Geotechnical Engineering Report

Cut Sections

Interstate 35 over Waterloo Road Interchange

Oklahoma and Logan Counties, Oklahoma

Job Piece No. 29843(04)

Engineering Contract No. EC-1500N

March 22, 2019

Terracon Project No. 03185253

Prepared for:

Garver, LLC.

Tulsa, Oklahoma

Prepared by:

Terracon Consultants, Inc.

Oklahoma City, Oklahoma

March 22, 2019

Garver, LLC.
6450 South Lewis, Suite 300
Tulsa, Oklahoma 74136

Attn: Mr. Jenny Sallee
P: [918] 858 4166
E: jesallee@garverusa.com

Re: Geotechnical Engineering Report
Cut Sections
Interstate 35 over Waterloo Road Interchange
Oklahoma and Logan Counties, Oklahoma
Job Piece No. 29843(04)
Engineering Contract No. EC-1500N
Terracon Project No. 03185253

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

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

Kristi Deason
for: Diana Vargas Suaza, E.I.
Senior Staff Engineer

Deep Khatri
for: Deep Khatri
Senior Staff Engineer

Norman Tan, P.E.
Oklahoma No. 23083

LICENSED PROFESSIONAL ENGINEER
NORMAN TAN
3/22/19
23083
OKLAHOMA

DVCS:NT\kld\n:\project documents\2018\03185253\mar2019
Copies to: Addressee (1 via email)

TABLE OF CONTENTS

TABLE OF CONTENTS - (Cont'd.)

GEOTECHNICAL ENGINEERING REPORT
CUT SECTIONS
INTERSTATE 35 OVER WATERLOO ROAD
OKLAHOMA AND LOGAN COUNTIES, OKLAHOMA
JOB PIECE NO. 29843(04)
ENGINEERING CONTRACT NO. EC-1500N

Terracon Project No. 03185253
March 22, 2019

1.0 INTRODUCTION

The proposed project is located at the Interstate 35 and Waterloo Road interchange in Oklahoma and Logan Counties, Oklahoma. A geotechnical exploration has been performed for the cut sections along the proposed new alignment. A total of fifteen borings, designated CS-1 through CS-15, were performed to depths of about 20 to 40 feet below the existing ground surface. A site location map and boring location diagrams along with logs of the borings 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
- rock cut slope stability analysis
- groundwater conditions
- rock rippability

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site layout	See Appendix A, Exhibits A-1 to A-4, Site Location and Boring Location Plans
Proposed Grading	We understand that the project will consist of the re-construction, widening realignment of the existing roadway of Interstate 35 over Waterloo Road, including the construction of Ramp D embankment and Waterloo Road from Sooner Road to North Air Depot Boulevard in Oklahoma and Logan Counties. We also understand that earthwork for the roadway for this project will include up to 20 feet of cut to develop design grades. Based on the grading plans provided to us by the client, cut sections to be analyzed for this project are located between following stations:

Item	Description
Proposed Grading	■ Cut Section 1: 113+00 to 119+00. Up to 13 feet of cut (Boring CS-1 & CS-2) ■ Cut Section 2: 135+00 to 138+00. Up to 20 feet of cut (Boring CS-3) ■ Cut Section 3: 149+00 to 167+25. Up to 20 feet of cut (Borings CS-4 to CS-8) ■ Cut Section 4 (includes Ramp D Boring): 146+00 to 167+25. Up to 15 feet of cut (Boring CS-9 to CB-14) ■ Cut Section 5 (Waterloo Road): 94+00 to 97+50. Up to 13 feet of cut (Boring CS-15)

2.2 Site Location and Description

Item	Description
Location	We understand that the project will consist of the re-construction, widening of the existing roadway of Interstate 35 and Waterloo Road interchange on their existing alignment, the construction of new embankment I-35 Ramp D and the reconstruction and widening of Waterloo Road from Sooner Road to North Air Depot Boulevard in Oklahoma and Logan Counties, Oklahoma. See Exhibits A-2 to A-4 in Appendix A.
Current ground cover	The current ground cover along the project alignment is vegetation and pavements. Grass, brushes, trees, topsoil, weathered sandstone and weathered shale outcrops were observed during our field exploration.

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 crossbedded 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 Subsurface Conditions

The subsurface conditions encountered in the borings are shown on the boring logs and are

briefly described below. The stratification lines shown on the 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 and rock cores. Petrographic analysis of rock cores may reveal other rock types.

The overburden soils consisted of sands with varying amounts of clay and silt, lean clays with varying amounts of sand and silt and sandy silts to depths of about 4 to 7 feet in all borings except for boring CS-14 where the overburden soils extended to a depth of about 25 feet below existing grades.

The overburden soils encountered in the cut section borings were underlain by interbedded layers of highly weathered to weathered sandstone, shale or siltstone. The highly weathered to weathered sandstone, shale or siltstone are generally various shades of red, brown and yellow with some pink, white, gray and black. Unconfined compressive strength of the highly weathered to weathered bedrock ranged from 10 to 2,270 psi.

Field reconnaissance of the proposed alignment revealed several areas of highly weathered to weathered bedrock outcrops along the project alignment. Highly weathered to weathered sandstone with highly weathered to weathered shale and siltstones seams was the dominant bedrock type along the proposed alignment. The approximate outcrop locations are shown on the boring locations plans in Exhibits A-2 to A-4. Photographic rock core logs are presented in Exhibit A-21 in Appendix A.

On a regional scale, the bedding of the sandstone formation in this area is relatively flat and generally appears to dip to the north and west. Locally, the dip of bedding varies with dips ranging from 5 to 17 degrees. Jointing within the bedrock was generally near vertical. The information on individual outcrops of highly weathered to weathered sandstone or shale, with strike and dip measurements, is presented in the boring location plan in Exhibits A-2 to A-4.

Laboratory tests were conducted on selected soil and rock samples. The test results are presented on the boring logs in Appendix A and also in Appendix C. A summary of the subsurface conditions is given as follows:

Cut Section 1 - Stations 113+00 to 119+00

Two borings, designated CS-1 and CS-2, were drilled in the cut section to depths of approximately 20 to 25.5 feet below the existing ground surface.

The overburden soils consisted of silty or clayey sands and sandy lean clays to depths of about 4 to 6 feet. Based on laboratory testing results, the plasticity of the soils varies between low to moderately plastic. The overburden soils were underlain by red, brown or yellow, highly weathered to weathered shale and sandstone. Based on the results of our exploration, highly

weathered to weathered sandstone interbedded with shale layers is the predominant bedrock material along this cut section.

Unconfined compressive strength tests performed on the bedrock materials resulted in values ranging from approximately 10 pounds per square inch (psi) to 490 psi.

Cut Section 2 - Stations 135+00 to 138+00
One boring, designated CS-3, was drilled between the above listed stations to a depth of approximately 25.5 feet below the existing ground surface.

Very stiff, lean clay with sand was encountered to a depth of about 5 feet below existing grade. Based on the laboratory testing results, the plasticity of the lean clay soils is low.

Underlying the overburden soils, we encountered highly weathered sandstone interbedded with highly weathered shale and a seam of highly weathered siltstone. The bedrock was generally various shades of red. Based on the results of our exploration, highly weathered shale interbedded with highly weathered sandstone are the predominant bedrock materials along the alignment.

Unconfined compressive strength tests performed on the bedrock materials resulted in values ranging from approximately 120 psi to 800 psi.

Cut Section 3 - Stations 149+00 to 167+25
Five borings, designated CS-4 through CS-8, were drilled between the above mentioned stations to depths of approximately 25 to 40 feet below the existing ground surface. Exposed highly weathered to weathered sandstone interbedded with highly weathered shale bedrock was encountered at the ground surface near borings CS-4 and CS-8.

Loose to dense silty or clayey sands, very loose silt and lean clays were encountered to depths ranging from about 5 to 7 feet. The overburden soils were underlain by highly weathered to weathered sandstone interbedded with highly weathered to weathered shale with seams of highly weathered to weathered siltstone. The bedrock generally varies in color from various shades of red, gray and brown with some yellow seams. Highly weathered sandstone interbedded with highly weathered shale and siltstone are the predominant bedrock materials along this cut section.

Unconfined compressive strength tests performed on the sandstone and limestone bedrock materials resulted in values ranging from approximately 30 psi to 1,040 psi.

Cut Section 4 - Stations 146+00 to 167+25
Six borings, designated CS-9 to CS-14, were drilled between the above mentioned stations to depths of approximately 26.5 to 35 feet below the existing ground surface. Exposed highly

weathered to weathered sandstone and highly weathered shale bedrock was encountered at the ground surface near borings CS-9 to CS-14.

The overburden soils generally consisted of very loose to very dense silty or clayey sand, and very stiff to hard lean clays extending to depths of about 5 to 6.3 feet below existing grade in borings C-9 to CS-13. The overburden soils extended to a depth of about 25 feet in boring CS-14. The overburden soils were underlain by highly weathered to weathered sandstone interbedded with highly weathered to weathered shale with seams of highly weathered siltstone. The bedrock generally varies in color from various shades of red, yellow, gray and brown. Highly weathered sandstone interbedded with highly weathered shale with siltstone seams are the predominant bedrock materials along this portion of the project.

Unconfined compressive strength tests performed on the bedrock materials resulted in values ranging from 20 psi to 2,270 psi.

Cut Section 5 (Waterloo Road)- Stations 94+00 to 97+50
One boring, designated CS-15 was drilled between the above listed stations to a depth of approximately 20 feet below the existing ground surface. Exposed highly weathered to weathered sandstone bedrock was encountered at the ground surface near boring CS-15.

The overburden soils generally consisted of loose clayey sand, extending to a depth of about 5 feet below existing grade in the boring. The overburden soils were underlain by highly weathered to weathered sandstone with highly weathered shale seam. The bedrock generally varies in color from various shades of brown, red and gray.

Unconfined compressive strength tests performed on the bedrock materials resulted in values ranging of 710 psi and 730 psi.

3.3 Groundwater

The boreholes were observed while drilling for the presence and level of groundwater. Because drilling fluid was introduced into the borings, groundwater observations were made prior to the introduction of drilling fluid. Water was bailed from the borings after boring completion. Water levels were then measured in the boreholes at least 24 hours after boring completion. Groundwater observations are summarized in the following table.

Boring	While Drilling (Depth / Elevation) (ft.)	After Boring (Depth / Elevation) (ft.)	24 Hours After Drilling (Depth / Elevation) (ft.)
CS-1	None to 10 feet[1]	Not measured	14.5 ft /1,121.7 ft (Dry Cave In)

Boring	While Drilling (Depth / Elevation) (ft.)	After Boring (Depth / Elevation) (ft.)	24 Hours After Drilling (Depth / Elevation) (ft.)
CS-2	None to 5.5 feet[1]	Not measured	21.0 ft / 1,115 ft
CS-3	None to 5.5 feet[1]	Not measured	19.5 ft / 1,087.5 ft
CS-4	None to 5.5 feet[1]	Not measured	19.0 ft / 1,107.9 ft (Dry Cave In)
CS-5	None to 5 feet[1]	Not measured	28.0 ft / 1,105.3 ft
CS-6	None to 10.5 feet[1]	Not measured	25.5 ft / 1,116.7 ft
CS-7	None to 5 feet[1]	Not measured	39.0 ft / 1,104.7
CS-8	None to 5 feet[1]	Not measured	Dry
CS-9	None to 5 feet[1]	Not measured	29.5 ft / 1,096.5 ft
CS-10	None to 5 feet[1]	Not measured	34.5 ft / 1,100.0 ft
CS-11	None to 5 feet[1]	Not measured	34.5 ft / 1,104.3
CS-12	None to 5 feet[1]	Not measured	Dry
CS-13	None to 5 feet[1]	Not measured	Dry
CS-14	Not Encountered	Not measured	Dry
CS-15	None to 5 feet[1]	Not measured	17.5 ft / 1,112.1 (Dry Cave In)

[1] Water was not encountered while drilling before fluid was introduced.

To obtain more accurate groundwater level information, longer observations in a monitoring well or piezometer that is sealed from the influence of surface water would be needed. 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. Evaluation of these factors and their effect on the groundwater levels is beyond the scope of this report. 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 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Stability of overburden soils is typically controlled by the type of soil, the presence of groundwater, the presence of surficial water, and the cut slope. Stability of slopes in rock is

typically controlled by the presence and orientation of bedding, joints, fractures or other discontinuities in the rock mass. The orientation of bedding in the rock along the alignment is relatively flat, and therefore, not adverse to the proposed cuts. However, the jointing and weak sandstone/shale could create unstable slopes.

Groundwater was encountered at depths ranging from 14.5 to 39 feet in the borings except for borings CS-8, CS-12, CS-13 and CS-14 that were dry by the time of water measurement. Localized seepage levels could be encountered during excavation and affect certain areas of some of the cuts. The groundwater conditions observed were modeled in the stability analyses.

We understand that sandstone/shale materials obtained during the excavation process will be used as fill materials for the construction of the adjacent embankments. Sandstones and shales should be watered during excavation of the cut sections to speed up the slaking and to facilitate the processing of these materials to a soil-like consistency. We recommend that the watering process start before hauling these materials to the fill sections.

Recommendations regarding design and construction of cut slopes, and bedrock rippability assessment are provided below.

4.2 Cut Slope Evaluations

Various geotechnical exploration and evaluation procedures were employed for the project to obtain necessary subsurface information to provide recommendations for the cut slopes proposed within the alignment. These included:

- Exploratory borings
- Seismic Refraction surveys
- Examining rock cores for rock decomposition, weathering, jointing, and fracture characteristics
- Determining the Rock Quality Designation (RQD) of the core samples
- Performing laboratory tests to obtain strength information for the soils and rock
- Gathering dip and dip direction measurements of representative geologic outcrops found along the proposed roadway where cut slopes are planned
- Conducting global slope stability analyses using the software program SLOPE/W 2016, version 8.16, by Geo-Slope International

4.3 Stability Analysis

Slope stability analyses of cut slopes 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. Stability was analyzed for the drained (long-term) condition.

Stability of cut slopes was evaluated at locations within each cut section where Terracon borings were located so that the geologic conditions could be modeled. Please note that some variations within the cuts may occur due to the relative geometry of the proposed roadway and natural variations in subsurface conditions. The profiles used in our analyses were based on the borings drilled for this project and our onsite observations.

Based on the results of our borings, laboratory testing results, and our field observations, the bedrock has different degrees of jointing and fracturing in the horizontal and vertical directions. The bedding of bedrock is generally near horizontal and not expected to provide failure paths. Shear strength parameters for the soil and rock were modeled in our analysis based on field and laboratory test results, available correlations, and our experience with similar soils. The soil and rock properties used in our analyses are summarized in the following table.

Material	Total Unit Weight (pcf)	Shear Strength Parameters	
		Cohesion, c (psf)	Friction Angle, ϕ (deg.)
Clayey Sand (SC)	120	0	28
Silty Sand (SM)	120	0	28
Lean Clay with Sand to Sandy Lean Clay (CL)	120	0	28
Lean Clay (CL)	120	0	27
Shaley Lean Clay/ Weathered to Highly Weathered Shale	130	150	24
Highly Weathered to Weathered Sandstone/Siltstone	135	0	32

Based on the results of the global stability analyses, we recommend the cut slopes be inclined no steeper than 3H:1V for overburden soils and 2.5H:1V in the bedrock. The results of the stability analysis for the cut slopes are presented in the following table.

Cut Slope	**Analyzed Station**	**Recommended Slope**		**Calculated Factor of Safety (FOS)**
		Overburden Soils (Lean Clay, Clayey Sands to Silty Sand)	**Bedrock (Sandstone, Shale and Siltstone)**	
Cut Slope 1 I-35 Southbound Station 113+00 to 119+00	116+00	3H:1V	2.5H:1V	1.8 (Exhibit D-1)

Cut Slope	Analyzed Station	Recommended Slope		Calculated Factor of Safety (FOS)
		Overburden Soils (Lean Clay, Clayey Sands to Silty Sand)	Bedrock (Sandstone, Shale and Siltstone)	
Cut Slope 2 I-35 Southbound Station 135+00 to 138+00	137+00	3H:1V	2.5H:1V	1.5 (Exhibit D-2)
Cut Slope 3 I-35 Southbound Station 149+00 to 167+25	153+00	3H:1V	2.5H:1V	1.6 (Exhibit D-3)
	159+00	3H:1V	2.5H:1V	1.6 (Exhibit D-4)
Cut Slope 4 I-35 Northbound Station 146+00 to 167+25	152+00	3H:1V	2.5H:1V	1.6 (Exhibit D-5)
	158+00	3H:1V	2.5H:1V	1.7 (Exhibit D-6)
	166+00	3H:1V	2.5H:1V	1.8 (Exhibit D-7)
Cut Slope 5 (Waterloo Rd.) Station 94+00 to 97.5+00	97+00	3H:1V	2.5H:1V	1.7 (Exhibit D-8)

See Exhibits D-1 through D-8 for the soil and rock parameters and profiles, and graphical outputs of the slope stability analyses.

4.4 Catchment Ditch

Complete design of a rock cut must consider and is contingent upon the appropriate configuration of the rockfall catchment ditch at the toe of the cut. If an adequate rockfall ditch can be designed, rockfall hazard to the roadway and traveling public can usually be reduced. The 2.5H:1V rock cut slopes do not require a catchment ditch analysis because they meet the minimal global stability requirements. The catchment ditch configuration shown in the ODOT typical sections of the ODOT Roadway Design Manual, shown in Appendix E-4, will provide the required typical ditch profile.

4.5 Erosion and Drainage Considerations

To reduce the potential of surface water from running over the crest onto the slopes, we recommend surface drainage ditches be constructed along the top of the cut slopes a few feet behind the crest where necessary to intercept surface runoff from upslope. These ditches should discharge at locations beyond the ends of the cut to reduce the possibility of erosion due to water flow.

In the cut sections where moderate plasticity clay and/or shale are exposed, the soil and/or shale near the surface may expand and get weaker with time which may result in shallow surface or near surface sloughing. Shallow surface or near surface sloughing is generally considered a maintenance issue and should be addressed through operations and maintenance (O&M) procedures, such as observation of the slope on a periodic basis and after prolonged precipitation events.

Cut sections with exposed cohesionless materials are more subject to erosion and scour due to water flow over the cut face than cut faces that expose lean to fat clays and rock. We recommend that cut 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.

4.6 Bedrock Rippability Assessment

Terracon performed seismic refraction surveys at select locations along the alignment. The seismic refraction surveys were performed using the p-wave refraction method.

Ripper performance charts published in the Caterpillar Performance Handbook correlate seismic velocity values for various rock types with tractor size. Our bedrock rippability assessment was performed based on ripper performance charts published in the Caterpillar Performance Handbook (48th Edition, 2018). According to the Caterpillar Performance Handbook, sandstone bedrock materials with seismic velocities of up to about 6,300 feet per second (ft/s) should be rippable using a D8R/T multi or Single Shank Ripper. Sandstone with seismic velocities of up to about 8,500 ft/s should be marginally rippable using a D8R/T.

ODOT 2009 Construction Specifications considers that material can be classified as rock and considered as rock excavation when the rock mass has a seismic velocity of 7,900 ft/s or greater or that the rock mass cannot be loosened or broken down by ripping with a bulldozer with a minimum net flywheel power rating of 370 hp.

A summary of the lines we tested and the approximate ranges of bedrock rippability based on seismic velocities at the mid-point of the line and the use of a D8R/T multi or Single Shank Ripper are provided in the following table. Please see the velocity models with the approximate boundaries for more detail (Exhibits B-1 to B-7).

Line	Stations	Borings	Rippable	Marginally Rippable	Non-Rippable
1	163+30 to 166+69	CS-8	To depths of about 30’	To depths of about 40’	Below depths of about 40’
2	150+70 to 154+09	CS-4 CS-5	To depths of about 35’ to 40’	To depths of about 70’	Below depths of about 70’
3	134+60 to 137+99	CS-3	To depths of about 20’ to 25’	To depths of about 25’ to 60’	Below depths of about 25’ to 60’
4	113+81 to 117+20	CS-1 CS-2	To depths of about 25’ to 35’	To depths of about 65’	Below depths of about 65’
5	155+20 to 158+59	CS-12 CS-13	To depths of about 20’	To depths of about 35’ to 80’	Below depths of about 35’ to 80’
6	96+60 to 97+92 Waterloo Road	CS-15	To depths of about 15’ to 25’	To depths of about 17’ to 30’	Below depths of about 17’ to 30’

The bedrock rippability assessment in the previous table, which is based on shear wave velocity, was performed based on ripper performance charts published in the Oklahoma Department of Transportation Geotechnical Specifications for Roadway Design, Appendix 3, and dated June 29, 2011. It must be realized that these are indicators only. The contractor bidding and performing the earthwork at this site should evaluate and determine for themselves the actual rippability of the rock and the excavation methods that will be required for this project.

Previous experience on ODOT projects using shear wave velocity as a guide to rippability of rock formations has proven reliable to our knowledge. However, a more conservative approach to establishing the depth to rippable rock might utilize engineering judgment based on a combination of seismic shear wave velocities, core log analysis and previous experience in the same or similar formation.

The rock formation is dependent upon a number of variables related to the rock mass including, but not limited to, discontinuity (joints/fractures/bedding) spacing and orientation, rock strength, angle of the equipment relative to the orientation of discontinuities, etc. Favorable conditions for rippability include frequent planes of weakness or discontinuities such as joints, fractures or laminations, weathering, moisture content, stratification, brittleness, and “lower” shear strength. Unfavorable conditions for rippability include massive rock with fewer planes of weakness, crystalline rocks, non-brittle energy-absorbing rock matrix, and “higher” shear strength. Other variables relative to rippability include the size of the equipment used, the skill of the operator,

inclusions or “hard spots” in the rock, the condition of the equipment used, and the orientation of any planes of weakness such as fractures or layer bedding.

The table below provides guidance to the design engineer for depths below which excavation quantities might be considered as rock excavation if focusing on the use of a D8R/T bulldozer and its capacity to loosen or break down the rock. The table below considers seismic velocity data, rock core data (recovery, RQD and unconfined strength), and ODOT’s recent experience with rock excavation in this formation.

Line	Stations	Borings	Rock Excavation Depths for Construction Earthwork Quantity Purposes*
1	163+30 to 166+69	CS-8	Below depths of about 5’
2	150+70 to 154+09	CS-4 CS-5	Below depths of about 5’
3	134+60 to 137+99	CS-3	Below depths of about 5’
4	113+81 to 117+20	CS-1 CS-2	Below depths of about 4’ to 6’
5	155+20 to 158+59	CS-12 CS-13	Below depths of about 5’
6	96+60 to 97+92 Waterloo Road	CS-15	Below depths of about 5’

***** Please note that depths presented in this table are shallower than the depths provided in the previous table that is based purely on shear wave velocities results. Even though the shear wave velocity of the sandstone indicates that the rock is rippable in the top 15 to 40 feet, the contractor may encounter difficulty ripping the sandstone due to the lack of vertical fractures observed on the cores. The fractures that we did observe in the cores may be a result of mechanical breaks resulting from the coring process and may not be actual fractures in the bedrock.

5.0 GENERAL COMMENTS

Terracon Consultants, Inc. should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon Consultants, Inc. also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in

this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of 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. Site safety, excavation support, and dewatering requirements are the responsibility of others. 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

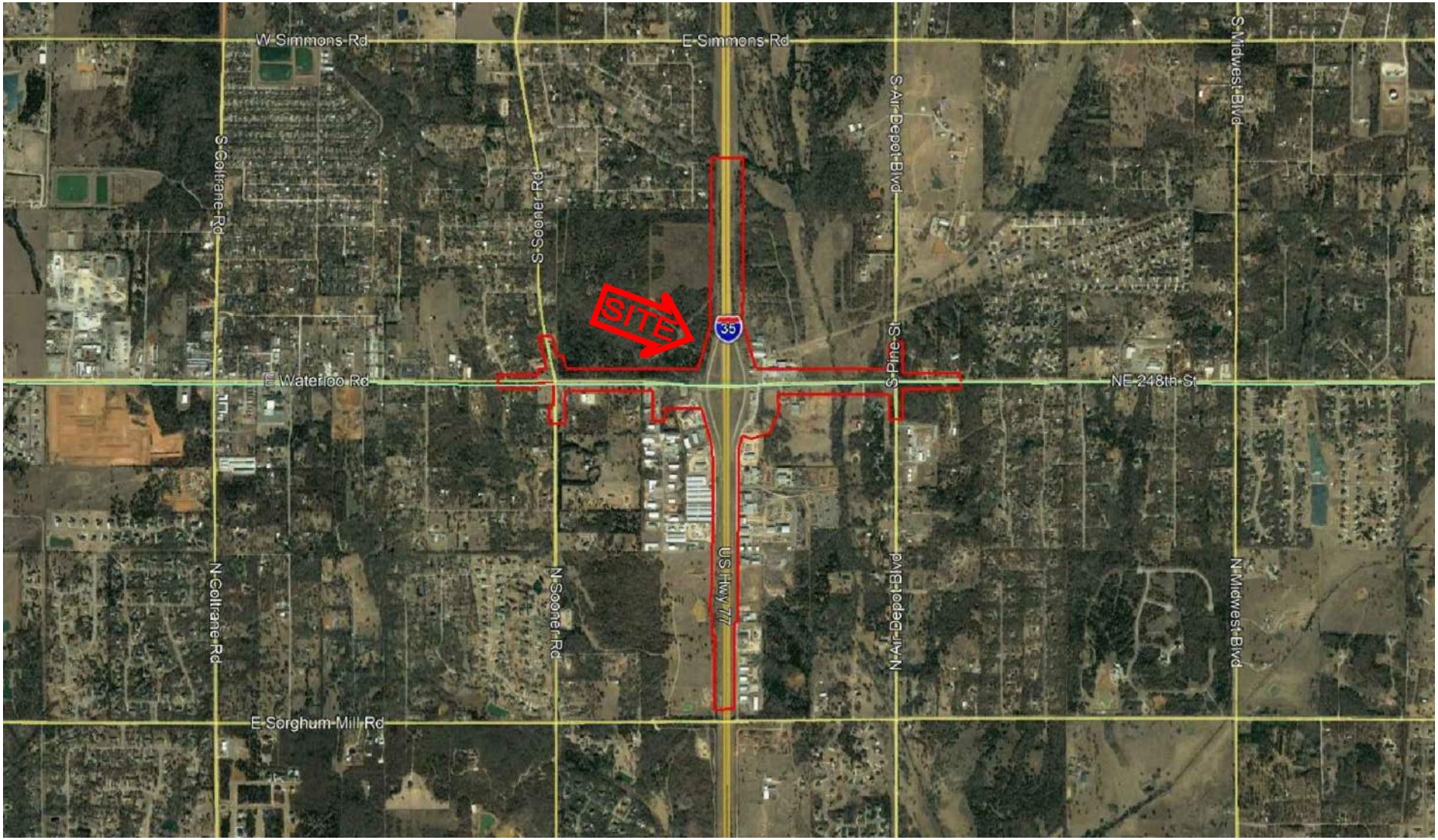


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES.

Project Mngr: DCVS	Project No. 03185253
Drawn By: CAN	Scale: NTS
Checked By: DCVS	File No. 03185253 (A1-A4)
Approved By: NKT	Date: MAR 2019

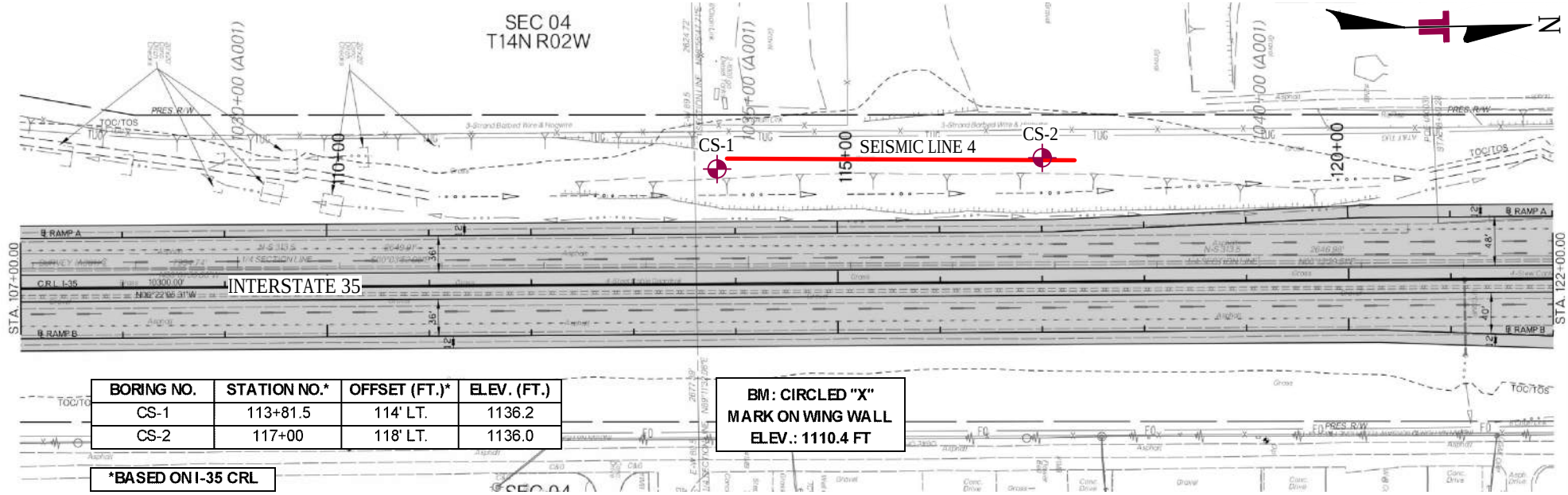
Terracon
Consulting Engineers and Scientists
4701 N STILES AVE OKLAHOMA CITY, OKLAHOMA 73105
PH. (405) 525-0453 FAX. (405) 557-0549

SITE LOCATION PLAN

CUT SECTIONS
INTERSTATE 35 OVER WATERLOO ROAD INTERCHANGE
LOGAN AND OKLAHOMA COUNTIES, OKLAHOMA

EXHIBIT

A1

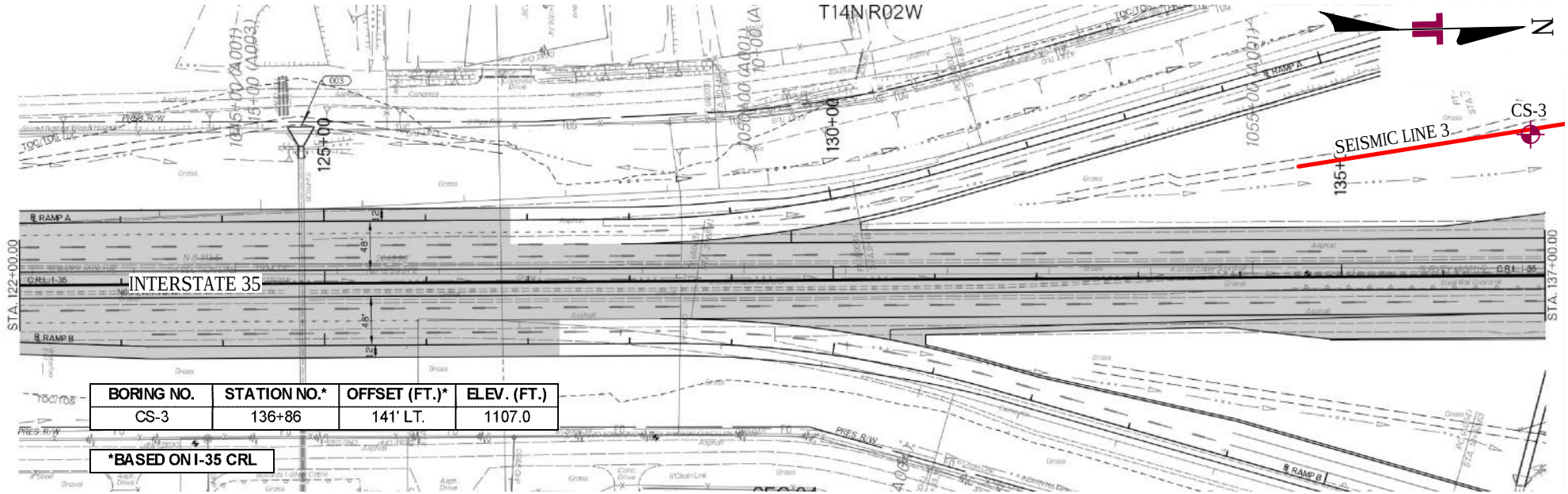


BORING NO.	STATION NO.*	OFFSET (FT.)*	ELEV. (FT.)
CS-1	113+81.5	114' LT.	1136.2
CS-2	117+00	118' LT.	1136.0

*BASED ON I-35 CRL

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

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



BORING NO.	STATION NO.*	OFFSET (FT.)*	ELEV. (FT.)
CS-3	136+86	141' LT.	1107.0

*BASED ON I-35 CRL

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

LEGEND

- BORING LOCATION
- SEISMIC LINE
- STRIKE AND DIP JOINT PLANES
- OUTCROPPED WEATHERED SANDSTONE

Project Mngr:	DCVS
Drawn By:	CAN
Checked By:	DCVS
Approved By:	NKT

Project No.	03185253
Scale:	NTS
File No.	03185253 (A1-A4)
Date:	MAR 2019

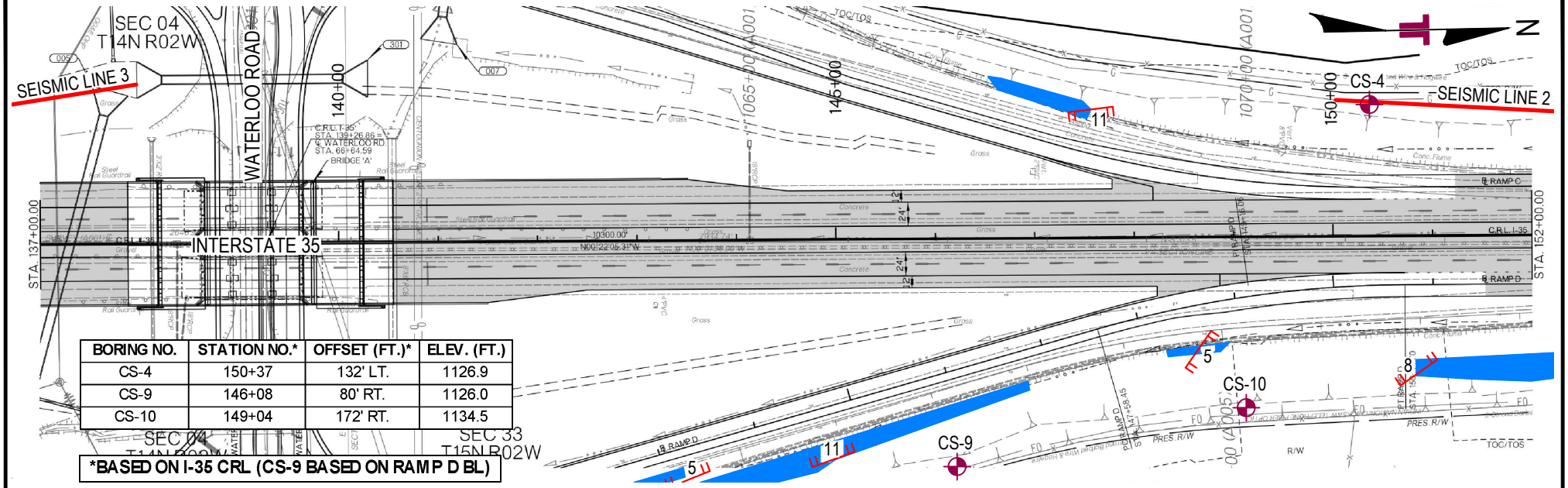
Terracon
Consulting Engineers and Scientists
4701 N STILES AVE OKLAHOMA CITY, OKLAHOMA 73105
PH. (405) 525-0453 FAX. (405) 557-0549

BORING LOCATION PLAN

CUT SECTIONS
INTERSTATE 35 OVER WATERLOO ROAD INTERCHANGE
LOGAN AND OKLAHOMA COUNTIES, OKLAHOMA

EXHIBIT

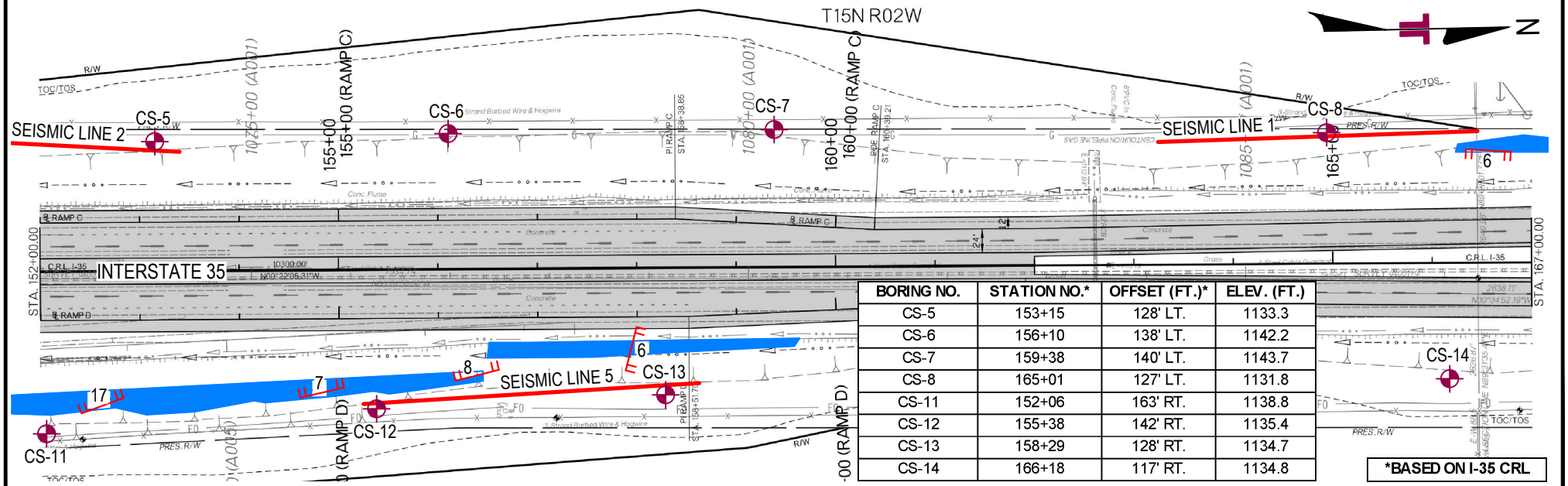
A2



BORING NO.	STATION NO.*	OFFSET (FT.)*	ELEV. (FT.)
CS-4	150+37	132' LT.	1126.9
CS-9	146+08	80' RT.	1126.0
CS-10	149+04	172' RT.	1134.5

*BASED ON I-35 CRL (CS-9 BASED ON RAMP D BL)

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



BORING NO.	STATION NO.*	OFFSET (FT.)*	ELEV. (FT.)
CS-5	153+15	128' LT.	1133.3
CS-6	156+10	138' LT.	1142.2
CS-7	159+38	140' LT.	1143.7
CS-8	165+01	127' LT.	1131.8
CS-11	152+06	163' RT.	1138.8
CS-12	155+38	142' RT.	1135.4
CS-13	158+29	128' RT.	1134.7
CS-14	166+18	117' RT.	1134.8

*BASED ON I-35 CRL

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

LEGEND

- BORING LOCATION
- SEISMIC LINE
- STRIKE AND DIP JOINT PLANES
- OUTCROPPED WEATHERED SANDSTONE

Project Mngr:	DCVS
Drawn By:	CAN
Checked By:	DCVS
Approved By:	NKT

Project No.	03185253
Scale:	NTS
File No.	03185253 (A1-A4)
Date:	MAR 2019

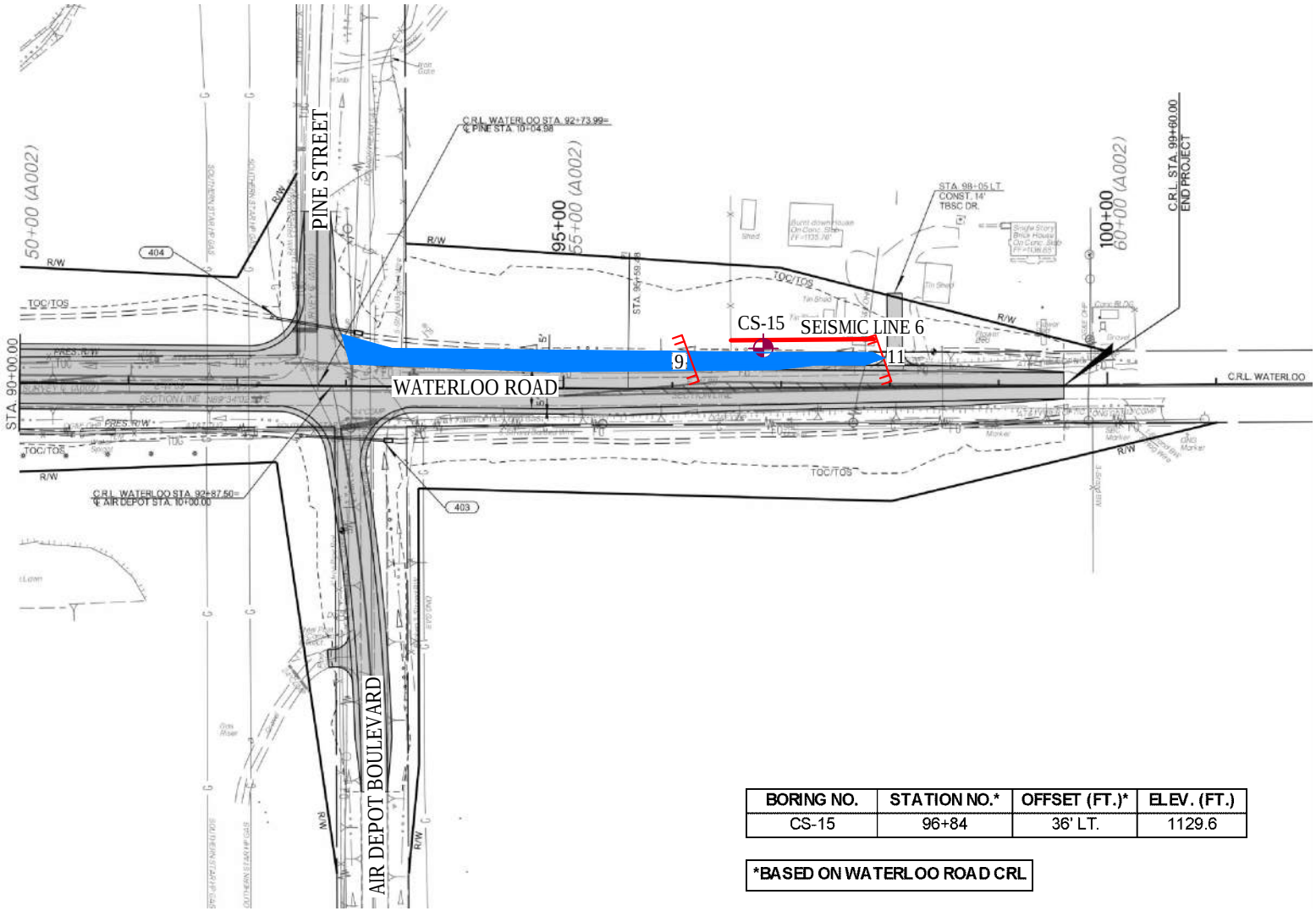
Terracon
Consulting Engineers and Scientists
4701 N STILES AVE OKLAHOMA CITY, OKLAHOMA 73105
PH. (405) 525-0453 FAX. (405) 557-0549

BORING LOCATION PLAN

CUT SECTIONS
INTERSTATE 35 OVER WATERLOO ROAD INTERCHANGE
LOGAN AND OKLAHOMA COUNTIES, OKLAHOMA

EXHIBIT

A3



N

BORING NO.	STATION NO.*	OFFSET (FT.)*	ELEV. (FT.)
CS-15	96+84	36' LT.	1129.6

*BASED ON WATERLOO ROAD CRL

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

LEGEND

- BORING LOCATION
- SEISMIC LINE
- STRIKE AND DIP JOINT PLANES
- OUTCROPPED WEATHERED SANDSTONE

Project Mngr:	DCVS
Drawn By:	CAN
Checked By:	DCVS
Approved By:	NKT

Project No.	03185253
Scale:	NTS
File No.	03185253 (A1-A4)
Date:	MAR 2019

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

BORING LOCATION PLAN

CUT SECTIONS
INTERSTATE 35 OVER WATERLOO ROAD INTERCHANGE
LOGAN AND OKLAHOMA COUNTIES, OKLAHOMA

EXHIBIT

A4

Field Exploration Description

Geotechnical Borings

The boring locations were initially established in the field by Terracon personnel using a handheld GPS device. The boring location coordinates were obtained based on the drawings provided to us by the client. Terracon determined the approximate ground surface elevations at the borings using an engineer's level. These elevations were referenced to BMs # 116, 117 and 119 and by the X mark on the northeast wing wall Southbound I-35 bridge over Waterloo Road and using reported elevations as shown on the boring location plans in Appendix A. Based on these benchmarks, the ground surface elevations at the boring locations ranged from 1,107 to 1,143.7 feet. The elevations shown on the boring logs have been rounded to the nearest 0.1 foot. The boring stations, offsets and elevations should be considered accurate only to the degree implied by the methods used to define them.

The borings were drilled with ATV-mounted rotary drill rigs using continuous flight solid-stem augers to advance the boreholes and rock coring techniques. Samples of the soil encountered in the borings were obtained using the split barrel and thin-walled tube sampling procedure. In the split-barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split-barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound auto-hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in-situ relative density of cohesionless soils, consistency of cohesive soils, and hardness of weathered bedrock. In the thin-walled tube sampling procedure, a seamless steel tube with a sharpened cutting end is hydraulically pushed into the bottom of the boring to obtain a relatively undisturbed cohesive soil sample.

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

We cored the bedrock from all borings, except for boring CS-14, using a NX-size diamond bit core barrel. After the core samples were retrieved, they were placed in a core box and logged. The rock was visually classified and the percent recovery and Rock Quality Designation (RQD) was determined for each core run. The percent recovery is a ratio of the recovered sample length to the cored length, expressed as a percentage. The RQD is the summation core pieces at least 4 inches in length divided by the length of core run, expressed as a percentage.

The sampling depths, penetration distances, and N values are reported on the boring logs. The samples were tagged for identification, sealed to reduce moisture loss and taken to the

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

Seismic Refraction Test

Terracon also performed seismic refraction surveys at 6 cut sections using the p-wave refraction method. Survey locations and their spacing were as followings:

- Line 1 was located to supplement boring CS-8. Located on the west side of the existing road, it was a 339-foot linear array trending north to south utilizing 13 foot spaced geophones (24 geophones) with 5 shot locations.

- Line 2 was located to supplement borings CS-4 and CS-5. Located on the west side of the existing road, it was a 339-foot linear array trending north to south utilizing 13 foot spaced geophones (24 geophones) with 5 shot locations.

- Line 3 was located to supplement boring CS-3. Located on the west side of the existing road, it was a 339-foot linear array trending northwest to southeast utilizing 13 foot spaced geophones (24 geophones) with 5 shot locations.

- Line 4 was located to supplement borings CS-1 and CS-2. Located on the west side of the existing road, it was a 339-foot linear array trending north to south utilizing 13 foot spaced geophones (24 geophones) with 5 shot locations.

- Line 5 was located to supplement boring CS-12 and CS-13. Located on the east side of the existing road, it was a 339-foot linear array trending north to south utilizing 13 foot spaced geophones (24 geophones) with 5 shot locations.

- Line 6 was located to supplement boring CS-15. Located on the north side of the existing Waterloo Road, it was a 132-foot linear array trending west to east utilizing 4 foot spaced geophones (24 geophones) with 5 shot locations.

A shot location is a spot where the source, in this case a 16 lb. sledgehammer and source plate was activated to create the p-waves. At each shot location, 6 to 10 hammer swings were recorded and stacked to make one shot. The geophones were triggered by the source, and a 0.5 second data set with a 0.125 millisecond sample interval was recorded for each shot. Geophone and shot location elevations were collected with a GPS system, yielding a topographic profile of the array.

The data sets for each shot location were combined and first break points were chosen. First break points are the time it takes the first p-wave to arrive at each of the 24 geophones. Using only the first break points and survey geometry, the data is forward modeled using a non-linear optimization technique called adaptive simulated annealing. This algorithm determines the p-wave velocity model with the minimum travel-time error without searching through every possible model. This method yields a true 2-D profile along the array.

The data sets for each shot location were combined and first break points were chosen. First break points are the time it takes the first p-wave to arrive at each of the 24 geophones. Using only the first break points and survey geometry, the data is forward modeled using a non-linear optimization technique called adaptive simulated annealing. This algorithm determines the p-wave velocity model with the minimum travel-time error without searching through every possible model. This method yields a true 2-D profile along the array.

BORING LOG NO. CS-1

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7181° Longitude: -97.4167°

Station: 113+81.5 Offset: 114' LT
Approximate Surface Elev.: 1136.2 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description
1.5	1134.5+/-	**SILTY SAND (SM)**, weak red (10R 4/2), loose
4.0	1132+/-	**SANDY LEAN CLAY (CL)**, weak red (10R 4/2) and dark red (10R 3/6)
6.0	1130+/-	**CLAYEY SAND (SC)**, red (2.5YR 5/6)
		HIGHLY WEATHERED SHALE WITH SANDSTONE LAYERS, red (2.5YR 5/8)
		-light red (2.5YR 6/6) below 10.5'
		-red (2.5YR 4/6) and light red (2.5YR 6/6) below 11'
		-dusky red (2.5YR 3/2) and red (2.5YR 4/6) below 13.5'
		-with silt seams, red (2.5YR 4/6) and gray (GLEY 1 7/N) below 15'
		-reddish brown (2.5YR 4/3) and yellowish brown (10YR 5/6) below 18'
		-light reddish brown (5YR 6/3) and weak red (10R 5/4) below 20'
25.0	1111+/-	***Boring Terminated at 25 Feet***

DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	18	2-2-4 N=6				13			
	21					16	110	38-13-25	69
5	17	7-9-50/6"				14		35-16-19	45
10	1	50/3"				5			
	49		82	15	20	20	110		
15	58		97	63					
					160	12	127		
20	59		98	8					
25					490	16	109		

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 10' Power Auger
10' - 25' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass and Topsoil
Station and Offset based on I-35 CRL

WATER LEVEL OBSERVATIONS

14.5' Dry Cave In After 24 Hours

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-12-2018 | Boring Completed: 12-12-2018
Drill Rig: 880 | Driller: R. Smalley
Project No.: 03185253 | Exhibit: A-6

BORING LOG NO. CS-2

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.719° Longitude: -97.4167°

Station: 117+00 Offset: 118' LT
Approximate Surface Elev.: 1136.0 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DESCRIPTION
0	1136.0+/-	**CLAYEY SAND (SC)**, brownish yellow (10YR 6/8), medium dense
4.0	1132+/-	**HIGHLY WEATHERED SANDSTONE**, red (10R 5/8) and reddish yellow (5YR 6/8)
		-weathered, dark reddish brown (5YR 2.5/2/2) below 10.5'
		-weathered shale seams below 13.5'
15.5	1120.5+/-	**HIGHLY WEATHERED SHALE**, red (2.5YR 4/6) and light red (2.5YR 6/8)
		-red (2.5YR 4/8) below 18.5'
		-pinkish white (2.5YR 8/2) and red (2.5YR 5/8) below 20.5'
23.5	1112.5+/-	**HIGHLY WEATHERED SANDSTONE**, dusky red (2.5YR 3/2)
25.5	1110.5+/-	***Boring Terminated at 25.5 Feet***

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
			18	3-5-6 N=11				16		30-15-15	41
5			6	50/5"				4			
			3		5	5					
10			52		87	35	10	18	115		
15			60		100	96	170	10	133		
20	▼		60		100	28	180	10	132		
25											

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5.5' Power Auger
5.5' - 25.5' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass and Topsoil
Station and Offset based on I-35 CRL

WATER LEVEL OBSERVATIONS

▼ *21' After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-11-2018 Boring Completed: 12-11-2018

Drill Rig: 880 Driller: R. Smalley

Project No.: 03185253 Exhibit: A-7

BORING LOG NO. CS-3

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7244° Longitude: -97.4167°

Station: 136+86 Offset: 141' LT
Approximate Surface Elev.: 1107.0 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0	1107.0	**LEAN CLAY WITH SAND (CL)**, red (2.5YR 4/8) and light red (2.5YR 6/8), very stiff	17	3-4-18 N=22				14		24-15-9	77
5.0	1102+/-		5	50/5"				4			
		HIGHLY WEATHERED SANDSTONE, light red (2.5YR 6/8) -light red (2.5YR 7/8) below 5.5' -red (2.5YR 5/8) below 6'	22		37	37					
10.5	1096.5+/-	**HIGHLY WEATHERED SHALE**, red (2.5YR 5/8)	60		100	18	120	11	132		
13.5	1093.5+/-	**HIGHLY WEATHERED SANDSTONE**, light red (2.5YR 6/6) and pink (2.5YR 8/3)									
15.5	1091.5+/-	**HIGHLY WEATHERED SILTSTONE**, red (2.5YR 5/8) and pink (2.5YR 8/4)	60		100	40	120	10	133		
18.5	1088.5+/-	**HIGHLY WEATHERED SANDSTONE**, light red (2.5YR 6/8)	58		97	43	800	16	115		
25.5	1081.5+/-	***Boring Terminated at 25.5 Feet***									

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5.5' Power Auger
5.5' - 25.5' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass and Topsoil
Station and Offset based on I-35 CRL

WATER LEVEL OBSERVATIONS

19.5' After 24 Hours

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-11-2018 Boring Completed: 12-11-2018

Drill Rig: 880 Driller: R. Smalley

Project No.: 03185253 Exhibit: A-8

BORING LOG NO. CS-4

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7281° Longitude: -97.4167°

Station: 150+37 Offset: 136' LT
Approximate Surface Elev.: 1126.9 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DESCRIPTION
0.0	1122+/-	**SILTY SAND (SM)**, dark reddish brown (5YR 3/4), loose
5.0	1121.5+/-	**HIGHLY WEATHERED SILTSTONE**, red (2.5YR 5/6), pink (5YR 7/3) and light gray (GLEY1 7/N), soft
5.5		**HIGHLY WEATHERED SANDSTONE**, reddish yellow (5YR 6/8), dark reddish brown (5 YR 3/3) and pink (5YR 7/4)
		-reddish yellow (5YR 6/6) and light red (2.5YR 6/8). weathered below 10.5'
15.5	1111.5+/-	**HIGHLY WEATHERED SHALE**, reddish brown (2.5YR 5/3)
18.5	1108.5+/-	**HIGHLY WEATHERED SANDSTONE**, light red (2.5YR 6/6)
		-reddish brown (2.5YR 5/3) and reddish yellow (5YR 6/8) below 20.5'
25.5	1101.5+/-	***Boring Terminated at 25.5 Feet***

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
			18	1-2-3 N=5				9		NP	17
5			6	50/6"				10			
			49		82	22	770	16	110		
10			58		97	87	30	15	115		
15			60		100	17	140	9	135		
20			57		95	22	110	11	128		
25											

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5.5' Power Auger
5.5' - 25.5' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass and Topsoil
Station and Offset based on I-35 CRL

WATER LEVEL OBSERVATIONS

19' Dry Cave In After 24 Hours

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-10-2018	Boring Completed: 12-11-2018
Drill Rig: 880	Driller: R. Smalley
Project No.: 03185253	Exhibit: A-9

BORING LOG NO. CS-5

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7289° Longitude: -97.4167°

Station: 153+15 Offset: 128' LT
Approximate Surface Elev.: 1133.3 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
			15	2-2-2 N=4				12		NP	27
5.0	1128.5+/-	5	5	50/5"				7			
			44		92	21	590	15	109		
		10	57		95	65	400	18	105		
		15	57		95	65	590	19	104		
18.5	1115+/-	20	60		100	25	100	13	126		
25.0	1108.5+/-	25	59		98	57	180	10	135		
30.0	1103.5+/-	30									

SILTY SAND (SM), dark reddish brown (5YR 3/2), loose

HIGHLY WEATHERED SANDSTONE, dark red (2.5YR 3/6) and light red (2.5YR 6/6)
-dark reddish brown (2.5YR 3/4) and yellowish red (5YR 5/8) below 6'
-red (2.5YR 5/6) and light reddish brown (2.5YR 6/4), weathered below 10'
-light reddish brown (2.5YR 6/4), red (10R 5/6) and strong brown (7.5YR 5/6) below 15'

HIGHLY WEATHERED SHALE, red (2.5YR 4/6)

WEATHERED SANDY SILTSTONE, red (2.5YR 5/6) and light gray (GLEY1 7/N)

Boring Terminated at 30 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5' Power Auger
5' - 30' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:
Surface Cover: Grass and Topsoil
Station and Offset based on I-35 CRL

WATER LEVEL OBSERVATIONS

28' After 24 Hours

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-10-2018	Boring Completed: 12-10-2018
Drill Rig: 880	Driller: R. Smalley
Project No.: 03185253	Exhibit: A-10

BORING LOG NO. CS-6

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7297° Longitude: -97.4167°

Station: 156+10 Offset: 138' LT
Approximate Surface Elev.: 1142.2 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Material Description
0.0	1142.2+/-	**CLAYEY SAND (SC)**, dark brown (7.5YR 3/2), loose
		-dusky red (10R 3/4) below 2'
		-light reddish brown (2.5YR 6/4), dense below 5'
7.0	1135+/-	**WEATHERED SANDSTONE**, pink (5YR 8/3)
		-strong brown (7.5YR 4/6) and strong brown(7.5YR 5/8) below 10.5'
		-reddish yellow (5YR 6/6), highly weathered below 15.5'
20.5	1121.5+/-	**HIGHLY WEATHERED SILTSTONE**, yellowish red (5YR 5/6)
25.5	1116.5+/-	**HIGHLY WEATHERED SANDSTONE**, reddish yellow (5YR 6/8)
30.5	1111.5+/-	

DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0	18	2-4-4 N=8				15			
5	18	17-19-29 N=48				9		30-14-16	32
10	3	50/3"							
	46		77	60	990	16	111		
15	59		98	20	930	14	114		
20	59		98	15	630	16	115		
25	58		97	38	1040	20	108		
30									

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 10.5' Power Auger
10.5' - 35.5' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass and Topsoil
Station and Offset based on I-35 CRL

WATER LEVEL OBSERVATIONS

▼ *25.5 After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-10-2018	Boring Completed: 12-10-2018
Drill Rig: 880	Driller: R. Smalley
Project No.: 03185253	Exhibit: A-11

BORING LOG NO. CS-6

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7297° Longitude: -97.4167°

Station: 156+10 Offset: 138' LT
Approximate Surface Elev.: 1142.2 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	RECOVERY (In.)	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
HIGHLY WEATHERED SHALE, red (2.5YR 4/8) *(continued)*										
-reddish yellow (5YR 6/8) below 32.5'			60	100	88	200	8	140		
35.5	1106.5+/-	35								
Boring Terminated at 35.5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 10.5' Power Auger
10.5' - 35.5' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

25.5 After 24 Hours

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-10-2018 | Boring Completed: 12-10-2018
Drill Rig: 880 | Driller: R. Smalley
Project No.: 03185253 | Exhibit: A-11

BORING LOG NO. CS-7

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7306° Longitude: -97.4167°

Station: 159+38 Offset: 140' LT
Approximate Surface Elev.: 1143.7 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DESCRIPTION
1.5	1142+/-	**CLAYEY SAND (SC)**, reddish brown (5YR 4/3), loose
5.0	1138.5+/-	**LEAN CLAY (CL)**, red (2.5YR 4/6)
		HIGHLY WEATHERED SILTY SANDSTONE, red (2.5YR 4/6) and white (2.5YR 8/1)
		-red (2.5YR 4/6) below 7'
		-red (2.5YR 4/6) and reddish brown (2.5YR 5/4) below 10'
		-with siltstone seams, dark reddish gray (2.5 YR 3/1) and red (10R 4/4) below 13'
		-light reddish brown (2.5YR 6/3) below 15'
		-red (10R 4/6), weak red (10R 5/2) and dusky red (7.5R 3/3), with embedded conglomerate seams below 20'
		-light gray (GLEY1 7/N) below 23'
25.0	1118.5+/-	**WEATHERED SHALE**, red (10R 4/8)

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		18	2-2-4 N=6				15		28-13-15	32
5		18	21-31-50/6"				9		NP	18
		15		42	0					
10		56		93	0					
15		44		73	17	770	17	107		
20		55		92	37	660	16	114		
25		59		98	57					
30						80	15	121		

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5' Power Auger
5' - 40' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass and Topsoil
Station and Offset based on I-35 CRL

WATER LEVEL OBSERVATIONS

39' After 24 Hours

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-07-2018 Boring Completed: 12-07-2018

Drill Rig: 880 Driller: R. Smalley

Project No.: 03185253 Exhibit: A-12

BORING LOG NO. CS-7

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7306° Longitude: -97.4167°

Station: 159+38 Offset: 140' LT
Approximate Surface Elev.: 1143.7 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
WEATHERED SHALE, red (10R 4/8) *(continued)*													
					53		88	78	110	11	131		
35.0	1108.5+/-	35											
WEATHERED SANDSTONE, dusky red (7.5R 3/4) and red (10R 5/6)													
			▼		60		100	92	510	14	111		
40.0	1103.5+/-	40											
Boring Terminated at 40 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5' Power Auger
5' - 40' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▼ *39' After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-07-2018 Boring Completed: 12-07-2018

Drill Rig: 880 Driller: R. Smalley

Project No.: 03185253 Exhibit: A-12

BORING LOG NO. CS-8

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7321° Longitude: -97.4167°

Station: 165+01 Offset: 127' LT
Approximate Surface Elev.: 1131.8 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1.5	1130.5+/-	**SANDY SILT (ML)**, dark reddish gray (5YR 4/2), very loose	18	2-1-2 N=3				15		NP	55
5.0	1127+/-	**LEAN CLAY (CL)**, yellowish red (5YR 5/6)	4	50/4"				2			
10.0	1122+/-	**HIGHLY WEATHERED SANDSTONE**, with conglomerate seams, pale red (7.5R 6/3) and weak red (7.5R 5/4) -dusky red (7.5R 3/2) and red (2.5YR 4/6) below 6'	29		60	15	50	6	148		
15.0	1117+/-	**HIGHLY WEATHERED SHALE**, red (2.5YR 4/6)	52		87	48	50	18	113		
25.0	1107+/-	**HIGHLY WEATHERED SANDSTONE**, red (2.5YR 4/6) and light gray (GLEY1 7/N) -red (10R 5/6) below 23'	55		92	42	60	10	134		
			41		68	43	560	15	110		
		Boring Terminated at 25 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5' Power Auger
5' - 20' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:
Surface Cover: Grass and Topsoil
Station and Offset based on I-35 CRL

WATER LEVEL OBSERVATIONS

Dry after 24 Hours

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-07-2018 Boring Completed: 12-07-2018
Drill Rig: 880 Driller: R. Smalley
Project No.: 03185253 Exhibit: A-13

BORING LOG NO. CS-9

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.727° Longitude: -97.4155°

Station: 146+09 Offset: 94' RT
Approximate Surface Elev.: 1126.0 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.0	1126.0	**SILTY SAND (SM)**, yellowish red (5YR 5/8) and reddish yellow (5YR 6/8), very dense				18	11-28-37 N=65				12		NP	14
5.0	1121+/-													
5.5	1120.5+/-	**HIGHLY WEATHERED SANDSTONE**, red (10R 4/6) and pale red (10R 7/2), cemented	5			3	50/3"				5			
		HIGHLY WEATHERED SILTY SANDSTONE, red (10R 4/6) and reddish yellow (7.5YR 6/6)				49		91	0					
10.0	1116+/-	**HIGHLY WEATHERED SANDSTONE**, pale red (10R 7/3) and trace black (10R 2.5/1)	10			56		93	33					
13.0	1113+/-	**WEATHERED SHALE**, red (10R 4/6) and light gray (GLEY1 7/N)								20	15	122		
		-silt seams, red (10R 4/6), dark gray (GLEY1 7/N) and dusky red (10R 3/4) below 15'	15			60		100	75	90	10	135		
20.0	1106+/-	**HIGHLY WEATHERED SILTSTONE**, red (10R 5/6) and pale red (10R 7/2)	20			60		100	23					
23.0	1103+/-	**HIGHLY WEATHERED SANDSTONE**, pale red (10R 6/4)								710	19	105		
		-pale red (10R 6/4) and light red (10R 6/6) below 25'	25			59		98	38					
30.0	1096+/-		30	▼						740	18	107		
		Boring Terminated at 30 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5' Power Auger
5' - 30' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass and Topsoil
Station and Offset based on Ramp D BL

WATER LEVEL OBSERVATIONS

▼ *29.5' After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-17-2018	Boring Completed: 12-17-2018
Drill Rig: 880	Driller: R. Smalley
Project No.: 03185253	Exhibit: A-14

BORING LOG NO. CS-10

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7278° Longitude: -97.4157°

Station: 149+04 Offset: 174' RT
Approximate Surface Elev.: 1134.5 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DESCRIPTION
1.5	1133+/-	**CLAYEY SAND (SC)**, dark reddish gray (5YR 4/2), loose
5.0	1129.5+/-	**LEAN CLAY (CL)**, reddish brown (5YR 4/3)
5.4	1129+/-	**HIGHLY WEATHERED SANDSTONE**, yellowish red (5YR 5/6), cemented
8.5	1126+/-	**HIGHLY WEATHERED SILTY SANDSTONE**, strong brown (7.5YR 5/6)
10.0	1124.5+/-	**HIGHLY WEATHERED SANDSTONE**, red (2.5YR 5/8), mottled black (2.5YR 2.5/1) dots
15.0	1119.5+/-	**HIGHLY WEATHERED SILTY SANDSTONE**, weak red (10R 4/4), light yellowish red (10YR 6/4) and pale red (10R 6/3)
20.0	1114.5+/-	**WEATHERED SANDSTONE**, trace conglomerate, light brown (7.5YR 6/4) and red (10R 4/6)
25.0	1109.5+/-	**WEATHERED SHALE**, with conglomerate, red (10R 4/6) and pale red (10R 6/4)
		HIGHLY WEATHERED SILTSTONE, red (10R 5/8) and pale red (10R 6/4)

DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	18	2-2-3 N=5				19		27-14-13	40
5	3	50/4"				12			
	45		83	9	380	16	109		
10	58		97	0					
	57		95	80	560	18	104		
20	60		100	77	90	8	139		
25	60		100	0	330	14	115		
30					70	11	127		

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5' Power Auger
5' - 35' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass and Topsoil
Station and Offset based on I-35 CRL

WATER LEVEL OBSERVATIONS

34.5' After 24 Hours

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-18-2018	Boring Completed: 12-18-2018
Drill Rig: 880	Driller: R. Smalley
Project No.: 03185253	Exhibit: A-15

BORING LOG NO. CS-10

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7278° Longitude: -97.4157°

Station: 149+04 Offset: 174' RT
Approximate Surface Elev.: 1134.5 (Ft.) +/-

GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	32.0	1102.5+/-												
	HIGHLY WEATHERED SANDSTONE, dusky red (10R 3/3) and red (10R 5/6)			▼		60		100	68					
	35.0	1099.5+/-	35											
	Boring Terminated at 35 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5' Power Auger
5' - 35' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▼ *34.5' After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-18-2018 Boring Completed: 12-18-2018

Drill Rig: 880 Driller: R. Smalley

Project No.: 03185253 Exhibit: A-15

BORING LOG NO. CS-11

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7286° Longitude: -97.4157°

Station: 152+06 Offset: 163' RT
Approximate Surface Elev.: 1138.8 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1.5	1137.5+/-	**CLAYEY SAND (SC)**, reddish brown (5YR 4/3), loose	18	2-2-4 N=6				18		27-15-12	37
5.0	1134+/-	**LEAN CLAY (CL)**, red (2.5YR 5/6)									
6.3	1132.5+/-	**LEAN CLAY WITH SAND (CL)**, red (2.5YR 4/6) and reddish brown (2.5YR 4/4)	14	12-28-50/2"				7			
7.0	1132+/-	**HIGHLY WEATHERED SILTSTONE**, red (2.5YR 5/8)									
10.0	1129+/-	**HIGHLY WEATHERED SILTY SANDSTONE**, red (10R 4/6)	36		100	0					
		HIGHLY WEATHERED SANDSTONE, pale red (10R 7/2) and black (10R 2.5/1)	49		82	0					
		-pale red (10R 7/2), weak red (10R 4/4) and yellowish brown (10YR 5/6) below 15'	60		100	40	950	16	110		
23.0	1116+/-	-yellowish brown (10YR 5/6), weathered below 20'	60		100	63	2270	3	156		
		WEATHERED SHALE, with silt seams, red (2.5YR 4/6)									
28.5	1110.5+/-	red (2.5YR 5/6) and light gray (GLEY1 7/N) below 25'	59		98	50	160	10	134		
		HIGHLY WEATHERED SANDSTONE, trace conglomerate, weak red (10R 5/4)									

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5' Power Auger
5' - 35' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass and Topsoil
Station and Offset based on I-35 CRL

WATER LEVEL OBSERVATIONS

34.5' After 24 Hours

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-17-2018	Boring Completed: 12-17-2018
Drill Rig: 880	Driller: R. Smalley
Project No.: 03185253	Exhibit: A-16

BORING LOG NO. CS-11

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7286° Longitude: -97.4157°

Station: 152+06 Offset: 163' RT
Approximate Surface Elev.: 1138.8 (Ft.) +/-

DEPTH	ELEVATION (Ft.)
35.0	1104+/-

GRAPHIC LOG	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
HIGHLY WEATHERED SANDSTONE, trace conglomerate, weak red (10R 5/4) *(continued)*		▼		59		98	17	720	15	109		
	35											
Boring Terminated at 35 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5' Power Auger
5' - 35' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▼ *34.5' After 24 Hours*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-17-2018 | Boring Completed: 12-17-2018
Drill Rig: 880 | Driller: R. Smalley
Project No.: 03185253 | Exhibit: A-16

BORING LOG NO. CS-12

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7295° Longitude: -97.4158°

Station: 155+38 Offset: 142' RT
Approximate Surface Elev.: 1135.4 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.0	1135.4+/-												
SILTY SAND (SM), strong brown (7.5YR 4/6), loose					16	2-3-3 N=6				13		NP	28
5.0	1130.5+/-	5			10	29-50/4"				8			
HIGHLY WEATHERED SANDSTONE, reddish yellow (5YR 6/8) and yellowish red (5YR 5/8) -with silt seams, light gray (GLEY1 7/N) below 5'					48		100	0					
-reddish yellow (5YR 6/8) and pink (7.5YR 7/3) below 10'		10			60		100	12	650	20	103		
-red (2.5YR 4/8), red (2.5YR 4/6) and very pale brown (10YR 7/3) below 15'		15			60		100	40	710	15	110		
-red (2.5YR 5/6), red (2.5YR 5/8) trace gray (GLEY1 7/N), weathered below 20'		20			57		95	57					
-shale seams, red (2.5YR 5/6), reddish yellow (7.5YR 6/6) and strong brown (7.5YR 5/8), highly weathered below 25'		25			60		100	0	130	11	131		
30.0	1105.5+/-	30											
Boring Terminated at 30 Feet													

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5' Power Auger
5' - 30' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass and Topsoil
Station and Offset based on I-35 CRL

WATER LEVEL OBSERVATIONS

Dry after 24 Hours

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-06-2018 Boring Completed: 12-06-2018

Drill Rig: 880 Driller: R. Smalley

Project No.: 03185253 Exhibit: A-17

BORING LOG NO. CS-13

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7303° Longitude: -97.4158°

Station: 158+29 Offset: 128' RT
Approximate Surface Elev.: 1134.7 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DESCRIPTION
0.0	1134.7+/-	**SILTY SAND (SM)**, dark reddish brown (5YR 3/2), very loose
5.0	1129.5+/-	**HIGHLY WEATHERED SANDSTONE**, yellow (10YR 8/6) and pale red (2.5YR 7/2) -trace roots, reddish yellow (5YR 6/8) and red (10R 5/8) and light gray (GLEY1 7/N) below 5.5'
		-weak red (10R 5/4), reddish brown (5YR 5/4) and dusky red (10R 3/3) , with conglomerate layers, weathered below 10'
15.0	1119.5+/-	**WEATHERED SHALE**, with conglomerate seams, red (10R 4/6). red (10R 4/8) and light gray (GLEY1 7/N)
		-red (10R 4/6), pale brown (10YR 6/3) and reddish brown (2.5YR 4/4) below 20'
		-highly weathered below 25'
30.0	1104.5+/-	***Boring Terminated at 30 Feet***

DEPTH (Ft.)	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0	18	1-1-2 N=3				11		NP	25
5	9	42-50/3"				5			
10	48		100	0	560	17	108		
	59		98	50	580	18	106		
15	57		95	72	70	15	122		
20	55		92	88	70	15	118		
25	57		95	0	130	10	130		
30									

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5' Power Auger
5' - 30' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass and Topsoil
Station and Offset based on I-35 CRL

WATER LEVEL OBSERVATIONS

Dry after 24 Hours

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-06-2018 Boring Completed: 12-06-2018

Drill Rig: 880 Driller: R. Smalley

Project No.: 03185253 Exhibit: A-18

BORING LOG NO. CS-14

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7325° Longitude: -97.4159°

Station: 166+18 Offset: 117' RT
Approximate Surface Elev.: 1134.8 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.0	1134.8+/-	**CLAYEY SAND (SC)**, dark reddish brown (2.5YR 3/3), loose				18	2-3-4 N=7				14		27-16-11	37
5.0	1130+/-	**SANDY LEAN CLAY (CL)**, red (2.5YR 5/8), very stiff	5			18	6-10-12 N=22				9		29-14-15	58
10.0	1125+/-	**SHALEY LEAN CLAY (CL)**, red (2.5YR 5/8), hard	10			14	11-15-18 N=33				14			
		-red (2.5YR 4/6) below 15'	15			14	15-19-26 N=45				11		43-20-23	92
			20			17	12-14-16 N=30				12			
25.0	1110+/-		25											
26.5	1108.5+/-	**HIGHLY WEATHERED SANDSTONE**, dark red (2.5YR 3/6), well cemented				1	50/1"				3			
		Boring Terminated at 26.5 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification 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-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:

Surface Cover: Grass and Topsoil
Station and Offset based on I-35 CRL

WATER LEVEL OBSERVATIONS

Dry after 24 Hours

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-06-2018	Boring Completed: 12-07-2018
Drill Rig: 880	Driller: R. Smalley
Project No.: 03185253	Exhibit: A-19

BORING LOG NO. CS-15

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

CLIENT: Garver, LLC
Tulsa, Oklahoma

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

LOCATION See Exhibits A-2 to A-4

Latitude: 35.7254° Longitude: -97.4061°

Station: 96+84 Offset: 36' LT
Approximate Surface Elev.: 1129.6 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description
0.0	1129.6+/-	**CLAYEY SAND (SC)**, dark reddish brown (5YR 3/2) and red (2.5YR 4/6), loose
5.0	1124.5+/-	
5.5	1124+/-	**WEATHERED SANDSTONE**, dark reddish brown (2.5YR 3/4), well cemented
		HIGHLY WEATHERED SHALE, red (2.5YR 4/6)
8.5	1121+/-	
10.0	1119.5+/-	**HIGHLY WEATHERED SANDSTONE**, light reddish brown (2.5YR 6/4), reddish brown (2.5YR 4/3) and light gray (GLEY 1 7/N)
		HIGHLY WEATHERED SILTY SANDSTONE, reddish brown (2.5YR 4/3) and red (2.5YR 4/6)
13.5	1116+/-	
		WEATHERED SANDSTONE, light reddish brown (2.5YR 6/4)
20.0	1109.5+/-	
		Boring Terminated at 20 Feet

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	ROCK RECOVERY	RQD	UNCONFINED COMPRESSIVE STRENGTH (psi)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
			15	1-2-4 N=6				17		25-16-9	22
5			1	50/2"				6			
			29		53	0					
10			55		92	22					
							710	17	108		
15							730	17	108		
			56		93	57					
20											

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification estimated from core sample; petrographic analysis may confirm other rock types.

Hammer Type: Automatic

Advancement Method:
0'- 5' Power Auger
5' - 20' Wash Boring

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

See Exhibit A-5 for description of field procedures

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

See Appendix E for explanation of symbols and abbreviations.

Notes:
Surface Cover: Bare Soils
Station and Offset based on Waterloo Road CRL

WATER LEVEL OBSERVATIONS

17.5' Dry Cave In after 24 Hours

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 12-18-2018 Boring Completed: 12-18-2018

Drill Rig: 880 Driller: R. Smalley

Project No.: 03185253 Exhibit: A-20

10’

20’

Boring CS-1
Depth: 10’ to 15’ – Recovery: 85% - RQD: 15%
Depth: 15’ to 20’ – Recovery: 97% - RQD: 63%

20’

25’

Boring CS-1
Depth: 20’ to 25’ – Recovery: 98% - RQD: 8%

5.5’

15.5’

Boring CS-2
Depth: 5.5’ to 10.5’ – Recovery: 5% - RQD: 5%
Depth: 10.5’ to 15.5’ – Recovery: 85% - RQD: 35%

15.5’

25.5’

Boring CS-2
Depth: 15.5’ to 20.5’ – Recovery: 100% - RQD: 96%
Depth: 20.5’ to 25.5’ – Recovery: 100% - RQD: 28%

5.5’

15.5’

Boring CS-3
Depth: 5.5’ to 10.5’ – Recovery: 37% - RQD: 37%
Depth: 10.5’ to 15.5’ – Recovery: 100% - RQD: 18%

15.5’

25.5’

Boring CS-3
Depth: 15.5’ to 20.5’ – Recovery: 100% - RQD: 40%
Depth: 20.5’ to 25.5’ – Recovery: 97% - RQD: 43%

5.5’

15.5’

Boring CS-4
Depth: 5.5’ to 10.5’ – Recovery: 82% - RQD: 22%
Depth: 10.5’ to 15.5’ – Recovery: 97% - RQD: 87%

15.5’

25.5’

Boring CS-4
Depth: 15.5’ to 20.5’ – Recovery: 100% - RQD: 17%
Depth: 20.5’ to 25.5’ – Recovery: 95% - RQD: 22%

6’

15’

Boring CS-5
Depth: 6’ to 10’ – Recovery: 92% - RQD: 21%
Depth: 10’ to 15’ – Recovery: 95% - RQD: 65%

15’

25’

Boring CS-5
Depth: 15’ to 20’ – Recovery: 95% - RQD: 65%
Depth: 20’ to 25’ – Recovery: 100% - RQD: 25%

25

30’

Boring CS-5
Depth: 25’ to 30’ – Recovery: 98% - RQD: 57%

10.5’

20.5’

Boring CS-6
Depth: 10.5’ to 15.5’ – Recovery: 77% - RQD: 60%
Depth: 15.5’ to 20.5’ – Recovery: 98% - RQD: 20%

20.5’

30.5’

Boring CS-6
Depth: 20.5’ to 25.5’ – Recovery: 98% - RQD: 15%
Depth: 25.5 to 30.5’ – Recovery: 97% - RQD: 38%

30.5

35.5’

Boring CS-6
Depth: 30.5 to 35.5’ – Recovery: 100% - RQD: 88%

7’

15’

Boring CS-7
Depth: 7 to 10’ – Recovery: 42% - RQD: 0%
Depth: 10’ to 15’ – Recovery: 93% - RQD: 0%

15’

25’

Boring CS-7
Depth: 15 to 20’ – Recovery: 73% - RQD: 17%
Depth: 20’ to 25’ – Recovery: 92% - RQD: 37%

25’

35’

Boring CS-7
Depth: 25 to 30’ – Recovery: 98% - RQD: 57%
Depth: 30 to 35’ – Recovery: 88% - RQD: 78%

35’

40’

Boring CS-7
Depth: 35’ to 40’ – Recovery: 100% - RQD: 92%

6’

15’

Boring CS-8
Depth: 6’ to 10’ – Recovery: 60% - RQD: 15%
Depth: 10 to 15’ – Recovery: 87% - RQD: 48%

15’

25’

Boring CS-8
Depth: 15 to 20’ – Recovery: 92% - RQD: 42%
Depth: 20 to 25’ – Recovery: 68% - RQD: 43%

5.5’

15’

Boring CS-9
Depth: 5.5’ to 10’ – Recovery: 91% - RQD: 0%
Depth: 10’ to 15’ – Recovery: 93% - RQD: 33%

15’

25’

Boring CS-9
Depth: 15 to 20’ – Recovery: 100% - RQD: 75%
Depth: 20 to 25’ – Recovery: 100% - RQD: 23%

25’

30’

Boring CS-9
Depth: 25’ to 30’ – Recovery: 98% - RQD: 38%

5.5’

15’

Boring CS-10
Depth: 5.5 to 10’ – Recovery: 83% - RQD: 9%
Depth: 10 to 15’ – Recovery: 97% - RQD: 0%

15’

25’

Boring CS-10
Depth: 15’ to 20’ – Recovery: 95% - RQD: 80%
Depth: 20’ to 25’ – Recovery: 100% - RQD: 77%

25’

35’

Boring CS-10
Depth: 25 to 30’ – Recovery: 100% - RQD: 0%
Depth: 30 to 35’ – Recovery: 100% - RQD: 68%

7’

15’

Boring CS-11
Depth: 7’ to 10’ – Recovery: 100% - RQD: 0%
Depth: 10’ to 15’ – Recovery: 82% - RQD: 0%

15’

25’

Boring CS-11
Depth: 15 to 20’ – Recovery: 100% - RQD: 40%
Depth: 20 to 25’ – Recovery: 100% - RQD: 63%

25’

35’

Boring CS-11
Depth: 25’ to 30’ – Recovery: 98% - RQD: 50%
Depth: 30’ to 35’ – Recovery: 98% - RQD: 17%

6’

15’

Boring CS-12
Depth: 6 to 10’ – Recovery: 100% - RQD: 0%
Depth: 10 to 15’ – Recovery: 100% - RQD: 12%

15’

25’

Boring CS-12
Depth: 15’ to 20’ – Recovery: 100% - RQD: 40%
Depth: 20’ to 25’ – Recovery: 95% - RQD: 57%

25’

30’

Boring CS-12
Depth: 25 to 30’ – Recovery: 100% - RQD: 0%

6’

15’

Boring CS-13
Depth: 6’ to 10’ – Recovery: 100% - RQD: 0%
Depth: 10’ to 15’ – Recovery: 98% - RQD: 50%

15’

25’

Boring CS-13
Depth: 15 to 20’ – Recovery: 95% - RQD: 72%
Depth: 20 to 25’ – Recovery: 92% - RQD: 88%

25’

30’

Boring CS-13
Depth: 25’ to 30’ – Recovery: 95% - RQD: 0%

5.5’

15’

Boring CS-15
Depth: 5.5 to 10’ – Recovery: 53% - RQD: 0%
Depth: 10’ to 15’ – Recovery: 92% - RQD: 22%
Depth: 15’ to 20’ – Recovery: 93% - RQD: 57%

Boring No. CS-1

STATION 113+81.5 114' LT
(12/12/2018)

Surface Elev. (Ft.): 1136.2

1,138						
1,136	**SILTY SAND (SM)** weak red (10R 4/2), loose	1136		1136+/-	SPT-1; N=6; SOIL REC=18 (In.); MC=13%	
1,134	**SANDY LEAN CLAY (CL)** weak red (10R 4/2) and dark red (10R 3/6)	1134.5		1134+/-	SH-2; SOIL REC=21 (In.); MC=16% LL= 38; PL= 13; PI= 25	
1,132	**CLAYEY SAND (SC)** red (2.5YR 5/6)	1132		1131+/-	SPT-3; N=50/6"; SOIL REC=17 (In.); MC=14% P200=45%; LL= 35; PL= 16; PI= 19	
1,130	**HIGHLY WEATHERED SHALE WITH SANDSTONE LAYERS** red (2.5YR 5/8)	1130		Top of Rock = 1130 Ft.		
1,128						
1,126	-light red (2.5YR 6/6) below 10.5'	1125.5		1126+/-	SPT-4; N=50/3"; SOIL REC=1 (In.); MC=5%	
	-red (2.5YR 4/6) and light red (2.5YR 6/6) below 11'	1125		1126+/-	DB-5; SOIL REC=49 (In.); ROCK REC=82(%); RQD=15(%); UCS=20 (psi)	
1,124						
1,122	-dusky red (2.5YR 3/2) and red (2.5YR 4/6) below 13.5'	1122.5		1121.5 +/-	14.5' Dry Cave In After 24 hours	
	-with silt seams, red (2.5YR 4/6) and gray (GLEY 1 7/N) below 15'	1121		1121+/-	DB-6; SOIL REC=58 (In.); ROCK REC=97(%); RQD=63(%); UCS=160 (psi)	
1,120						
1,118	-reddish brown (2.5YR 4/3) and yellowish brown (10YR 5/6) below 18'	1118				
1,116	-light reddish brown (5YR 6/3) and weak red (10R 5/4) below 20'	1116		1116+/-	DB-7; SOIL REC=59 (In.); ROCK REC=98(%); RQD=8(%); UCS=490 (psi)	
1,114						
1,112						
1,110						

BT-25.00
Elevation: 1111+/-

Boring No. CS-2

STATION 117+00 118' LT
(12/11/2018)

Surface Elev. (Ft.): 1136.0

1,138						
1,136	**CLAYEY SAND (SC)** brownish yellow (10YR 6/8), medium dense	1136		1136+/-	SPT-1; N=11; SOIL REC=18 (In.); MC=16% P200=41%; LL= 30; PL= 15; PI= 15	
1,134						
1,132	**HIGHLY WEATHERED SANDSTONE** red (10R 5/8) and reddish yellow (5YR 6/8)	1132		Top of Rock = 1132 Ft.		
				1131+/-	SPT-2; N=50/5"; SOIL REC=6 (In.); MC=4%	
1,130				1130.5+/-	DB-3; SOIL REC=3 (In.); ROCK REC=5 (%); RQD=5(%)	
1,128						
1,126	-weathered, dark reddish brown (5YR 2.5/2/2) below 10.5'	1125.5		1125.5+/-	DB-4; SOIL REC=52 (In.); ROCK REC=87 (%); RQD=35(%); UCS=10 (psi)	
1,124						
1,122	-weathered shale seams below 13.5'	1122.5				
1,120	**HIGHLY WEATHERED SHALE** red (2.5YR 4/6) and light red (2.5YR 6/8)	1120.5		1120.5+/-	DB-5; SOIL REC=60 (In.); ROCK REC=100 (%); RQD=96(%); UCS=170 (psi)	
1,118	-red (2.5YR 4/8) below 18.5'	1117.5				
1,116	-pinkish white (2.5YR 8/2) and red (2.5YR 5/8) below 20.5'	1115.5		1115.5+/-	DB-6; SOIL REC=60 (In.); ROCK REC=100 (%); RQD=28(%); UCS=180 (psi)	
1,114						
1,112	**HIGHLY WEATHERED SANDSTONE** dusky red (2.5YR 3/2)	1112.5				
1,110						

BT-25.50
Elevation: 1110.5+/-

REVISIONS

REV. NO.	DESCRIPTION	DATE

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.

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 crossbedded 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.

GEOTECHNICAL REPORT

ALL GEOTECHNICAL INFORMATION CONTAINED ON THIS SHEET IS COVERED BY THE ENGINEERING SEAL AFFIXED TO AN ORIGINAL GEOTECHNICAL ENGINEERING REPORT THAT HAS BEEN STAMPED AND SEALED BY A PROFESSIONAL ENGINEER LICENSED IN OKLAHOMA. TO OBTAIN A COPY OF THE COMPLETE REPORT, CONTACT THE ODOT OFFICE ENGINEER AT (405) 521-2625. THE CONTRACTOR SHOULD BE FULLY AWARE OF THE SITE CONDITIONS PRIOR TO BEGINNING WORK. ANY ADDITIONAL GEOTECNICAL INFORMATION WHICH MAY BE DESIRED IS THE RESPONSIBILITY OF THE CONTRACTOR.

Terracon

OKLAHOMA AND LOGAN COUNTIES

SUBSURFACE PROFILE
(SHEET 1 of 8)

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-22

REVISIONS		
REV. NO.	DESCRIPTION	DATE

Boring No. CS-4

STATION 150+37 136' LT
(12/11/2018)

Surface Elev. (Ft.): 1126.9

Description	Depth Elev.	Sample Elev.	Sample Data
SILTY SAND (SM) dark reddish brown (5YR 3/4), loose	1127	1127+/-	SPT-1; N=5; SOIL REC=18 (In.); MC=9%; P200=17%; LL= NP; PL= NP; PI= NP
HIGHLY WEATHERED SILTSTONE red (2.5YR 5/6), pink (5YR 7/3) and light gray (GLEY1 7/N), soft	1122 / 1121.5	1122+/- / 1121.5+/-	SPT-2; N=50/6"; SOIL REC=6 (In.); MC=10%; DB-3; SOIL REC=49 (In.); ROCK REC=82(%); RQD=22(%); UCS=770 (psi)
HIGHLY WEATHERED SANDSTONE reddish yellow (5YR 6/8), dark reddish brown (5 YR 3/3) and pink (5YR 7/4)			
-reddish yellow (5YR 6/6) and light red (2.5YR 6/8). weathered below 10.5'	1116.5	1116.5+/-	DB-4; SOIL REC=58 (In.); ROCK REC=97(%); RQD=87(%); UCS=30 (psi)
HIGHLY WEATHERED SHALE reddish brown (2.5YR 5/3)	1111.5	1111.5+/-	DB-5; SOIL REC=60 (In.); ROCK REC=100 (%); RQD=17(%); UCS=140 (psi)
HIGHLY WEATHERED SANDSTONE light red (2.5YR 6/6)	1108.5	1108.0	19' Dry Cave In after 24 Hours
-reddish brown (2.5YR 5/3) and reddish yellow (5YR 6/8) below 20.5'	1106.5	1106.5+/-	DB-6; SOIL REC=57 (In.); MC=11%; ROCK REC=95 (%); RQD=22(%); UCS=110 (psi)

Top of Rock = 1122 Ft.

BT-25.50
Elevation: 1101.5+/-

Boring No. CS-3

STATION 136+86 141' LT
(12/11/2018)

Surface Elev. (Ft.): 1107.0

Description	Depth Elev.	Sample Elev.	Sample Data
LEAN CLAY WITH SAND (CL) red (2.5YR 4/8) and light red (2.5YR 6/8), very stiff	1107	1107+/-	SPT-1; N=22; SOIL REC=17 (In.); MC=14%; P200=77%; LL= 24; PL= 15; PI= 9
HIGHLY WEATHERED SANDSTONE light red (2.5YR 6/8)	1102 / 1101.5 / 1101	1102+/- / 1101.5+/-	SPT-2; N=50/5"; SOIL REC=5 (In.); MC=4%; DB-3; SOIL REC=22 (In.); ROCK REC=37 (%); RQD=37(%)
-light red (2.5YR 7/8) below 5.5'			
-red (2.5YR 5/8) below 6'			
HIGHLY WEATHERED SHALE red (2.5YR 5/8)	1096.5	1096.5+/-	DB-4; SOIL REC=60 (In.); ROCK REC=100 (%); RQD=18(%); UCS=120 (psi)
HIGHLY WEATHERED SANDSTONE light red (2.5YR 6/6) and pink (2.5YR 8/3)	1093.5		
HIGHLY WEATHERED SILTSTONE red (2.5YR 5/8) and pink (2.5YR 8/4)	1091.5	1091.5+/-	DB-5; SOIL REC=60 (In.); MC=10%; ROCK REC=100 (%); RQD=40(%); UCS=120 (psi)
HIGHLY WEATHERED SANDSTONE light red (2.5YR 6/8)	1088.5	1086.5+/-	DB-6; SOIL REC=58 (In.); ROCK REC=97(%); RQD=43(%) UCS=800 (psi)

Top of Rock = 1102 Ft.

BT-25.50
Elevation: 1081.5+/-

Elevation scale: 1,130; 1,125; 1,120; 1,115; 1,110; 1,105; 1,100; 1,095; 1,090; 1,085; 1,080

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.

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 crossbedded 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.

GEOTECHNICAL REPORT

ALL GEOTECHNICAL INFORMATION CONTAINED ON THIS SHEET IS COVERED BY THE ENGINEERING SEAL AFFIXED TO AN ORIGINAL GEOTECHNICAL ENGINEERING REPORT THAT HAS BEEN STAMPED AND SEALED BY A PROFESSIONAL ENGINEER LICENSED IN OKLAHOMA. TO OBTAIN A COPY OF THE COMPLETE REPORT, CONTACT THE ODOT OFFICE ENGINEER AT (405) 521-2625. THE CONTRACTOR SHOULD BE FULLY AWARE OF THE SITE CONDITIONS PRIOR TO BEGINNING WORK. ANY ADDITIONAL GEOTECHNICAL INFORMATION WHICH MAY BE DESIRED IS THE RESPONSIBILITY OF THE CONTRACTOR.

Terracon

OKLAHOMA AND LOGAN COUNTIES

SUBSURFACE PROFILE
(SHEET 2 of 8)

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(4) SHEET NO XXX

REVISIONS		
REV. NO.	DESCRIPTION	DATE

Boring No. CS-5

STATION 153+15 128' LT
(12/10/2018)

Surface Elev. (Ft.): 1133.3

SILTY SAND (SM) dark reddish brown (5YR 3/2), loose	1133.5	1133.5+/-	SPT-1; N=4; SOIL REC=15 (In.); MC=12% P200=27%; LL= NP; PL= NP; PI= NP
HIGHLY WEATHERED SANDSTONE dark red (2.5YR 3/6) and light red (2.5YR 6/6)	1128.5	1128.5+/-	SPT-2; N=50/5"; SOIL REC=5 (In.); MC=7%
-dark reddish brown (2.5YR 3/4) and yellowish red (5YR 5/8) below 6'	1127.5	1127.5+/-	DB-3; SOIL REC=44 (In.); ROCK REC=92(%); RQD=21(%); UCS=590 (psi)
			Top of Rock = 1128.5 Ft.
-red (2.5YR 5/6) and light reddish brown (2.5YR 6/4), weathered below 10'	1123.5	1123.5+/-	DB-4; SOIL REC=57 (In.); ROCK REC=95(%); RQD=65(%); UCS=400 (psi)
-light reddish brown (2.5YR 6/4), red (10R 5/6) and strong brown (7.5YR 5/6) below 15'	1118.5	1118.5+/-	DB-5; SOIL REC=57 (In.); ROCK REC=95 (%); RQD=65(%); UCS=590 (psi)
HIGHLY WEATHERED SHALE red (2.5YR 4/6)	1115	1113.5+/-	DB-6; SOIL REC=60 (In.); ROCK REC=100 (%); RQD=25(%); UCS=100 (psi)
WEATHERED SANDY SILTSTONE red (2.5YR 5/6) and light gray (GLEY1 7/N)	1108.5	1108.5+/-	DB-7; SOIL REC=59 (In.); ROCK REC=98(%); RQD=57(%); UCS=180 (psi)

BT-30.00
Elevation: 1103.5+/-

Boring No. CS-6

STATION 156+10 138' LT
(12/10/2018)

Surface Elev. (Ft.): 1142.2

CLAYEY SAND (SC) dark brown (7.5YR 3/2), loose	1142	1142+/-	SPT-1; N=8; SOIL REC=18 (In.); MC=15%
-dusky red (10R 3/4) below 2'	1140		
-light reddish brown (2.5YR 6/4), dense below 5'	1137	1137+/-	SPT-2; N=48; SOIL REC=18 (In.); MC=9% P200=32%; LL= 30; PL= 14; PI= 16
WEATHERED SANDSTONE pink (5YR 8/3)	1135		
			Top of Rock = 1135 Ft.
		1132+/-	SPT-3; N=50/3"; SOIL REC=3 (In.)
-strong brown (7.5YR 4/6) and strong brown(7.5YR 5/8) below 10.5'	1131.5	1131.5+/-	DB-4; SOIL REC=46 (In.); ROCK REC=77(%); RQD=60(%); UCS=990 (psi)
-reddish yellow (5YR 6/6), highly weathered below 15.5'	1126.5	1126.5+/-	DB-5; SOIL REC=59 (In.); ROCK REC=98(%); RQD=20(%); UCS=930 (psi)
HIGHLY WEATHERED SILTSTONE yellowish red (5YR 5/6)	1121.5	1121.5+/-	DB-6; SOIL REC=59 (In.); ROCK REC=98(%); RQD=15(%); UCS=630 (psi)
HIGHLY WEATHERED SANDSTONE reddish yellow (5YR 6/8)	1116.5	1116.5+/-	DB-7; SOIL REC=58 (In.); ROCK REC=97(%); RQD=38(%); UCS=1040 (psi)
HIGHLY WEATHERED SHALE red (2.5YR 4/8)	1111.5	1111.5+/-	DB-8; SOIL REC=60 (In.); ROCK REC=100(%); RQD=88(%); UCS=200 (psi)
-reddish yellow (5YR 6/8) below 32.5'	1109.5		

BT-35.50
Elevation: 1106.5+/-

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.

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 crossbedded 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.

GEOTECHNICAL REPORT

ALL GEOTECHNICAL INFORMATION CONTAINED ON THIS SHEET IS COVERED BY THE ENGINEERING SEAL AFFIXED TO AN ORIGINAL GEOTECHNICAL ENGINEERING REPORT THAT HAS BEEN STAMPED AND SEALED BY A PROFESSIONAL ENGINEER LICENSED IN OKLAHOMA. TO OBTAIN A COPY OF THE COMPLETE REPORT, CONTACT THE ODOT OFFICE ENGINEER AT (405) 521-2625. THE CONTRACTOR SHOULD BE FULLY AWARE OF THE SITE CONDITIONS PRIOR TO BEGINNING WORK. ANY ADDITIONAL GEOTECNICAL INFORMATION WHICH MAY BE DESIRED IS THE RESPONSIBILITY OF THE CONTRACTOR.

Terracon

OKLAHOMA AND LOGAN COUNTIES

SUBSURFACE PROFILE
(SHEET 3 of 8)

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 NOXXX

Boring No. CS-7

STATION 159+38 140' LT
(12/7/2018)

Surface Elev. (Ft.): 1143.7

CLAYEY SAND (SC) reddish brown (5YR 4/3), loose	1143.5	1143.5+/-	SPT-1; N=6; SOIL REC=18 (In.); MC=15% P200=32%; LL= 28; PL= 13; PI= 15
LEAN CLAY (CL) red (2.5YR 4/6)	1142		
HIGHLY WEATHERED SILTY SANDSTONE red (2.5YR 4/6) and white (2.5YR 8/1)	1138.5	1138.5+/-	SPT-2; N=50/6"; SOIL REC=18 (In.); MC=9% P200=18%; LL= NP; PL= NP; PI= NP
-red (2.5YR 4/6) below 7'	1136.5	1136.5+/-	DB-3; SOIL REC=15 (In.); ROCK REC=42(%); RQD=0(%)
			Top of Rock = 1138.5 Ft.
-red (2.5YR 4/6) and reddish brown (2.5YR 5/4) below 10'	1133.5	1133.5+/-	DB-4; SOIL REC=56 (In.); ROCK REC=93(%); RQD=0(%)
-with siltstone seams, dark reddish gray (2.5 YR 3/1) and red (10R 4/4) below 13'	1130.5		
-light reddish brown (2.5YR 6/3) below 15'	1128.5	1128.5+/-	DB-5; SOIL REC=44 (In.); ROCK REC=73(%); RQD=17(%); UCS=770(psi)
-red (10R 4/6), weak red (10R 5/2) and dusky red (7.5R 3/3), with embedded conglomerate seams below 20'	1123.5	1123.5+/-	DB-6; SOIL REC=55 (In.); ROCK REC=92(%); RQD=37(%); UCS=660 (psi)
-light gray (GLEY17/N) below 23'	1120.5		
WEATHERED SHALE red (10R 4/8)	1118.5	1118.5+/-	DB-7; SOIL REC=59 (In.); ROCK REC=98(%); RQD=57(%); USC=80 (psi)
		1113.5+/-	DB-8; SOIL REC=53 (In.); ROCK REC=88(%); RQD=78(%); UCS=110 (psi)
WEATHERED SANDSTONE dusky red (7.5R 3/4) and red (10R 5/6)	1108.5	1108.5+/-	DB-9; SOIL REC=60 (In.); ROCK REC=100(%); RQD=92(%); UCS=510 (psi)

BT-40.00
Elevation: 1103.5+/-

Boring No. CS-8

STATION 165+01 127' LT
(12/7/2018)

Surface Elev. (Ft.): 1131.8

SANDY SILT (ML) dark reddish gray (5YR 4/2), very loose	1132	1132+/-	SPT-1; N=3; SOIL REC=18 (In.); MC=15% P200=55%; LL= NP; PL= NP; PI= NP
LEAN CLAY (CL) yellowish red (5YR 5/6)	1130.5		
HIGHLY WEATHERED SANDSTONE with conglomerate seams, pale red (7.5R 6/3) and weak red (7.5R 5/4)	1127	1127+/-	SPT-2; N=50/4"; SOIL REC=4 (In.); MC=2%
-dusky red (7.5R 3/2) and red (2.5YR 4/6) below 6'	1126	1126+/-	DB-3; SOIL REC=29 (In.); ROCK REC=60(%); RQD=15(%), UCS=50 (psi)
			Top of Rock = 1127 Ft.
HIGHLY WEATHERED SHALE red (2.5YR 4/6)	1122	1122+/-	DB-4; SOIL REC=52 (In.); ROCK REC=87(%); RQD=48(%); UCS=50 (psi)
HIGHLY WEATHERED SANDSTONE red (2.5YR 4/6) and light gray (GLEY1 7/N)	1117	1117+/-	DB-5; SOIL REC=55 (In.); ROCK REC=92(%); RQD=42(%); UCS=60 (psi)
		1112+/-	DB-6; SOIL REC=41(In.); ROCK REC=68(%); RQD=43(%); UCS=560 (psi)
-red (10R 5/6) below 23'	1109		

BT-25.00
Elevation: 1107+/-

REVISIONS		
REV. NO.	DESCRIPTION	DATE

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.

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 crossbedded 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.

GEOTECHNICAL REPORT

ALL GEOTECHNICAL INFORMATION CONTAINED ON THIS SHEET IS COVERED BY THE ENGINEERING SEAL AFFIXED TO AN ORIGINAL GEOTECHNICAL ENGINEERING REPORT THAT HAS BEEN STAMPED AND SEALED BY A PROFESSIONAL ENGINEER LICENSED IN OKLAHOMA. TO OBTAIN A COPY OF THE COMPLETE REPORT, CONTACT THE ODOT OFFICE ENGINEER AT (405) 521-2625. THE CONTRACTOR SHOULD BE FULLY AWARE OF THE SITE CONDITIONS PRIOR TO BEGINNING WORK. ANY ADDITIONAL GEOTECNICAL INFORMATION WHICH MAY BE DESIRED IS THE RESPONSIBILITY OF THE CONTRACTOR.

Terracon

OKLAHOMA AND LOGAN COUNTIES

SUBSURFACE PROFILE
(SHEET 4 of 8)

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 NOXXX

REVISIONS

REV. NO.	DESCRIPTION	DATE

Boring No. CS-9

STATION 146+09 94' RT
(12/17/2018)

Surface Elev. (Ft.): 1126.0

Elev.	Description	Depth marker	Sample data
1126	**SILTY SAND (SM)** yellowish red (5YR 5/8) and reddish yellow (5YR 6/8), very dense	1126+/-	SPT-1; N=65; SOIL REC=18 (In.); MC=12% P200=14%; LL= NP; PL= NP; PI= NP
1121	**HIGHLY WEATHERED SANDSTONE** red (10R 4/6) and pale red (10R 7/2), cemented	1121+/-	SPT-2; N=50/3"; SOIL REC=3 (In.); MC=5%
1120.5	**HIGHLY WEATHERED SILTY SANDSTONE** red (10R 4/6) and reddish yellow (7.5YR 6/6)	1120.5+/-	DB-3; SOIL REC=49 (In.); ROCK REC=9(%).; RQD=0(%)
1116	**HIGHLY WEATHERED SANDSTONE** pale red (10R 7/3) and trace black (10R 2.5/1)	1116+/-	DB-4; SOIL REC=56 (In.); ROCK REC=93(%); RQD=33(%); UCS=20 (psi)
1113	**WEATHERED SHALE** red (10R 4/6) and light gray (GLEY1 7/N)		
1111	-silt seams, red (10R 4/6), dark gray (GLEY1 7/N) and dusky red (10R 3/4) below 15'	1111+/-	DB-5; SOIL REC=60 (In.); ROCK REC=100(%); RQD=75(%); USC=90 (psi)
1106	**HIGHLY WEATHERED SILTSTONE** red (10R 5/6) and pale red (10R 7/2)	1106+/-	DB-6; SOIL REC=60 (In.); ROCK REC=100(%); RQD=23(%); UCS=710 (psi)
1103	**HIGHLY WEATHERED SANDSTONE** pale red (10R 6/4)		
1101	-pale red (10R 6/4) and light red (10R 6/6) below 25'	1101+/-	DB-7; SOIL REC=59 (In.); ROCK REC=98(%).; RQD=38(%); UCS=740 (psi)

Top of Rock = 1121 Ft.

BT-30.00
Elevation: 1096+/-

Boring No. CS-10

STATION 149+04 174' RT
(12/18/2018)

Surface Elev. (Ft.): 1134.5

Elev.	Description	Depth marker	Sample data
1134.5	**CLAYEY SAND (SC)** dark reddish gray (5YR 4/2), loose	1134.5+/-	SPT-1; N=5; SOIL REC=18 (In.); MC=19% P200=40%; LL= 27; PL= 14; PI= 13
1133	**LEAN CLAY (CL)** reddish brown (5YR 4/3)		
1129.5	**HIGHLY WEATHERED SANDSTONE** yellowish red (5YR 5/6), cemented	1129.5+/-	SPT-2; N=50/4"; SOIL REC=3 (In.); MC=12%
1129	**HIGHLY WEATHERED SILTY SANDSTONE** strong brown (7.5YR 5/6)	1129+/-	DB-3; SOIL REC=45 (In.); ROCK REC=83(%); RQD=9(%); USC=380 (psi)
1126	**HIGHLY WEATHERED SANDSTONE** red (2.5YR 5/8), mottled black (2.5YR 2.5/1) dots		
1124.5	**HIGHLY WEATHERED SILTY SANDSTONE** weak red (10R 4/4), light yellowish red (10YR 6/4) and pale red (10R 6/3)	1124.5+/-	DB-4; SOIL REC=58 (In.); ROCK REC=97(%); RQD=0(%)
1119.5	**WEATHERED SANDSTONE** trace conglomerate, light brown (7.5YR 6/4) and red (10R 4/6)	1119.5+/-	DB-5; SOIL REC=57 (In.); ROCK REC=95(%); RQD=80(%); UCS=560 (psi)
1114.5	**WEATHERED SHALE** with conglomerate, red (10R 4/6) and pale red (10R 6/4)	1114.5+/-	DB-6; SOIL REC=60 (In.); ROCK REC=100(%); RQD=77(%); UCS=90 (psi)
1109.5	**HIGHLY WEATHERED SILTSTONE** red (10R 5/8) and pale red (10R 6/4)	1109.5+/-	DB-7; SOIL REC=60 (In.); ROCK REC=100(%); RQD=0(%); UCS=330 (psi)
		1104.5+/-	DB-8; SOIL REC=60 (In.); ROCK REC=100(%); RQD=68(%); UCS=70 (psi)
1102.5	**HIGHLY WEATHERED SANDSTONE** dusky red (10R 3/3) and red (10R 5/6)		

Top of Rock = 1129.5 Ft.

BT-35.00
Elevation: 1099.5+/-

Elevation scale: 1,135; 1,130; 1,125; 1,120; 1,115; 1,110; 1,105; 1,100; 1,095

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.

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 crossbedded 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.

GEOTECHNICAL REPORT

ALL GEOTECHNICAL INFORMATION CONTAINED ON THIS SHEET IS COVERED BY THE ENGINEERING SEAL AFFIXED TO AN ORIGINAL GEOTECHNICAL ENGINEERING REPORT THAT HAS BEEN STAMPED AND SEALED BY A PROFESSIONAL ENGINEER LICENSED IN OKLAHOMA. TO OBTAIN A COPY OF THE COMPLETE REPORT, CONTACT THE ODOT OFFICE ENGINEER AT (405) 521-2625. THE CONTRACTOR SHOULD BE FULLY AWARE OF THE SITE CONDITIONS PRIOR TO BEGINNING WORK. ANY ADDITIONAL GEOTECHNICAL INFORMATION WHICH MAY BE DESIRED IS THE RESPONSIBILITY OF THE CONTRACTOR.

Terracon

OKLAHOMA AND LOGAN COUNTIES

SUBSURFACE PROFILE
(SHEET 5 of 8)

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-26

Boring No. CS-11

STATION 152+06 163' RT
(12/17/2018)

Surface Elev. (Ft.): 1138.8

CLAYEY SAND (SC) reddish brown (5YR 4/3), loose	1139	1139+/-	SPT-1; N=6; SOIL REC=18 (In.); MC=18% P200=37%; LL= 27; PL= 15; PI= 12
	1137.5		
LEAN CLAY (CL) red (2.5YR 5/6)			
LEAN CLAY WITH SAND (CL) red (2.5YR 4/6) and reddish brown (2.5YR 4/4)	1134	1134+/-	SPT-2; N=50/2"; SOIL REC=14 (In.); MC=7%
HIGHLY WEATHERED SILTSTONE red (2.5YR 5/8)	1132.5	1132+/-	DB-3; SOIL REC=36 (In.); ROCK REC=100(%); RQD=0(%)
	1132		Top of Rock = 1132.5 Ft.
HIGHLY WEATHERED SILTY SANDSTONE red (10R 4/6)			
HIGHLY WEATHERED SANDSTONE pale red (10R 7/2) and black (10R 2.5/1)	1129	1129+/-	DB-4; SOIL REC=49 (In.); ROCK REC=82(%); RQD=0(%)
-pale red (10R 7/2), weak red (10R 4/4) and yellowish brown (10YR 5/6) below 15'	1124	1124+/-	DB-5; SOIL REC=60 (In.); ROCK REC=100(%); RQD=40(%); UCS=950 (psi)
-yellowish brown (10YR 5/6), weathered below 20'	1119	1119+/-	DB-6; SOIL REC=60 (In.); ROCK REC=100(%); RQD=63(%); UCS=2270 (psi)
WEATHERED SHALE with silt seams, red (2.5YR 4/6)	1116		
red (2.5YR 5/6) and light gray (GLEY1 7/N) below 25'	1114	1114+/-	DB-7; SOIL REC=59 (In.); ROCK REC=98(%); RQD=50(%); UCS=160 (psi)
HIGHLY WEATHERED SANDSTONE trace conglomerate, weak red (10R 5/4)	1110.5	1109+/-	DB-8; SOIL REC=59 (In.); ROCK REC=98(%); RQD=17(%); UCS=720 (psi)

BT-35.00
Elevation: 1104+/-

Boring No. CS-12

STATION 155+38 142' RT
(12/6/2018)

Surface Elev. (Ft.): 1135.4

SILTY SAND (SM) strong brown (7.5YR 4/6), loose	1135.5	1135.5+/-	SPT-1; N=6; SOIL REC=16 (In.); MC=13% P200=28%; LL= NP; PL= NP; PI= NP
HIGHLY WEATHERED SANDSTONE reddish yellow (5YR 6/8) and yellowish red (5YR 5/8)	1130.5	1130.5+/-	SPT-2; N=50/4"; SOIL REC=10 (In.); MC=8%
-with silt seams, light gray (GLEY1 7/N) below 5'	1130	1129.5+/-	DB-3; SOIL REC=48 (In.); ROCK REC=100(%); RQD=0(%)
			Top of Rock = 1130.5 Ft.
-reddish yellow (5YR 6/8) and pink (7.5YR 7/3) below 10'	1125.5	1125.5+/-	DB-4; SOIL REC=60 (In.); ROCK REC=100(%); RQD=12(%); UCS=650 (psi)
-red (2.5YR 4/8), red (2.5YR 4/6) and very pale brown (10YR 7/3) below 15'	1120.5	1120.5+/-	DB-5; SOIL REC=60 (In.); ROCK REC=100(%); RQD=40(%); UCS=710 (psi)
-red (2.5YR 5/6), red (2.5YR 5/8) trace gray (GLEY17/N), weathered below 20'	1115.5	1115.5+/-	DB-6; SOIL REC=57 (In.); ROCK REC=95(%); RQD=57(%); UCS=130 (psi)
-shale seams, red (2.5YR 5/6), reddish yellow (7.5YR 6/6) and strong brown (7.5YR 5/8), highly weathered below 25'	1110.5	1110.5+/-	DB-7; SOIL REC=60 (In.); ROCK REC=100(%); RQD=0(%)

BT-30.00
Elevation: 1105.5+/-

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.

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 crossbedded 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.

GEOTECHNICAL REPORT

ALL GEOTECHNICAL INFORMATION CONTAINED ON THIS SHEET IS COVERED BY THE ENGINEERING SEAL AFFIXED TO AN ORIGINAL GEOTECHNICAL ENGINEERING REPORT THAT HAS BEEN STAMPED AND SEALED BY A PROFESSIONAL ENGINEER LICENSED IN OKLAHOMA. TO OBTAIN A COPY OF THE COMPLETE REPORT, CONTACT THE ODOT OFFICE ENGINEER AT (405) 521-2625. THE CONTRACTOR SHOULD BE FULLY AWARE OF THE SITE CONDITIONS PRIOR TO BEGINNING WORK. ANY ADDITIONAL GEOTECNICAL INFORMATION WHICH MAY BE DESIRED IS THE RESPONSIBILITY OF THE CONTRACTOR.

REVISIONS

REV. NO.	DESCRIPTION	DATE

Terracon

OKLAHOMA AND LOGAN COUNTIES

SUBSURFACE PROFILE
(SHEET 6 of 8)

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

Boring No. CS-13

STATION 158+29 128' RT
(12/6/2018)

Surface Elev. (Ft.): 1134.7

1,135	**SILTY SAND (SM)** dark reddish brown (5YR 3/2), very loose	1134.5	1134.5+/-	SPT-1; N=3; SOIL REC=18 (In.); MC=11% P200=25%; LL= NP; PL= NP; PI= NP	
1,130	**HIGHLY WEATHERED SANDSTONE** yellow (10YR 8/6) and pale red (2.5YR 7/2)	1129.5	1129.5+/-	SPT-2; N=50/3"; SOIL REC=9 (In.); MC=5%	
	-trace roots, reddish yellow (5YR 6/8) and red (10R 5/8) and light gray (GLEY1 7/N) below 5.5'	1129	1128.5+/-	DB-3; SOIL REC=48 (In.); ROCK REC=100(%); RQD=0(%); UCS=560 (psi)	
				Top of Rock = 1129.5 Ft.	
1,125	-weak red (10R 5/4), reddish brown (5YR 5/4) and dusky red (10R 3/3), with conglomerate layers, weathered below 10'	1124.5	1124.5+/-	DB-4; SOIL REC=59 (In.); ROCK REC=98(%); RQD=50(%); UCS=580 (psi)	
1,120	**WEATHERED SHALE** with conglomerate seams, red (10R 4/6). red (10R 4/8) and light gray (GLEY1 7/N)	1119.5	1119.5+/-	DB-5; SOIL REC=57 (In.); ROCK REC=95(%); RQD=72(%); UCS=70 (psi)	
1,115	-red (10R 4/6), pale brown (10YR 6/3) and reddish brown (2.5YR 4/4) below 20'	1114.5	1114.5+/-	DB-6; SOIL REC=55 (In.); ROCK REC=92(%); RQD=88(%); UCS=70 (psi)	
1,110	-highly weathered below 25'	1109.5	1109.5+/-	DB-7; SOIL REC=57 (In.); ROCK REC=95(%); RQD=0(%); UCS=130 (psi)	
1,105					
1,100					

BT-30.00
Elevation: 1104.5+/-

Boring No. CS-14

STATION 166+18 117' RT
(12/7/2018)

Surface Elev. (Ft.): 1134.8

	CLAYEY SAND (SC) dark reddish brown (2.5YR 3/3), loose	1135	1135+/-	SPT-1; N=7; SOIL REC=18 (In.); MC=14% P200=37%; LL= 27; PL= 16; PI= 11	1,135
	SANDY LEAN CLAY (CL) red (2.5YR 5/8), very stiff	1130	1130+/-	SPT-2; N=22; SOIL REC=18 (In.); MC=9% P200=58%; LL= 29; PL= 14; PI= 15	1,130
	SHALEY LEAN CLAY (CL) red (2.5YR 5/8), hard	1125	1125+/-	SPT-3; N=33; SOIL REC=14 (In.); MC=14%	1,125
	-red (2.5YR 4/6) below 15'	1120	1120+/-	SPT-4; N=45; SOIL REC=14 (In.); MC=11% P200=92%; LL= 43; PL= 20; PI= 23	1,120
			1115+/-	SPT-5; N=30; SOIL REC=17 (In.); MC=12%	1,115
	HIGHLY WEATHERED SANDSTONE dark red (2.5YR 3/6), well cemented	1110	1110+/-	SPT-6; N=50/1"; SOIL REC=1 (In.); MC=3%	1,110
				Top of Rock = 1110 Ft.	1,105
					1,100

BT-26.50
Elevation: 1108.5+/-

REVISIONS

REV. NO.	DESCRIPTION	DATE

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.

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 crossbedded 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.

GEOTECHNICAL REPORT

ALL GEOTECHNICAL INFORMATION CONTAINED ON THIS SHEET IS COVERED BY THE ENGINEERING SEAL AFFIXED TO AN ORIGINAL GEOTECHNICAL ENGINEERING REPORT THAT HAS BEEN STAMPED AND SEALED BY A PROFESSIONAL ENGINEER LICENSED IN OKLAHOMA. TO OBTAIN A COPY OF THE COMPLETE REPORT, CONTACT THE ODOT OFFICE ENGINEER AT (405) 521-2625. THE CONTRACTOR SHOULD BE FULLY AWARE OF THE SITE CONDITIONS PRIOR TO BEGINNING WORK. ANY ADDITIONAL GEOTECHNICAL INFORMATION WHICH MAY BE DESIRED IS THE RESPONSIBILITY OF THE CONTRACTOR.

Terracon

OKLAHOMA AND LOGAN COUNTIES

SUBSURFACE PROFILE
(SHEET 7 of 8)

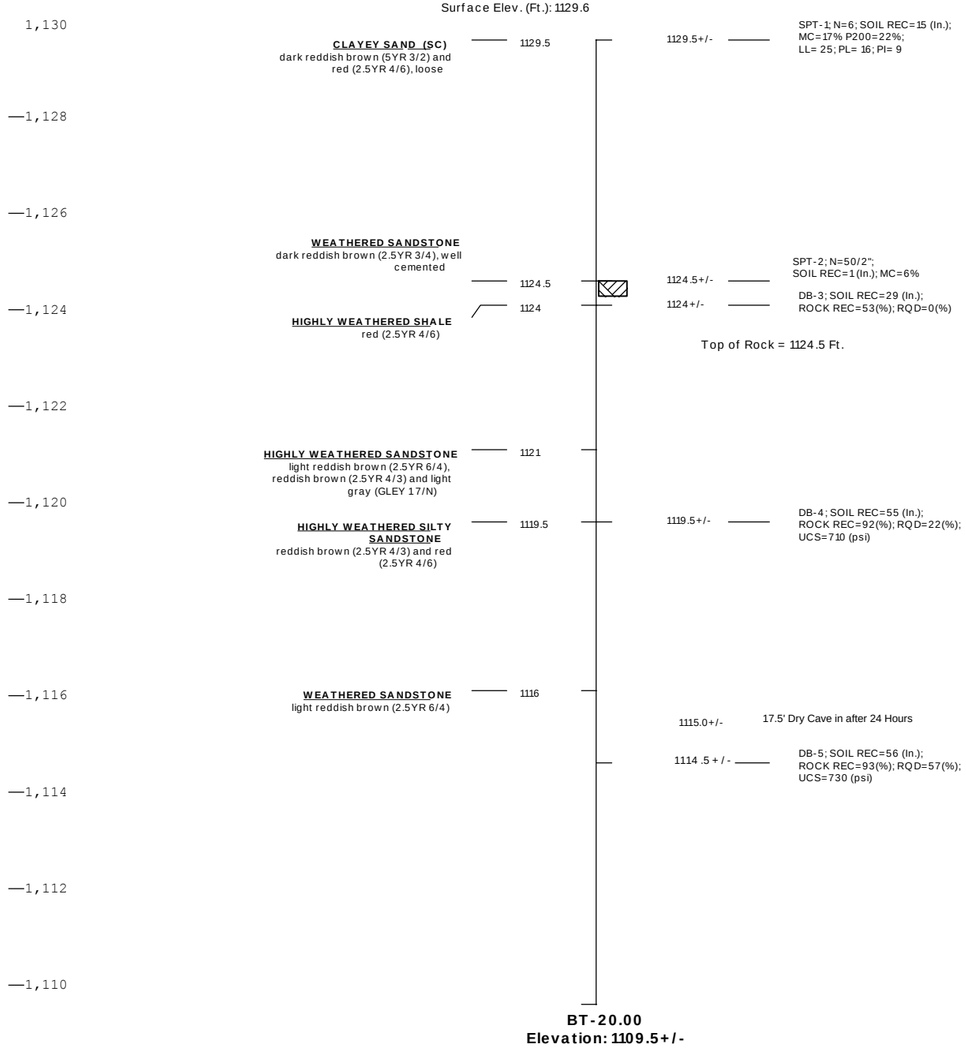
Design	XX	X/XX
Detail	XX	X/XX
Check	XX	X/XX
Squad:	XXXXXXX	
Engr.:	XXXXXXXX	

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

Boring No. CS-15

STATION 96+84 36' LT
(12/18/2018)

Surface Elev. (Ft.): 1129.6



CLAYEY SAND (SC)
dark reddish brown (5YR 3/2) and red (2.5YR 4/6), loose
1129.5

1129.5+/- SPT-1; N=6; SOIL REC=15 (In.); MC=17% P200=22%; LL= 25; PL= 16; PI= 9

WEATHERED SANDSTONE
dark reddish brown (2.5YR 3/4), well cemented
1124.5

1124.5+/- SPT-2; N=50/2"; SOIL REC=1(In.); MC=6%

HIGHLY WEATHERED SHALE
red (2.5YR 4/6)
1124

1124+/- DB-3; SOIL REC=29 (In.); ROCK REC=53(%); RQD=0(%)

Top of Rock = 1124.5 Ft.

HIGHLY WEATHERED SANDSTONE
light reddish brown (2.5YR 6/4), reddish brown (2.5YR 4/3) and light gray (GLEY 17/N)
1121

HIGHLY WEATHERED SILTY SANDSTONE
reddish brown (2.5YR 4/3) and red (2.5YR 4/6)
1119.5

1119.5+/- DB-4; SOIL REC=55 (In.); ROCK REC=92(%); RQD=22(%); UCS=710 (psi)

WEATHERED SANDSTONE
light reddish brown (2.5YR 6/4)
1116

1115.0+/- 17.5' Dry Cave in after 24 Hours

1114 .5 + / - DB-5; SOIL REC=56 (In.); ROCK REC=93(%); RQD=57(%); UCS=730 (psi)

BT-20.00
Elevation: 1109.5+/-

REVISIONS		
REV. NO.	DESCRIPTION	DATE

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.

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 crossbedded 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.

GEOTECHNICAL REPORT

ALL GEOTECHNICAL INFORMATION CONTAINED ON THIS SHEET IS COVERED BY THE ENGINEERING SEAL AFFIXED TO AN ORIGINAL GEOTECHNICAL ENGINEERING REPORT THAT HAS BEEN STAMPED AND SEALED BY A PROFESSIONAL ENGINEER LICENSED IN OKLAHOMA. TO OBTAIN A COPY OF THE COMPLETE REPORT, CONTACT THE ODOT OFFICE ENGINEER AT (405) 521-2625. THE CONTRACTOR SHOULD BE FULLY AWARE OF THE SITE CONDITIONS PRIOR TO BEGINNING WORK. ANY ADDITIONAL GEOTECNICAL INFORMATION WHICH MAY BE DESIRED IS THE RESPONSIBILITY OF THE CONTRACTOR.

Terracon

OKLAHOMA AND LOGAN COUNTIES

SUBSURFACE PROFILE
(SHEET 8 of 8)

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-29

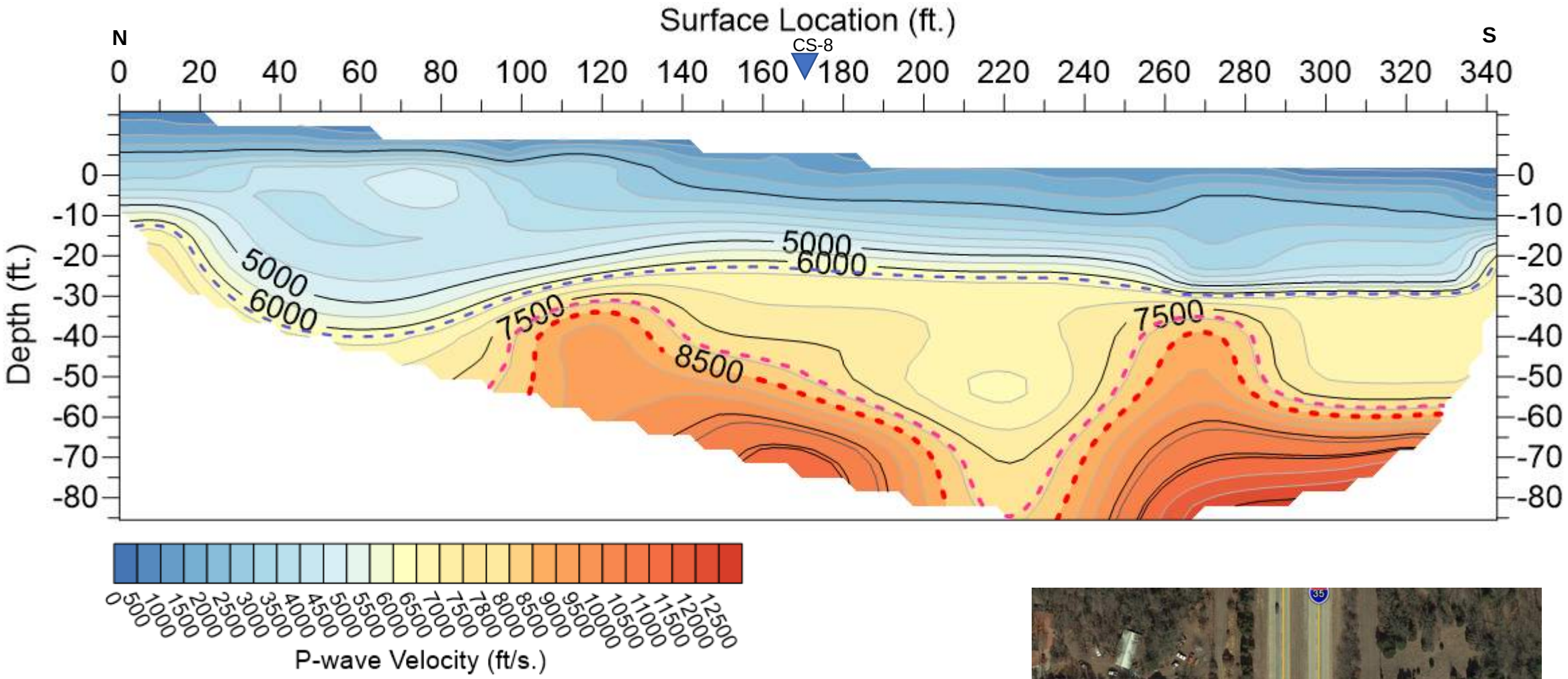
APPENDIX B

FIELD TESTING RESULTS

N

Project Manager: DVS	Project No. 03185253	Terracon Consulting Engineers & Scientists	Location Diagram
Drawn by: JWA	Scale: N.T.S.	4701 N. STILES AVE OKLAHOMA CITY, OKLAHOMA 74145	Seismic Lines I-35 & Waterloo Road Edmond, Oklahoma
Checked by: RMK	File Name: LOC	PH. (405) 525-0453 FAX. (405) 557-0549	Exhibit B1
Approved by: NKT	Date: JAN 2019		

LINE 1 P-WAVE VELOCITY (Vp) PROFILE



N

Up to 6,300 ft/s rippable with D8R/D8T

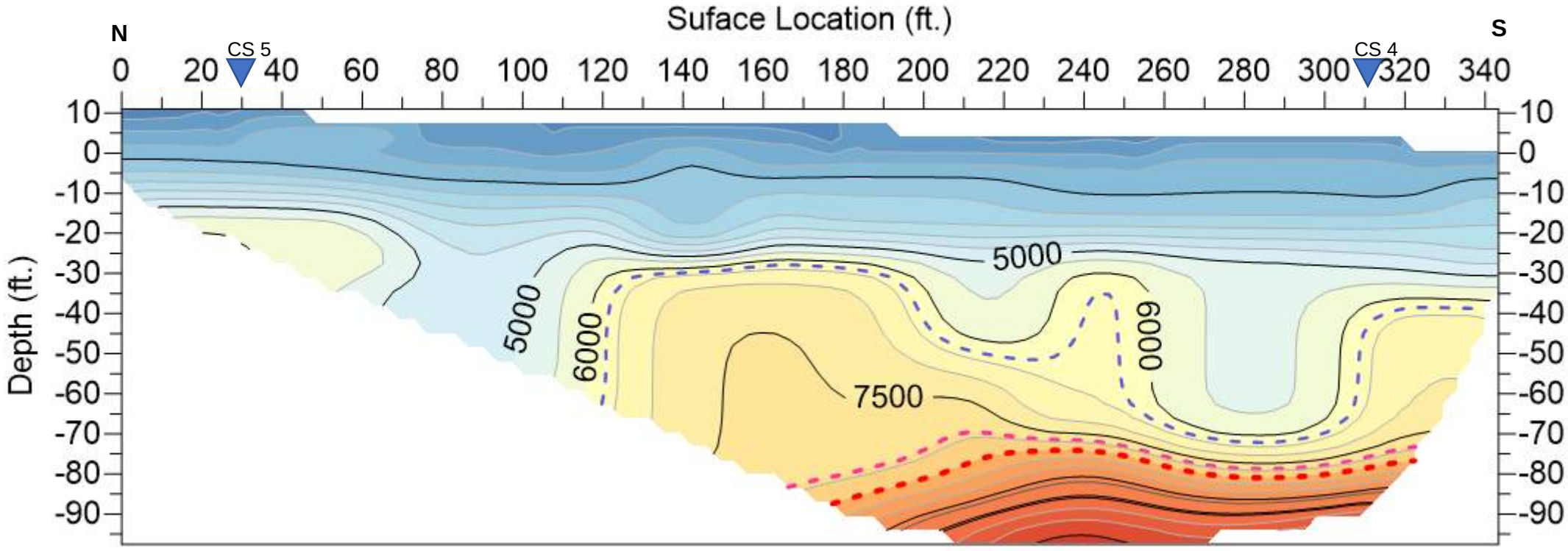
7,900 ft/s ODOT Rock excavation threshold

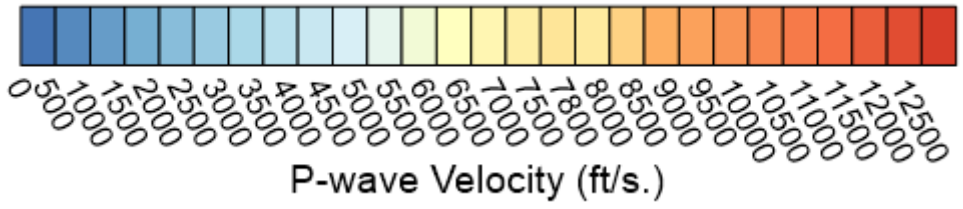
Up to 8,500 ft/s marginally rippable with D8R/D8T

CS — Cut Section Boring

Project Manager: DVS	Project No. 03185253	Terracon Consulting Engineers & Scientists 4701 N. STILES AVE OKLAHOMA CITY, OKLAHOMA 74145 PH. (405) 525-0453 FAX. (405) 557-0549	SEISMIC RESULTS Seismic Lines I-35 & Waterloo Road Edmond, Oklahoma
Drawn by: JWA	Scale: N.T.S.		
Checked by: RMK	File Name: LOC		Exhibit B2
Approved by: NKT	Date: JAN 2019		

LINE 2 P-WAVE VELOCITY (Vp) PROFILE





Up to 6,300 ft/s rippable with D8R/D8T

7,900 ft/s ODOT Rock excavation threshold

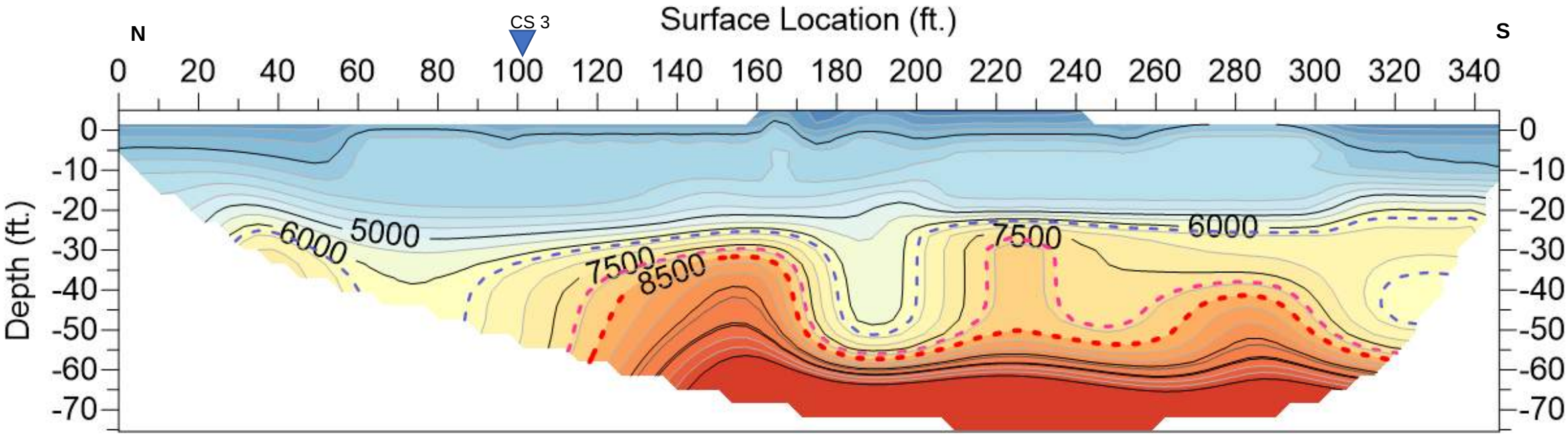
Up to 8,500 ft/s marginally rippable with D8R/D8T

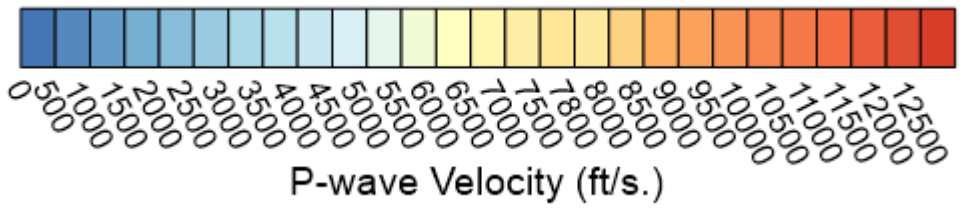
CS

Cut Section Boring

Project Manager: DVS	Project No. 03185253	Terracon Consulting Engineers & Scientists	SEISMIC RESULTS	Exhibit
Drawn by: JWA	Scale: N.T.S.	4701 N. STILES AVE OKLAHOMA CITY, OKLAHOMA 74145	Seismic Lines	B3
Checked by: RMK	File Name: LOC	PH. (405) 525-0453 FAX. (405) 557-0549	I-35 & Waterloo Road	
Approved by: NKT	Date: JAN 2019		Edmond, Oklahoma	

LINE 3 P-WAVE VELOCITY (Vp) PROFILE





Up to 6,300 ft/s rippable with D8R/D8T

7,900 ft/s ODOT Rock excavation threshold

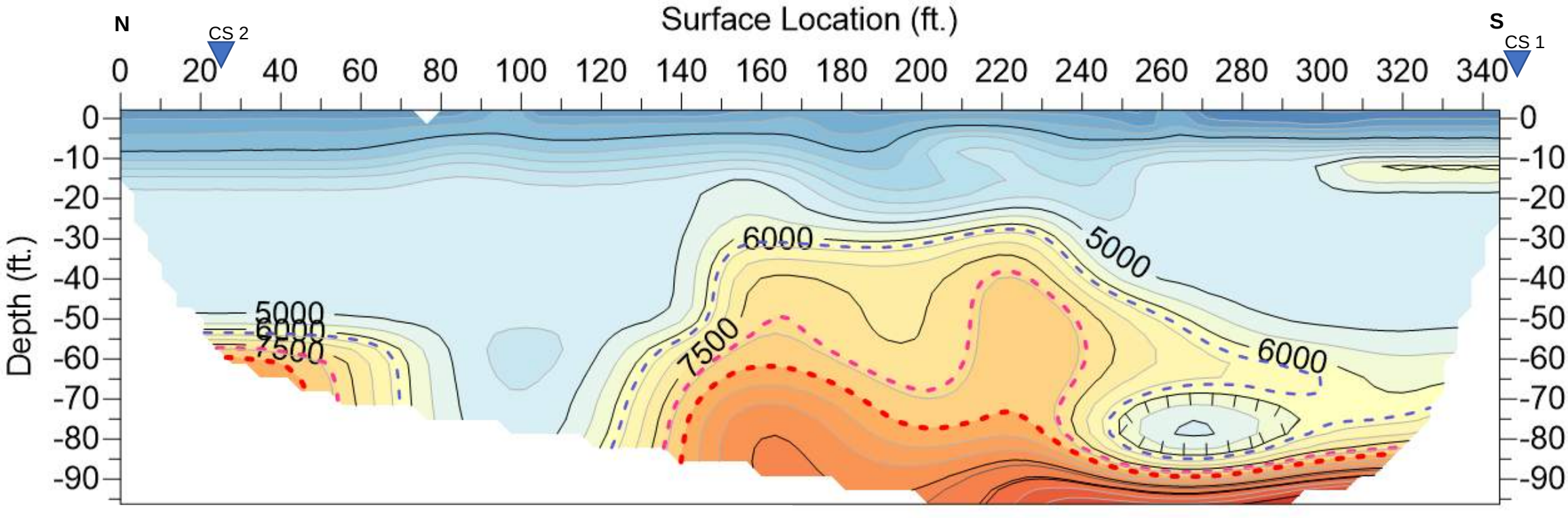
Up to 8,500 ft/s marginally rippable with D8R/D8T

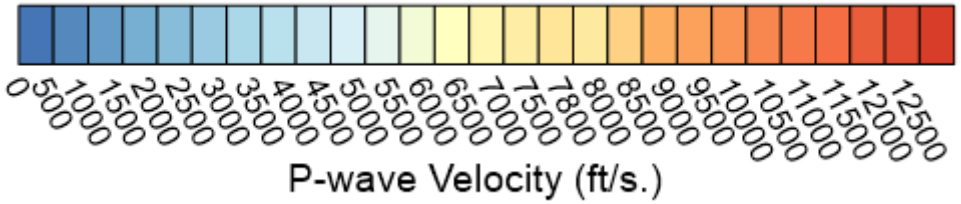
CS

Cut Section Boring

Project Manager: DVS	Project No. 03185253	Terracon Consulting Engineers & Scientists	SEISMIC RESULTS
Drawn by: JWA	Scale: N.T.S.	4701 N. STILES AVE OKLAHOMA CITY, OKLAHOMA 74145	Seismic Lines I-35 & Waterloo Road Edmond, Oklahoma
Checked by: RMK	File Name: LOC	PH. (405) 525-0453 FAX. (405) 557-0549	Exhibit B4
Approved by: NKT	Date: JAN 2019		

LINE 4 P-WAVE VELOCITY (Vp) PROFILE





Up to 6,300 ft/s rippable with D8R/D8T

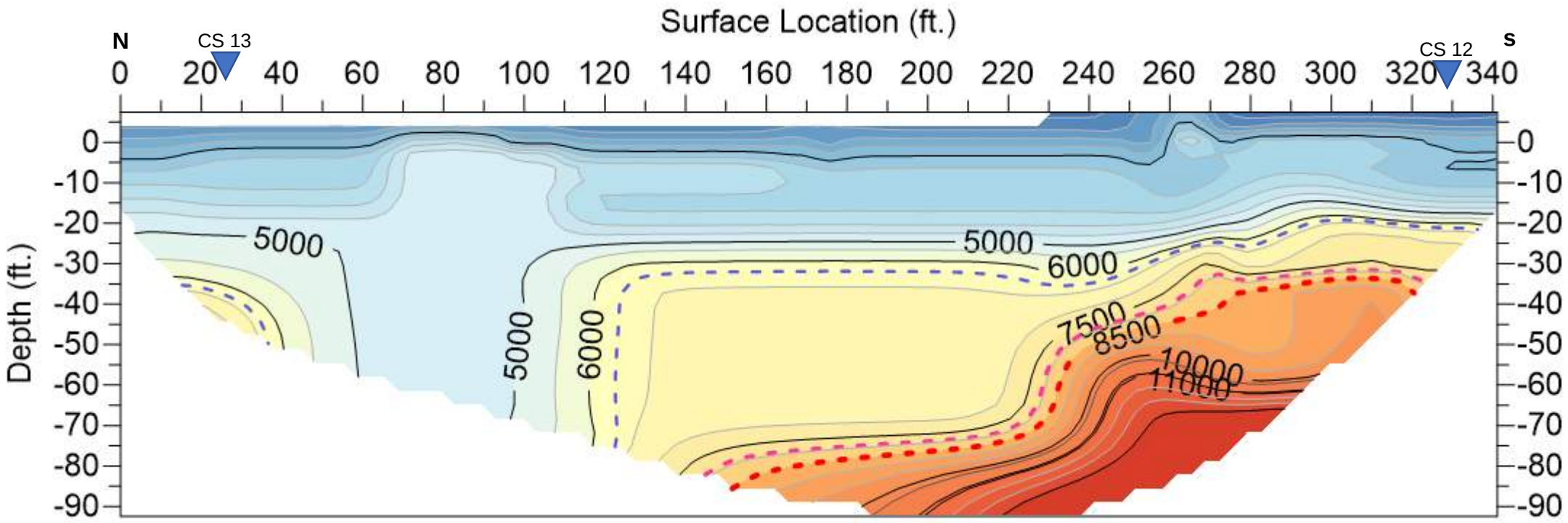
7,900 ft/s ODOT Rock excavation threshold

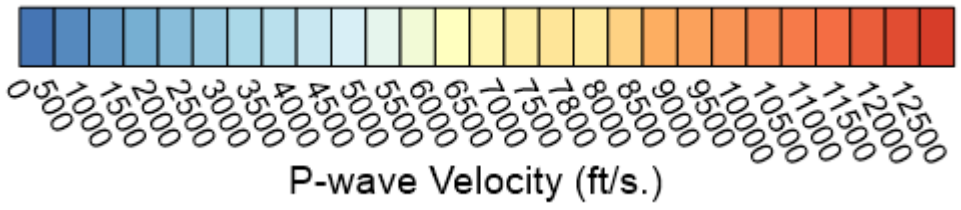
Up to 8,500 ft/s marginally rippable with D8R/D8T

CS — Cut Section Boring

Project Manager: DVS	Project No. 03185253	Terracon Consulting Engineers & Scientists	SEISMIC RESULTS	Exhibit
Drawn by: JWA	Scale: N.T.S.	4701 N. STILES AVE OKLAHOMA CITY, OKLAHOMA 74145	Seismic Lines I-35 & Waterloo Road Edmond, Oklahoma	B5
Checked by: RMK	File Name: LOC	PH. (405) 525-0453 FAX. (405) 557-0549		
Approved by: NKT	Date: JAN 2019			

LINE 5 P-WAVE VELOCITY (Vp) PROFILE





N

Up to 6,300 ft/s rippable with D8R/D8T

7,900 ft/s ODOT Rock excavation threshold

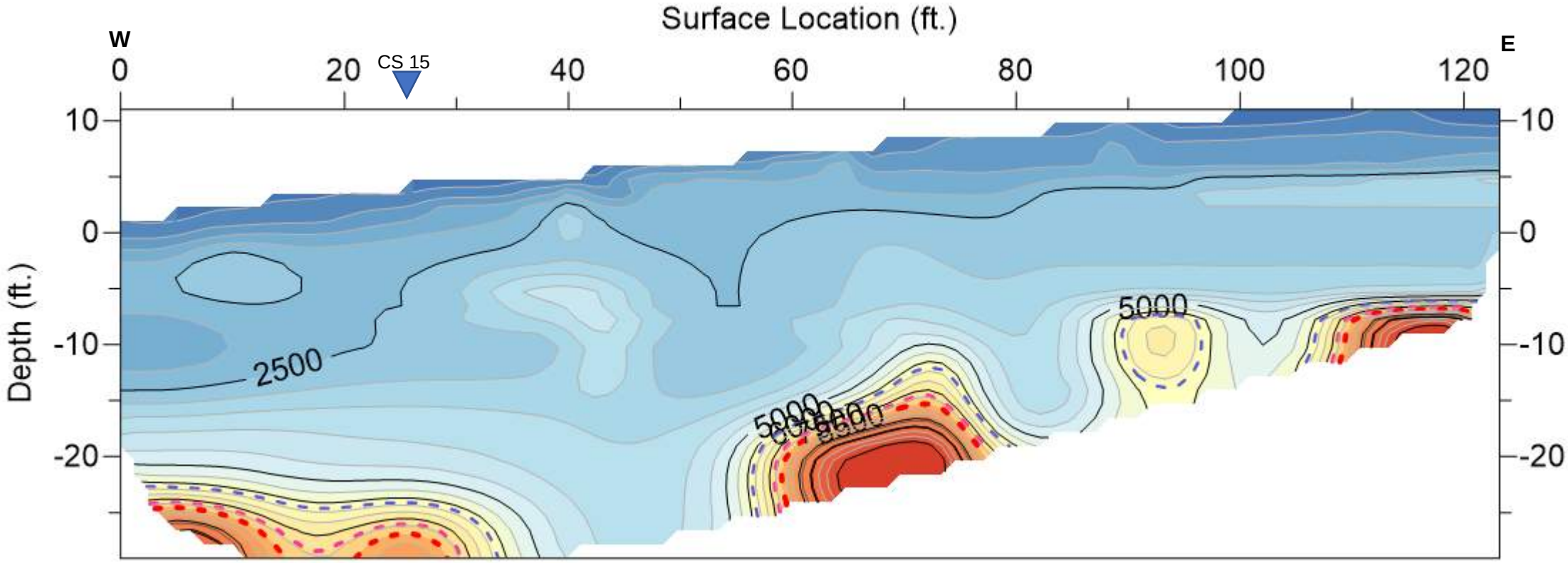
Up to 8,500 ft/s marginally rippable with D8R/D8T

CS

Cut Section Boring

Project Manager: DVS	Project No. 03185253	Terracon Consulting Engineers & Scientists	SEISMIC RESULTS
Drawn by: JWA	Scale: N.T.S.	4701 N. STILES AVE OKLAHOMA CITY, OKLAHOMA 74145	Seismic Lines I-35 & Waterloo Road Edmond, Oklahoma
Checked by: RMK	File Name: LOC	PH. (405) 525-0453 FAX. (405) 557-0549	Exhibit B6
Approved by: NKT	Date: JAN 2019		

LINE 6 P-WAVE VELOCITY (Vp) PROFILE



Up to 6,300 ft/s rippable with D8R/D8T

7,900 ft/s ODOT Rock excavation threshold

Up to 8,500 ft/s marginally rippable with D8R/D8T

CS — Cut Section Boring

Project Manager: DVS	Project No. 03185253	Terracon Consulting Engineers & Scientists	SEISMIC RESULTS	Exhibit
Drawn by: JWA	Scale: N.T.S.	4701 N. STILES AVE OKLAHOMA CITY, OKLAHOMA 74145 PH. (405) 525-0453 FAX. (405) 557-0549	Seismic Lines I-35 & Waterloo Road Edmond, Oklahoma	B7
Checked by: RMK	File Name: LOC			
Approved by: NKT	Date: JAN 2019			

APPENDIX C

LABORATORY TESTING

Laboratory Testing

Samples retrieved during the field exploration from the cut sections 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 E.

Laboratory tests were conducted on selected soil and rock samples in general accordance with the applicable AASHTO, local or other accepted standards. The field descriptions were modified as necessary based on visual observation and laboratory test results. The laboratory test results are presented on the boring logs next to the respective samples.

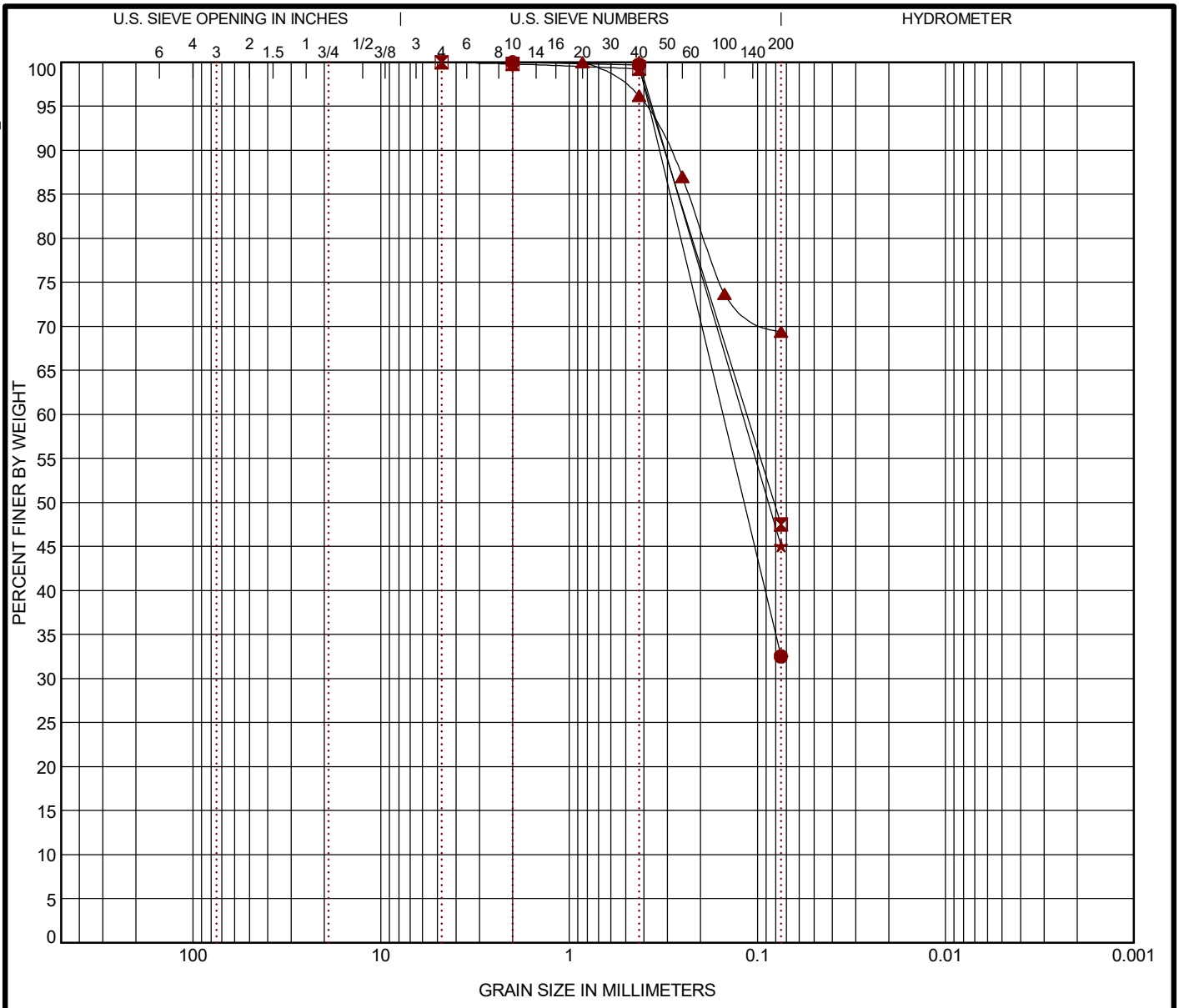
The following laboratory tests were performed on selected overburden soil and rock samples obtained from the site:

- In-situ Water Content
- Sieve Analysis
- Atterberg Limits
- Rock Core Unconfined Compressive Strength
- In-Situ Dry Density
- Moisture Density Relationship
- Direct Shear Test
- Consolidated Undrained Triaxial Compression Test

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



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	Bulk CS-2	0 - 4	CLAYEY SAND (SC)	A-2-6 (1)		29	16	13		
⊠	Bulk CS-6	0 - 5	CLAYEY SAND (SC)	A-6 (4)		32	15	17		
▲	CS-1	2 - 4	SANDY LEAN CLAY (CL)	A-6 (15)	16	38	13	25		
★	CS-1	5 - 6.5	CLAYEY SAND (SC)	A-6 (4)	14	35	16	19		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	Bulk CS-2	0 - 4	2	0.152			0.0	67.5		32.5	
⊠	Bulk CS-6	0 - 5	4.75	0.114			0.0	52.5		47.5	
▲	CS-1	2 - 4	0.85				0.0	30.6		69.4	
★	CS-1	5 - 6.5	0.425	0.12			0.0	54.9		45.1	

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

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

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03185253

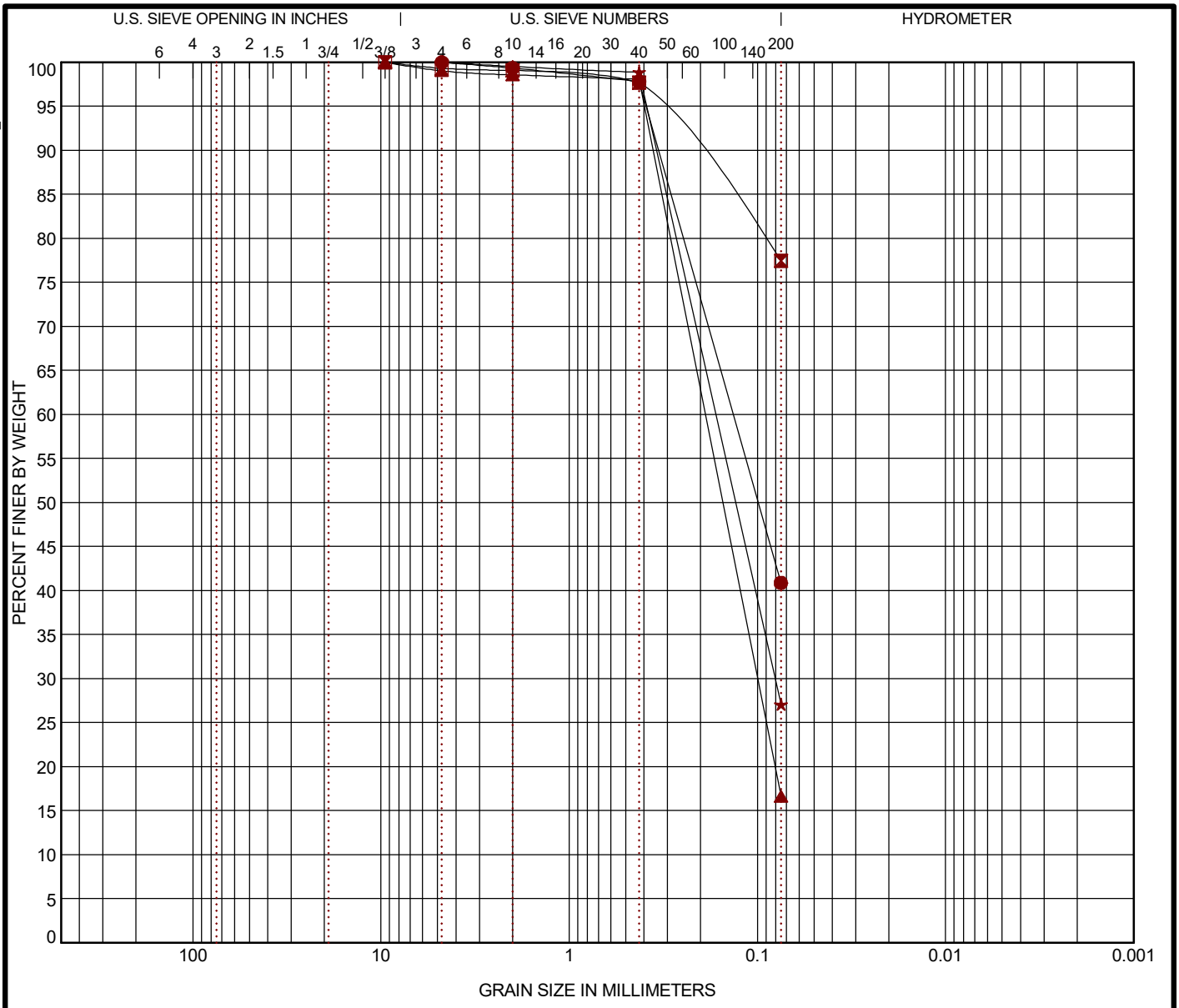
CLIENT: Garver, LLC
Tulsa, Oklahoma

EXHIBIT: C-2

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO DESC COMBINED USE THIS ONE - 03185253 CUT SECTIONS - I-35 OVER WATERLOO ROAD PHASE II.GPJ TERRACON_DATATEMPLATE.GDT 2/12/1

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	CS-2	0 - 1.5	CLAYEY SAND (SC)	A-6 (2)	16	30	15	15		
⊠	CS-3	0 - 1.5	LEAN CLAY with SAND (CL)	A-4 (4)	14	24	15	9		
▲	CS-4	0 - 1.5	SILTY SAND (SM)	A-2-4 (0)	9	NP	NP	NP		
★	CS-5	0 - 1.5	SILTY SAND (SM)	A-2-4 (0)	12	NP	NP	NP		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	CS-2	0 - 1.5	4.75	0.134			0.0	59.1		40.9	
⊠	CS-3	0 - 1.5	9.5				0.7	21.8		77.5	
▲	CS-4	0 - 1.5	9.5	0.189	0.1		1.0	82.4		16.7	
★	CS-5	0 - 1.5	4.75	0.166	0.08		0.0	72.9		27.1	

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

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

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03185253

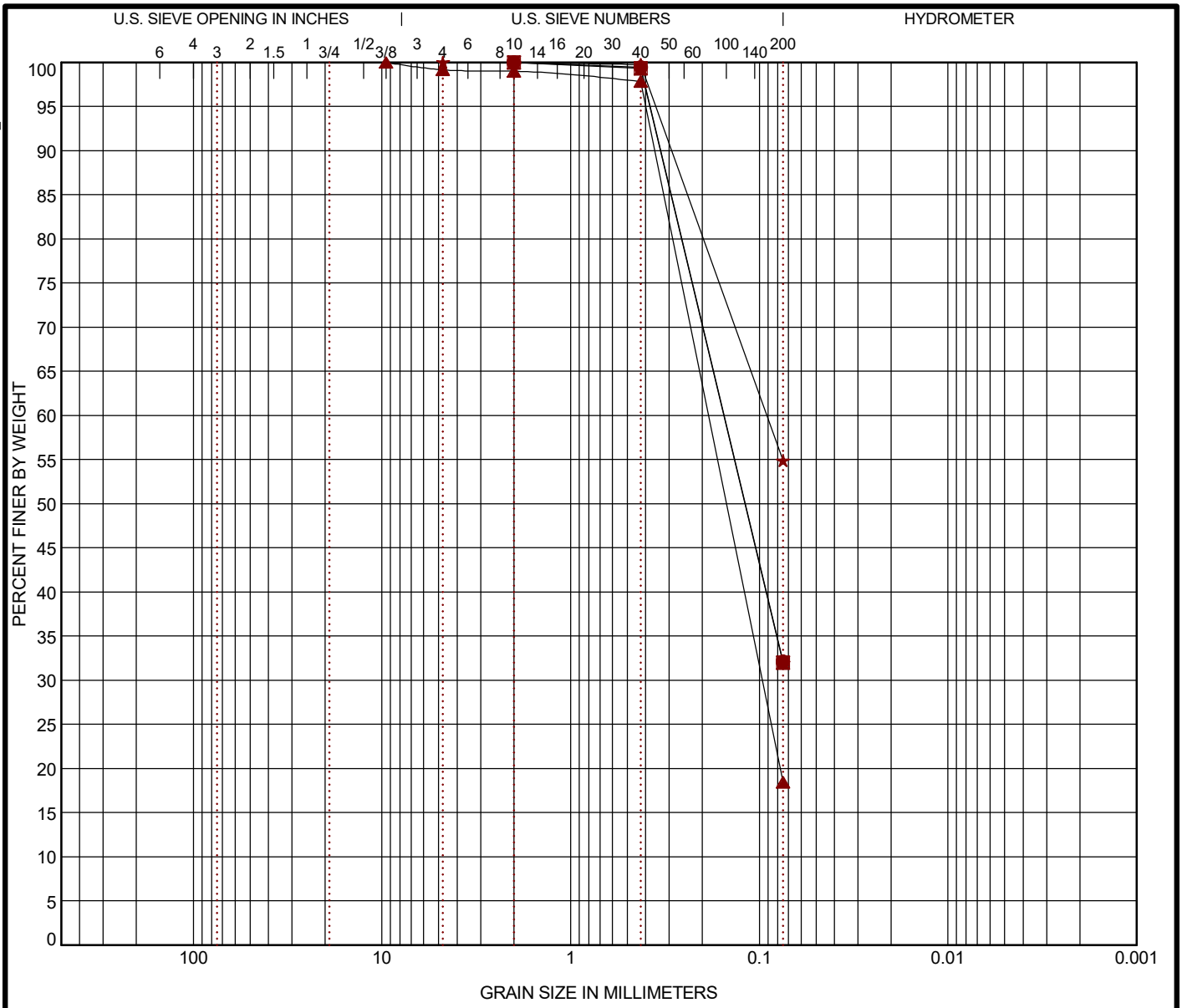
CLIENT: Garver, LLC
Tulsa, Oklahoma

EXHIBIT: C-3

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO DESC COMBINED USE THIS ONE - 03185253 CUT SECTIONS - I-35 OVER WATERLOO ROAD PHASE II.GPJ TERRACON_DATATEMPLATE.GDT 2/12/1

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	CS-6	5 - 6.5	CLAYEY SAND (SC)	A-2-6 (1)	9	30	14	16		
⊠	CS-7	0 - 1.5	CLAYEY SAND (SC)	A-2-6 (1)	15	28	13	15		
▲	CS-7	5 - 6.5	HIGHLY WEATHERED SILTY SANDSTONE		9	NP	NP	NP		
★	CS-8	0 - 1.5	SANDY SILT (ML)	NE A-4 (0)	15	NP	NP	NP		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	CS-6	5 - 6.5	2	0.154			0.0	67.9		32.1	
⊠	CS-7	0 - 1.5	2	0.154			0.0	68.0		32.0	
▲	CS-7	5 - 6.5	9.5	0.186	0.096		0.8	80.7		18.5	
★	CS-8	0 - 1.5	4.75	0.091			0.0	45.1		54.9	

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

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

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03185253

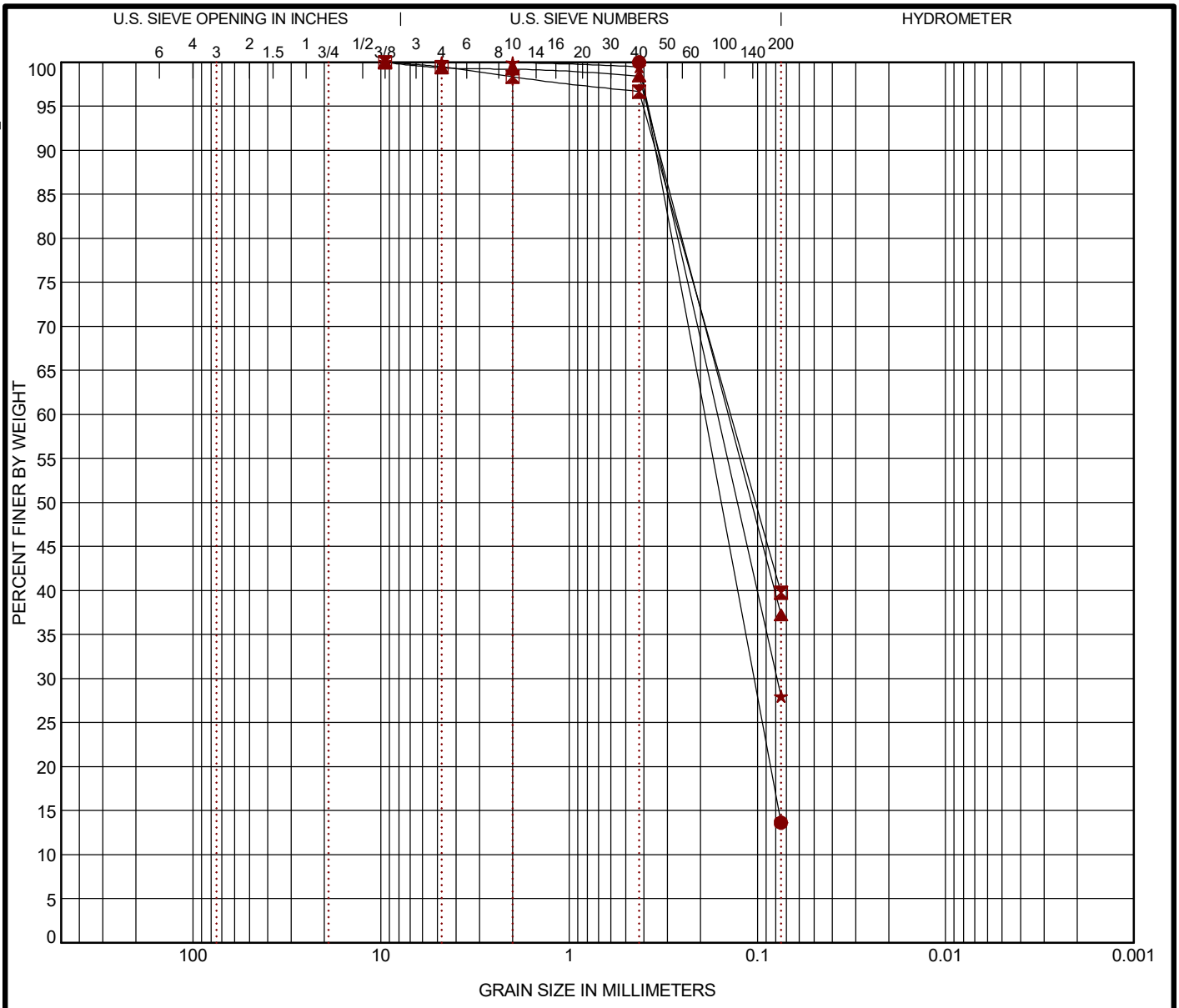
CLIENT: Garver, LLC
Tulsa, Oklahoma

EXHIBIT: C-4

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO DESC COMBINED USE THIS ONE - 03185253 CUT SECTIONS - I-35 OVER WATERLOO ROAD PHASE II.GPJ TERRACON_DATATEMPLATE.GDT 2/12/1

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	CS-9	0 - 1.5	SILTY SAND (SM)	A-2-4 (0)	12	NP	NP	NP		
⊠	CS-10	0 - 1.5	CLAYEY SAND (SC)	A-6 (1)	19	27	14	13		
▲	CS-11	0 - 1.5	CLAYEY SAND (SC)	A-6 (1)	18	27	15	12		
★	CS-12	0 - 1.5	SILTY SAND (SM)	A-2-4 (0)	13	NP	NP	NP		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	CS-9	0 - 1.5	0.425	0.19	0.104		0.0	86.4		13.6	
⊠	CS-10	0 - 1.5	9.5	0.139			0.5	59.7		39.8	
▲	CS-11	0 - 1.5	9.5	0.143			0.6	62.1		37.3	
★	CS-12	0 - 1.5	9.5	0.163	0.079		0.1	72.0		28.0	

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

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

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03185253

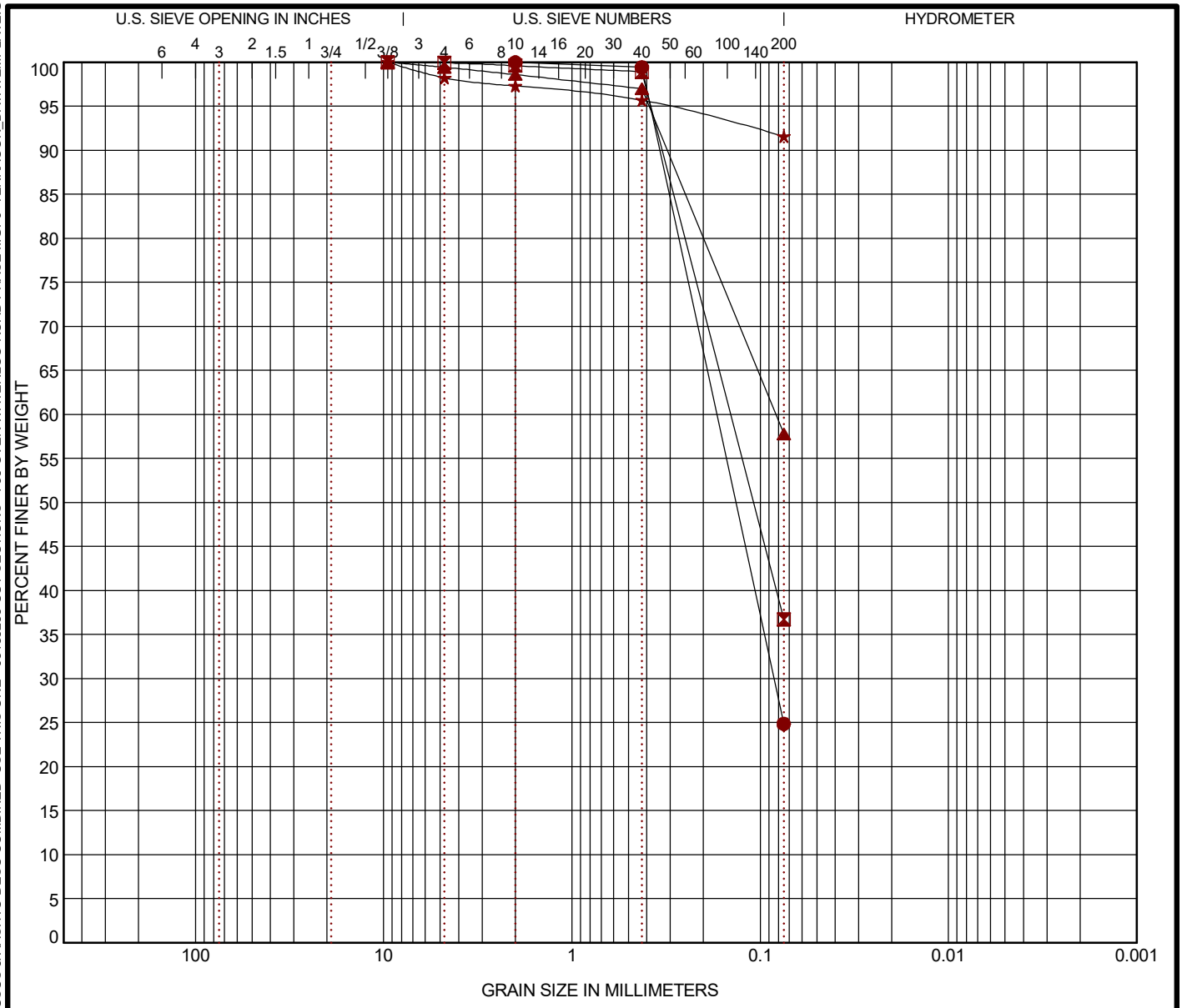
CLIENT: Garver, LLC
Tulsa, Oklahoma

EXHIBIT: C-5

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO DESC COMBINED USE THIS ONE - 03185253 CUT SECTIONS - I-35 OVER WATERLOO ROAD PHASE II.GPJ TERRACON_DATATEMPLATE.GDT 2/12/1

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	CS-13	0 - 1.5	SILTY SAND (SM)	A-2-4 (0)	11	NP	NP	NP		
⊠	CS-14	0 - 1.5	CLAYEY SAND (SC)	A-6 (0)	14	27	16	11		
▲	CS-14	5 - 6.5	SANDY LEAN CLAY (CL)	A-6 (5)	9	29	14	15		
★	CS-14	15 - 16.5	LEAN CLAY (CL)	A-7-6 (22)	11	43	20	23		

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	CS-13	0 - 1.5	2	0.17	0.085		0.0	75.1		24.9	
⊠	CS-14	0 - 1.5	9.5	0.143			0.1	63.2		36.7	
▲	CS-14	5 - 6.5	9.5	0.083			0.6	41.6		57.8	
★	CS-14	15 - 16.5	9.5				1.8	6.6		91.6	

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

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

Terracon
4701 N Stiles Ave
Oklahoma City, OK

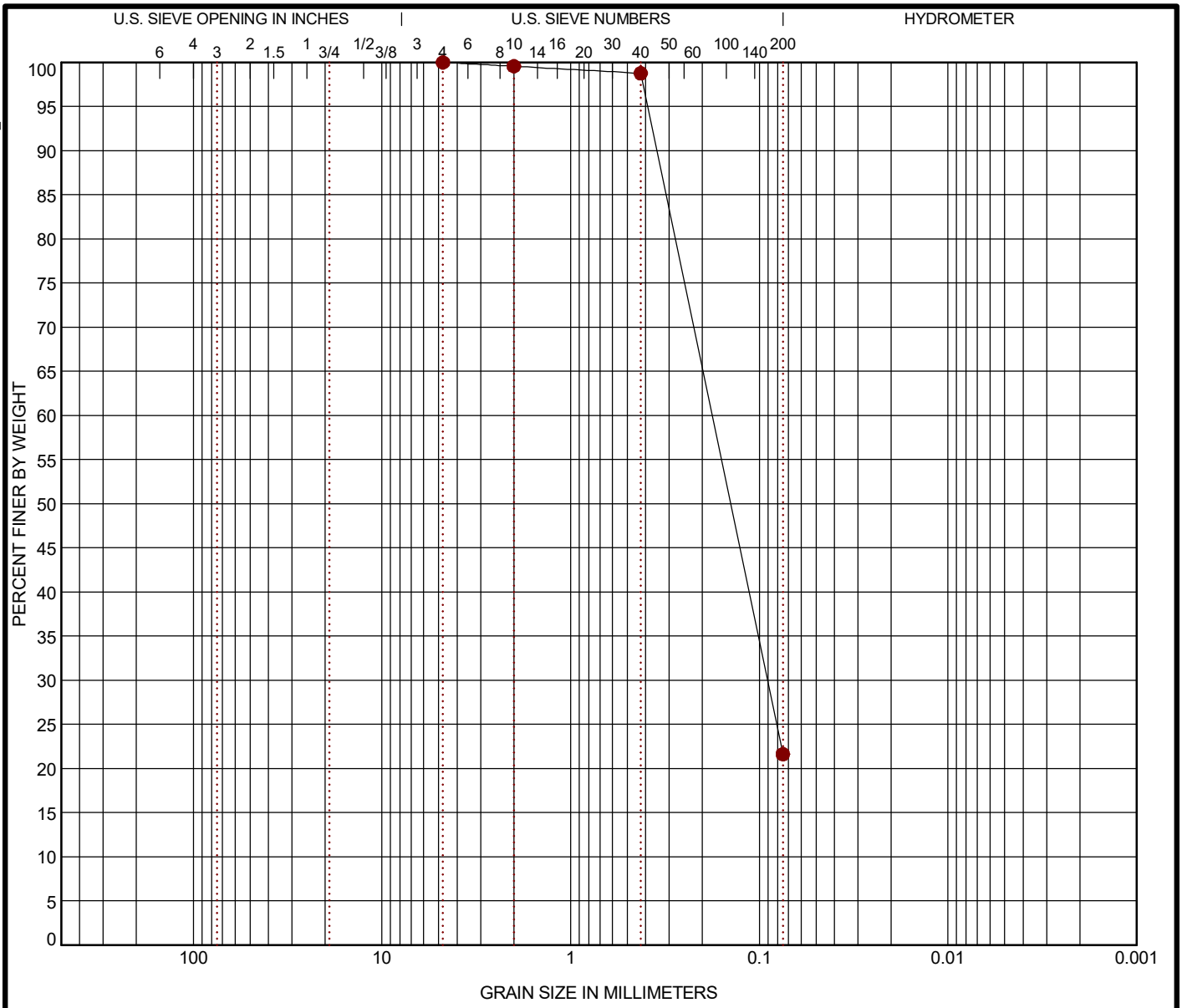
PROJECT NUMBER: 03185253

CLIENT: Garver, LLC
Tulsa, Oklahoma

EXHIBIT: C-6

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
CS-15	0 - 1.5	CLAYEY SAND (SC)	A-2-4 (0)	17	25	16	9		

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
CS-15	0 - 1.5	4.75	0.178	0.091		0.0	78.4		21.6	

PROJECT: Cut Sections I-35 over Waterloo Road Interchange

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

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03185253

CLIENT: Garver, LLC
Tulsa, Oklahoma

EXHIBIT: C-7

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS & AASHTO DESC COMBINED USE THIS ONE - 03185253 CUT SECTIONS - I-35 OVER WATERLOO ROAD PHASE II.GPJ TERRACON_DATATEMPLATE.GDT 2/12/1

Laboratory Compaction Characteristics of Soil

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

Client Name: Garver, LLC
Project Name: Cut Sections
Location: I-35 over Waterloo Road Interchange
Oklahoma and Logan Counties, Oklahoma

Source Material: Bulk CS-1 (2.0 to 4.0")
Sample Description: Sandy Lean Clay, Weak Red (10R 4/2)
and Dark Red (10R 3/6)
Material Designation: Lab 3 Sample date: 12/12/18
Test Method: Method A
Test Procedure: ASTM D-698
Sample Preparation: Dry
Rammer: X Mechanical ___ Manual

Project No.: 03185253 Date: 01/09/19

TEST RESULTS
Maximum Dry Unit Wt.: 111.9 pcf
Optimum Water Content: 13.8 %

Liquid Limit: 38 Plastic Limit: 13
Plasticity Index: 25
% passing # 200 sieve: 69
AASHTO Class. A-6(15) USCS: CL
Reviewed by: DCVS

Zero air voids for specific gravity of 2.70

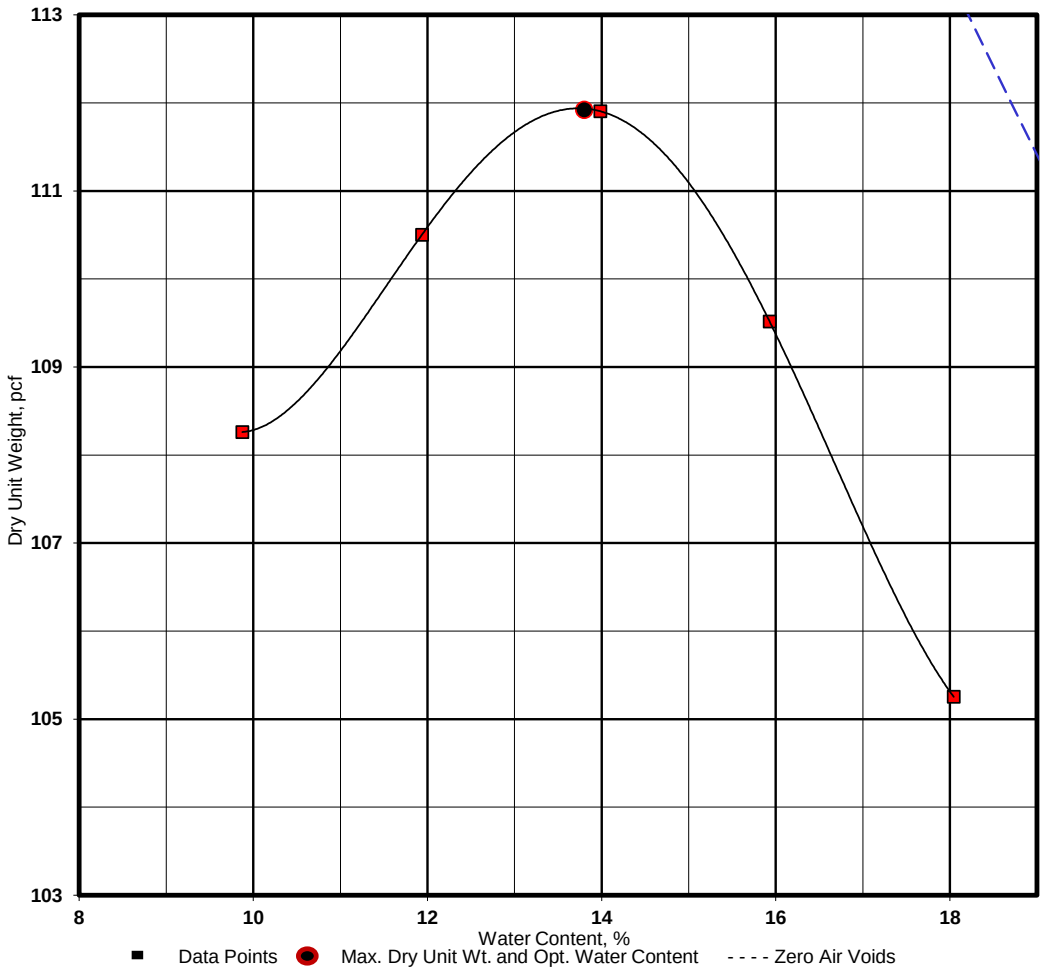


Exhibit C-8

Laboratory Compaction Characteristics of Soil

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

Client Name: Garver, LLC
Project Name: Cut Sections
Location: I-35 over Waterloo Road Interchange
Oklahoma and Logan Counties, Oklahoma

Source Material: Bulk-CS-2 (0.0 to 4.0')
Sample Description: Clayey Sand, Brownish Yellow (10YR 6/8)

Material Designation: Lab 4 Sample date: 12/11/18
Test Method: Method A
Test Procedure: ASTM D-698
Sample Preparation: Dry
Rammer: X Mechanical ___ Manual

Project No.: 03185253 Date: 01/09/19

TEST RESULTS
Maximum Dry Unit Wt.: 109.4 pcf
Optimum Water Content: 15.3 %

Liquid Limit: 29 Plastic Limit: 16
Plasticity Index: 13
% passing # 200 sieve: 33
AASHTO Class. A-2-6(1) USCS: SC
Reviewed by: DCVS

Zero air voids for specific gravity of 2.70

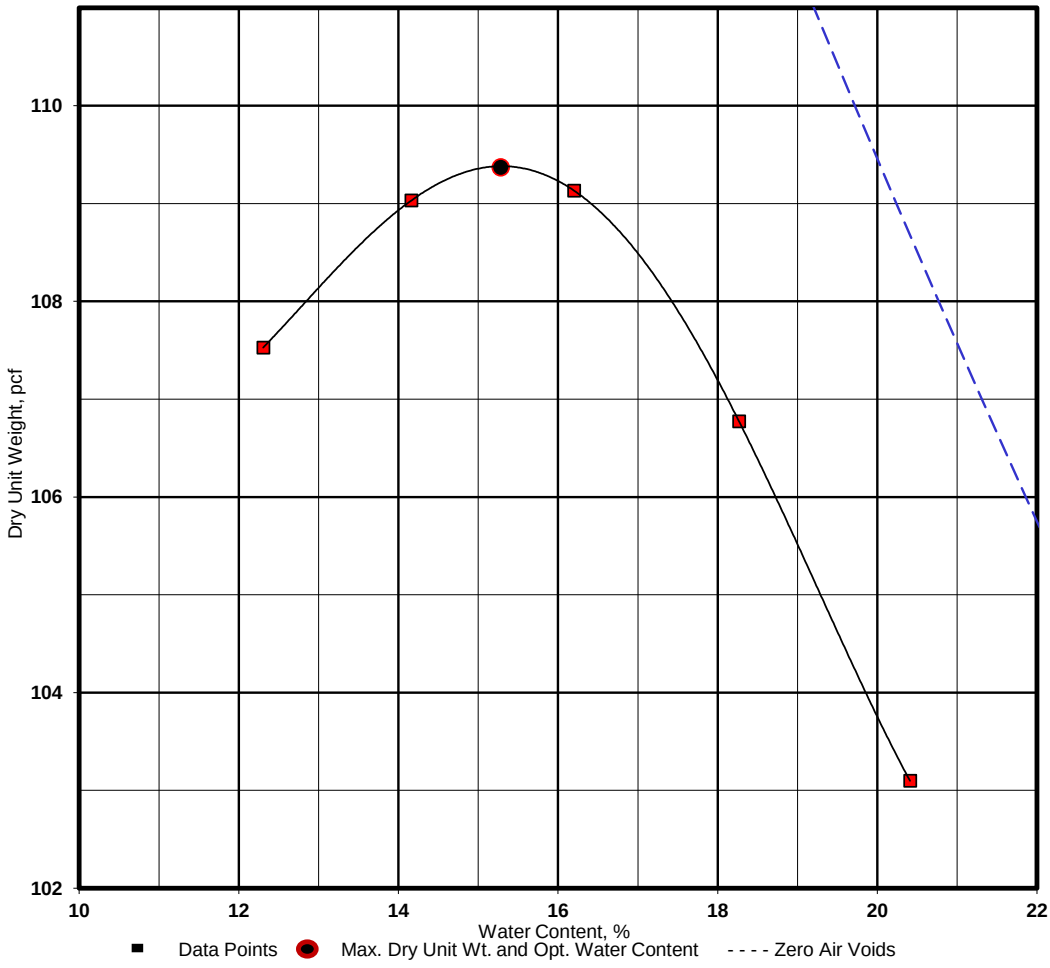


Exhibit C-9

Laboratory Compaction Characteristics of Soil

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

Client Name: Garver, LLC
Project Name: Cut Sections
Location: I-35 over Waterloo Road Interchange
Oklahoma and Logan Counties, Oklahoma

Source Material: Bulk CS-6 (0.0 to 5.0')
Sample Description: Clayey Sand, Dark Brown (7.5YR 3/2) and Dusky Red (10R 3/4)
Material Designation: Lab 855 Sample date: 12/10/18
Test Method: Method A
Test Procedure: ASTM D-698
Sample Preparation: Dry
Rammer: X Mechanical ___ Manual

Project No.: 03185253 Date: 01/08/19

TEST RESULTS
Maximum Dry Unit Wt.: 113.9 pcf
Optimum Water Content: 14.2 %

Liquid Limit: 32 Plastic Limit: 15
Plasticity Index: 17
% passing # 200 sieve: 48
AASHTO Class. A-6(4) USCS: SC
Reviewed by: DCVS

Zero air voids for specific gravity of 2.70

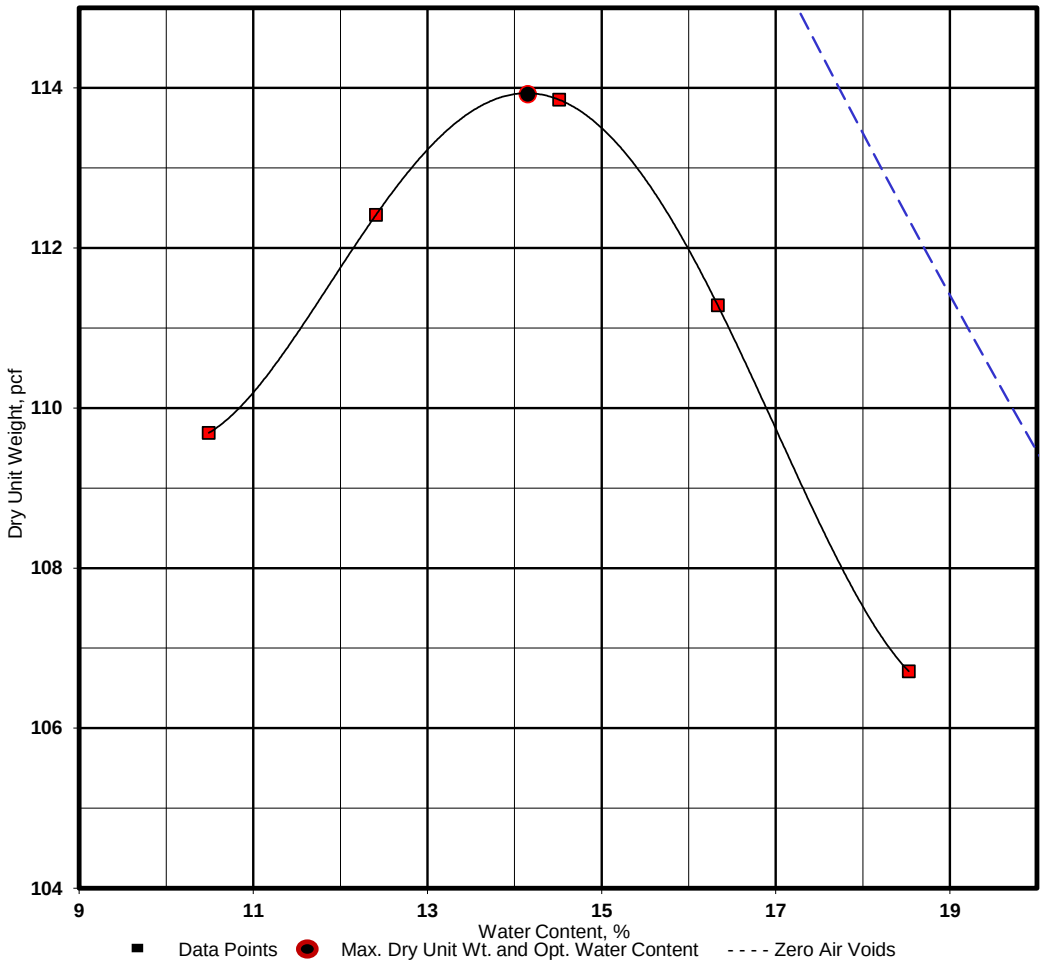
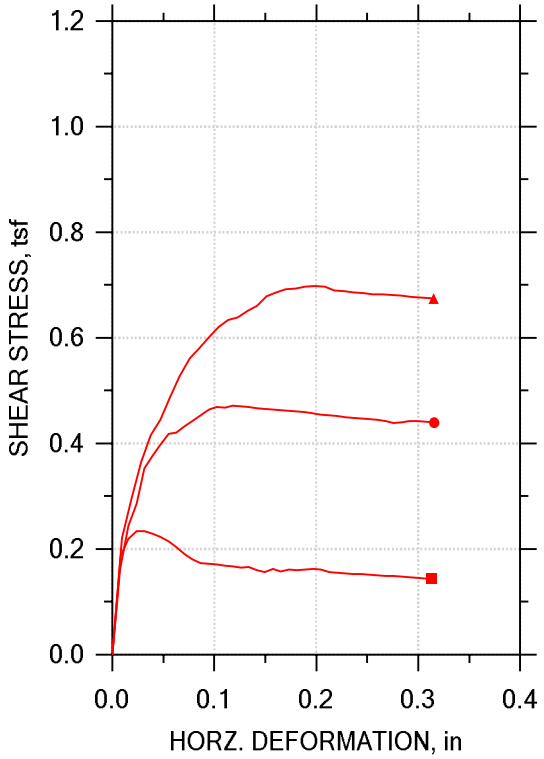
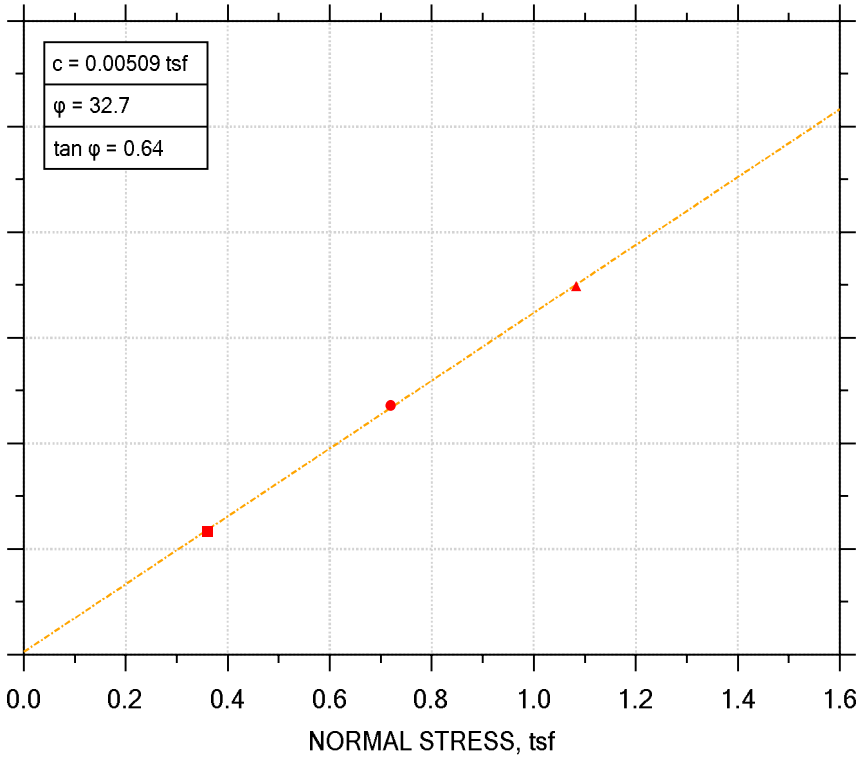


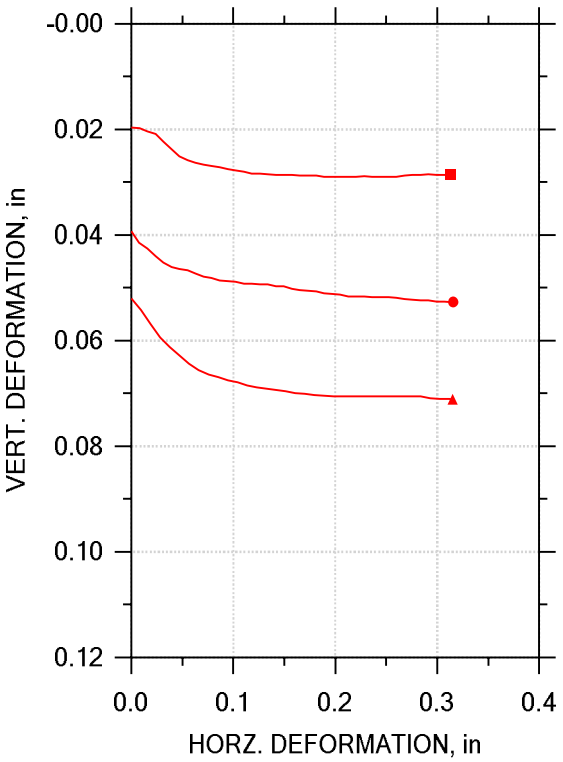
Exhibit C-10

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.		BULK	BULK	BULK	
Shape		Circular	Circular	Circular	
Initial	Dimension, in	2.5028	2.5008	2.4988	
	Area, in²	4.9196	4.9118	4.9041	
	Height, in	1.1531	1.1524	1.15	
	Water Content, %	14.37	14.31	14.64	
	Dry Density, pcf	107.9	108.1	108.3	
	Saturation, %	68.09	68.27	70.11	
	Void Ratio	0.57391	0.57031	0.56797	
Consol. Height, in		1.1335	1.1131	1.098	
Consol. Void Ratio		0.54703	0.51679	0.49711	
Final	Water Content, %	19.44	18.21	17.24	
	Dry Density, pcf	110.6	113.3	115.4	
	Saturation, %	98.87	99.36	99.56	
	Void Ratio	0.53483	0.49851	0.47101	
Normal Stress, tsf		0.35973	0.7196	1.0829	
Max. Shear Stress, tsf		0.2338	0.47205	0.69838	
Ult. Shear Stress, tsf		0.14331	0.43927	0.67443	
Time to Failure, min		188.12	694.64	964.77	
Disp. Rate, in/min		0.00017323	0.00017323	0.00017323	
Estimated Specific Gravity		2.72	2.72	2.72	
Liquid Limit		30	30	30	
Plastic Limit		14	14	14	
Plasticity Index		16	16	16	

Project: CUT SECTIONS I-35 OVER WATERLOO RD INTERCHANGE

Location: OKLAHOMA & LOGAN COUNTIES, OK

Project No.: 03185253

Boring No.: CS-6 BULK Depth: 0.0'-5.0'

Sample Type: RECONSTITUTED

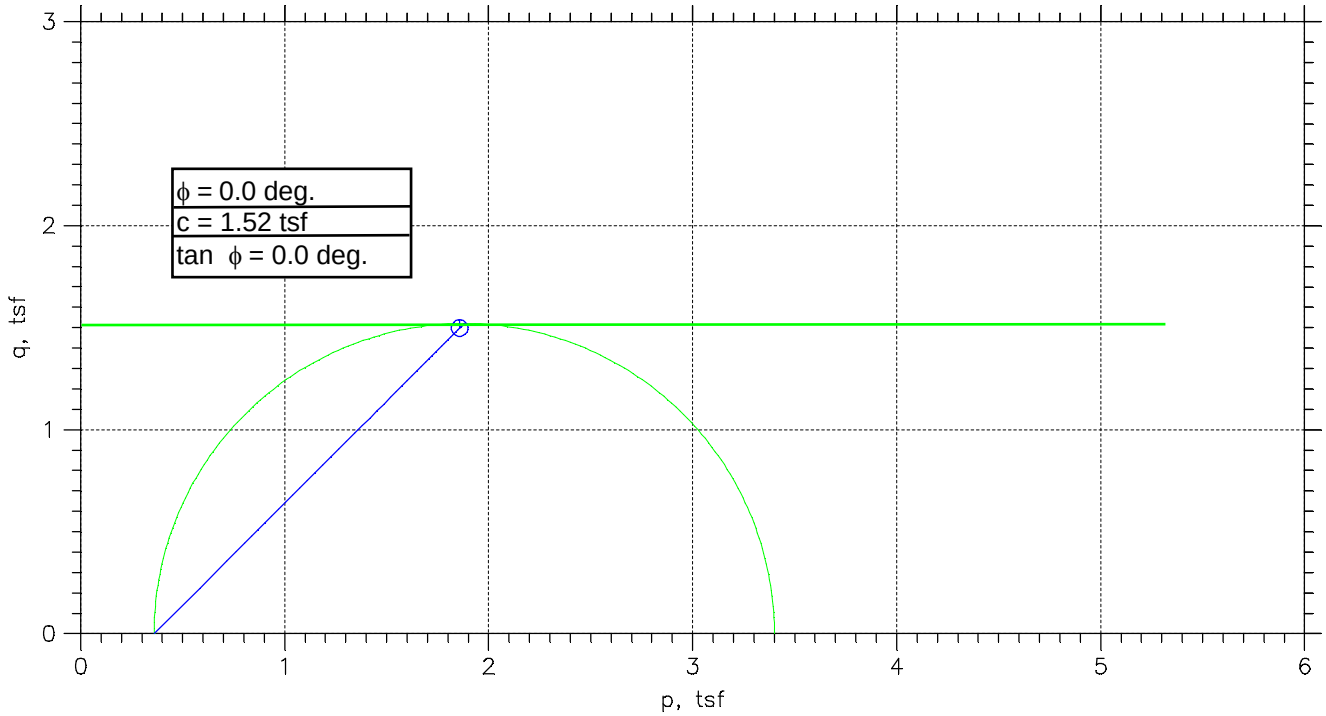
Description: CLAYEY SAND, DARK BROWN (7.5YR 3/2), DUSKY RED(10R 3/4)

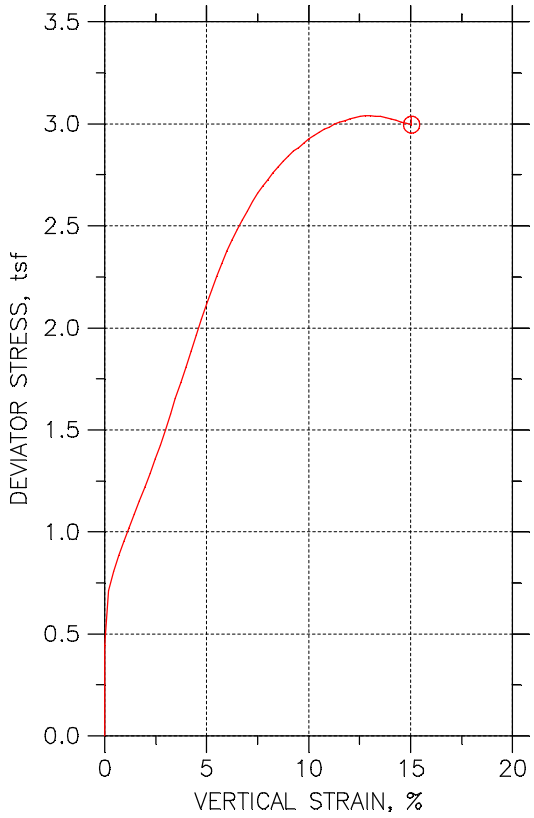
Remarks: TEST PERFORMED AS PER ASTM 3080 SPECIMEN RECONSTITUTED TO 95.0% SPD @ OMC

Exhibit C-11

UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST
ASTM D2850

Terracon
Consulting Engineers & Scientists





Symbol		⏲			
Test No.		5.0 PSI			
Initial	Diameter, in	2.822			
	Height, in	6.1264			
	Water Content, %	16.48			
	Dry Density, pcf	110.29			
	Saturation, %	83.09			
	Void Ratio	0.53962			
Before Shear	Water Content, %	16.48			
	Dry Density, pcf	110.29			
	Saturation, %	83.09			
	Void Ratio	0.53962			
	Back Press., tsf	---			
Minor Prin. Stress, tsf		0.36			
Max. Dev. Stress, tsf		3.0404			
Time to Failure, min		12.751			
Strain Rate, %/min		1			
B-Value		---			
Estimated Specific Gravity		2.72			
Liquid Limit		38			
Plastic Limit		13			
Plasticity Index		25			

Project: CUT SECTIONS I-35 OVER WATERLOO RD INTERCHANGE

Location: OKLAHOMA & LOGAN COUNTIES, OK

Project No.: 03185253 Depth: 2.0'-4.0'

Boring No.: CS-1 S-2

Sample Type: 3" ST

Failure Sketch

Description: SANDY LEAN CLAY, WEAK RED (10R 4/2) AND DARK RED (10R 3/6)

Remarks: FAILURE CRITERIA = MAXIMUM DEVIATOR STRESS TEST PERFORMED AS PER ASTM D2850.

Exhibit C-12

Wed, 16-JAN-2019 17:09:30

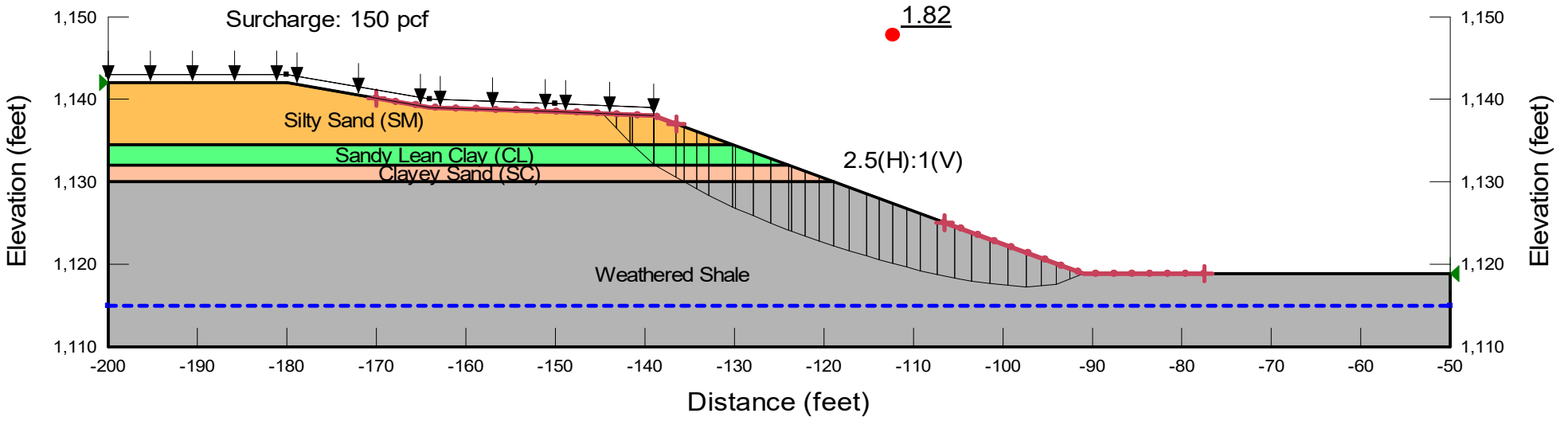
APPENDIX D

SLOPE STABILITY ANALYSIS

SLOPE STABILITY ANALYSIS AT STATION 116+00.00 (I-35 SOUTHBOUND)

Project: Cut Sections I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185253
File Name: I-35SB Station 116+00.00 - REV.gsz
Created By: Khatri, Deep K
Date: 3/12/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Clayey Sand (SC)	120	0	28
	Sandy Lean Clay (CL)	120	0	28
	Silty Sand (SM)	120	0	28
	Weathered Shale	130	150	24



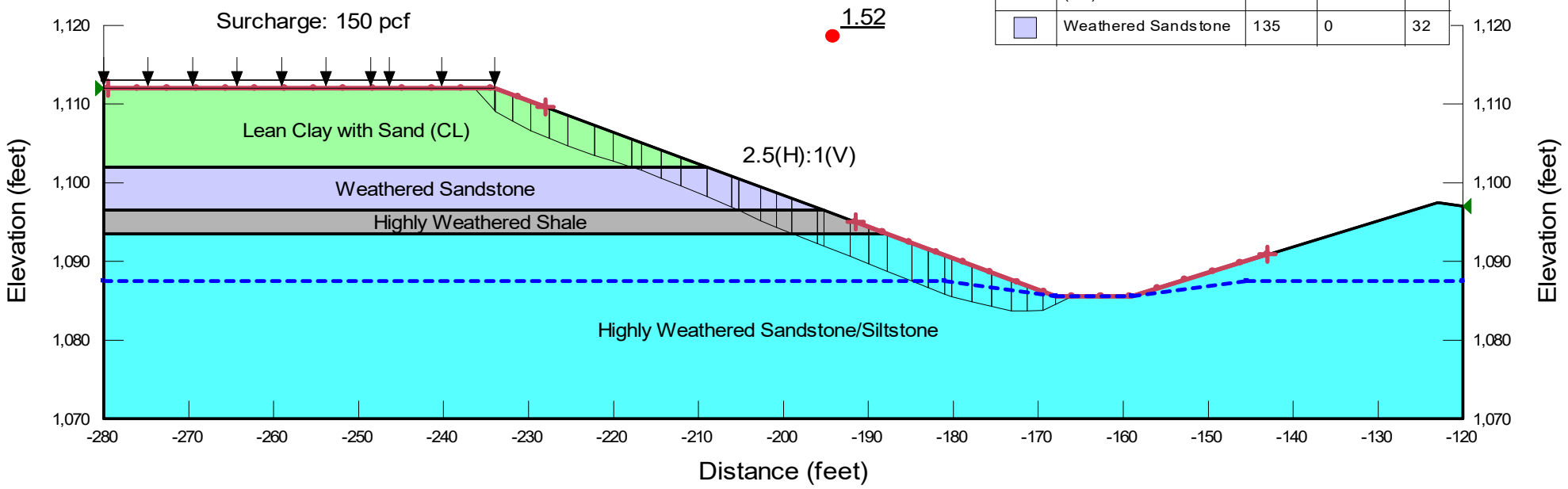
Note: Soil Profile was delineated from CS-1 boring.

Drawn by: DKK	Exhibit D-1
Reviewed by: NKT	Global Slope Stabiltiy Analysis
Scale: As Shown	Cut Sections I-35 over Waterloo Road Interchange Oklahoma and Logan Counties, Oklahoma
Terracon Project No. 03185253	Terracon

SLOPE STABILITY ANALYSIS AT STATION 137+00.00 (I-35 SOUTHBOUND)

Project: Cut Sections I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185253
File Name: I-35SB Station 137+30.00 - REV.gsz
Created By: Khatri, Deep K
Date: 3/13/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Highly Weathered Sandstone/Siltstone	135	0	32
	Highly Weathered Shale	130	150	24
	Lean Clay with Sand (CL)	120	0	28
	Weathered Sandstone	135	0	32



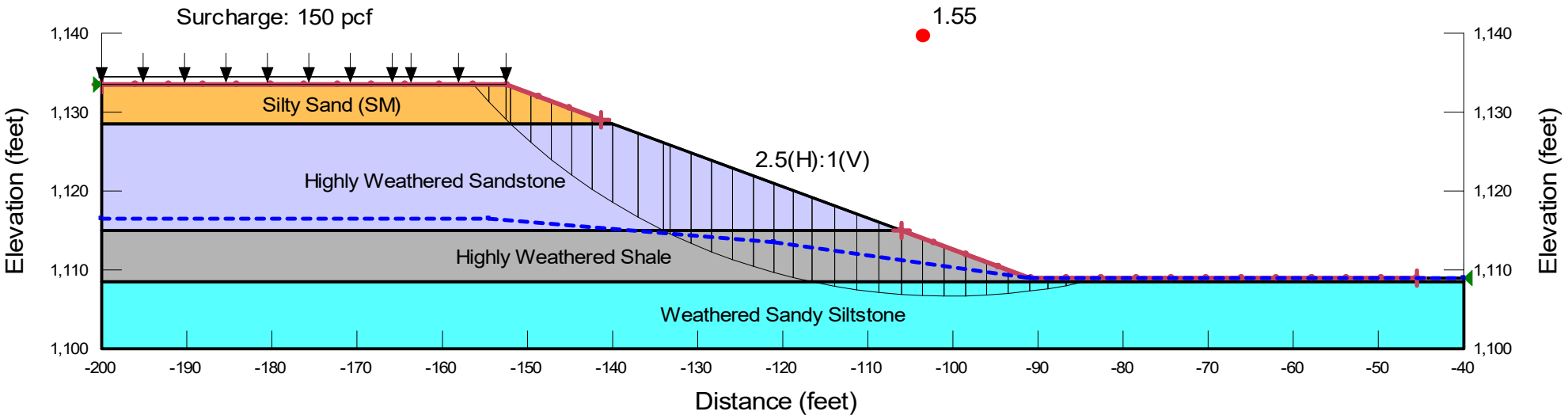
Note: Soil Profile was delineated from CS-3 boring.

Drawn by: DKK	Exhibit D-2
Reviewed by: NKT	Global Slope Stabiltiy Analysis
Scale: As Shown	Cut Sections I-35 over Waterloo Road Interchange Oklahoma and Logan Counties, Oklahoma
Terracon Project No. 03185253	Terracon

SLOPE STABILITY ANALYSIS AT STATION 153+00.00 (I-35 SOUTHBOUND)

Project: Cut Sections I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185253
File Name: I-35SB Station 153+00.00 - REV.gsz
Created By: Khatri, Deep K
Date: 3/13/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Highly Weathered Sandstone	135	0	32
	Highly Weathered Shale	130	150	24
	Silty Sand (SM)	120	0	28
	Weathered Sandy Siltstone	135	0	32



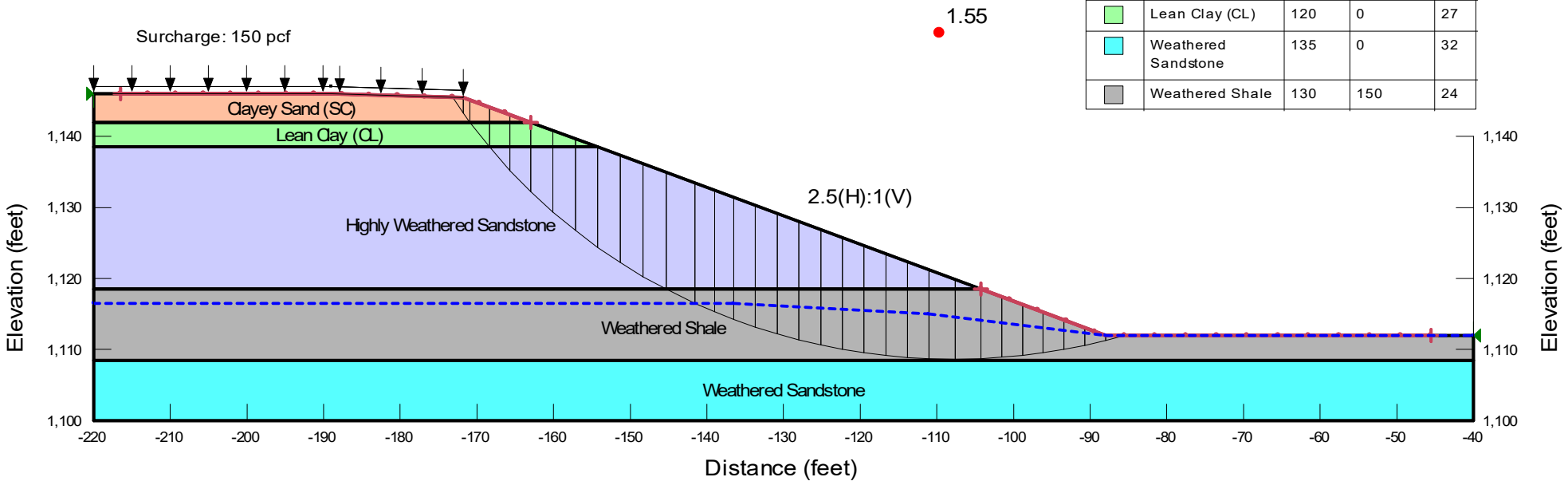
Note: Soil Profile was delineated from CS-5 boring.

Drawn by: DKK	Exhibit D-3
Reviewed by: NKT	Global Slope Stabiltiy Analysis
Scale: As Shown	Cut Sections I-35 over Waterloo Road Interchange Oklahoma and Logan Counties, Oklahoma
Terracon Project No. 03185253	Terracon

SLOPE STABILITY ANALYSIS AT STATION 159+00.00 (I-35 SOUTHBOUND)

Project: Cut Sections I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185253
File Name: I-35SB Station 159+00.00 - REV.gsz
Created By: Khatri, Deep K
Date: 3/13/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Clayey Sand (SC)	120	0	28
	Highly Weathered Sandstone	135	0	32
	Lean Clay (CL)	120	0	27
	Weathered Sandstone	135	0	32
	Weathered Shale	130	150	24



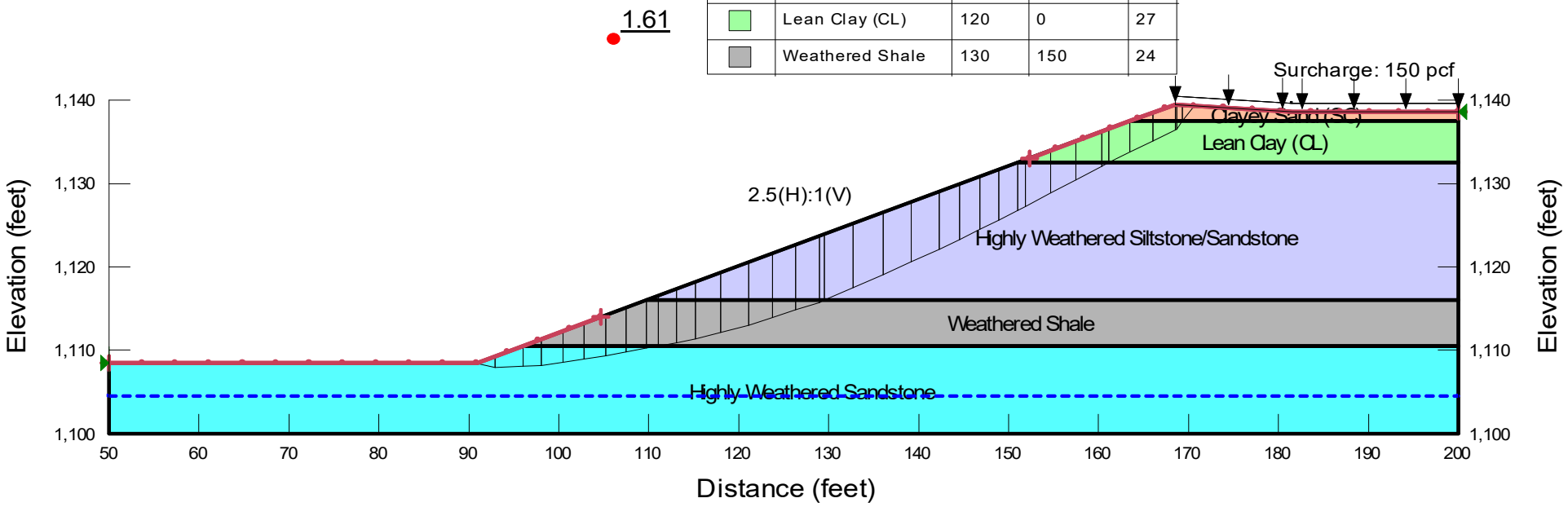
Note: Soil Profile was delineated from CS-7 boring.

Drawn by: DKK	Exhibit D-4
Reviewed by: NKT	Global Slope Stabiltiy Analysis
Scale: As Shown	Cut Sections I-35 over Waterloo Road Interchange Oklahoma and Logan Counties, Oklahoma
Terracon Project No. 03185253	Terracon

SLOPE STABILITY ANALYSIS AT STATION 152+00.00 (I-35 NORTHBOUND)

Project: Cut Sections I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185253
File Name: I-35NB Station 152+00.00 - REV.gsz
Created By: Khatri, Deep K
Date: 3/13/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Clayey Sand (SC)	120	0	28
	Highly Weathered Sandstone	135	0	32
	Highly Weathered Siltstone/Sandstone	135	0	32
	Lean Clay (CL)	120	0	27
	Weathered Shale	130	150	24



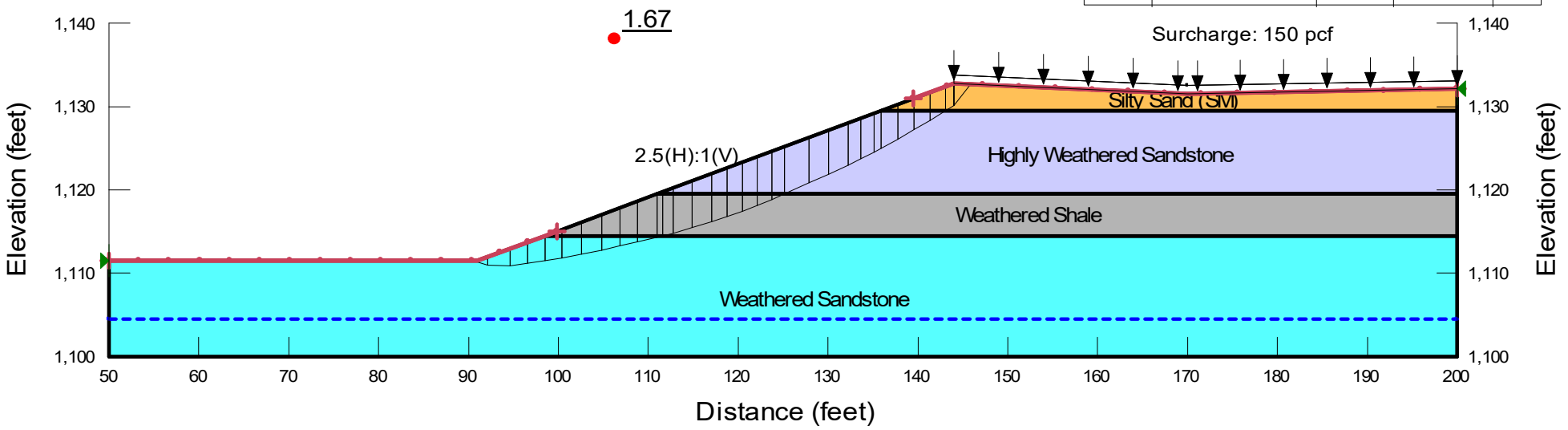
Note: Soil Profile was delineated from CS-11 boring.

Drawn by: DKK	Exhibit D-5
Reviewed by: NKT	Global Slope Stabiltiy Analysis
Scale: As Shown	Cut Sections I-35 over Waterloo Road Interchange Oklahoma and Logan Counties, Oklahoma
Terracon Project No. 03185253	Terracon

SLOPE STABILITY ANALYSIS AT STATION 158+00.00 (I-35 NORTHBOUND)

Project: Cut Sections I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185253
File Name: I-35NB Station 158+00.00 - REV.gsz
Created By: Khatri, Deep K
Date: 3/13/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Highly Weathered Sandstone	135	0	32
	Silty Sand (SM)	120	0	28
	Weathered Sandstone	135	0	32
	Weathered Shale	130	150	24



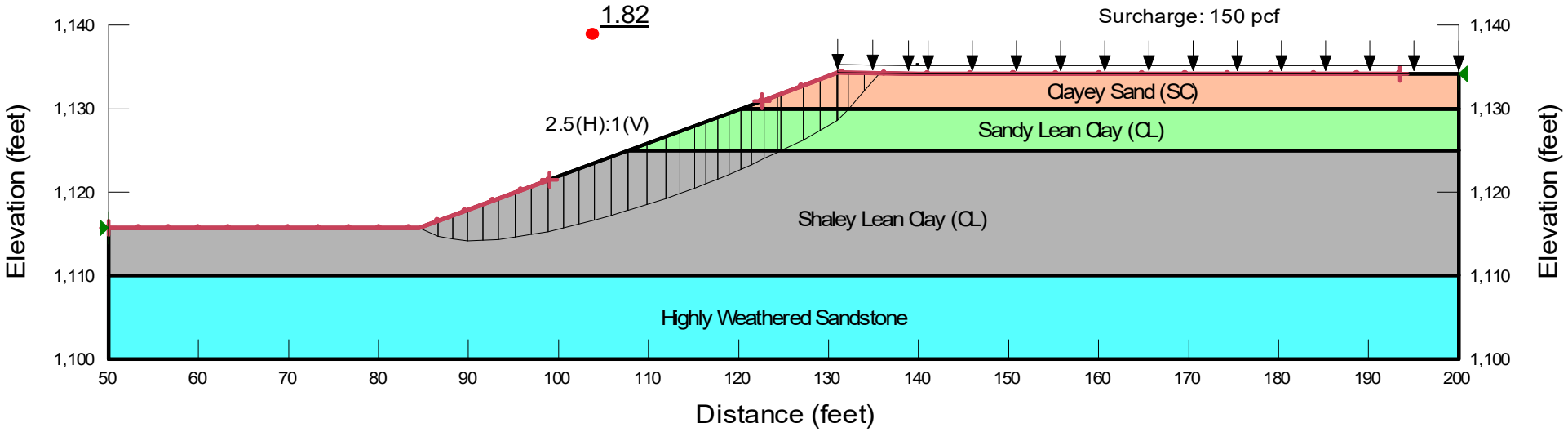
Note: Soil Profile was delineated from CS-13 boring.

Drawn by: DKK	Exhibit D-6
Reviewed by: NKT	Global Slope Stabiltiy Analysis
Scale: As Shown	Cut Sections I-35 over Waterloo Road Interchange Oklahoma and Logan Counties, Oklahoma
Terracon Project No. 03185253	Terracon

SLOPE STABILITY ANALYSIS AT STATION 166+00.00 (I-35 NORTHBOUND)

Project: Cut Sections I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185253
File Name: I-35NB Station 166+00.00 - REV.gsz
Created By: Khatri, Deep K
Date: 3/13/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Clayey Sand (SC)	120	0	28
	Highly Weathered Sandstone	135	0	32
	Sandy Lean Clay (CL)	120	0	28
	Shaley Lean Clay (CL)	130	150	24



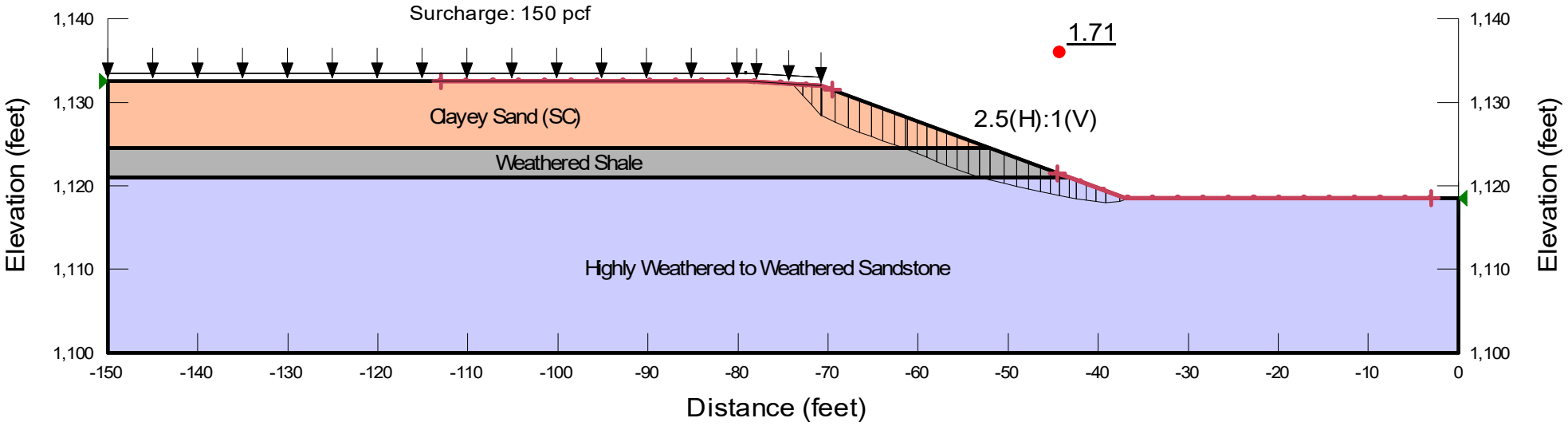
Note: Soil Profile was delineated from CS-14 boring.

Drawn by: DKK	Exhibit D-7
Reviewed by: NKT	Global Slope Stabiltiy Analysis
Scale: As Shown	Cut Sections I-35 over Waterloo Road Interchange Oklahoma and Logan Counties, Oklahoma
Terracon Project No. 03185253	Terracon

SLOPE STABILITY ANALYSIS AT STATION 97+00.00 (NE 248TH STREET)

Project: Cut Sections I-35 Over Waterloo Road Interchange
Location: Oklahoma & Logan Counties, Oklahoma
Terracon Project No. : 03185253
File Name: NE 248th Street Station 97+00.00 - REV.gsz
Created By: Khatri, Deep K
Date: 3/13/2019

Color	Name	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Clayey Sand (SC)	120	0	28
	Highly Weathered to Weathered Sandstone	135	0	32
	Weathered Shale	130	150	24



Note: Soil Profile was delineated from CS-15 boring.

Drawn by: DKK	Exhibit D-8
Reviewed by: NKT	Global Slope Stabiltiy Analysis
Scale: As Shown	Cut Sections I-35 over Waterloo Road Interchange Oklahoma and Logan Counties, Oklahoma
Terracon Project No. 03185253	Terracon

APPENDIX E

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

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

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

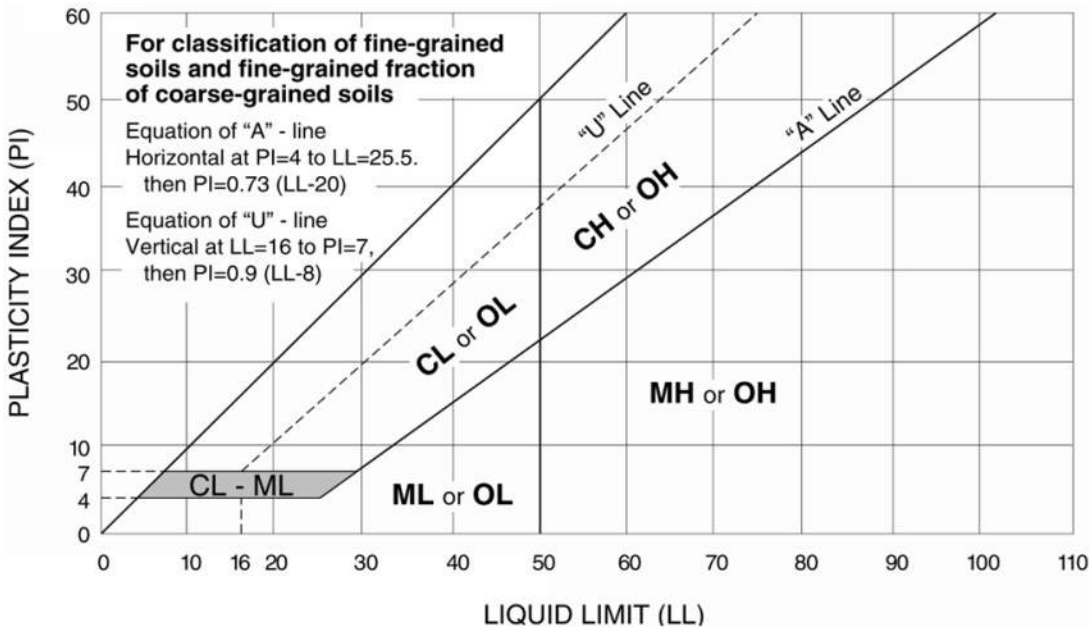
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



Terracon

GENERAL NOTES

Sedimentary Rock Classification

DESCRIPTIVE ROCK CLASSIFICATION:

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

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

PHYSICAL PROPERTIES:

DEGREE OF WEATHERING

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

HARDNESS AND DEGREE OF CEMENTATION

Limestone and Dolomite:

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

Shale, Siltstone and Claystone

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

Sandstone and Conglomerate

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

BEDDING AND JOINT CHARACTERISTICS

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

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

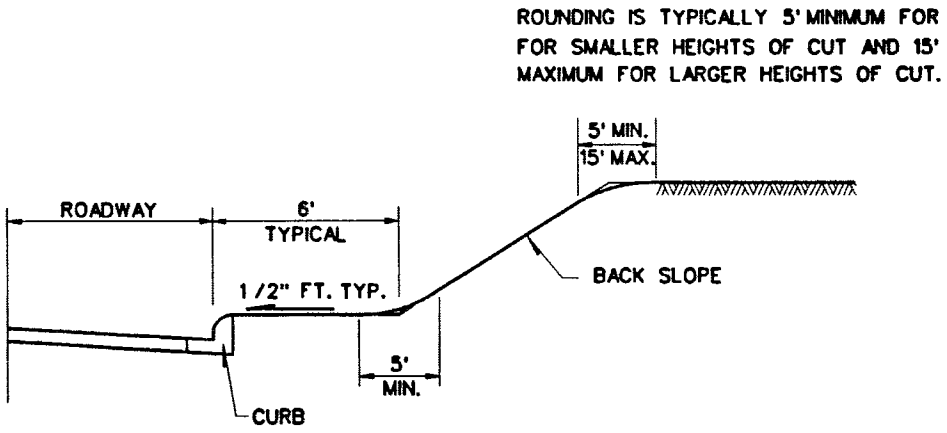
SOLUTION AND VOID CONDITIONS

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

Terracon

Table 8.3D

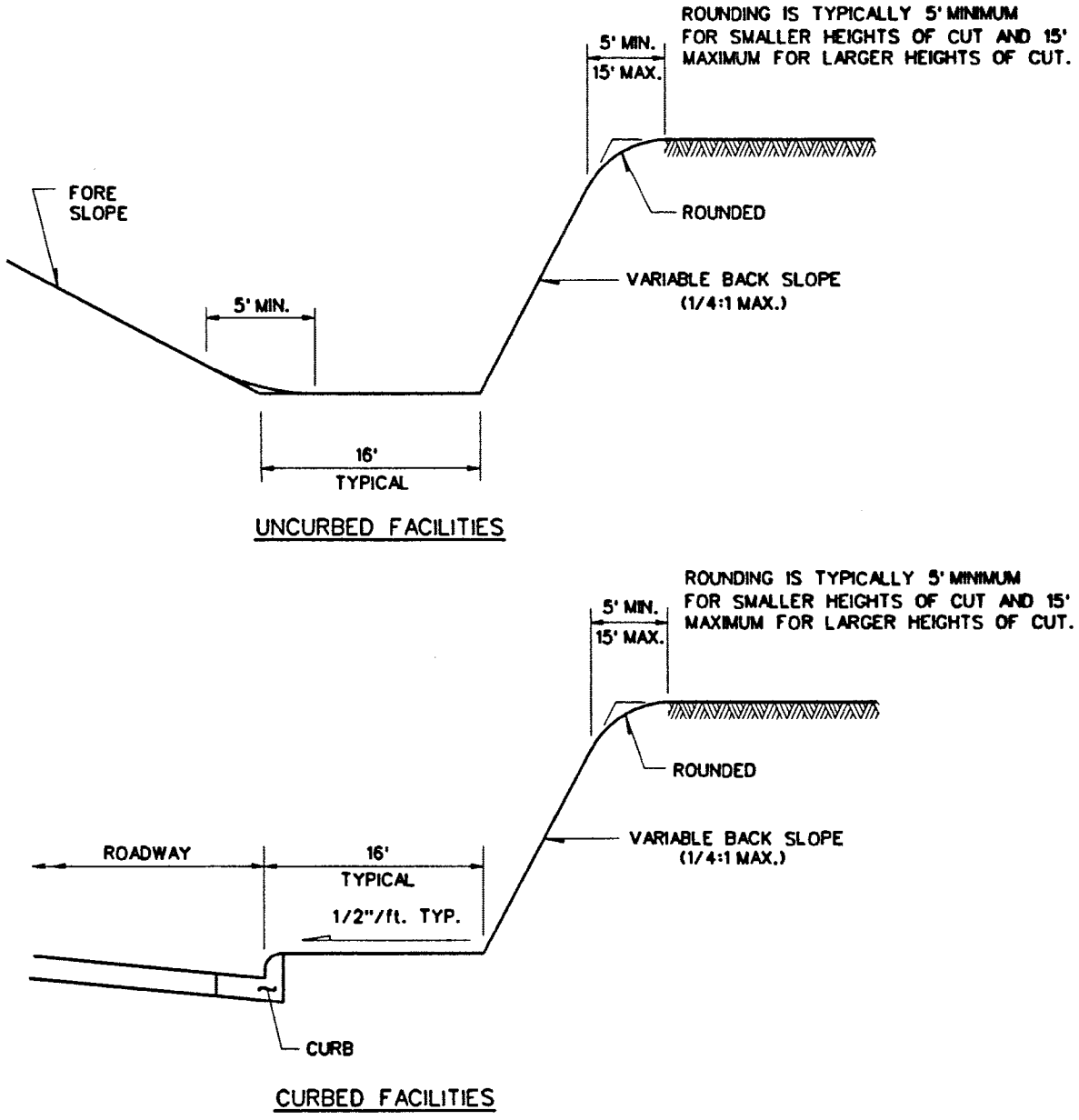
TYPICAL EARTH CUT SLOPES
(Curbed Facilities)



Facility	Back Slope
Freeways	6:1
Arterials	3:1
Collectors/Locals	2:1

Notes: 1. See Figure 8.3B for dimensions in rock cuts.

2. Check Geotechnical Report to determine stability for all slopes 3:1 and steeper.



Notes: 1. Back slope in rock cut may or may not require benching.

2. Check Geotechnical Report for difficult and/or unusual conditions.

TYPICAL ROCK CUT SLOPES

Figure 8.3B