METCO

MIDWEST ENGINEERING & TESTING CORPORATION

GEOTECHNICAL ENGINEERING SERVICES REPORT

For the
PROPOSED TWO SPAN BRIDGE ON TURNER TURNPIKE
OVER SH-33
CREEK COUNTY, OKLAHOMA

Prepared for
BENHAM DESIGN, LLC.
ONE WEST 3RD STREET, SUITE 200
TULSA, OKLAHOMA 74103-3513

Prepared by
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OKLAHOMA CITY, OKLAHOMA 73128

405-681-6737

METCO PROJECT NO: OGR-16057
APRIL 2016

METCO

MIDWEST ENGINEERING & TESTING CORPORATION

April 29, 2016

Benham Design, LLC.
One West 3rd Street, Suite 200
Tulsa, Oklahoma 74103-3513
Phone: 918-492-1600
Fax: 918-

Attention: Ms. Rhonda J. Dudeck, P.E.
Regional Engineering Manager

Subject: Geotechnical Engineering Services Report
Proposed Two Span Bridge on Turner Turnpike Over SH-33
Creek County, Oklahoma
METCO Project No: OGR-16057

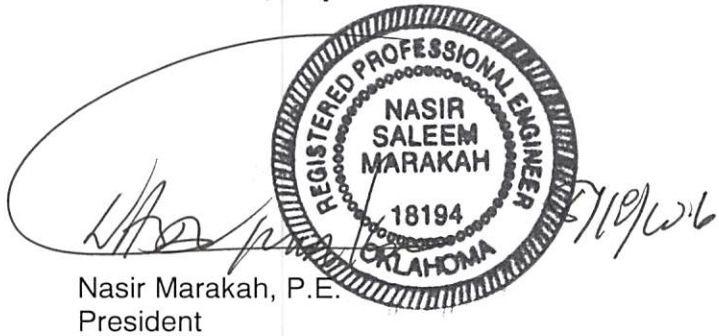
Dear Ms. Dudeck:

Midwest Engineering and Testing Corporation (METCO) is pleased to submit this Geotechnical Engineering Services Report for the above-referenced project. The purpose of our services was to assist the design team in designing general foundations and preparing plans and specifications for construction of the proposed project. Our services were completed in general accordance with the scope of work as outlined in METCO proposal number OGP-15215 dated November 30, 2015. Written authorization was provided by Ms. Kara Lampe on January 28, 2016.

We appreciate the opportunity to assist you on this project. Please do not hesitate to contact our office at 405-681-6737.

Respectfully Submitted,

Midwest Engineering & Testing Corporation
CA No. 4198, Expires 06/30/2017



Nasir Marakah, P.E.
President

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Proposed Two Span Bridge on Turner Turnpike Over SH-33
Creek County, Oklahoma
April 2016

1.0 Introduction

Midwest Engineering and Testing Corporation (METCO) has completed a geotechnical exploration and evaluation of the subsurface conditions for the above-referenced project. The work was performed in general accordance with METCO proposal number OGP-15215 dated November 30, 2015. Written authorization was provided by Ms. Kara Lampe on January 28, 2016.

2.0 Project Description

Based on project information provided by Ms. Dudeck, we understand the proposed construction will consist of the following:

Bridge	Two-Span Bridge Structure Approximately 97.83 Feet in Length Structural Loads Supported on H-piles or Drilled Piers
Alignment	New Bridge Alignment Will Approximately Match the Existing Bridge Alignment

The location of the site is shown on the Site location Map.

3.0 Scope of Work

The purpose of this exploration and evaluation was to assess the subsurface soil conditions at the project site, at the boring locations, in order to help in the evaluation of acceptable foundation systems for the proposed project.

Our scope of services included the items presented in the following sections.

3.1 Subsurface Exploration

A total of 3 soil borings were drilled using truck-mounted hollow-stem type drilling equipment. As per the scope of work requested, 3 borings were drilled within the general vicinity of the proposed replacement bridge. These borings were drilled to approximate termination depths/elevations of 56.5' (790.370'), 35.0' (791.161') and 46.0' (794.330') in borings B-1, B-2, and B-3, respectively below existing grade. Locations of the proposed replacement bridge as well as the soil borings are shown on the Boring Location Plan. Logs of the borings are presented in the Appendix.

Soil samples were taken at regular intervals during the drilling process. Samples were identified in the field, placed in sealed plastic bags, and transported to the laboratory for further classification and testing.

When the split spoon sampler was used, Standard Penetration Tests (SPT's) were performed at regular intervals in general accordance with ASTM Designation D1586, samples collected, and results presented on the boring logs. The SPT used in soil borings is performed by driving

a 2-inch, O.D., split-spoon sampler into the undisturbed formation located at the bottom of the advanced auger with repeated blows of a 140-pound, pin-guided, hammer falling a vertical distance of 30 inches. The number of blows required to drive the sampler one foot is a measure of the soil consistency.

When the Texas Cone Penetration test was used to evaluate the bedrock, the cone was driven into the bedrock material with a 140 pound automatic hammer that falls 30 inches. After the cone was seated, the distance the TCP is driven was recorded after each of two 50 blow counts.

3.2 Laboratory Evaluation

Selected samples of the subsurface soils were tested in the laboratory to determine materials properties for further evaluation and approximate unified soil classifications were determined by visual inspection. The laboratory evaluation consisted of visual and textural examinations, moisture content (ASTM D2216), Atterberg limit tests (ASTM D 4318), and percent passing the No. 200 sieve (ASTM D 422). Results of the tests are shown on the attached logs of borings.

3.3 Engineering Analysis

Engineering analysis and recommendations regarding general foundation design including soil bearing pressures are included in this report.

This geotechnical engineering report presents recommendations derived from existing and available information pertaining to the proposed project; relevant laboratory data, information, and test results; subsurface materials encountered in our borings, and the proposed bridge location. The attached entire report should be read and the contents evaluated so that to facilitate any changes that may be desired. If any changes or corrections are desired, please inform METCO in writing so that we may amend the presented recommendations

METCO cannot be responsible for the interpretation or implementation of this report by others. METCO should be retained to provide observation and testing during construction. Foundations, earthwork, and all other construction related activities should be observed by METCO. METCO will not accept any responsibility for the performance of the subgrade, foundations, bridge, retaining wall or any structure nor will it accept any responsibility for any conditions which deviated from those described in this report.

4.0 Surface and Subsurface Features

4.1 Site Description

The site of the referenced project is located on Turner Turnpike over SH-33 in Creek County, Oklahoma. The general location of the project location is shown in the appendix.

The proposed beginning of the bridge (BOB) is at approximate station 887+60.83 and the end of bridge (EOB) is at approximate station 888+58.67 along the CRL. The overall bridge length is approximately 97.83 feet. The preliminary design plans were prepared by Benham Design, LLC.

4.2 Site Geology

The Soil Survey of Creek County (May 1959) does not provide a geologic map and geologic description of Creek County and lists only the underlying geologic descriptions associated with the soil series.

According to the Oklahoma Department of Transportation (ODOT) Engineering Classification of Geologic Materials, Division Eight, 1965 (Red Book), the underlying geology for this project site is the Nellie Bly Unit (IPnb). This unit consists dominantly of yellowish–brown shale and sandy shales containing some sandstone and siltstone. The shale ranges from clay shale in the lower portion grading upward to silty and sandy shale. A black fissile shale marks the top of the Unit locally. Sandstones are prominent in the southern part of Division 8 including Creek County, and they present as massive beds up to 40 feet thick. Northward the Nellie Bly is mostly shale with thin siltstone beds and some beds of sandstone which are generally less than one foot thick, but the sandstones locally thicken to about 10 feet. The thickness of the Nellie Bly Unit in the Tulsa area is about 280 feet and in the vicinity of Collinsville is about 240 feet.

According to the Oklahoma Geological Survey Hydrological Atlas 4, by Roy H. Bingham and Robert L. Moore of the U.S. Geological Survey, 2004, the geology underlying this project site is the Nellie Bly Formation and Hogshooter Limestone (IPnb). The Nellie Bly Formation consists mainly of shale interbedded with many fine–grained sandstone beds and limestone beds locally in the upper part. The thickness of the Nellie Bly ranges from 250 to 550 feet thick. The underlying Hogshooter Limestone is massive crinoidal limestone ranging from 1 to 15 feet thick. The Nellie Bly Formation and Hogshooter Limestone are of Pennsylvanian geologic age.

The Oklahoma Geological Survey (OGS) does have a current definitive geologic publication for this portion of northern Creek County in Bulletin 81 by Malcolm C. Oakes, 1959. In Bulletin 81 a detailed geologic description and colored geologic map are presented. The Nellie Bly Formation can be characterized as consisting mostly of sandstones and silty shales, which both are fossiliferous locally. In addition, there is a minor amount of sandy limestone in beds which range in thickness from a few inches to a few feet and are of local occurrence. The shales form three map units, lower (IPnb–1), middle (IPnb–m) and upper (IPnb–u). The three shale map units are separated by and interfinger and intergrade with sandstone mapped units (IPnb–2) and (IPnb–4). The Nellie Bly Formation thickness in Creek County ranges from 220 feet thick at T.18 N. (parallel with Sapulpa) and 395 feet at T.16 N. (approximately parallel with Bristow).

The correct geologic description at the bridge site is judged to be the Nellie Bly Formation (Sandston & Shale). A profile and description of the Nellie Bly Formation above the Hogshooter Formation is shown in Figure 13 in the Appendix. Note the sandstone mapped unit (IPnb–2) is the thickest of the sandstone units.

4.3 Soil Subsurface Conditions

Below approximately 6.0 inches of grass and topsoil or 8.5 inches of concrete, the borings generally encountered soils consisting of clay and sand to approximate depths/elevations 26.0 feet (820.870'), 4.0 feet (822.161') and 15.0 feet (825.330') below existing grade in borings, B-1, B-2 and B-3, respectively. These soils were underlain by moderately hard to hard sandstone and/or shale to boring termination depths/elevations of approximately 56.5' (790.370'), 35.0' (791.161') and 46.0' (794.330') in borings B-1, B-2, and B-3, respectively below existing grade. Standard penetration resistances (N-values) recorded in the soils ranged between 11 to 20

blows per foot (bpf), indicating stiff to very stiff consistencies in the cohesive soils and medium relative densities in the cohesionless soils. Texas cone penetration test results in the bedrocks ranged from 100 blows for 6.5 inches of penetration to 100 blows for 0.3 inch of penetration indicating soft to hard sandstone and/or shale. The type and approximate depths of the sandstone and/or shale formations are presented in the table below:

Boring	Type	Approximate Depth to Bedrock (feet)	Approximate Elevation (feet)
B-1	Shale	26.00	820.870
B-2	Sandstone and/or Shale	4.00	822.161
B-3	Shale and/or Sandstone	15.00	825.330

Laboratory tests indicated that the site soils had plasticity indices ranging from NP (Non-Plastic) to 14 and grain size distribution tests show that the tested soils contain about 36 to 73 percent fines (that material passing a No. 200 mesh sieve). The encountered soils were classified as CL and SM in accordance with the Unified Soil Classification System.

The above description of the subsurface conditions constitutes a generalization that emphasizes the subsurface stratification features and characteristics. The data and information at the specific boring locations are recorded in the boring logs. These logs present a description of subsurface soil and rock, applicable laboratory and field test results, sample location, and general stratification. Variations in the stratification presented in the boring logs should be expected across the site and between boring locations as the presented strata description is only indicative of the boring location.

4.4 Groundwater

Groundwater was encountered in our borings at as documented in the table below:

Boring	Water Level Readings (feet)					
	At Completion		End of Day		Within 24 to 48 Hours	
	Depth (ft)	Elevation	Depth (ft)	Elevation	Depth (ft)	Elevation
B-1	35.0	811.870	35.0	811.870	Dry*	N/A
B-2	16.0	810.161	18.0	808.161	N/A	N/A
B-3	23.0	817.330	23.0	817.330	Dry*	N/A

*Boring collapsed

Seasonal Variations of groundwater should be expected. The contractor should determine the actual groundwater levels prior to construction. It should be noted that some of the borings collapsed upon auger removal as indicated on the boring logs.

4.5 IBC Seismic Zone Coefficients

Earthquake related design parameters may be obtained from the International Building Code 2009 Edition, using *a Site Class **C** Definition*. The site coefficient is based on a maximum boring depth of approximately 100 feet and the assumption that the bedrock encountered is consistent and extends to a depth of at least 100 feet. The USGS-2009 AASHTO Guide

Specification for LRFD Seismic Bridge Design probabilistic ground motion values near 35.987° N and longitude -96.194° W are as follows.

Seismic Design Criteria			
Period (seconds)	7% Probability of Event in 75 years (g)	Site Coefficient Fa	Site Coefficient Fv
PGA	0.045	N/A	N/A
0.2 (Ss)	0.102	1.2	N/A
1.0 (S_1)	0.040	N/A	1.7

5.0 Evaluation and Recommendations

It is our understanding that H-piles and drilled piers are your preferred foundation systems for the proposed abutments and interior supports, respectively. Adequate pile driving or pier drilling equipment should be utilized by the contractor. **Some difficulties may be encountered during the pile driving or pier drilling due to the nature of the subsurface formations. It is our understanding that the existing bridge will be removed. The design engineer should determine if any left in-place elements of the existing bridge would impact the new construction.**

Soft to hard yellowish brown and gray sandstone and/or shale was encountered at approximate depths as presented in the table below:

Boring	Surface Elevation (feet)	Type	Approximate Depth to Bedrock (feet)	Approximate Elevation (feet)
B-1	846.870	Shale	26.0	820.870
B-2	826.161	Sandstone and/or Shale	4.0	822.161
B-3	840.330	Shale and/or Shale	15.0	825.330

5.1 H-Piles

Driven low displacement piles such as H-piles could be used due to their ability to withstand high driving stresses. **The piles should be driven to practical refusal into the sandstone and/or shale strata**. The piles should penetrate the rock a minimum of 3 feet, if possible without damaging the piles. It is expected that the nominal resistance (ultimate pile capacity) of the piles to be controlled by the structural limit state of the pile. It should be noted that pilot holes may be required to achieve the required piling length that will be determined by the design engineer. It is recommended that pilot holes for abutment piling be drilled with 24 inch pilot holes to the required pile tip elevation as will be determined by the design engineer. Concrete should be used to backfill the voids after placement of piling.

Proper drivability analysis should be performed to verify the actual pile capacity and piles should not be overstressed during driving. Proper precautions should be taken to protect the pile tips. Driving shoes or welded reinforcement could be utilized to lower the risk of damage during driving. To protect the integrity of the piles, the number of splices should be kept at a minimum, if splicing is required. Piles should not be spaced closer than three times the maximum pile dimension measured center to center.

Actual penetrations could vary depending on the type of hammer, site subsurface conditions, and hammer operating efficiency. The pile type and capacity will be selected by the structural engineer. Once the pile type is selected, METCO can be contacted for further evaluation, if needed. **A resistance factor of 0.40 should be utilized**.

All piles should be installed in accordance with ODOT's standard specifications for Highway Construction, section 514.

The weathering process of sandstone and/or shale is erratic and variations in the sandstone and/or shale profiles can be expected in small lateral distances. The sandstone and/or shale profiles should be completely defined prior to requesting lump sum bids. All shale and/or sandstone depths should be confirmed at the time of construction.

5.2 Drilled Piers

A drilled pier foundation system was evaluated to support the bridge structural loads. The base of the drilled piers should bear a minimum of 5 feet or one pier diameter, whichever is deeper, into the sandstone and/or shale strata. The presented table below is based on the Texas Cone Penetration Tests.

To compute nominal resistance, the drilled piers can be designed for a nominal (ultimate) end bearing pressure and a nominal (ultimate) skin friction based on the table presented below:

Boring No.	Minimum Embedment Depth (feet)	Nominal (Ultimate) End Bearing (tsf)	Nominal (Ultimate) Side Friction (tsf)	Comments
B-1	26.5-36.5	60	9.0	
	36.5-46.5	20	3.0	
	46.5-56.5	40	6.9	
B-2	10.0-25.0	40	6.9	
	25.0-35.0	60	9.0	
B-3	16.0-46.0	60	9.0	

Resistance factors of 0.55 and 0.5 should be utilized for skin side resistance and tip resistance, respectively for factored axial static capacity.

The table in the appendix should be reviewed for end bearing capacity and skin friction values at various depths as obtained from the Texas Highway Department chart titled "Drilled Shafts Foundation Design" and dated 7/72.

To reduce difficulties associated with sloughing and/or ground water related problems, casing could be used. A slurry displacement method could also be used. Once the casing is sealed into rock, the remaining soil can be removed and the excavation pumped to remove any groundwater or slurry from the shaft. Any loose material should be removed from the pier bottom. The pier bottom and the socket should be observed for continuity and to verify that the material is acceptable for support of the proposed loads and that the material is consistent with the materials encountered in our borings. When the drilling operations and inspection is

complete, concrete should be placed immediately. Sufficient concrete head should be maintained inside the casing to offset the water hydrostatic head and to prevent groundwater and/or slurry intrusion into the pier.

The weathering process of the shale and/or sandstone is erratic and variations in the shale and/or sandstone profiles can be expected in small lateral distances. The shale and/or sandstone profiles should be completely defined prior to requesting lump sum bids. All shale and/or sandstone depths should be confirmed at the time of construction.

All drilled piers construction and observation should be accomplished in accordance with the Standard Specifications of Oklahoma Department of Transportation (ODOT).

5.3 Compacted Fill Requirements

It is anticipated that an off-site borrow source will be required for grading operations for the proposed project. It is advisable to use a single borrow source to produce better uniformity. All fill placement should be performed per ODOT specifications, subsection 202.

5.4 Rock Rippability

Hard to very hard sandstone bedrock materials were encountered at depths as indicated previously in this report. For construction considerations, difficulties in excavating for drilled piers may be encountered due to the hardness of some of the layers of bedrock and the possibility of the presence of limestone lenses. Generally, overburden soils and sedimentary rock which have a penetration of 3 inches or more per 50 blows as determined by the Standard Penetration Test (SPT) drive hammer or 2 inches or more per 100 blows of the Texas Cone Penetrometer (TCP) test can typically be excavated with hydraulic excavating equipment with rock teeth. Sedimentary rock which has a penetration of less than 3 inches per 50 blows of the SPT drive hammer or 2 inches or less per 100 blows of the Texas Cone Penetrometer (TCP) test will typically require heavy duty equipment for excavations. It should be noted that TCP results in the bore holes ranged from 0.3 inch for 100 blows to 6.5 inches for 100 blows. Based on past experiences, some difficulties in foundation construction is anticipated. The boring logs should be made available to pier contractors. **Pier drilling contractors should make their own conclusions in regards to the rippability of the rock formations**.

5.5 Excavation and Temporary Slopes

The contractor, designated as "responsible person" in OSHA Construction Standards for Excavations, 29 CFR Part 1926, is solely responsible for planning and implementing all safety procedures. All excavation height, slope, and depth must adhere to all specifications outlined in local, state, and federal safety regulations.

METCO does not assume any responsibility for construction site safety or any party's, including the contractor, compliance with the applicable local, state, and federal safety regulations or any other applicable regulations.

5.6 Weather Considerations

The upper soils encountered at this site maybe sensitive to moisture variations and construction traffic disturbances during wet weather. The soil strength is significantly reduced when the soil is wet and significant delays in the grading and compaction activities can take place. Thus, it is advantageous to perform construction activities during periods of dry weather.

6.0 General

The conclusions and recommendations presented in this report are subject to the following general conditions:

6.1 Use of Report

This report has been prepared for the exclusive use of Benham Design, LLC., for the specific application to the proposed Two Span Bridge on Turner Turnpike Over SH-33, in Creek County, Oklahoma. This report should not be appropriate for other structures or purposes. We recommend that parties contemplating other structures or purposes contact us. Unless our written approval is provided, we make no representation and assume no responsibility to other parties regarding this report.

6.2 Level of Care

The recommendations contained in this report are based on the available subsurface information obtained by METCO, and design details furnished for the proposed project. If there are any revisions to the plans for this project, or if deviations from the subsurface conditions noted in this report are encountered during construction, METCO should be notified immediately to determine if changes in the recommendations are required. If METCO is not retained to perform these functions, METCO will not be responsible for the impact of those conditions on the project.

METCO should be retained to provide observation and testing during construction. Foundations, earthwork, and all other construction related activities should be observed by METCO.

Services performed by the geotechnical engineer for this project have been conducted with that level of care and skill ordinarily exercised by members of the profession currently practicing in this area. **No warranty, expressed or implied, is made**.

Table 1
Texas Cone Penetration Test Results
Proposed Two Span Bridge on Turner Turnpike Over SH-33
OGR-16057

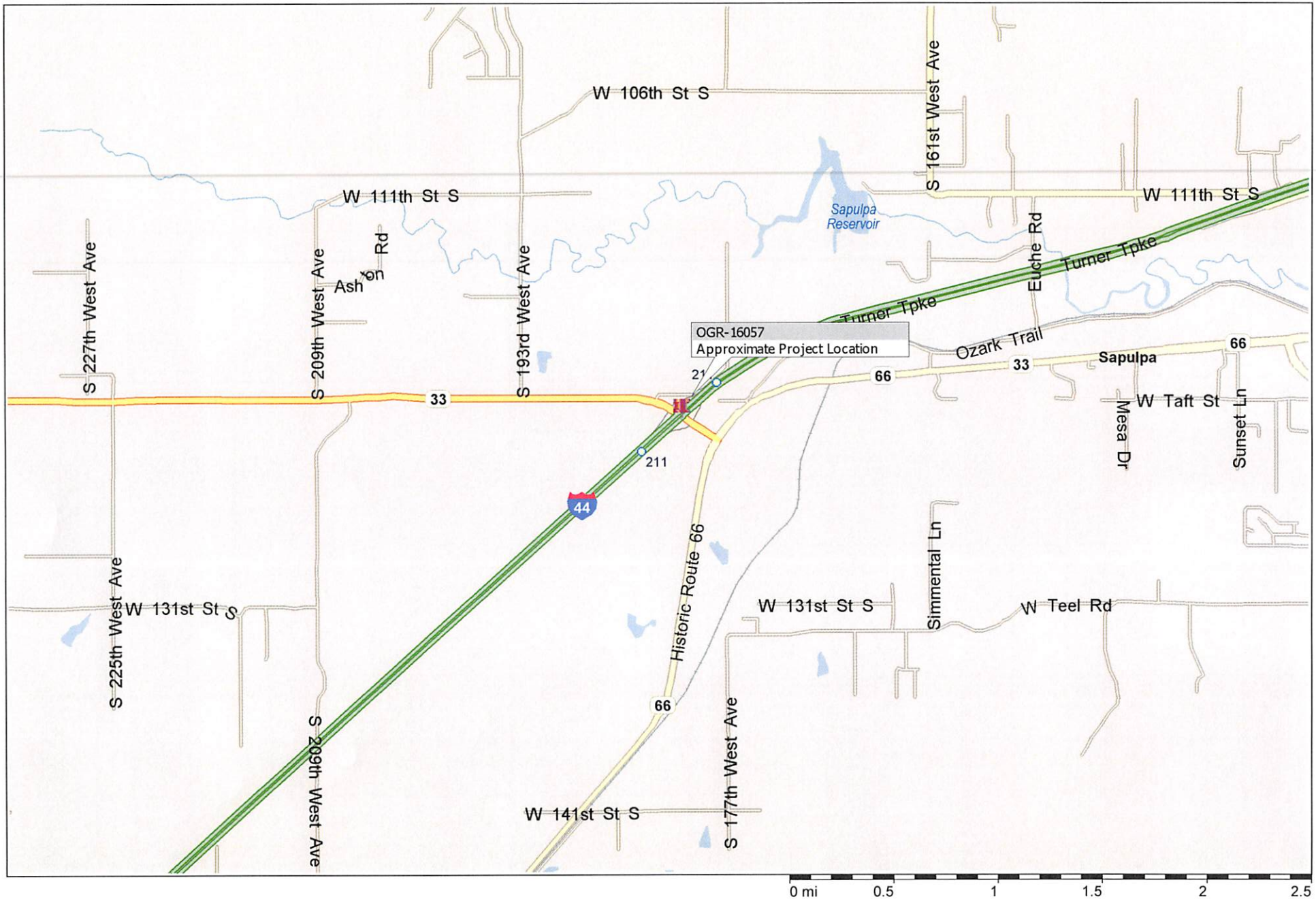
Boring #	Test Depth (Feet)	Texas Cone Penetration (in/100 blows)	Elevation of Test (Feet)	Nominal (Ultimate) End Bearing (tsf)	Nominal (Ultimate) Side Friction (tsf)
B-1	26.5	1.0	820.370	60.0	9.0
	31.5	1.5	815.370	60.0	9.0
	36.5	1.3	810.370	60.0	9.0
	41.5	6.0	805.370	20.0	3.0
	46.5	1.0	800.370	60.0	9.0
	51.5	2.8	795.370	40.0	6.9
	56.5	1.0	790.370	60.0	9.0
B-2	5.0	6.5	821.161	18.0	3.0
	10.0	1.0	816.161	60.0	9.0
	15.0	2.5	811.161	48.0	7.8
	20.0	2.8	806.161	40.0	6.9
	25.0	0.5	801.161	60.0	9.0
	30.0	1.5	796.161	60.0	9.0
	35.0	0.5	791.161	60.0	9.0
B-3	16.0	0.3	824.330	60.0	9.0
	21.0	1.3	819.330	60.0	9.0
	26.0	1.0	814.330	60.0	9.0
	31.0	1.0	809.330	60.0	9.0
	36.0	0.5	804.330	60.0	9.0
	41.0	2.0	799.330	60.0	9.0
	46.0	1.0	794.330	60.0	9.0

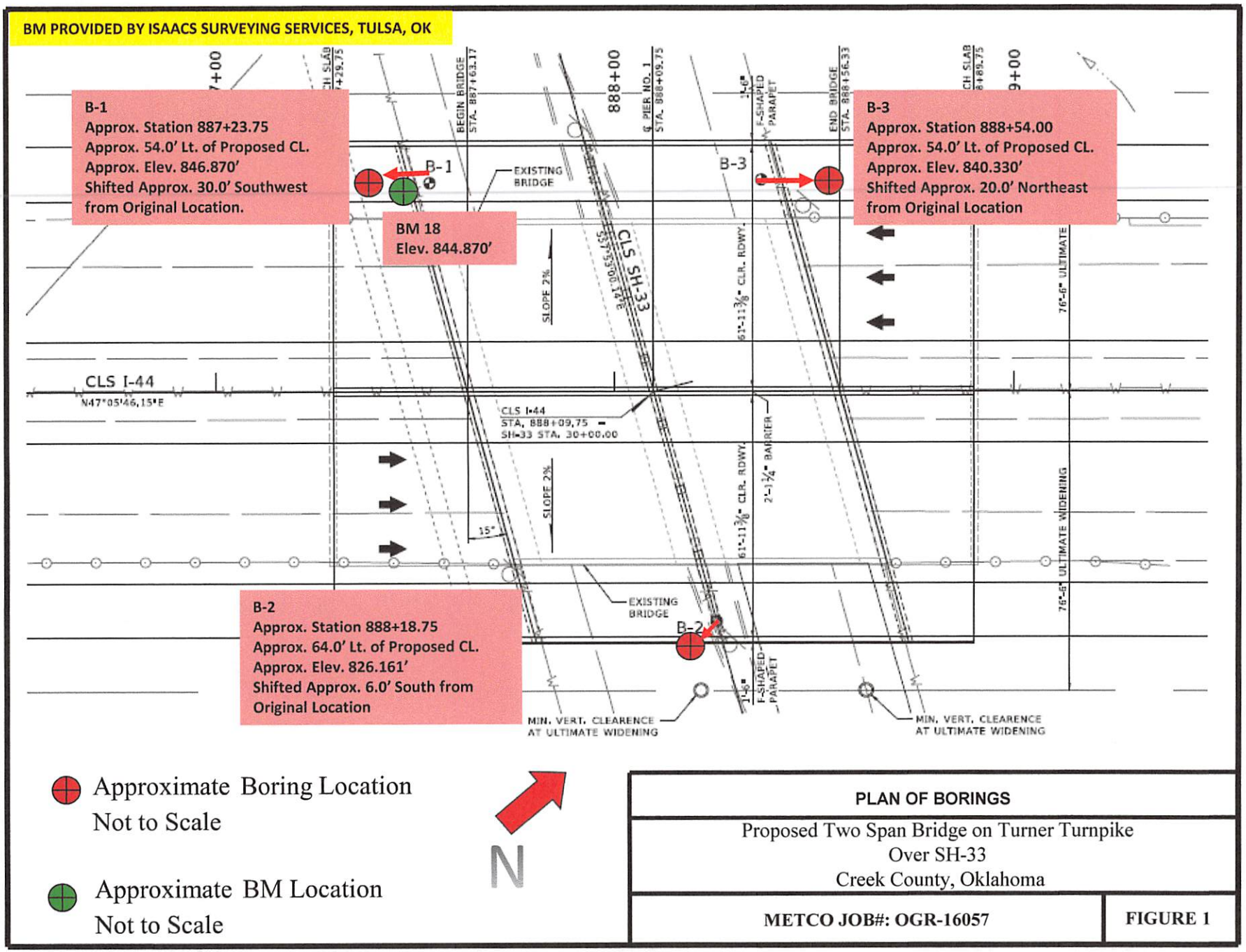
Table 2
Estimated Rock Elevation for Pile Design
Proposed Two Span Bridge on Turner Turnpike Over SH-33
OGR-16057

Boring	Approximate Station	Surface Elevation	Pile Type	Estimated Top of Bedrock Elevation
B-1	887+23.75	846.870'	Selected by Designer	820.870'
B-3	888+54.00	840.330'	Selected by Designer	825.330'

APPENDIX A

Oklahoma, United States, North America




BM PROVIDED BY ISAACS SURVEYING SERVICES, TULSA, OK
B-1
Approx. Station 887+23.75
Approx. 54.0' Lt. of Proposed CL.
Approx. Elev. 846.870'
Shifted Approx. 30.0' Southwest
from Original Location.
BM 18
Elev. 844.870'
B-3
Approx. Station 888+54.00
Approx. 54.0' Lt. of Proposed CL.
Approx. Elev. 840.330'
Shifted Approx. 20.0' Northeast
from Original Location
B-2
Approx. Station 888+18.75
Approx. 64.0' Lt. of Proposed CL.
Approx. Elev. 826.161'
Shifted Approx. 6.0' South from
Original Location
CLS I-44
N47°05'46.15"E
CLS SH-33
CLS I-44
STA. 888+09.75
SH-33 STA. 30+00.00
BEGIN BRIDGE
STA. 887+63.17
888+00
℄ PIER NO. 1
STA. 888+09.75
END BRIDGE
STA. 888+56.33
F-SHAPED PARAPET
EXISTING BRIDGE
SLOPE 2%
61'-11⅜" CLR. RDWY.
2'-1¼" BARRIER
76'-6" ULTIMATE
76'-6" ULTIMATE WIDENING
15°
MIN. VERT. CLEARENCE
AT ULTIMATE WIDENING
Approximate Boring Location
Not to Scale
Approximate BM Location
Not to Scale
N
PLAN OF BORINGS
Proposed Two Span Bridge on Turner Turnpike
Over SH-33
Creek County, Oklahoma
METCO JOB#: OGR-16057
FIGURE 1

METCO

LOG OF BORING B-1

PROJECT: Proposed Two Span Bridge on Turner Turnpike Over SH-33, Creek County, Oklahoma — Project No.: OGR-16057

Date Drilled: 4/9/2016 — Location: Approx. Sta. 887+23.75, Approx. 54.0' Lt. of Prop. CL. — Elevation: 846.870'

Depth To Water At Completion: 35.0' — Depth To Water On: 4/10/2016 — Was: Dry*

Drilled By: Rocky — Logger: Shafe — Approximate Completion Depth: 56.5'

DEPTH FEET	SYMBOL	SAMPLE TYPE	DESCRIPTION	MC %	LL %	PL %	PI %	-#200 %	swell %	PP TSF
1–5			6.0" Grass and topsoil SANDY LEAN CLAY (CL) with iron stains and roots, brown , stiff							
6–10		5/6" 6/6" 7/6"		14	25	15	10	60		
11–15		4/6" 5/6" 6/6"	LEAN CLAY WITH SAND (CL) with iron stains, brown, stiff	17	27	15	12	71		
16–20		9/6" 6/6" 7/6" 8/6" 9/6" 9/6"	SANDY LEAN CLAY (CL) with iron stains, light brown, stiff to hard	15 14	27 27	16 15	11 12	68 69		
21–25		5/6" 9/6" 11/6"		16	26	15	11	66		
26		8/6" 8/6"	LEAN CLAY WITH SAND (CL), light brown, hard	16	29	16	13	73		
27–30		50/5" 100/1.0"	SHALE with sandstone layers, yellowish brown, soft to hard TC @ 26.5' : 50/0.8", 50/0.2"							

NOTES: * Boring collapsed to approximate depth of 9.0 feet below existing grade, upon auger removal

Subsurface Conditions may significantly vary at other site locations

Difficulties may be encountered during construction due to the nature of subsurface formations

LOG OF BORING B-1

PROJECT: Proposed Two Span Bridge on Turner Turnpike Over SH-33, Creek County, Oklahoma Project No.: OGR-16057

Date Drilled: 4/9/2016 Location: Approx. Sta. 887+23.75, Approx. 54.0' Lt. of Prop. CL. Elevation: 846.870'

Depth To Water At Completion: 35.0' Depth To Water On: 4/10/2016 Was: Dry*

Drilled By: Rocky Logger: Shafe Approximate Completion Depth: 56.5'

DEPTH FEET	SYMBOL	SAMPLE TYPE	DESCRIPTION	MC %	LL %	PL %	PI %	-#200 %	swell %	PP TSF
31			SHALE with sandstone layers, yellowish brown, soft to hard (Continued)							
32		100/1.5"	TC @ 31.5' : 50/1.0", 50/0.5"							
33										
34										
35										
36										
37		100/1.3"	SHALE with sandstone layers, yellowish brown and light gray, hard to soft							
38										
39			TC @ 36.5' : 50/1.0", 50/0.3"							
40										
41										
42		100/6.0"	SANDY SHALE, yellowish brown, soft to hard	22	22	14	8	56		
43										
44			TC @ 41.5' : 50/3.0", 50/3.0"							
45										
46										
47		100/1.0"	SHALE, gray, hard to moderately hard	21	39	18	21	96		
48			TC @ 46.5' : 50/0.8", 50/0.2"							
49										
50										
51										
52		100/2.8"	SHALE with sandstone seams, gray, moderately hard to hard							
53										
54			TC @ 51.5' : 50/2.0", 50/0.8"							
55										
56										
57		100/1.0"	TC @ 56.5' : 50/0.8", 50/0.2"							
58										
59										
60										

NOTES: * Boring collapsed to approximate depth of 9.0 feet below existing grade, upon auger removal

Subsurface Conditions may significantly vary at other site locations

Difficulties may be encountered during construction due to the nature of subsurface formations

LOG OF BORING B-2

PROJECT: Proposed Two Span Bridge on Turner Turnpike Over SH-33, Creek County, Oklahoma — Project No.: OGR-16057

Date Drilled: 4/14/2016 — Location: Approx. Sta. 888+18.75, Approx. 64.0' Rt. of Prop. CL. — Elevation: 826.161'

Depth To Water At Completion: 16.0' — Depth To Water On: End of Day — Was: 18.0'

Drilled By: Rocky — Logger: Shafe — Approximate Completion Depth: 35.0'

DEPTH FEET	SYMBOL	SAMPLE TYPE	DESCRIPTION	MC %	LL %	PL %	PI %	-#200 %	swell %	PP TSF
1–4			8.5" Reinforced Concrete SILTY SAND (SM), light brown, dense							
5		50/5"	SILTY SANDSTONE, yellowish brown, soft to hard TC @ 5.0' : 50/4.0", 50/2.5"	10	NP	NP	NP	30		
6–10		100/6.5"								
11–15		100/1.0"	SILTY SANDSTONE, yellowish brown, hard to moderately hard TC @ 10.0' : 50/0.8", 50/0.2"	14	NP	NP	NP	42		
16–20		100/2.5"	SILTY SHALEY SANDSTONE, yellowish brown and light gray, moderately hard to hard TC @ 15.0' : 50/2.0", 50/0.5"	13	20	14	6	46		
21–25		100/2.8"	TC @ 20.0' : 50/2.0", 50/0.8"	31	18	14	4	37		
26–30		100/0.5"	SHALE with sandstone layers, gray, hard TC @ 25.0' : 50/0.3", 50/0.2"	29	31	16	15	81		

NOTES: * Boring collapsed to approximate depth of 20.0 feet below existing grade, upon auger removal

Subsurface Conditions may significantly vary at other site locations

Difficulties may be encountered during construction due to the nature of subsurface formations

LOG OF BORING B-2

PROJECT: Proposed Two Span Bridge on Turner Turnpike Over SH-33, Creek County, Oklahoma Project No.: OGR-16057

Date Drilled: 4/14/2016 Location: Approx. Sta. 888+18.75, Approx. 64.0' Rt. of Prop. CL. Elevation: 826.161'

Depth To Water At Completion: 16.0' Depth To Water On: End of Day Was: 18.0'

Drilled By: Rocky Logger: Shafe Approximate Completion Depth: 35.0'

DEPTH FEET	SYMBOL	SAMPLE TYPE	DESCRIPTION	MC %	LL %	PL %	PI %	-#200 %	swell %	PP TSF
31		100/1.5"	SHALE with sandstone layers, gray, hard (Continued)	27	35	18	17	76		
32			TC @ 30.0' : 50/1.0", 50/0.5"							
33										
34										
35		100/0.5"	TC @ 35.0' : 50/0.3", 50/0.2"	25	33	17	16	74		
36										
37										
38										
39										
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41										
42										
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57										
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60										

NOTES: * Boring collapsed to approximate depth of 20.0 feet below existing grade, upon auger removal

Subsurface Conditions may significantly vary at other site locations

Difficulties may be encountered during construction due to the nature of subsurface formations

LOG OF BORING B-3

PROJECT: Proposed Two Span Bridge on Turner Turnpike Over SH-33, Creek County, Oklahoma — Project No.: OGR-16057

Date Drilled: 4/9/2016 — Location: Approx. Sta. 888+54.00, Approx. 54.0' Lt. of Prop. CL. — Elevation: 840.330'

Depth To Water At Completion: 23.0' — Depth To Water On: 4/10/2016 — Was: Dry*

Drilled By: Rocky — Logger: Shafe — Approximate Completion Depth: 46.0'

DEPTH FEET	SYMBOL	SAMPLE TYPE	DESCRIPTION	MC %	LL %	PL %	PI %	-#200 %	swell %	PP TSF
1–5			6.0" Grass and topsoil SANDY LEAN CLAY (CL) with iron stains and roots, brown , stiff							
6–10		4/6" 6/6" 7/6"		16 17	26 29	15 15	11 14	67 63		
11–15		4/6" 6/6" 6/6"	SILTY SAND (SM), light brown, medium to dense	13	NP	NP	NP	36		
16–20		50/3" 100/0.3"	SANDY SHALE, yellowish brown, moderately hard to hard TC @ 16.0' : 50/0.2", 50/0.1"	14	24	13	11	60		
21–25		100/1.3"	SANDY SILTY SHALE, yellowish brown, hard TC @ 21.0' : 50/1.0", 50/0.3"	14	21	14	7	58		
26–30		100/1.0"	TC @ 26.0' : 50/0.8", 50/0.2"	16	18	13	5	50		

NOTES: * Boring collapsed to approximate depth of 8.0 feet below existing grade, upon auger removal

Subsurface Conditions may significantly vary at other site locations

Difficulties may be encountered during construction due to the nature of subsurface formations

LOG OF BORING B-3

PROJECT: Proposed Two Span Bridge on Turner Turnpike Over SH-33, Creek County, Oklahoma — Project No.: OGR-16057

Date Drilled: 4/9/2016 — Location: Approx. Sta. 888+54.00, Approx. 54.0' Lt. of Prop. CL. — Elevation: 840.330'

Depth To Water At Completion: 23.0' — Depth To Water On: 4/10/2016 — Was: Dry*

Drilled By: Rocky — Logger: Shafe — Approximate Completion Depth: 46.0'

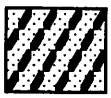
DEPTH FEET	SYMBOL	SAMPLE TYPE	DESCRIPTION	MC %	LL %	PL %	PI %	-#200 %	swell %	PP TSF
31			SANDY SILTY SHALE, yellowish brown, hard (Continued)							
32		100/1.0"		14	NP	NP	NP	41		
33			SILTY SANDSTONE, yellowish brown, hard							
34			TC @ 31.0' : 50/0.8", 50/0.2"							
35										
36										
37		100/0.5"	SILTY SHALEY SANDSTONE, yellowish brown and light gray, hard to moderately hard	14	20	14	6	48		
38										
39										
40			TC @ 36.0' : 50/0.3", 50/0.2"							
41										
42		100/2.0"	SILTY SHALEY SANDSTONE, yellowish brown, moderately hard to hard	18	19	14	5	48		
43										
44			TC @ 41.0' : 50/1.0", 50/1.0"							
45										
46										
47		100/1.0"	SANDY SHALE, gray, hard	20	24	15	9	68		
48			TC @ 46.0' : 50/0.5", 50/0.5"							
49										
50										
51										
52										
53										
54										
55										
56										
57										
58										
59										
60										

NOTES: * Boring collapsed to approximate depth of 8.0 feet below existing grade, upon auger removal

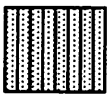
Subsurface Conditions may significantly vary at other site locations

Difficulties may be encountered during construction due to the nature of subsurface formations

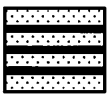
KEY TO SYMBOLS & PATTERNS USED ON BORING LOGS

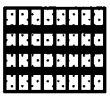

Sandy Lean Clay

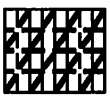

Lean Clay

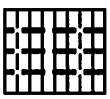

Silty Sand


Shale


Sandy Shale


Sandy Silty Shale


Silty Shaley Sandstone


Silty Sandstone


Standard Penetration Test

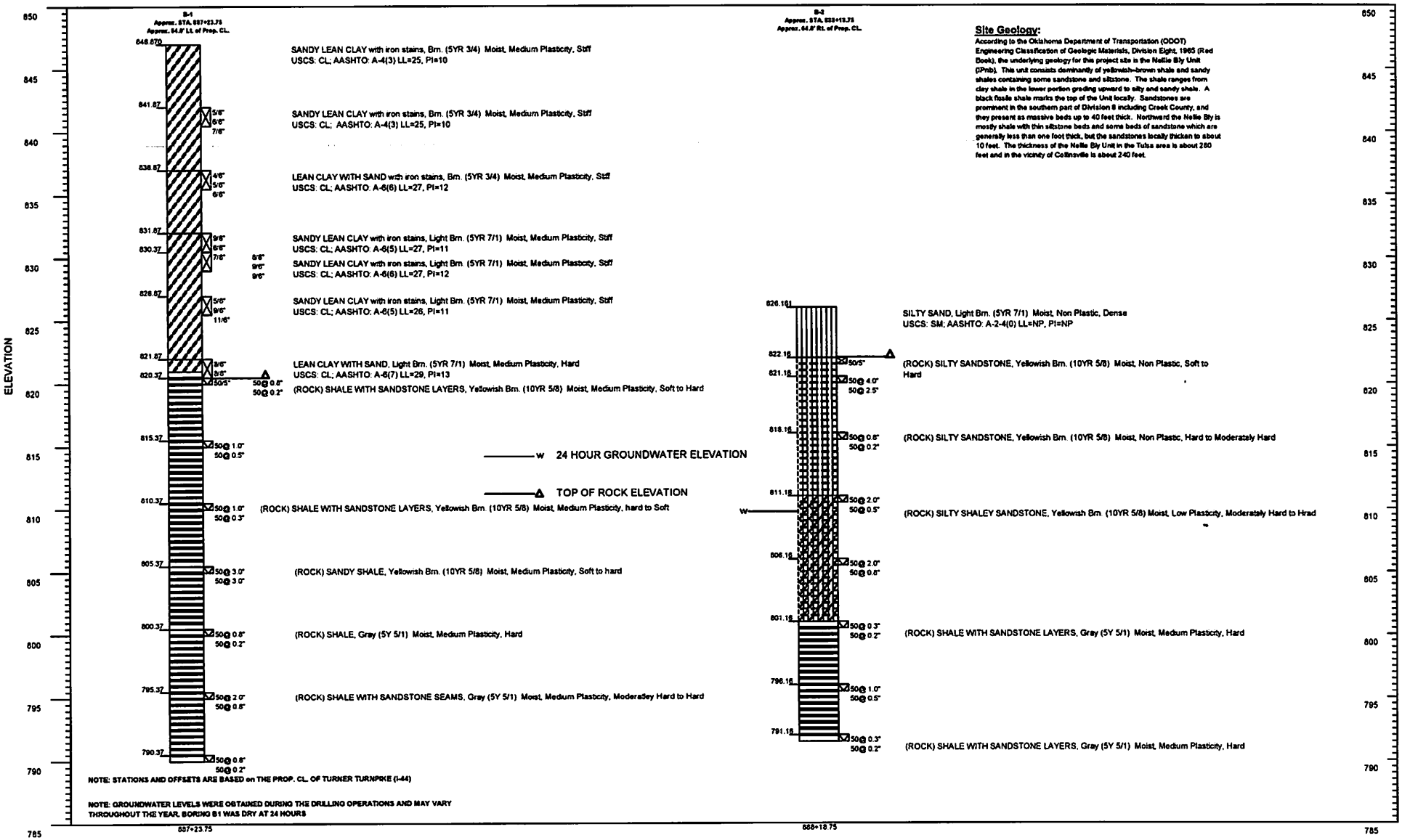
Bag Sample


Texas Cone Penetrometer Test

ABBREVIATIONS USED

MC, %	Moisture Content expressed in percentage
LL, %	Liquid Limit expressed in percentage
PI, %	Plasticity Index expressed in percentage
DD, PCF	Dry Density expressed in pounds per cubic feet
-#200, %	Soil Fraction Passing No. 200 Sieve expressed in percentage
swell, %	Free swell under overburden pressure expressed in percentage
PP, TSF	Pocket Penetrometer Reading expressed in tons per square feet

Proposed Two Span Bridge on Turner Turnpike Over SH-33, Creek County, Oklahoma



Site Geology:

According to the Oklahoma Department of Transportation (ODOT) Engineering Classification of Geologic Materials, Division Eight, 1965 (Red Book), the underlying geology for this project site is the Nellie Bly Unit (IPnb). This unit consists dominantly of yellowish-brown shale and sandy shales containing some sandstone and siltstone. The shale ranges from clay shale in the lower portion grading upward to silty and sandy shale. A black fissile shale marks the top of the Unit locally. Sandstones are prominent in the southern part of Division 8 including Creek County, and they present as massive beds up to 40 feet thick. Northward the Nellie Bly is mostly shale with thin siltstone beds and some beds of sandstone which are generally less than one foot thick, but the sandstones locally thicken to about 10 feet. The thickness of the Nellie Bly Unit in the Tulsa area is about 280 feet and in the vicinity of Collinsville is about 240 feet.

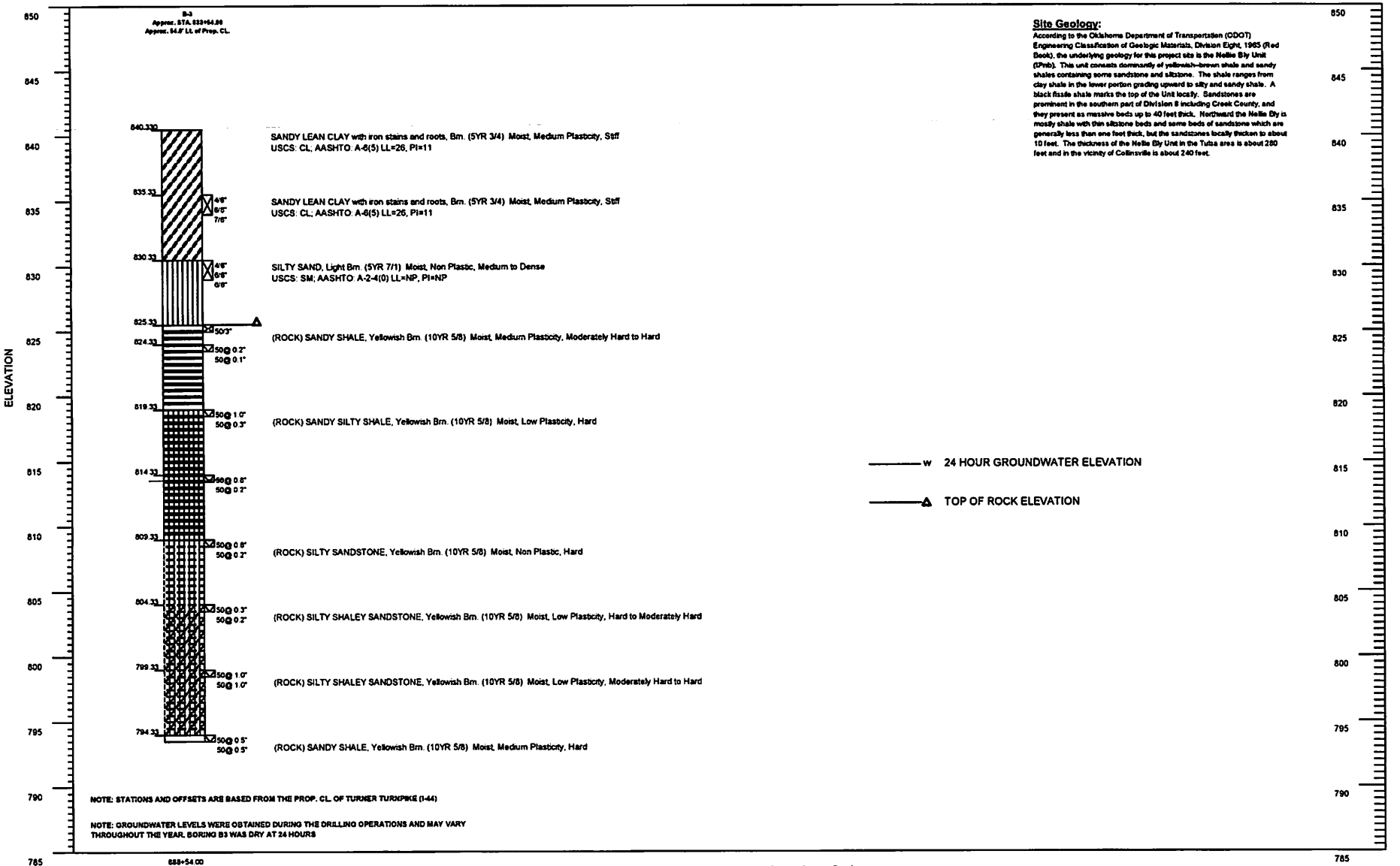
NOTE: STATIONS AND OFFSETS ARE BASED on THE PROP. CL. OF TURNER TURNPIKE (I-44)

NOTE: GROUNDWATER LEVELS WERE OBTAINED DURING THE DRILLING OPERATIONS AND MAY VARY THROUGHOUT THE YEAR. BORING B1 WAS DRY AT 24 HOURS

METCO

FIGURE 9-A

Proposed Two Span Bridge on Turner Turnpike Over SH-33, Creek County, Oklahoma



Site Geology:

According to the Oklahoma Department of Transportation (ODOT) Engineering Classification of Geologic Materials, Division Eight, 1965 (Red Book), the underlying geology for this project site is the Nellie Bly Unit (IPnb). This unit consists dominantly of yellowish–brown shale and sandy shales containing some sandstone and siltstone. The shale ranges from clay shale in the lower portion grading upward to silty and sandy shale. A black fissile shale marks the top of the Unit locally. Sandstones are prominent in the southern part of Division 8 including Creek County, and they present as massive beds up to 40 feet thick. Northward the Nellie Bly is mostly shale with thin siltstone beds and some beds of sandstone which are generally less than one foot thick, but the sandstones locally thicken to about 10 feet. The thickness of the Nellie Bly Unit in the Tulsa area is about 280 feet and in the vicinity of Collinsville is about 240 feet.

NOTE: STATIONS AND OFFSETS ARE BASED FROM THE PROP. CL. OF TURNER TURNPIKE (I-44)

NOTE: GROUNDWATER LEVELS WERE OBTAINED DURING THE DRILLING OPERATIONS AND MAY VARY THROUGHOUT THE YEAR. BORING B3 WAS DRY AT 24 HOURS

METCO

FIGURE 9-B

SUMMARY OF TESTS IN THE OVERBURDEN AND BEDROCK

Project Name: Proposed Two Span Bridge on Turner Turnpike Over SH-33, Creek County, Oklahoma

METCO Project No: OGR-16057

Date: 4/22/2016

IDENTIFICATION		SOIL SURVEY			PHYSICAL & MECHANICAL ANALYSIS											
BORING NO:	SAMPLE DEPTH	N Blows/Ft	TCP inch/100 Blows	SOIL DESCRIPTION	LL	PL	PI	M%	PERCENT PASSING				AASHTO	OSI	USCS	PH
									#4	#10	#40	#200				
B-1	5.0	13	-	Sandy Lean Clay	25	15	10	14	100	100	97	60	A-4 (3)	7	CL	-
	10.0	11	-	Lean Clay with Sand	27	15	12	17	100	100	96	71	A-6 (6)	10	CL	-
	15.0	13	-	Sandy Lean Clay	27	16	11	15	100	100	93	68	A-6 (5)	9	CL	-
	16.5	18	-	Sandy Lean Clay	27	15	12	14	100	100	96	69	A-6 (6)	10	CL	-
	20.0	20	-	Sandy Lean Clay	26	15	11	16	100	100	96	66	A-6 (5)	8	CL	-
	25.0	-	-	Lean Clay with Sand	29	16	13	16	100	100	95	73	A-6 (7)	11	CL	-
	26.5	-	1.0"	Shale with Sandstone layers	-	-	-	-	-	-	-	-	-	-	-	-
	31.5	-	1.5"	Shale with Sandstone layers	-	-	-	-	-	-	-	-	-	-	-	-
	36.5	-	1.3"	Shale with Sandstone layers	-	-	-	-	-	-	-	-	-	-	-	-
	41.5	-	6.0"	Sandy Shale	22	14	8	22	100	100	98	56	-	-	-	-
	46.5		1.0"	Shale	39	18	21	21	100	100	99	96	-	-	-	-
	51.5		2.8"	Shale	-	-	-	-	-	-	-	-	-	-	-	-
	56.5		1.0"	Shale	-	-	-	-	-	-	-	-	-	-	-	-

FIGURE 10

SUMMARY OF TESTS IN THE OVERBURDEN AND BEDROCK

Project Name: Proposed Two Span Bridge on Turner Turnpike Over SH-33, Creek County, Oklahoma

METCO Project No: OGR-16057

Date: 4/22/2016

IDENTIFICATION		SOIL SURVEY			PHYSICAL & MECHANICAL ANALYSIS											
BORING NO:	SAMPLE DEPTH	N Blows/Ft	TCP inch/100 Blows	SOIL DESCRIPTION	LL	PL	PI	M%	PERCENT PASSING				AASHTO	OSI	USCS	PH
									#4	#10	#40	#200				
B-2	4.0	50/5"	-	Silty Sandstone	NP	NP	NP	-	-	-	-	-	-	-	-	-
	5.0	-	6.5"	Silty Sandstone	NP	NP	NP	10	100	100	100	30	-	-	-	-
	10.0	-	1.0"	Silty Sandstone	NP	NP	NP	14	100	100	96	42	-	-	-	-
	15.0	-	2.5"	Silty Shaley Sandstone	20	14	6	13	100	100	97	46	-	-	-	-
	20.0	-	2.8"	Silty Shaley Sandstone	18	4	4	31	100	100	100	37	-	-	-	-
	25.0	-	0.5"	Shale with Sandstone Layers	31	16	15	29	100	100	95	81	-	-	-	-
	30.0	-	1.5"	Shale with Sandstone Layers	35	18	17	27	100	100	84	76	-	-	-	-
	35.0		0.5"	Shale with Sandstone Layers	33	17	16	25	100	100	86	74				

FIGURE 11

SUMMARY OF TESTS IN THE OVERBURDEN AND BEDROCK

Project Name: Proposed Two Span Bridge on Turner Turnpike Over SH-33, Creek County, Oklahoma

METCO Project No: OGR-16057

Date: 4/22/2016

IDENTIFICATION		SOIL SURVEY			PHYSICAL & MECHANICAL ANALYSIS											
BORING NO:	SAMPLE DEPTH	N Blows/Ft	TCP inch/100 Blows	SOIL DESCRIPTION	LL	PL	PI	M%	PERCENT PASSING				AASHTO	OSI	USCS	PH
									#4	#10	#40	#200				
B-3	5.0	13	-	Sandy Lean Clay	26	15	11	16	100	100	84	67	A-6 (5)	9	CL	-
	10.0	12	-	Silty Sand	NP	NP	NP	13	100	100	99	36	A-2-4 (0)	0	SM	-
	15.0	50/3"	-	Sandy Shale	NP	NP	NP	14	100	100	99	60	-	-	-	-
	16.0	-	0.3"	Sandy Shale	24	13	11	14	100	100	100	60	-	-	-	-
	21.0	-	1.3"	Sandy Silty Shale	21	14	7	14	100	100	100	58	-	-	-	-
	26.0	-	1.0"	Sandy Silty Shale	18	13	5	16	100	100	99	50	-	-	-	-
	31.0	-	1.0"	Silty Sandstone	NP	NP	NP	14	100	100	100	41	-	-	-	-
	36.0	-	0.5"	Silty Shaley Sandstone	20	14	6	14	100	100	100	48	-	-	-	-
	41.0	-	2.0"	Silty Shaley Sandstone	19	14	5	18	100	100	100	48	-	-	-	-
	46.0	-	1.0"	Sandy Shale	24	15	9	20	100	100	100	68	-	-	-	-

FIGURE 12

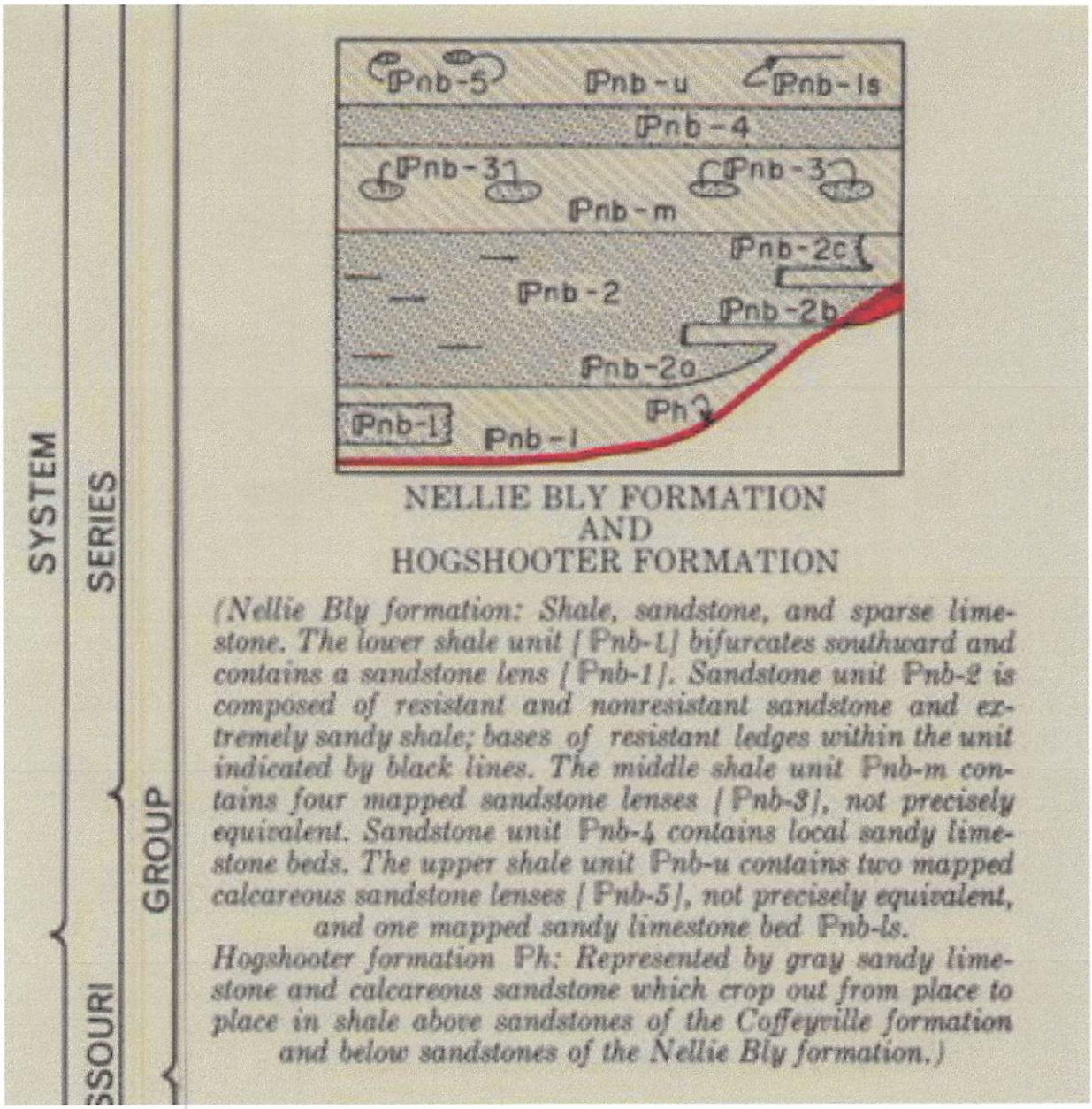


Figure 13. Profile and brief description of the Nellie Bly Formation; note the Hogshooter Formation underlies the Nellie Bly Formation.