ANALYSIS AT STATION 12+50 (LONG-TERM CONDITION)

Project: Embankment Survey I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185252
File Name: Station 12+50 (Updated).gsz
Created By: Khatri, Deep K
Date: 1/24/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟪	Clayey to Silty Clayey Sand	120	0	27
🟥	Existing Fill-Clayey Sand	125	0	29
🟨	New Fill-Lean Clay to Silty/Clayey Sand	125	0	28
🟩	Sandy Lean Clay	120	0	27
🟧	Silty Sand 1	120	0	27
🟧	Silty Sand 2	120	0	29



Drawn by:	Exhibit C-8
DKK	
Reviewed by:	Global Slope Stabiltiy Analysis
NKT	Embankment Soil Survey – I-35 over Waterloo Road Interchange Oklahoma and Logan Counties, Oklahoma
Scale:	
As Shown	
Terracon Project No.	
03185252	

APPENDIX D

SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

▯ **Auger**	⊠ **Split Spoon**
■ **Shelby Tube**	▥ **Pressure Meter**
◪ **Texas Cone**	▯ **Rock Core**
✋ **Grab Sample**	▱ **No Recovery**

WATER LEVEL

▽	**Water Initially Encountered**
▽	**Water Level After a Specified Period of Time**
▼	**Water Level After a Specified Period of Time**

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

FIELD TESTS

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

DESCRIPTIVE SOIL CLASSIFICATION

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

LOCATION AND ELEVATION NOTES

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

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, psf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

GRAIN SIZE TERMINOLOGY

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

RELATIVE PROPORTIONS OF FINES

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

PLASTICITY DESCRIPTION

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

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UNIFIED SOIL CLASSIFICATION SYSTEM

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

[A] Based on the material passing the 3-inch (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] $Cu = D_{60}/D_{10} \qquad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[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.

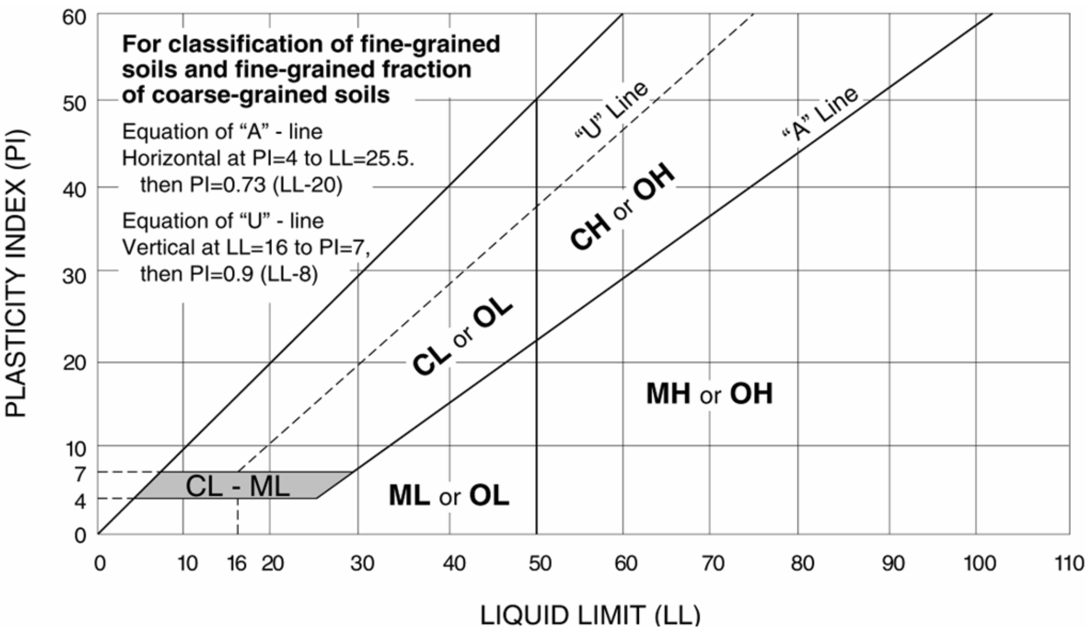

Exhibit D-2

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 (SiO_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.

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Form 110—6-85

Exhibit D-3

CPT GENERAL NOTES

DESCRIPTION OF MEASUREMENTS AND CALIBRATIONS

To be reported per ASTM D5778:

Uncorrected Tip Resistance, q_c
Measured force acting on the cone divided by the cone's projected area

Corrected Tip Resistance, q_t
Cone resistance corrected for porewater and net area ratio effects
$q_t = q_c + U2(1 - a)$

Where a is the net area ratio, a lab calibration of the cone typically between 0.70 and 0.85

Pore Pressure, U1/U2
Pore pressure generated during penetration
U1 - sensor on the face of the cone
U2 - sensor on the shoulder (more common)

Sleeve Friction, fs
Frictional force acting on the sleeve divided by its surface area

Normalized Friction Ratio, FR
The ratio as a percentage of fs to q_t, accounting for overburden pressure

To be reported per ASTM D7400, if collected:

Shear Wave Velocity, Vs
Measured in a Seismic CPT and provides direct measure of soil stiffness

DESCRIPTION OF GEOTECHNICAL CORRELATIONS

Normalized Tip Resistance, Q_t
$Q_t = (q_t - \sigma_{V0})/\sigma'_{V0}$

Over Consolidation Ratio, OCR
$OCR\ (1) = 0.25(Q_t)^{1.25}$
$OCR\ (2) = 0.33(Q_t)$

Undrained Shear Strength, Su
$Su = Q_t \times \sigma'_{V0}/N_{kt}$
N_{kt} is a geographical factor (shown on Su plot)

Sensitivy, St
$St = (q_t - \sigma_{V0}/N_{kt}) \times (1/fs)$

Effective Friction Angle, ϕ'
$\phi'\ (1) = \tan^{-1}(0.373[\log(q_t/\sigma'_{V0}) + 0.29])$
$\phi'\ (2) = 17.6 + 11[\log(Q_t)]$

Unit Weight
$UW = (0.27[\log(FR)]+0.36[\log(q_t/atm)]+1.236) \times UW_{water}$
σ_{V0} is taken as the incremental sum of the unit weights

Small Strain Shear Modulus, G_0
$G_0\ (1) = \rho Vs^2$
$G_0\ (2) = 0.015 \times 10^{(0.55Ic + 1.68)}(q_t - \sigma_{V0})$

Soil Behavior Type Index, Ic
$Ic = [(3.47 - \log(Q_t)^2 + (\log(FR) + 1.22)^2]^{0.5}$

SPT N_{60}
$N_{60} = (q_t/atm) / 10^{(1.1268 - 0.2817Ic)}$

Elastic Modulus, Es (assumes $q/q_{ultimate} \sim 0.3$, i.e. FS = 3)
$Es\ (1) = 2.6\psi G_0$ where $\psi = 0.56 - 0.33\log Q_{t,clean\ sand}$
$Es\ (2) = G_0$
$Es\ (3) = 0.015 \times 10^{(0.55Ic + 1.68)}(q_t - \sigma_{V0})$
$Es\ (4) = 2.5q_t$

Constrained Modulus, M
$M = \alpha_M(q_t - \sigma_{V0})$
For Ic > 2.2 (fine-grained soils)
$\alpha_M = Q_t$ with maximum of 14
For Ic < 2.2 (coarse-grained soils)
$\alpha_M = 0.0188 \times 10^{(0.55Ic + 1.68)}$

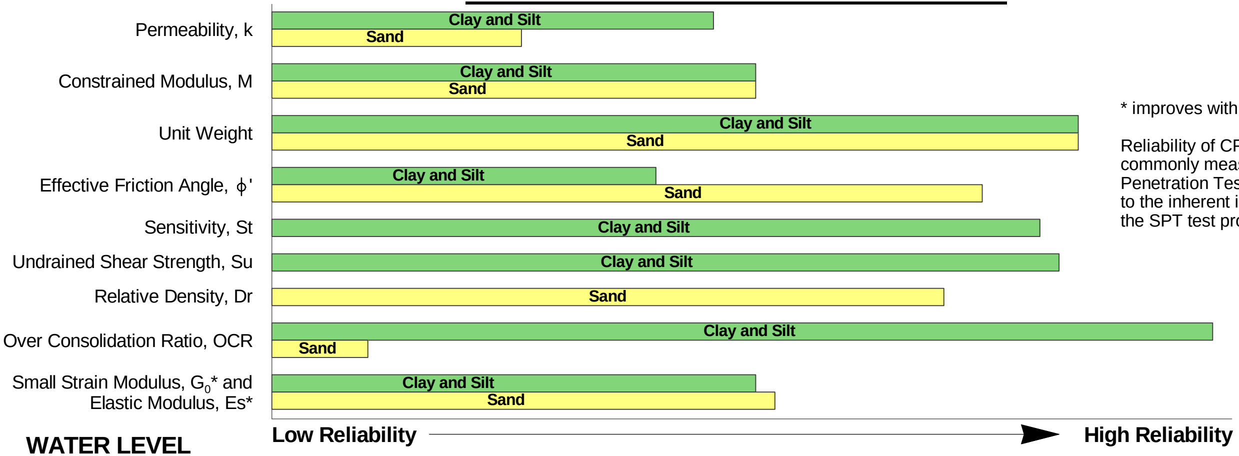
Hydraulic Conductivity, k
For $1.0 < Ic < 3.27$ $k = 10^{(0.952 - 3.04Ic)}$
For $3.27 < Ic < 4.0$ $k = 10^{(-4.52 - 1.37Ic)}$

Relative Density, Dr
$Dr = (Q_t / 350)^{0.5} \times 100$

REPORTED PARAMETERS

CPT logs as provided, at a minimum, report the data as required by ASTM D5778 and ASTM D7400 (if applicable). This minimum data include tip resistance, sleeve resistance, and porewater pressure. Other correlated parameters may also be provided. These other correlated parameters are interpretations of the measured data based upon published and reliable references, but they do not necessarily represent the actual values that would be derived from direct testing to determine the various parameters. The following chart illustrates estimates of reliability associated with correlated parameters based upon the literature referenced below.

RELATIVE RELIABILITY OF CPT CORRELATIONS



* improves with seismic Vs measurements

Reliability of CPT-predicted N_{60} values as commonly measured by the Standard Penetration Test (SPT) is not provided due to the inherent inaccuracy associated with the SPT test procedure.

WATER LEVEL

The groundwater level at the CPT location is used to normalize the measurements for vertical overburden pressures and as a result influences the normalized soil behavior type classification and correlated soil parameters. The water level may either be "measured" or "estimated:"

Measured - Depth to water directly measured in the field

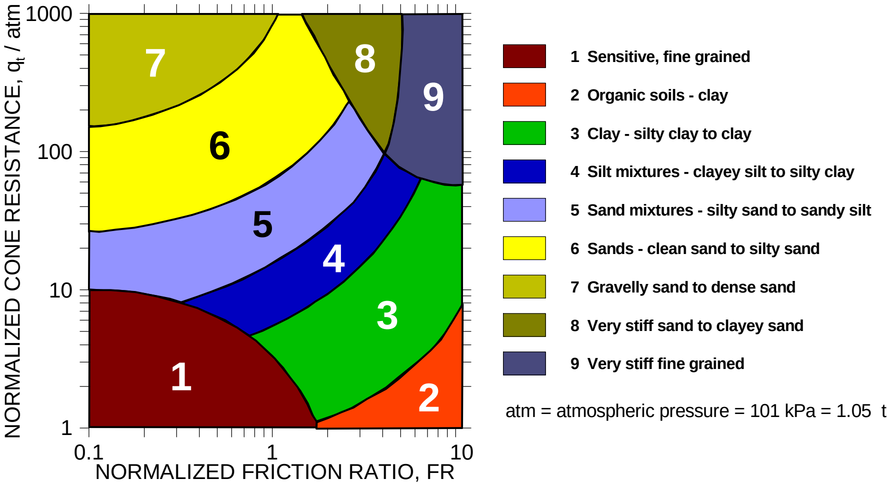
Estimated - Depth to water interpolated by the practitioner using pore pressure measurements in coarse grained soils and known site conditions

While groundwater levels displayed as "measured" more accurately represent site conditions at the time of testing than those "estimated," in either case the groundwater should be further defined prior to construction as groundwater level variations will occur over time.

CONE PENETRATION SOIL BEHAVIOR TYPE

The estimated stratigraphic profiles included in the CPT logs are based on relationships between corrected tip resistance (q_t), friction resistance (fs), and porewater pressure (U2). The normalized friction ratio (FR) is used to classify the soil behavior type.

Typically, silts and clays have high FR values and generate large excess penetration porewater pressures; sands have lower FRs and do not generate excess penetration porewater pressures. Negative pore pressure measurements are indicative of fissured fine-grained material. The adjacent graph (Robertson et al.) presents the soil behavior type correlation used for the logs. This normalized SBT chart, generally considered the most reliable, does not use pore pressure to determine SBT due to its lack of repeatability in onshore CPTs.



atm = atmospheric pressure = 101 kPa = 1.05 tsf

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Exhibit D-4