

RED ROCK

C O N S U L T I N G

Report of Geotechnical Investigation

**CUT ANALYSIS – WEST PHASE 1
SH 29
STEPHENS COUNTY, OKLAHOMA
29657(10)**

Prepared For:

**SRB
100 Northeast 5th Street
Oklahoma City, Oklahoma 73104
Attention: Mr. Greg Allen, PE**

Prepared By:

**Red Rock Consulting, LLC
PO Box 30591
Edmond, Oklahoma 73003
(405) 562-3328**

**September 6, 2018
Project No. 18043**

RED ROCK CONSULTING

September 6, 2018

SRB
100 Northeast 5th Street
Oklahoma City, Oklahoma 73104

Attention: Mr. Greg Allen, PE

Re: Report of Geotechnical Investigation
SH 29 Cut Analysis – West Phase 1
Stephens County, Oklahoma
29657(10)
Project No. 18043

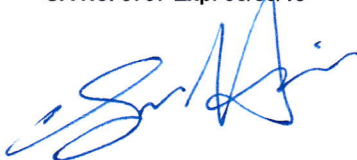
Dear Mr. Allen:

I am pleased to submit herewith this report entitled "Geotechnical Investigation, SH 29 Cut Analysis – West Phase 1, Stephens County, Oklahoma, 29657(10)".

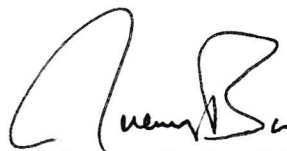
In an effort to provide a more environmentally friendly service, this report has been provided electronically. If you wish to receive a hard copy of this report, please contact our office.

It has been our pleasure to assist you with this project. Should you have any questions regarding the contents of this report, please contact Red Rock Consulting.

Yours very truly,
RED ROCK CONSULTING, LLC
CA No. 5707 Exp. 06/30/19



Spencer Harris
Project Specialist



Jeremy Basler, PE
Geotechnical Manager
Oklahoma PE No. 20233



REPORT OF GEOTECHNICAL INVESTIGATION

SH 29 CUT ANALYSIS – WEST PHASE 1 STEPHENS COUNTY, OKLAHOMA

29657(10)

PROJECT NO. 18043

INTRODUCTION.....	1
GENERAL.....	1
PROPOSED CONSTRUCTION	1
SCOPE OF WORK	2
FIELD AND LABORATORY INVESTIGATIONS	3
FIELD EXPLORATION	3
LABORATORY TESTING.....	4
SITE DESCRIPTION.....	6
SURFACE CONDITIONS	6
SITE GEOLOGY	7
SUBSURFACE CONDITIONS	9
GROUNDWATER CONDITIONS	10
RIPPABILITY OF BEDROCK.....	11
CLOSURE.....	13

APPENDICES

APPENDIX A – Field Investigation
APPENDIX B – Laboratory Results
APPENDIX C – General Notes

REPORT OF GEOTECHNICAL INVESTIGATION

SH 29 CUT ANALYSIS – WEST PHASE 1 STEPHENS COUNTY, OKLAHOMA

29657(10)

PROJECT NO. 18043

INTRODUCTION

General

This report presents the results of the geotechnical investigation performed for the cut analysis associated with the offset alignment of SH 29 through Stephens County, Oklahoma. The purpose of this investigation is to evaluate the subsurface conditions at the site and to provide information pertaining to the geotechnical aspects of the proposed project.

Proposed Construction

The approximate 5.44-mile-long project consists of the construction of a new roadway on an offset alignment from 11.48 miles east of US 81 extending east 5.44 miles in Stephens County, Oklahoma. This report focuses on the cut sections required for the construction of the project.

For phase 1, four out of the seven significant cut sections that will be required to construct the proposed project are discussed in this report. The remaining three cut sections will be performed at a later date once ODOT acquires the properties. The first cut section, which includes CW-1 and CW-2, will be approximately 900 feet long between stations 652+00 to 661+00. The maximum proposed cut depth is 17 feet at station 654+00. The second cut section, which includes CW-3 and CW-4, will be approximately 860 feet long between stations 674+00 to 682+59. The maximum proposed cut depth is 15 feet at station 682+59. The third cut section, which includes CW-5, CW-6 and CW-7, will be approximately 900 feet long between stations 767+00 to 776+17. The maximum proposed cut depth is 32 feet at station 772+00. The fourth cut section, which includes CW-8 and CW-9, will be approximately 1200 feet long between stations 842+00 to 854+00. The maximum proposed cut depth is 17 feet at station 847+00. The first, third and fourth cut sections are to accommodate the proposed offset alignment. The second cut section is for an expanded drainage area to the south of the existing roadway.

Scope of Work

The scope of this investigation includes the following:

1. Review of previous geotechnical and geological information of sites near this site. This was augmented with data obtained during the field investigation phase of the project.
2. Investigation of the subsurface soils by drilling and testing a total of 9 boreholes within the planned project area
3. A laboratory testing program consisting of moisture content, Atterberg limits, and sieve analysis on representative samples of the overburden soils
4. Rippability analysis of the bedrock encountered within the proposed cut depths

FIELD AND LABORATORY INVESTIGATIONS

Field Exploration

Subsurface exploration was performed on May 16 and July 11 - July 13, 2018. The borings were located in the field by a representative of Red Rock Consulting by measuring distances from known site reference points as depicted on plans provided by SRB. The locations of the borings should be considered accurate only to the degree implied by the methods used to define them.

The subsurface exploration program consisted of drilling 9 borings under the full-time supervision of a geologist. The borings are shown on the Boring Location Diagrams, which are included in Appendix A.

The borings were advanced with solid stem augers in all borings except CW-6, which was advanced using wet rotary drilling methods. All borings were advanced to depths approximately equal to 10 feet below the maximum anticipated cut depth using an all-terrain vehicle (ATV) mounted CME-750 drill rig equipped with an automatic hammer. The approximate cut and boring depths are summarized in Table 1.

Table 1 – Cut & Boring Depths

Boring	Station	CRL Offset (feet)	Proposed Cut Depth (feet)	Boring Depth (feet)
CW-1	654+00	50 left	17	30
CW-2	656+00	50 left	16	25
CW-3	676+00	50 left	14	25
CW-4	682+59	95 left	15	25
CW-5	770+00	50 left	20	30
CW-6	772+00	50 left	32	45
CW-7	774+00	50 left	20	30
CW-8	847+00	55 right	17	30
CW-9	849+00	50 right	13	25

Samples of the overburden materials were obtained in the borings as per Oklahoma Department of Transportation (ODOT) specifications. Representative samples of the overburden materials were obtained from the split-barrel sampler used for the standard penetration test (SPT) in general accordance with ASTM Specifications D-1586. After SPT refusal was attained, the hardness of bedrock was evaluated using a Texas Cone Penetrometer (TCP). The TCP was used in accordance with the AASHTO Manual on Subsurface Investigation and as modified by the Oklahoma Department of

Transportation. The sampling procedures are presented on the Boring Logs in Appendix A.

The SPT test uses a standard, 2-inch outside diameter, split-barrel sampling spoon that is driven into the bottom of the boring with a 140-pound automatic drive hammer that falls 30 inches. The blows per foot, N, is the number of hammer blows required to advance the sampling spoon the last 12 inches, or less, of an 18-inch sampling interval. The N value is used to estimate the in-situ relative density of granular soils, the consistency of cohesive soils, and the hardness of weathered bedrock.

The TCP test is a standard test developed by the Texas Highway Department to evaluate the consistency or hardness of the bedrock material. The TCP test drives a penetrometer cone into the bedrock material with a 140-pound automatic drive hammer that falls 30 inches. The TCP is driven for a series of blows, the first 10 being seating blows, followed by two 50 blow counts. After 50 blows of the automatic hammer, the distance the TCP has advanced is measured and recorded. The distance the TCP is driven is used to estimate the hardness of bedrock.

After performing SPT and TCP tests, the holes were backfilled with grout and cuttings as required by the Oklahoma State Statutes for Geotechnical drilling.

Samples were collected and transported back to the lab for further classification and testing. The final boring logs were developed from the draft logs, observations and test results of the samples returned to the laboratory. The stratigraphic contacts indicated are only for the specific dates and locations reported, and therefore, are not necessarily representative of other locations and times. The boring logs, presenting conditions encountered at each location explored, are included in Appendix A.

Laboratory Testing

Representative soil samples were tested to refine the field classifications and evaluate physical properties of the soils which may affect the geotechnical aspects of project design and construction.

The laboratory testing program included the following:

- Moisture content (AASHTO T265 / ASTM D2216)
- Liquid limit and plastic limit (AASHTO T89 & T90 / ASTM D4318)
- Particle size analysis of soils (AASHTO T88 / ASTM D1140)

The results of the physical laboratory tests conducted are shown on the Boring Logs in Appendix A and are also included in Appendix B.

The above laboratory tests were performed in general accordance with applicable AASHTO or ASTM procedures, or generally accepted practice. It should be noted that reference to AASHTO or ASTM procedures does not imply that all cross-referenced procedures in AASHTO or ASTM standards have been used, or that all AASHTO or ASTM procedures used have been followed exactly. Only those AASHTO or ASTM procedures and/or portions of procedures, which, in the professional judgment of the geotechnical engineer of record for this report, are applicable, appropriate, and necessary for this project, have been used or followed.

SITE DESCRIPTION

Surface Conditions

At the time of the field investigation, SH 29 was a two-lane undivided asphalt surfaced highway in the project area. There were grass shoulders to each side of the roadway through the cut sections. All the cut sections included in this report had shallow ditches.

The first cut section, CW-1 and CW-2, was located on the north side of SH 29 in a grass and dirt covered pasture. The pasture was elevated approximately 10 feet above the existing roadway. The west side of the second cut section, CW-3, was located on the north side of SH 29 in a grass yard. The yard was approximately 5 feet above the existing roadway. The east side of the second cut section, CW-4, was located on the north side of SH 29 in a relatively dense wooded area. There was a dry creek running north and south approximately 40 feet to the east, then curving to the west of the boring approximately 40 feet to the north. The third cut section, CW-5, CW-6 and CW-7, was located on the north side of SH 29 on top of a hill. The hill had exposed rock outcrops near the existing roadway and was approximately 20 feet above the existing roadway. The area was a moderately dense wooded area with small patches of clearings. There was a 70-foot-wide clearing north of the boring locations running east and west for a pipeline. The fourth cut section, CW-8 and CW-9, was located south of SH 29 on the side of a hill covered in grass and dirt. The boring locations were approximately 10 feet above the existing roadway.

There were only two boring locations within ODOT right of way; CW-8 and CW-9. Landowner permission was required for access to the rest of the borings. Dozer work was needed to access CW-4.

The surfaces were relatively flat where the borings were drilled. The boring locations were dry at the time of the field investigation. The ATV drill rig did not have any trouble moving around the sites.

The surface elevations were estimated from plans provided by SRB. Based on the plans, the elevations of the borings ranged between 1141 and 1228 feet. The approximate elevation at each boring location is shown on the Boring Location Diagrams and on the Boring Logs in Appendix A.

Site Geology

The geology of the cut sections was researched using the “Division Seven Engineering Classification of Geological Materials”, published by the Oklahoma Department of Transportation (ODOT) and the Geologic Map of the “Hydrologic Atlas 3, Reconnaissance of the Water Resources of the Ardmore and Sherman quadrangles, southern Oklahoma,” by Donald L. Hart, Jr., published by the Oklahoma Geological Survey in cooperation with the U.S. Geological Survey, 1974 and 1983.

ODOT PUBLICATION

The ODOT publication indicates all of the cut sections are underlain by the **El Reno unit** (Per). The geologic deposit and unit are described therein as follows:

The El Reno unit consists of **a heterogeneous mixture of sandstones, shale, siltstone, and siltstone conglomerate**. In northeastern Stephens County, the lowermost 40 to 100 feet of the unit consists dominantly of sandstones which are coarse-grained, nearly white to buff, and moderately soft; but a few hard, massive sandstone beds up to six feet thick occur near the base of the unit. **Northward, across Grady County, the sandstones of this lower section become red, progressively finer grained, and moderately hard to hard.**

The upper portion of the unit is known as “The Purple Series” in Stephens and Grady Counties. Here, some 80 feet of soft purple sandstone, 50 feet of soft pink sandstones, and 50 feet of moderately soft purple mudstone conglomerate are present in descending order. Westward, in Comanche and southern Caddo counties, the sandstones grade into red shales with minor amounts of gypsum and siltstones. Locally, in southeastern Grady County, near Cox City, a few sandstone beds in the upper portion are hard, limy, and occur in beds up to seven feet thick.

The unit thickens northward from 420 feet in Stephens County to 460 feet in Western Caddo County to 660 feet in northern Grady County.

The El Reno unit outcrops in a four to eight-mile-wide northwest-southeast band across southern Caddo, northeastern Comanche, and northwestern Stephens Counties. The outcrop then circles the southeastern end of the Anadarko basin in northern Stephens County and covers a broad area up to eighteen miles wide across northeastern Stephens and Grady Counties of Division 7. In Grady and eastern Caddo Counties, north of T4N, the upper 0 to 230 feet is mapped separately as the Dog Creek-Blaine subunits undifferentiated. Northward, in Division 4, and westward from Caddo County, in Division 5, the rock strata of the El Reno unit are separable and are mapped as the Flowerpot, Blaine, and Dog Creek units.

Topographically, the unit generally forms rolling hills with a pronounced escarpment at the base in Stephens and southern Grady Counties where the sandstones are thickest. Northwestward, the topography is rolling with gently rolling topography dominant in western Caddo County where the shales are thickest. The sandstone ridges are usually marked by oak vegetation and erosional gullies in the sandy soils. The shales generally form the valleys and gently rolling hills and support the growth of short grass. Some mesquite and prickly pear are evident in the salty or gypsiferous areas.

OKLAHOMA GEOLOGICAL SURVEY

According to the hydrologic atlas, all the cut sections are underlain by the **Duncan Sandstone (Pd) of the Permian-aged El Reno Group**. The geologic deposit and formation are described therein as follows:

Duncan Sandstone: **Sandstone**, white to buff, fine to coarse grained, **moderately indurated, with interbedded mudstone conglomerates and siltstone**; thickness, 100 to 400 feet, decreasing southeastward. Yields small to moderate amounts of water of fair quality.

Subsurface Conditions

Information collected during this investigation indicates that the overburden consisted of clays with varying amounts of sand and sands with varying amounts of silt and clay that extended from the surface to the top of bedrock in all borings. The overburden materials, including the sandstone rock, appeared to be native to the site.

The bedrock was the same in all the boring discussed in this report with slight variations in color. The color was observed as a light gray with reddish brown variations as shown on the Boring Logs in Appendix A. The approximate depths and types of bedrock are summarized in Table 2.

Table 2 – Depth & Type of Bedrock

Boring	Depth to Bedrock (feet)	Elevation (feet)	Type
CW-1	0.5	1227.5	sandstone
CW-2	6	1220	sandstone
CW-3	10.5	1203.5	sandstone
CW-4	20	1171.5	sandstone
CW-5	6	1135	sandstone
CW-6	4.5	1150	sandstone
CW-7	5	1137.5	sandstone
CW-8	4	1171	sandstone
CW-9	4	1163	sandstone

The rippability of bedrock is discussed in the *Rippability of Bedrock* section of this report. Subsurface conditions are described in greater detail on the Boring Logs in Appendix A.

Groundwater Conditions

Groundwater conditions were monitored in the borings during and immediately following the completion of drilling activities. The approximate groundwater levels are summarized in Table 3. All the borings remained open (did not cave in) following drilling.

Table 3 – Groundwater Levels

Boring	During Drilling		After Drilling	
	Depth (feet)	Elevation (feet)	Depth (feet)	Elevation (feet)
CW-1	none	none	none	none
CW-2	none	none	none	none
CW-3	none	none	none	none
CW-4	23	1168.5	21	1170.5
CW-5	15	1126	16.5	1124.5
CW-6	none	none	None	None
CW-7	none	none	None	None
CW-8	10	1165	12	1163
CW-9	none	none	none	none

To obtain more accurate groundwater level information, long-term observations in a well or piezometer that is sealed from the influence of surface water would be needed. Fluctuations in groundwater levels can occur due to seasonal variations in the amount of rainfall, runoff, altered drainage paths, and other factors not evident at the time borings were advanced. Consequently, the contractor should be aware of these possibilities while constructing this project.

RIPPABILITY OF BEDROCK

Very poorly cemented to very well cemented sandstone bedrock was encountered in the borings and are summarized in Table 4. **Difficulties in excavating due to the hardness of the bedrock generally are not anticipated for this project; however, there will likely be some areas that are non-rippable.**

Table 4 – Hardness of Bedrock Materials

Boring	Depth to Bedrock (feet)	Elevation (feet)	Type	TCP Value (in/100 blows)	Hardness
CW-1	0.5	1227.5	sandstone	6.8-7.1	very poorly cemented
	16	1212	sandstone	1.3	well cemented
	21	1207	sandstone	0.9	very well cemented
	26	1202	sandstone	1-1.1	well cemented
CW-2	6	1220	sandstone	8	very poorly cemented
	10	1216	sandstone	1-1.3	well cemented
CW-3	10.5	1203.5	sandstone	2.4	cemented
	15	1199	sandstone	2	well cemented
	20	1194	sandstone	0.8-0.9	very well cemented
CW-4	20	1171.5	sandstone	1.4	well cemented
	25.5	1166	sandstone	0.4	very well cemented
CW-5	6	1135	sandstone	5.1	poorly cemented
	10	1131	sandstone	2.8	cemented
	15	1126	sandstone	1.2	well cemented
	20	1121	sandstone	3.5	poorly cemented
	25	1116	sandstone	1.2-1.5	well cemented
CW-6	4.5	1150	sandstone	5	poorly cemented
	10	1144.5	sandstone	2.8	cemented
	15	1139.5	sandstone	0.5-0.8	very well cemented
	35	1129.5	sandstone	1.2-1.4	well cemented
CW-7	5	1137.5	sandstone	2.1	cemented
	10	1132.5	sandstone	1.3-1.8	well cemented
	20	1122.5	sandstone	2.5	cemented
	25	1117.5	sandstone	1.4	well cemented
	30	1112.5	sandstone	0.8	very well cemented
CW-8	4	1171	sandstone	2.1-2.3	cemented
	14.5	1160.5	sandstone	1.1-1.5	well cemented
CW-9	4	1163	sandstone	1.3-1.5	well cemented
	14.5	1152.5	sandstone	0.8	very well cemented
	19.5	1147.5	sandstone	2.3	cemented
	24.5	1142.5	sandstone	1.4	well cemented

Generally, sedimentary rock which have a penetration of 2 inches or more per 100 blows of the Texas Cone Penetrometer (TCP) test can typically be excavated with normal excavating equipment. Most of the sandstone bedrock encountered in the proposed cut sections at this site that was tested for hardness falls into (or is very close to) the “rippable” category. The TCP tests that resulted in a penetration of less than 1 inch is assumed to be the massive basal sandstone mentioned below that is considered non-rippable. The non-rippable sandstone was mostly encountered below the proposed cut section depths, except for CW-6. A non-rippable section was observed between 15-35 feet as shown in table 4. Additional non-rippable areas will likely be encountered in the cut sections because hardness of bedrock can be variable between borings or in relatively short distances.

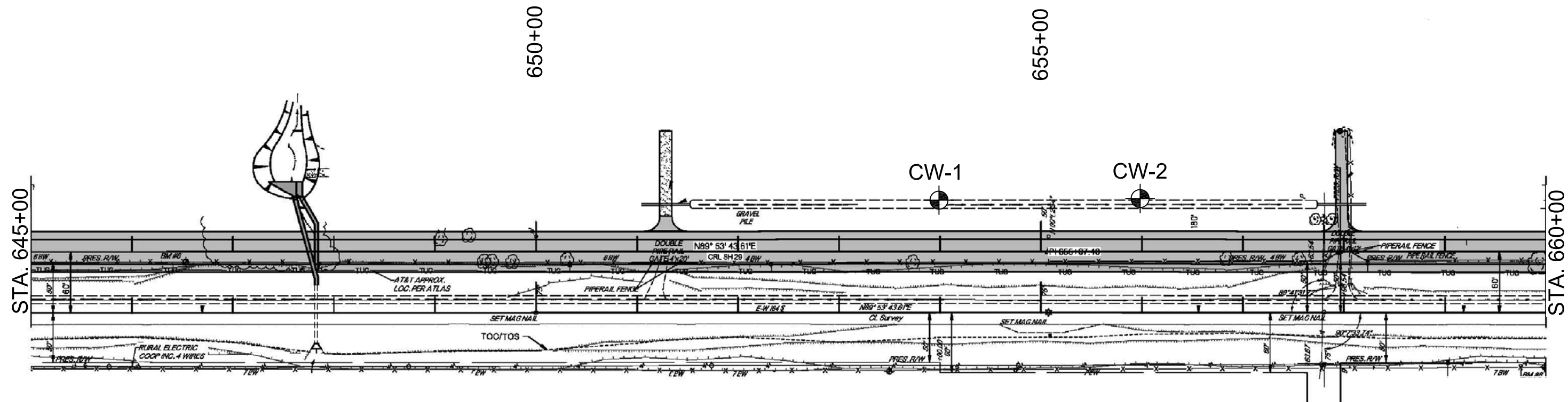
It should also be noted the “Engineering Classification of Geologic Materials” manual published by the Oklahoma Department of Transportation (ODOT) indicates that the apparent rippability of the bedrock materials (as defined for the El Reno geologic unit in Stephens County) is “**generally rippable; six feet thick massive basal sandstone is non-rippable**”. The ODOT publication also defines rippability as the susceptibility of a rock to be broken by a ripping device as pulled by a Caterpillar D9 or its equivalent.

CLOSURE

The data presented in this report are based on the negotiated scope for this project and site conditions as they existed at the time of the field exploration. The conditions encountered in the exploratory borings are representative subsurface conditions within the study area.

This report was prepared for the exclusive use of SRB, ODOT and their agents and consultants. It should be made available to prospective contractors for information and factual data only and not as a warranty of subsurface conditions similar to those interpreted from the boring logs or discussions presented herein.

APPENDIX A



BORING LOCATIONS AND ELEVATIONS			
Boring	Station	CRL Offset	Elevation
CW-1	654+00	50' LT	1228'
CW-2	656+00	50' LT	1226'

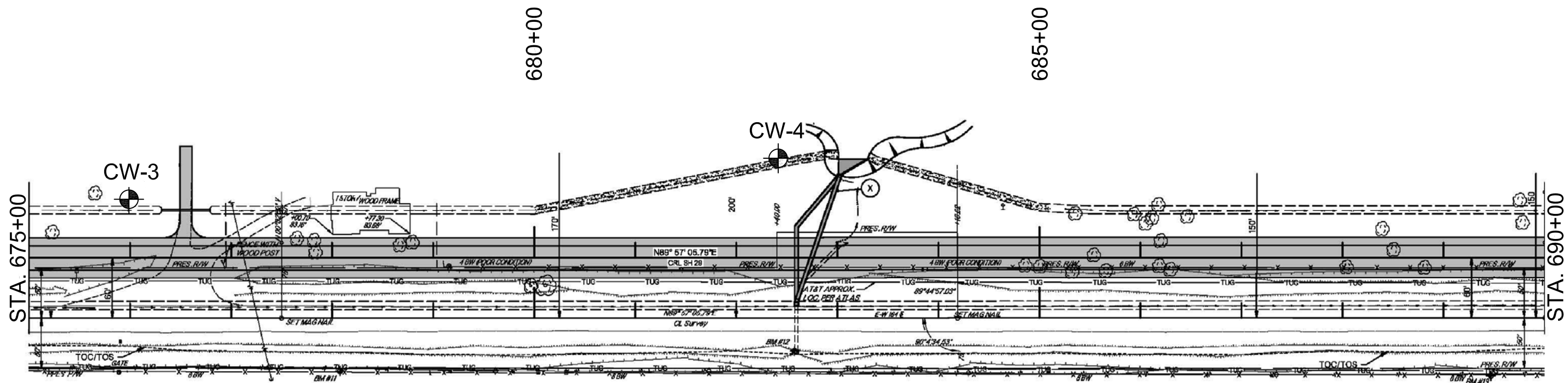
Boring stations, offsets and elevations estimated from plans provided by SRB

RED ROCK
CONSULTING

PO Box 30591
Edmond, Oklahoma 73003
(405) 562-3328

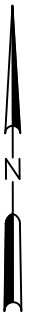
BORING LOCATION DIAGRAM
CUT ANALYSIS - WEST PHASE 1
STATE HIGHWAY 29
STEPHENS COUNTY, OKLAHOMA
29657(10)

Project Mngr: SAH	Project No. 18043
Designed By: SAH	Scale: NOT TO SCALE
Checked By: JWB	Date: 8/15/2018
Approved By: JWB	Page No: 1/4



BORING LOCATIONS AND ELEVATIONS			
Boring	Station	CRL Offset	Elevation
CW-3	676+00	50' LT	1214'
CW-4	682+59	95' LT	1191.5'

Boring stations, offsets and elevations estimated from plans provided by SRB

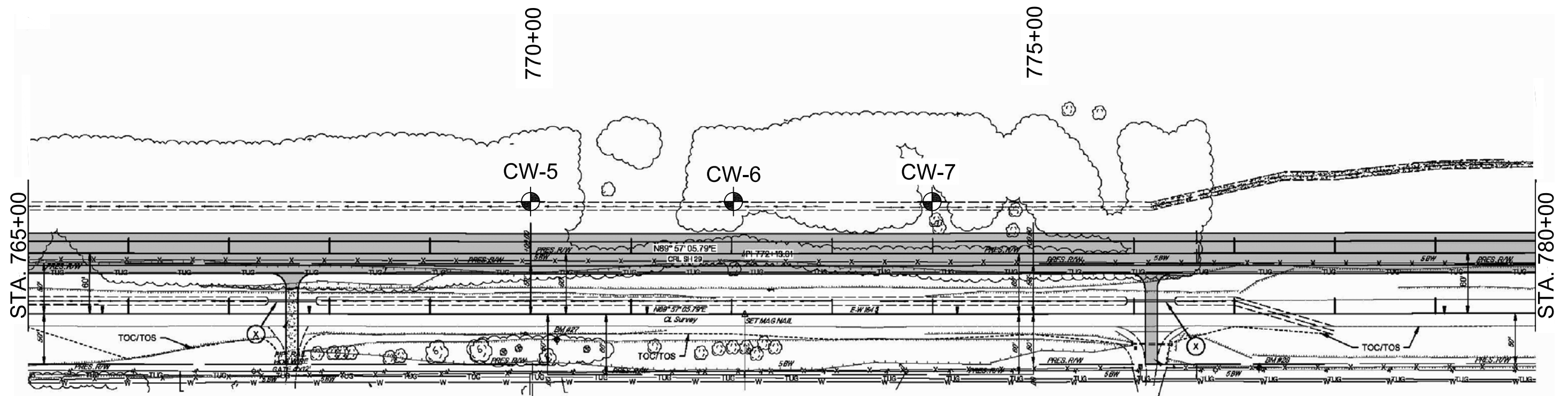


RED ROCK
CONSULTING

PO Box 30591
Edmond, Oklahoma 73003
(405) 562-3328

BORING LOCATION DIAGRAM
CUT ANALYSIS - WEST PHASE 1
STATE HIGHWAY 29
STEPHENS COUNTY, OKLAHOMA
29657(10)

Project Mngr:	SAH	Project No. 18043
Designed By:	SAH	Scale: NOT TO SCALE
Checked By:	JWB	Date: 8/16/2018
Approved By:	JWB	Page No: 2/4



BORING LOCATIONS AND ELEVATIONS

Boring	Station	CRL Offset	Elevation
CW-5	770+00	50' LT	1141'
CW-6	772+00	50' LT	1154.5'
CW-7	774+00	50' LT	1142.5'

Boring stations, offsets and elevations estimated from plans provided by SRB

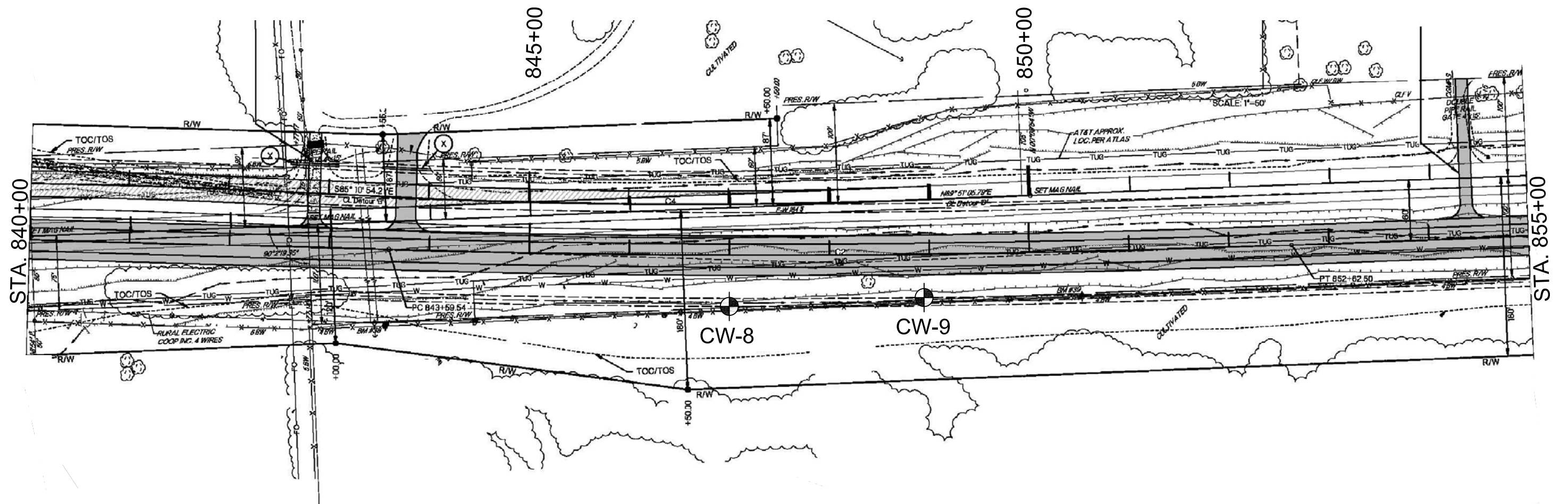


RED ROCK CONSULTING

PO Box 30591
Edmond, Oklahoma 73003
(405) 562-3328

BORING LOCATION DIAGRAM
CUT ANALYSIS - WEST PHASE 1
STATE HIGHWAY 29
STEPHENS COUNTY, OKLAHOMA
29657(10)

Project Mngr:	SAH	Project No.	18043
Designed By:	SAH	Scale:	NOT TO SCALE
Checked By:	JWB	Date:	8/16/2018
Approved By:	JWB	Page No:	3/4



BORING LOCATIONS AND ELEVATIONS

Boring	Station	CRL Offset	Elevation
CW-8	847+00	55' RT	1175'
CW-9	849+00	50' RT	1167'

Boring stations, offsets and elevations estimated from plans provided by SRB

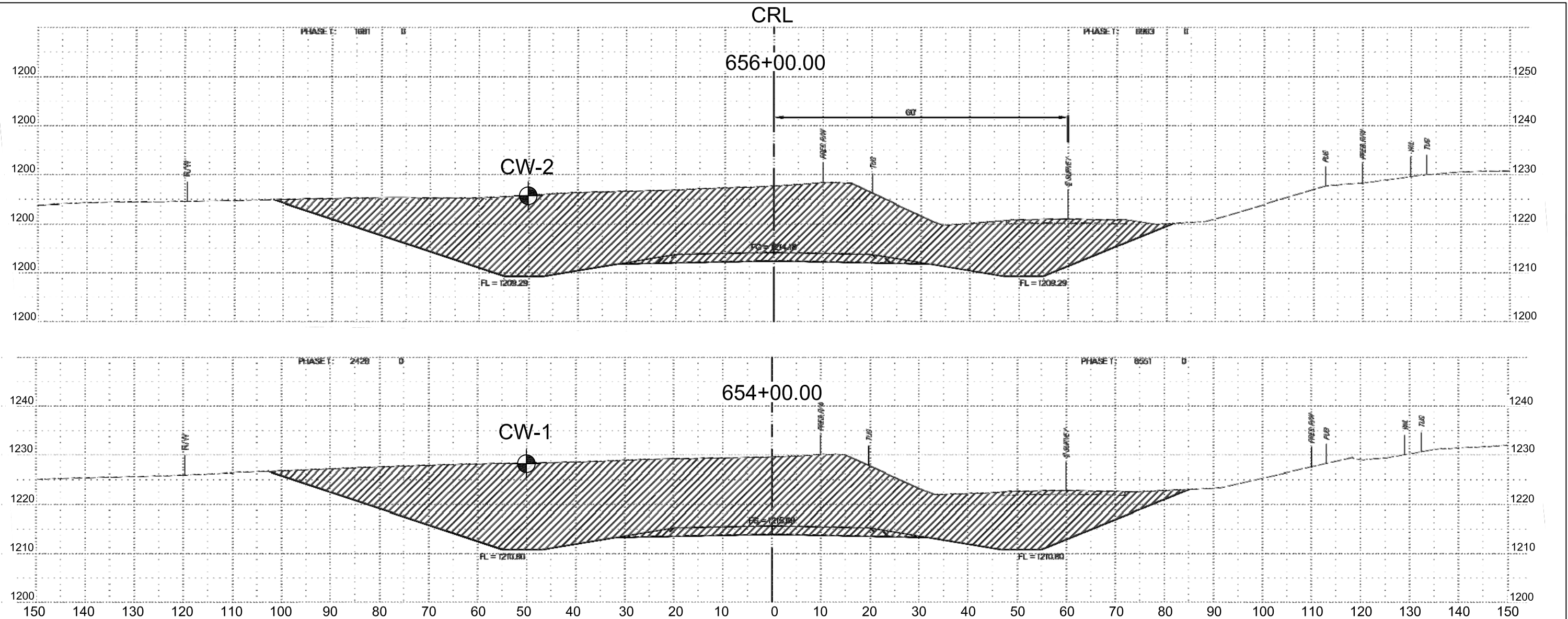


RED ROCK CONSULTING

PO Box 30591
Edmond, Oklahoma 73003
(405) 562-3328

BORING LOCATION DIAGRAM
CUT ANALYSIS - WEST PHASE 1
STATE HIGHWAY 29
STEPHENS COUNTY, OKLAHOMA
29657(10)

Project Mngr:	SAH	Project No.	18043
Designed By:	SAH	Scale:	NOT TO SCALE
Checked By:	JWB	Date:	8/16/2018
Approved By:	JWB	Page No:	4/4



BORING LOCATIONS AND ELEVATIONS			
Boring	Station	CRL Offset	Elevation
CW-1	654+00	50' LT	1228'
CW-2	656+00	50' LT	1226'

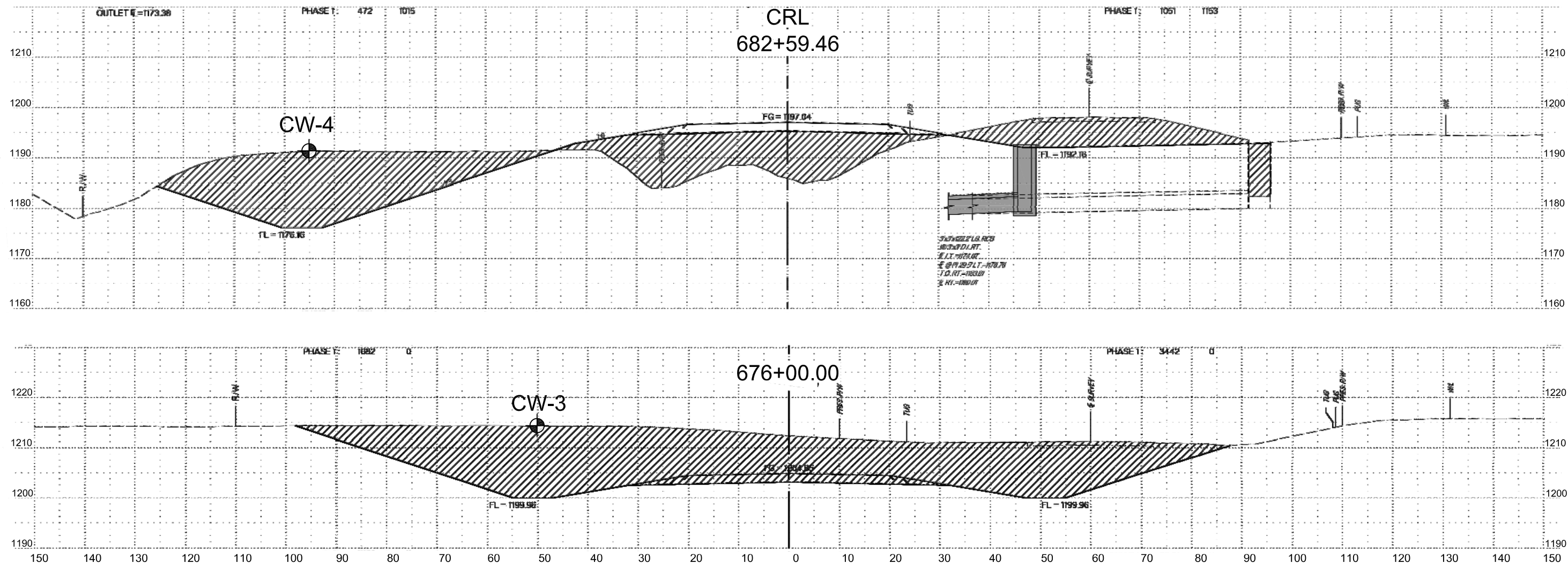
Boring stations, offsets and elevations estimated from plans provided by SRB

**RED ROCK
CONSULTING**

PO Box 30591
Edmond, Oklahoma 73003
(405) 562-3328

BORING LOCATION DIAGRAM - CROSS SECTIONS
CUT ANALYSIS - WEST PHASE 1
STATE HIGHWAY 29
STEPHENS COUNTY, OKLAHOMA
29657(10)

Project Mngr:	SAH	Project No.	18043
Designed By:	SAH	Scale:	NOT TO SCALE
Checked By:	JWB	Date:	8/16/2018
Approved By:	JWB	Page No:	1/4



BORING LOCATIONS AND ELEVATIONS			
Boring	Station	CRL Offset	Elevation
CW-3	676+00	50' Left	1214
CW-4	682+59	95' Left	1191.5

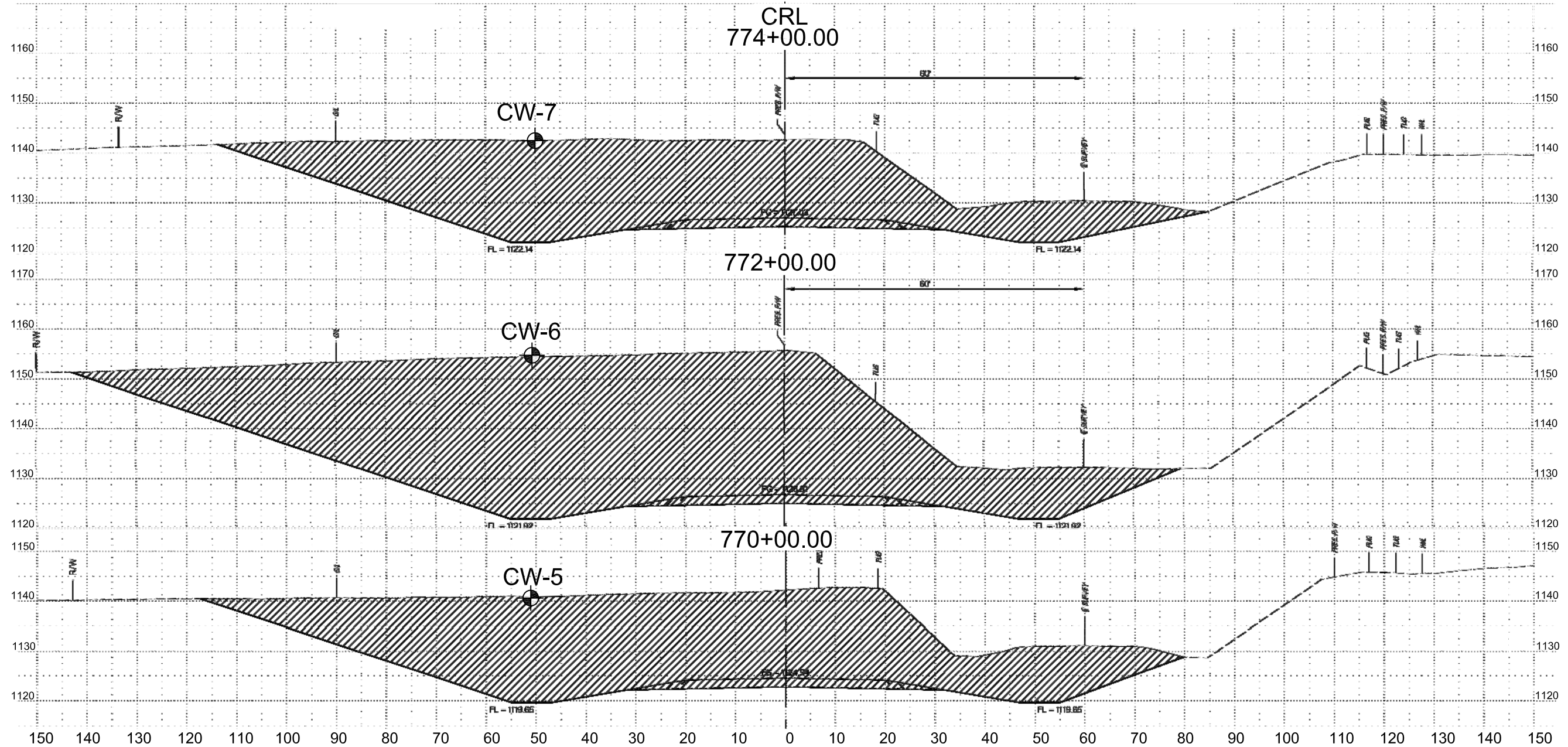
Boring stations, offsets and elevations estimated from plans provided by SRB

RED ROCK CONSULTING

PO Box 30591
Edmond, Oklahoma 73003
(405) 562-3328

BORING LOCATION DIAGRAM - CROSS SECTIONS
CUT ANALYSIS - WEST PHASE 1
STATE HIGHWAY 29
STEPHENS COUNTY, OKLAHOMA
29657(10)

Project Mngr:	SAH	Project No.	18043
Designed By:	SAH	Scale:	NOT TO SCALE
Checked By:	JWB	Date:	8/17/2018
Approved By:	JWB	Sheet No.	2/4



BORING LOCATIONS AND ELEVATIONS			
Boring	Station	CRL Offset	Elevation
CW-5	770+00	50' Left	1141'
CW-6	772+00	50' Left	1154.5'
CW-7	774+00	50' Left	1142.5'

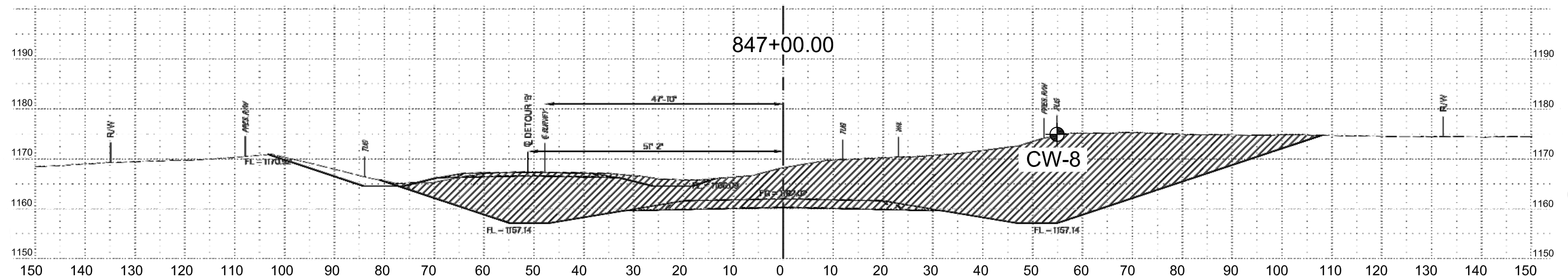
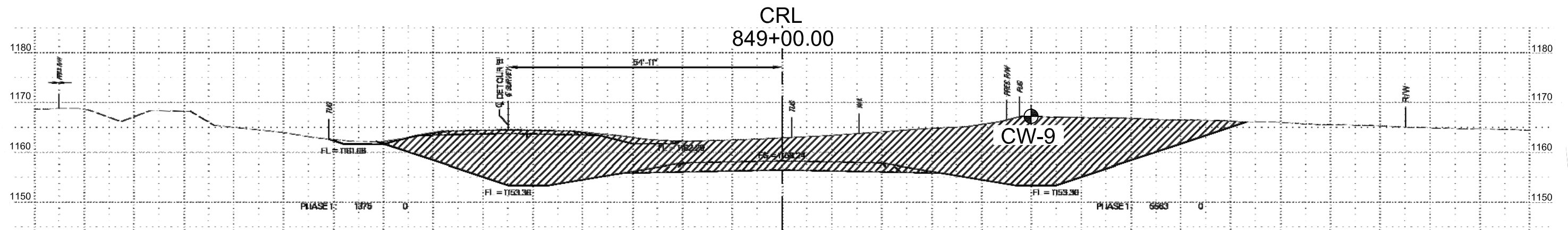
Boring stations, offsets and elevations estimated from plans provided by SRB

**RED ROCK
CONSULTING**

PO Box 30591
Edmond, Oklahoma 73003
(405) 562-3328

BORING LOCATION DIAGRAM - CROSS SECTIONS
CUT ANALYSIS - WEST PHASE 1
STATE HIGHWAY 29
STEPHENS COUNTY, OKLAHOMA
29657(10)

Project Mngr:	SAH	Project No.	18043
Designed By:	SAH	Scale:	NOT TO SCALE
Checked By:	JWB	Date:	8/17/2018
Approved By:	JWB	Sheet No.	3/4



BORING LOCATIONS AND ELEVATIONS			
Boring	Station	CRL Offset	Elevation
CW-8	847+00	55' right	1175'
CW-9	849+00	50' right	1167'

Boring stations, offsets and elevations estimated from plans provided by SRB

RED ROCK
CONSULTING

PO Box 30591
Edmond, Oklahoma 73003
(405) 562-3328











BORING LOCATION DIAGRAM - CROSS SECTIONS
CUT ANALYSIS - WEST PHASE 1
STATE HIGHWAY 29
STEPHENS COUNTY, OKLAHOMA
29657(10)

Project Mngr:	SAH	Project No.	18043
Designed By:	SAH	Scale:	NOT TO SCALE
Checked By:	JWB	Date:	8/17/2018
Approved By:	JWB	Sheet No.	4/4

CLIENT <u>SRB</u>	PROJECT NAME <u>SH 29 Cut Analysis - West Phase 1</u>
PROJECT NUMBER <u>18043</u>	PROJECT LOCATION <u>Stephens County, Oklahoma</u>
DATE STARTED <u>5/16/18</u> COMPLETED <u>5/16/18</u>	GROUND ELEVATION <u>1228 ft</u> STATION <u>654+00</u> OFFSET <u>50' LT</u>
DRILLING CONTRACTOR <u>DSO - Drilling Services of Oklahoma</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>4.5" augers - CME 750 ATV</u>	DURING DRILLING <u>none</u>
LOGGED BY <u>SAH</u> CHECKED BY <u>JWB</u>	0 hrs AFTER DRILLING <u>none</u>
NOTES <u>JP# 29657(10)</u>	Cave In Depth <u>none</u>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS N	MOISTURE CONTENT (%)	ATTERBERG LIMITS			PASSING #200 SIEVE (%)
0							LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
			SANDY LEAN CLAY , reddish brown with white, soft	1228'	4	2	24	15	9	64
			SANDSTONE , light gray with purple, very poorly cemented to very well cemented	1227.5'	50/6" 50/4.3" 50/2.8"					
1225	5			TC	50/4.3" 50/2.5"					
1220	10			TC	32/6" 50/4.8"					
1215	15			TC	50/0.8" 50/0.5"					
1210	20			TC	50/0.6" 50/0.3"					
1205	25			TC	50/0.8" 50/0.3"					
1200	30			TC	50/0.6" 50/0.4"					
1195			Boring Termination Depth = 31 feet Boring Completed and Backfilled on 5/16/18	1197'						
1190										
1185										
1180										

CLIENT <u>SRB</u>	PROJECT NAME <u>SH 29 Cut Analysis - West Phase 1</u>
PROJECT NUMBER <u>18043</u>	PROJECT LOCATION <u>Stephens County, Oklahoma</u>
DATE STARTED <u>5/16/18</u> COMPLETED <u>5/16/18</u>	GROUND ELEVATION <u>1226 ft</u> STATION <u>656+00</u> OFFSET <u>50' LT</u>
DRILLING CONTRACTOR <u>DSO - Drilling Services of Oklahoma</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>4.5" augers - CME 750 ATV</u>	DURING DRILLING <u>none</u>
LOGGED BY <u>SAH</u> CHECKED BY <u>JWB</u>	0 hrs AFTER DRILLING <u>none</u>
NOTES <u>JP# 29657(10)</u>	Cave In Depth <u>none</u>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS N	MOISTURE CONTENT (%)	ATTERBERG LIMITS			PASSING #200 SIEVE (%)
							LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
1225	0		<u>LEAN CLAY WITH SAND</u> , reddish brown, medium stiff 1226'	 SPT	5	21	47	19	28	72.6
	5									
1220			<u>SANDY LEAN CLAY</u> , light brown, hard 1221'	 SPT	10 27	5	25	12	13	61.8
			<u>SANDSTONE</u> , light gray, very poorly cemented to well cemented 1220'	 TC	50/5.5" 50/3.5" 50/4.5"					
	10									
1215			 TC	50/0.8" 50/0.5"						
	15									
1210			 TC	50/0.8" 50/0.5"						
	20									
1205			 TC	50/0.6" 50/0.4"						
	25									
1200			Boring Termination Depth = 25 feet Boring Completed and Backfilled on 5/16/18 1201'	 TC	50/0.8" 50/0.4"					
1195										
1190										
1185										
1180										

CLIENT <u>SRB</u>	PROJECT NAME <u>SH 29 Cut Analysis - West Phase 1</u>
PROJECT NUMBER <u>18043</u>	PROJECT LOCATION <u>Stephens County, Oklahoma</u>
DATE STARTED <u>5/16/18</u> COMPLETED <u>5/16/18</u>	GROUND ELEVATION <u>1214 ft</u> STATION <u>676+00</u> OFFSET <u>50' LT</u>
DRILLING CONTRACTOR <u>DSO - Drilling Services of Oklahoma</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>4.5" augers - CME 750 ATV</u>	DURING DRILLING <u>none</u>
LOGGED BY <u>SAH</u> CHECKED BY <u>JWB</u>	0 hrs AFTER DRILLING <u>none</u>
NOTES <u>JP# 29657(10)</u>	Cave In Depth <u>none</u>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS N	MOISTURE CONTENT (%)	ATTERBERG LIMITS			PASSING #200 SIEVE (%)
0							LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
			<u>CLAYEY SAND</u> , reddish brown, very loose 1214'	☒ SPT	3	13	32	12	20	48.4
1210	5		<u>LEAN CLAY WITH SAND</u> , reddish brown, very stiff 1209'	☒ SPT	25	10	43	15	28	81.1
1205	10		<u>SANDY SILT</u> , reddish brown, very dense 1204'	☒ SPT	30	7	0	0	NP	53.9
1200	15		<u>SANDSTONE</u> , light gray with reddish brown, cemented to very well cemented 1203.5'	▼ TC	50/6" 50/1.4" 50/1"					
1195	20			▼ TC	50/1.5" 50/0.5"					
1190	25			▼ TC	50/0.5" 50/0.4"					
1185			Boring Termination Depth = 25 feet Boring Completed and Backfilled on 5/16/18 1189'	▼ TC	50/0.5" 50/0.3"					
1180										
1175										
1170										
1165										

CLIENT <u>SRB</u>	PROJECT NAME <u>SH 29 Cut Analysis - West Phase 1</u>
PROJECT NUMBER <u>18043</u>	PROJECT LOCATION <u>Stephens County, Oklahoma</u>
DATE STARTED <u>7/13/18</u> COMPLETED <u>7/13/18</u>	GROUND ELEVATION <u>1191.5 ft</u> STATION <u>682+59</u> OFFSET <u>95' LT</u>
DRILLING CONTRACTOR <u>DSO - Drilling Services of Oklahoma</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>4.5" augers - CME 750 ATV</u>	▽ DURING DRILLING <u>23.0 ft / Elev 1168.5 ft</u>
LOGGED BY <u>SAH</u> CHECKED BY <u>JWB</u>	▼ 0 hrs AFTER DRILLING <u>21.0 ft / Elev 1170.5 ft</u>
NOTES <u>JP# 29657(10)</u>	Cave In Depth <u>none</u>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS N	MOISTURE CONTENT (%)	ATTERBERG LIMITS			PASSING #200 SIEVE (%)
							LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
1190	0		SANDY LEAN CLAY , orangish brown, stiff	1191.5' X SPT	14	8	27	13	14	50.5
1185	5		SILTY SAND , orangish brown, medium dense	1186.5' X SPT	17	7	0	0	NP	42.5
1180	10			X SPT	16	4	0	0	NP	30.0
1175	15		SILTY, CLAYEY SAND , light gray, medium dense	1176.5' X SPT	22	4	23	17	6	28.6
1170	20	▼	SANDSTONE , orangish brown, well cemented to very well cemented	1171.5' X SPT	50/5.8"	10	21	15	6	40.5
		▽		TC	50/1"					
					50/0.4"					
1165	25		Boring Termination Depth = 25.5 feet Boring Completed and Grouted on 7/13/18	1166' ▼ TC	50/0.3"					
					50/0.1"					
1160										
1155										
1150										
1145										


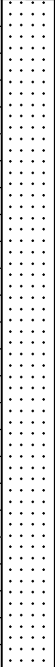
CLIENT <u>SRB</u>	PROJECT NAME <u>SH 29 Cut Analysis - West Phase 1</u>
PROJECT NUMBER <u>18043</u>	PROJECT LOCATION <u>Stephens County, Oklahoma</u>
DATE STARTED <u>7/11/18</u> COMPLETED <u>7/11/18</u>	GROUND ELEVATION <u>1141 ft</u> STATION <u>770+00</u> OFFSET <u>50' LT</u>
DRILLING CONTRACTOR <u>DSO - Drilling Services of Oklahoma</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>4.5" augers - CME 750 ATV</u>	▽ DURING DRILLING <u>15.0 ft / Elev 1126.0 ft</u>
LOGGED BY <u>SAH</u> CHECKED BY <u>JWB</u>	▼ 0 hrs AFTER DRILLING <u>16.5 ft / Elev 1124.5 ft</u>
NOTES <u>JP# 29657(10)</u>	Cave In Depth <u>none</u>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS N	MOISTURE CONTENT (%)	ATTERBERG LIMITS			PASSING #200 SIEVE (%)
0							LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
1140			<u>SILTY SAND</u> , brown, loose	1141' X SPT	8	4	0	0	NP	22.6
1135	5		<u>SANDY SILTY CLAY</u> , reddish brown, very stiff	1136' X SPT	13	8	22	15	7	55.8
			<u>SANDSTONE</u> , light gray, poorly cemented to well cemented	1135' ▼ TC	50/5" 50/3.3" 50/1.8"					
1130	10			▼ TC	50/1.8" 50/1"					
1125	15	▽		▼ TC	50/0.8" 50/0.4"					
1120	20			▼ TC	50/2.5" 50/1"					
1115	25			▼ TC	50/1" 50/0.5"					
1110	30		Boring Termination Depth = 30 feet Boring Completed and Grouted on 7/11/18	1111' ▼ TC	50/0.8" 50/0.4"					
1105										
1100										
1095										

CLIENT <u>SRB</u>	PROJECT NAME <u>SH 29 Cut Analysis - West Phase 1</u>
PROJECT NUMBER <u>18043</u>	PROJECT LOCATION <u>Stephens County, Oklahoma</u>
DATE STARTED <u>7/12/18</u> COMPLETED <u>7/12/18</u>	GROUND ELEVATION <u>1154.5 ft</u> STATION <u>772+00</u> OFFSET <u>50' LT</u>
DRILLING CONTRACTOR <u>DSO - Drilling Services of Oklahoma</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>wet rotary - CME 750 ATV</u>	DURING DRILLING <u>none</u>
LOGGED BY <u>SAH</u> CHECKED BY <u>JWB</u>	0 hrs AFTER DRILLING <u>none</u>
NOTES <u>JP# 29657(10)</u>	Cave In Depth <u>none</u>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS N	MOISTURE CONTENT (%)	ATTERBERG LIMITS			PASSING #200 SIEVE (%)
0							LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
			<u>SILTY, CLAYEY SAND</u> , light brown, medium dense 1154.5'	⊗ SPT	20	5	23	16	7	30.4
1150	5		<u>SILTY SAND</u> , light brown, very dense 1150.5'	⊗ SPT	30	8	0	0	NP	23.0
			<u>SANDSTONE</u> , light gray, poorly cemented to very well cemented 1150'	▼ TC	50/4" 50/3" 50/2"					
1145	10			▼ TC	50/1.8" 50/1"					
1140	15			▼ TC	50/0.3" 50/0.3"					
1135	20			▼ TC	50/0.4" 50/0.3"					
1130	25			▼ TC	50/0.5" 50/0.3"					
1125	30			▼ TC	50/0.4" 50/0.1"					
1120	35			▼ TC	50/1" 50/0.4"					
1115	40			▼ TC	50/0.8" 50/0.4"					
1110	45		Boring Termination Depth = 45 feet Boring Completed and Backfilled on 7/12/18 1109.5'	▼ TC	50/0.8" 50/0.5"					
1105										

CLIENT <u>SRB</u>	PROJECT NAME <u>SH 29 Cut Analysis - West Phase 1</u>
PROJECT NUMBER <u>18043</u>	PROJECT LOCATION <u>Stephens County, Oklahoma</u>
DATE STARTED <u>7/11/18</u> COMPLETED <u>7/11/18</u>	GROUND ELEVATION <u>1142.5 ft</u> STATION <u>774+00</u> OFFSET <u>50' LT</u>
DRILLING CONTRACTOR <u>DSO - Drilling Services of Oklahoma</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>4.5" augers - CME 750 ATV</u>	DURING DRILLING <u>none</u>
LOGGED BY <u>SAH</u> CHECKED BY <u>JWB</u>	0 hrs AFTER DRILLING <u>none</u>
NOTES <u>JP# 29657(10)</u>	Cave In Depth <u>none</u>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS N	MOISTURE CONTENT (%)	ATTERBERG LIMITS			PASSING #200 SIEVE (%)
0							LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
1140	5		<u>SANDY LEAN CLAY</u> , reddish brown, stiff 1142.5'	⊗ SPT	11	11	25	16	9	51.3
1135	10		<u>SANDSTONE</u> , light gray with reddish brown, cemented to very well cemented 1137.5'	▼ SPT TC	50/5" 50/1.3" 50/0.8"	4	0	0	NP	24.1
1130	15			▼ TC	50/1.3" 50/0.5"					
1125	20			▼ TC	50/1" 50/0.3"					
1120	25			▼ TC	50/1.5" 50/1"					
1115	30			▼ TC	50/1" 50/0.4"					
1110			Boring Termination Depth = 30 feet Boring Completed and Backfilled on 7/11/18 1112.5'	▼ TC	50/0.4" 50/0.4"					
1105										
1100										
1095										







1 DURING AFTER CAVE IN 18043 LOGS.GPJ DATA TEMPLATE.GDT 9/6/18

CLIENT <u>SRB</u>	PROJECT NAME <u>SH 29 Cut Analysis - West Phase 1</u>
PROJECT NUMBER <u>18043</u>	PROJECT LOCATION <u>Stephens County, Oklahoma</u>
DATE STARTED <u>5/16/18</u> COMPLETED <u>5/16/18</u>	GROUND ELEVATION <u>1175 ft</u> STATION <u>847+00</u> OFFSET <u>55' RT</u>
DRILLING CONTRACTOR <u>DSO - Drilling Services of Oklahoma</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>4.5" augers - CME 750 ATV</u>	▽ DURING DRILLING <u>10.0 ft / Elev 1165.0 ft</u>
LOGGED BY <u>SAH</u> CHECKED BY <u>JWB</u>	▼ 0 hrs AFTER DRILLING <u>12.0 ft / Elev 1163.0 ft</u>
NOTES <u>JP# 29657(10)</u>	Cave In Depth <u>none</u>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION		SAMPLE TYPE	BLOW COUNTS N	MOISTURE CONTENT (%)	ATTERBERG LIMITS			PASSING #200 SIEVE (%)
								LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
1175	0										
			<u>SILTY SAND</u> , reddish brown, medium dense	1175'	⊗ SPT	30	9	0	0	NP	32.6
1170	5		<u>SANDSTONE</u> , reddish brown with interbedded light gray layers, cemented to well cemented	1171'	⊗ SPT ▼ TC	50/4" 50/1.3" 50/0.8"	5	0	0	NP	29.6
1165	10	▽			▼ TC	50/1.3" 50/1"					
1160	15				▼ TC	50/0.8" 50/0.5"					
1155	20				▼ TC	50/1" 50/0.5"					
1150	25				▼ TC	50/0.8" 50/0.3"					
1145			Boring Termination Depth = 29.5 feet Boring Completed and Grouted on 5/16/18	1145.5'	▼ TC	50/0.8" 50/0.6"					
1140											
1135											
1130											
1125											

1 DURING AFTER CAVE IN 18043 LOGS.GPJ DATA TEMPLATE.GDT 9/6/18

CLIENT <u>SRB</u>	PROJECT NAME <u>SH 29 Cut Analysis - West Phase 1</u>
PROJECT NUMBER <u>18043</u>	PROJECT LOCATION <u>Stephens County, Oklahoma</u>
DATE STARTED <u>5/16/18</u> COMPLETED <u>5/16/18</u>	GROUND ELEVATION <u>1167 ft</u> STATION <u>849+00</u> OFFSET <u>50' RT</u>
DRILLING CONTRACTOR <u>DSO - Drilling Services of Oklahoma</u>	GROUND WATER LEVELS:
DRILLING METHOD <u>4.5" augers - CME 750 ATV</u>	DURING DRILLING <u>none</u>
LOGGED BY <u>SAH</u> CHECKED BY <u>JWB</u>	0 hrs AFTER DRILLING <u>none</u>
NOTES <u>JP# 29657(10)</u>	Cave In Depth <u>none</u>

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE	BLOW COUNTS N	MOISTURE CONTENT (%)	ATTERBERG LIMITS			PASSING #200 SIEVE (%)
0							LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	
1165			<u>LEAN CLAY WITH SAND</u> , reddish brown, light gray, stiff	1167'  SPT	12	8	24	16	8	78.9
5			<u>SANDSTONE</u> , reddish brown, light gray, cemented to very well cemented	1163'  TC	50/3" 50/1" 50/0.5"	4	33	17	16	52.2
10				 TC	50/0.8" 50/0.5"					
15				 TC	50/0.5" 50/0.3"					
20				 TC	50/1.3" 50/1"					
Boring Termination Depth = 24.5 feet Boring Completed and Backfilled on 5/16/18				 TC	50/1" 50/0.4"					

APPENDIX B



P.O. Box 30591
73003
Telephone: 405-562-3328

SUMMARY OF LABORATORY RESULTS

PROJECT NUMBER 18043

PROJECT NAME
CLIENT

SH 29 Cut Analysis - West Phase 1
SRB

Borehole	Depth (ft)	% Moist.	Liquid Limit	Plastic Limit	Plastic Index	-3" Sieve	-3/4" Sieve	-1/2" Sieve	-4 Sieve	-10 Sieve	-40 Sieve	-200 Sieve	pH	Resistivity (Ω -cm)	Sulfates (ppm)
CW-1	0	2.2	24	15	9	100	100	100	99	96	82	64.0			
CW-2	0	20.6	47	19	28	100	100	100	100	100	100	72.6			
CW-2	5	5.1	25	12	13	100	100	100	100	99	97	61.8			
CW-3	0	13.2	32	12	20	100	100	100	100	100	100	48.4			
CW-3	5	9.6	43	15	28	100	100	100	100	100	99	81.1			
CW-3	10	6.6	NV	NP	NP	100	100	100	100	100	100	53.9			
CW-4	0	8.2	27	13	14	100	100	100	100	100	100	50.5			
CW-4	5	6.6	NV	NP	NP	100	100	100	100	100	100	42.5			
CW-4	10	3.5	NV	NP	NP	100	100	100	100	100	100	30.0			
CW-4	15	4.3	23	17	6	100	100	100	98	97	95	28.6			
CW-4	20	10.4	21	15	6	100	100	100	100	100	99	40.5			
CW-5	0	4.4	NV	NP	NP	100	100	100	100	100	96	22.6			
CW-5	5	7.5	22	15	7	100	100	100	99	98	96	55.8			
CW-6	0	4.6	23	16	7	100	100	100	100	100	99	30.4			
CW-6	4	8.2	NV	NP	NP	100	100	100	100	100	98	23.0			
CW-7	0	11.1	25	16	9	100	100	100	100	100	99	51.3			
CW-7	5	4.2	NV	NP	NP	100	100	100	100	100	99	24.1			
CW-8	0	8.8	NV	NP	NP	100	100	100	100	100	98	32.6			
CW-8	4	4.6	NV	NP	NP	100	100	100	99	97	80	29.6			
CW-9	0	7.8	24	16	8	100	100	100	99	98	97	78.9			
CW-9	4	3.7	33	17	16	100	100	100	100	100	99	52.2			

APPENDIX C

GENERAL NOTES

SOIL PROPERTY ABBREVIATIONS

N	Uncorrected SPT Penetration, blows per foot
N ₆₀	Corrected SPT Penetration, blows per foot
Q _u	Unconfined Compressive Strength, psf
Mc	Moisture Content, %
LL	Liquid Limit, %
PL	Plastic Limit, %
PI	Plasticity Index, %

DRILLING & SAMPLING ABBREVIATIONS

BS	Bag Sample
SPT	Split Spoon Sample
ST	Shelby Tube Sample
AU	Auger Sample
TC	Texas Cone Penetrometer
DCP	Dynamic Cone Penetrometer

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D 2487)

-- used to classify all soils unless otherwise noted --

Major Divisions			Group Symbol	Typical Names
Course-Grained Soils >50% retained on #200 sieve	Gravels 50% + of course fraction retained on #4 sieve	Clean Gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
		Gravels with Fines	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	Sands 50% + of course fraction passes #4 sieve	Clean Sands	SW	Well-graded sands and gravelly sands, little or no fines
			SP	Poorly graded sands and gravelly sands, little or no fines
		Sands with Fines	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
Fine-Grained Soils <50% passes #200 sieve	Silts and Clays Liquid Limit ≤ 50%		ML	Inorganic silts, very fine sands, rock four, silty or clayey fine sands
			CL	Inorganic clays of low to medium plasticity, gravelly/sandy/silty/lean clays
			OL	Organic silts and organic silty clays of low plasticity
	Silts and Clays Liquid Limit > 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
			CH	Inorganic clays or high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
Highly Organic Soils			PT	Peat, muck, and other highly organic soils

Prefix: G = Gravel, S = Sand, M = Silt, C = Clay, O = Organic **Suffix:** W = Well Graded, P = Poorly Graded, M = Silty, L = Clay, LL < 50%, H = Clay, LL > 50%

PLASTICITY OF COHESIVE SOIL

Degree of Plasticity	Plasticity Index	Swell Potential
None	0 to 4	Very Low
Slight	5 to 9	Low
Medium	10 to 19	Low to Medium
High	20 to 39	Medium to High
Very High	40+	Very High

CONSISTENCY - COHESIVE SOILS

Consistency	SPT
Very Soft	<2
Soft	2 to 4
Medium Stiff	5 to 8
Stiff	9 to 14
Very Stiff	15 to 30
Hard	31+

ROCK HARDNESS

SPT (in/50)	TCP (in/100)	Rock Description
6+	6+	Very Soft / Very Poorly Cemented
5 - 6	3 - 6	Soft / Poorly Cemented
4 - 5	2 - 3	Moderately Hard / Cemented
3 - 4	1 - 2	Hard / Well Cemented
<3	<1	Very Hard / Very Well Cemented

MOISTURE OF COHESIVE SOIL

Description	Condition	Moisture Content
Dry, Dusty	Dry	0 to 10%
Damp	Moist	10 to 30%
Free Water	Wet	30 to 70%

DENSITY - COHESIONLESS SOILS

Relative Density	SPT
Very Loose	<4
Loose	4 to 10
Medium Dense	11 to 30
Dense	31 to 50
Very Dense	51+

ROCK CORE QUALITY

Core Quality	RQD
Excellent Quality	90 – 100%
Good Quality	75 – 90%
Fair Quality	50 – 75%
Poor Quality	25 – 50%
Very Poor Quality	<25%