Oklahoma City
Water Utilities Trust

WM-0342 & WM-0343
Lake Atoka Road Rehabilitation
Preliminary Engineering Report

April 2023

Submitted By:

Poe & Associates, Inc.
Consulting Engineers

THE OKLAHOMA CITY WATER UTILITIES TRUST

APPROVAL SHEET

OCWUT Project Nos. WM-0342 & WM-0343
Atoka Lake Road Rehabilitation
Lake Atoka

Prepared by:

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4/11/2023

Todd Cochran
Todd Cochran, P.E., Project Engineer

Recommended for Approval

Utilities Engineering

Chris Browning
Chris Browning, General Manager

Debbie Miller
Eric J. Wenger, P.E., City Engineer

APPROVED by the Trustees and signed by the Chairman of the Oklahoma City Water Utilities Trust this 9TH day of MAY, 2023.

ATTEST:

Amy K. Simpson
SECRETARY

CHAIRMAN

CONCURRED by the Council and signed by the Mayor of the City of Oklahoma City this 23RD day of MAY, 2023.

ATTEST:

Amy K. Simpson
CITY CLERK

VICE- MAYOR

PRELIMINARY ENGINEERING REPORT

OKLAHOMA CITY WATER UTILITIES TRUST

PROJECTS WM-0342 & WM-0343, LAKE ATOKA ROAD REHABILITATION

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EXECUTIVE SUMMARY

Scope

The Oklahoma City Water Utilities Trust (OCWUT) desires to improve the four miles of asphalt road along the east and south side of Lake Atoka Reservoir near Stringtown, OK. Project WM-0342 includes two miles of road from the Lake Atoka Reservoir dam south to US-69, and project WM-0343 includes two miles of road from the dam north to the north connection to US-69. The existing asphalt road is two 12-foot lanes without shoulder.

The 4 miles of pavement along these two projects has deteriorated extensively due to the poor base material on which the pavement was constructed and also due to the thin depth of asphalt pavement originally constructed. Intermittent patches of missing asphalt are evidence of the deterioration along project WM-0342. Extensive longitudinal cracking of the existing pavement is evidence of deterioration along project WM-0343. Photos of these deteriorated areas are included in the Appendix.

Projects WM-0342 and WM-0343 will replace the existing pavement surface with either asphalt or concrete and improve the base on which the pavement is built.

Budget

The fixed limit of construction for each project WM-0342 and WM-0343 is $2,500,000. The estimated construction cost for WM-0342 is $3,467,000 and $3,330,600 for WM-0343. No right-of-way or utility relocations are anticipated for either of these projects.

Schedule

Final Plans Completion Date: September 2023
Begin Construction Date: March 2024
Construction Completion Date: October 2024

Recommendations

Solutions investigated for these projects concentrated on removing some of the poor, unstable material under the existing pavement and replacing it with aggregate to provide a better base material for a new pavement surface. A life cycle cost analysis was performed to determine if the new pavement should be concrete or asphalt from a cost perspective. The analysis found that asphalt is the least cost alternative over the life of the pavement.

Four alternatives were developed for the project including combinations of base depths (6 inches or 12 inches) and pavement types (P.C concrete and asphalt). For both projects WM-0342 and WM-0343, it is recommended that the projects be improved with a six-inch depth of new aggregate base material and surfaced with six inches of asphalt pavement.

The existing pavement will not be removed but will be pulverized in place and used as a subbase below the placement of the new aggregate base. Pulverizing the existing pavement will save the cost of hauling new material to the site and will provide a good base for the new aggregate and pavement. Damaged guardrail will also be replaced. No utility relocation and no new right-of-way is anticipated for either project.

PROJECT LOCATION MAPS

PROJECT WM-0342 LOCATION MAP

PROJECT WM-0343 LOCATION MAP

SECTION 1 – PURPOSE AND BACKGROUND AND EXISTING CONDITIONS

Purpose and Background

The Oklahoma City Water Utilities Trust (OCWUT) desires to improve four miles of asphalt road along the south end of Lake Atoka Reservoir near Stringtown, OK. Project WM-0342 includes two miles of road from the Lake Atoka Reservoir dam south to US-69, and project WM-0343 includes two miles of road from the dam north to the north connection to US-69. The existing asphalt road is two 12-foot lanes without shoulder. The project will replace the existing pavement with either asphalt or Portland concrete (P.C.) pavement. This report outlines the recommended improvements to rehabilitate the pavement for these two projects.

Existing Conditions

Borings accomplished during the preliminary engineering phase indicate that the existing pavement and base conditions along both projects consist of 2.5 to 7 inches of asphalt on top of either a 6-inch treated subgrade or 6-inch aggregate base. The existing pavement is experiencing significant deterioration. There are extensive patches of asphalt which have disintegrated into loose gravel along project WM-0342. Along much of project WM-0343, longitudinal cracking, several inches in width in some locations, is present.

The area of widest longitudinal cracks present in project WM-0343 occurs where the roadway is closest to the lake. Supplemental geotechnical stability analysis performed in this area concluded there were no stability issues under the roadway or down the slope from the roadway. Geotechnical sampling and analysis determined that the base material for the existing pavement along both projects is generally comprised of soils having high plasticity. These high plasticity, expansive soils are prone to shrink and swell cycles corresponding to exposure to seasonal or prolonged dry and wet weather durations. This shrink/swell process coupled with the shallow existing pavement depths has been determined as the main cause for the deterioration of the roadways throughout both projects.

SECTION 2 – PROJECT DATA ACQUISTION

Utilities

A Call Okie design request was submitted to determine the potential utilities located along the 2 projects. A list of owners was requested from Call Okie. The following is a list of potential utility owners in the project area:

- Enable Gas Trans-Ada
- Enable OK Intra Trans-Ada
- Public Services of OK/AEP
- OKC/Water-Atoka Pipeline
- USIC/Dobson/OneNet
- Cherokee Tele
- OKC/Water&Waste
- Centerpoint Energy

- Atoka City of
- AT&T Distribution
- Windstream

Overhead utility poles, hydrants, fiber markers, and utility pedestals were all observed in the field. No utility relocation is anticipated to be needed for this project, however coordination with each utility in the above list will take place during final design.

Geotechnical Investigation

Geotechnical field borings and pavement cores were performed to sample pavement thickness and subgrade conditions. Pavement and base recommendations were provided in the two separate reports for WM-0342 and WM-0343. A life cycle cost analysis was performed based on the pavement recommendations. A supplemental Geotech report was conducted to determine if there were global stability issues for about 2,000 feet of extensive longitudinal cracking in a segment of project WM-0343. The following is a summary of Geotech work and reports accomplished.

- Geotechnical field work included the following:
    - Pavement borings at approximately 18 locations along the 4 miles of the project
    - Two deep boring locations – 3 borings at each location
- Geotechnical analysis and recommendations include the following:
    - Pavement design alternatives
    - Pavement life cycle cost
    - Slope stability analysis
- Engineering site visit
- Supplemental borings to investigate stability
- Alternatives estimated construction cost
- Plan and cross section development
- Preliminary engineering report

The following Geotechnical reports have been provided for the project and are included in the Appendix of this report:

- WM-0342 Pavement Design Report, Atoka Lake – North Section, April 8, 2022
- WM-0343 Pavement Design Report, Atoka Lake – South Section, April 8, 2022
- Life Cycle Cost Analysis, April 8, 2022
- WM-0343, Supplemental Report, Atoka Lake – North Section, February 6, 2023

SECTION 3 – ENGINEERING DESIGN

Design Alternatives

Pavement Material Alternatives and Life Cycle Cost Analysis

Recommendations for the pavement alternatives, 6-inch asphalt depth or 5.5-inch P.C. concrete depth were developed from the pavement design portion of the geotechnical analysis.

A life cycle cost analysis was conducted in accordance to the FHWA guidance in Publication FHWA-SA-98-079 "Life Cycle Cost Analysis in Pavement Design." The analysis utilized costs associated with each alternative over a period of 45 years. This 45-year period allows enough time to capture maintenance activities and costs associated for both pavements. The following costs considered in the life cycle cost analysis include:

- Initial construction cost – cost to construct each pavement type based on current unit bid prices
- Maintenance cost
    - Asphalt – cost of mill and overlay at year 20 and year 40
    - Concrete – cost of cleaning and resealing joints, patching, and diamond grinding at year 20 and year 40
- Pavement value at the end of 45 years – value of the pavement after 45 years, expressed as an estimated percentage of initial construction cost

AASHTO Pavement ME software was utilized to estimate performance of the alternatives over the life of the pavements. The initial cost, maintenance costs and remaining service life costs were converted to a Net Present Value to determine costs in today's value of the dollar. The following is a summary of the Net Present Value for the initial construction cost, maintenance cost, and remaining service life:

ALTERNATIVES COST SUMMARY (Net Present Value - 2022 Dollars)		
	Alt 1 – 6" Asphalt, FDR Base	Alt 3 – 5.5" PC Conc, FDR Base
Initial Cost	$605,241	$796,983
Maintenance Cost	$203,584	$251,257
Remaining Service Life	($77,712)	($68,221)
TOTAL Present Worth	$731,112	$980,019
Average Annual Cost	$35,285	$47,298

Over the 45-year life cycle of the two pavements, asphalt was found to have the lowest average annual cost.

Base Material Alternatives

As mentioned in the existing conditions section, the poor base soils that are prone to the shrink and swell process under the pavement are the primary cause of the pavement deterioration. Complete removal of these expansive foundation soils to several feet below the existing pavement is a potential solution but not a cost-effective one. The amount of soil that would need to be removed and replaced would be too extensive and would impact existing utilities in the ground. Two base improvement alternatives were developed that minimize the amount of necessary base material replacement.

The first base improvement alternative proposed is to utilize a geosynthetic moisture barrier in order to maintain the moisture content of the base soils. The moisture barrier would be placed on top of a stabilized subgrade and would prevent the swell and shrink process by preventing moisture from entering or exiting the subgrade and/or the deeper base soils. A 6-inch lift of aggregate base would be placed on top of the moisture barrier and finally topped with the concrete or asphalt surfacing. Application of the moisture barrier is shown in the typical sections.

The second base improvement alternative proposed is to remove approximately 12 inches of the base and replace with 12 inches of aggregate base material. A permeable fabric separator would be placed on top of the stabilized subgrade, followed by the 12 inches of aggregate, then finished with the concrete or asphalt surfacing.

For both alternatives, a rock shoulder would be placed to drain the aggregate base. For the moisture barrier alternative, a perforated underdrain on the hill side of the road would need to be placed where moisture from the drainage ditch may enter into the base material.

Subbase Material

Full-depth reclamation is a process in which the existing pavement is pulverized and combined with the existing base and/or subgrade. Portland cement concrete or lime is added to the blended pavement and base material, then compacted to provide a stable base for the pavement placement.

Full-depth reclamation provides an advantage of utilizing the existing pavement materials in place without having to remove and haul away. Utilizing the reclaimed pavement materials can help to make a good solid base for the new pavement. In addition to eliminating the cost of removal and haul of existing materials away from the site, it also eliminates the cost of new base material and the haul of that material to the site.

Full-depth reclamation is recommended to be utilized and is shown in the typical sections included in the Appendix.

Project Design Alternatives Considered

Alternatives considered for each project, WM-0342 and WM-0343, include a combination of the pavement and base material described above. The alternatives considered include:

Alternative	Pavement	Base
1	6" Asphalt	6" Aggregate Base w/ Moisture Barrier
2	6" Asphalt	12" Aggregate Base (no Moisture Barrier)
3	5.5" P.C. Concrete	6" Aggregate Base w/ Moisture Barrier
4	5.5" P.C. Concrete	12" Aggregate Base (no Moisture Barrier)

Alternative Cost Estimates

Anticipated construction cost estimates were developed for the anticipated bid items associated with the pavement and base alternatives as well as all other ancillary bid items anticipated for the project. A detailed preliminary cost estimate is included in the Appendix and is summarized below:

SUMMARY OF COST ESTIMATES			
WM-0342 - LAKE ATOKA ROAD (SOUTH 2 MILES)			
ALT	**SURFACE**	**BASE**	**COST**
1	ASPHALT	MOISTURE BARRIER + AGGREGATE	$ 3,466,982.82
2	ASPHALT	AGGREGATE ONLY	$ 3,661,318.39
3	P.C. CONCRETE	MOISTURE BARRIER + AGGREGATE	$ 3,623,764.62
4	P.C. CONCRETE	AGGREGATE ONLY	$ 3,818,100.19
WM-0343 - LAKE ATOKA ROAD (NORTH 2 MILES)			
ALT	**SURFACE**	**BASE**	**COST**
1	ASPHALT	MOISTURE BARRIER + AGGREGATE	$ 3,330,590.23
2	ASPHALT	AGGREGATE ONLY	$ 3,475,939.63
3	P.C. CONCRETE	MOISTURE BARRIER + AGGREGATE	$ 3,462,461.83
4	P.C. CONCRETE	AGGREGATE ONLY	$ 3,607,811.23

Recommended Alternative and Improvements

It is recommended that both WM-0342 and WM-0343 project be constructed with 6 inches of asphalt pavement with 6 inches of aggregate base and moisture barrier.

Additional improvements will include replacement of guardrail that is either damaged or needs to be updated to the latest standards.

Right-of-Way

Acquisition of right-of-way is not anticipated for this project.

PHOTOS

WM-0342 Pavement Deterioration

WM-0342 Pavement Deterioration

WM-0342 – Gravel Covered Roadway

WM-0342 Pavement Deterioration

WM-0342 – Gravel Covered Roadway at Dam

WM-0342 – Pavement w/ Longitudinal Cracking


WM-0343 – Longitudinal Cracking


WM-0343 – Longitudinal Cracking


WM-0343 – Widest Longitudinal Cracking


WM-0343 – Widest Longitudinal Cracking

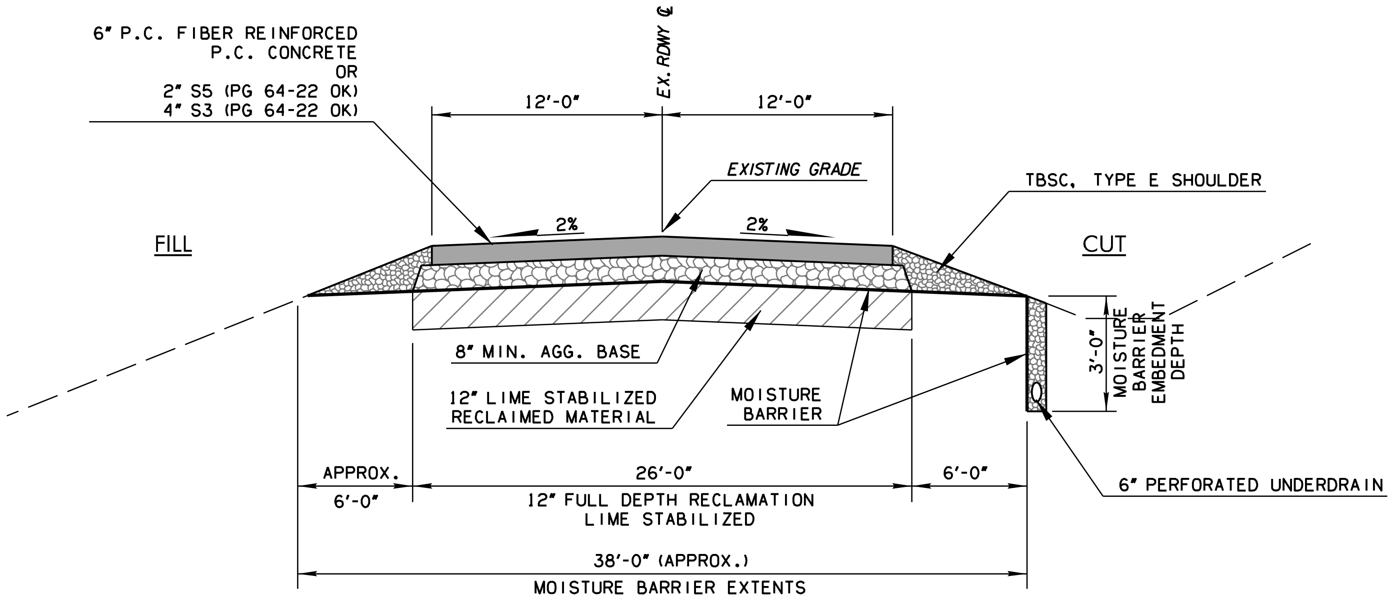

WM-0343 – Widest Longitudinal Cracking

APPENDIX A

ALTERNATIVES TYPICAL SECTIONS

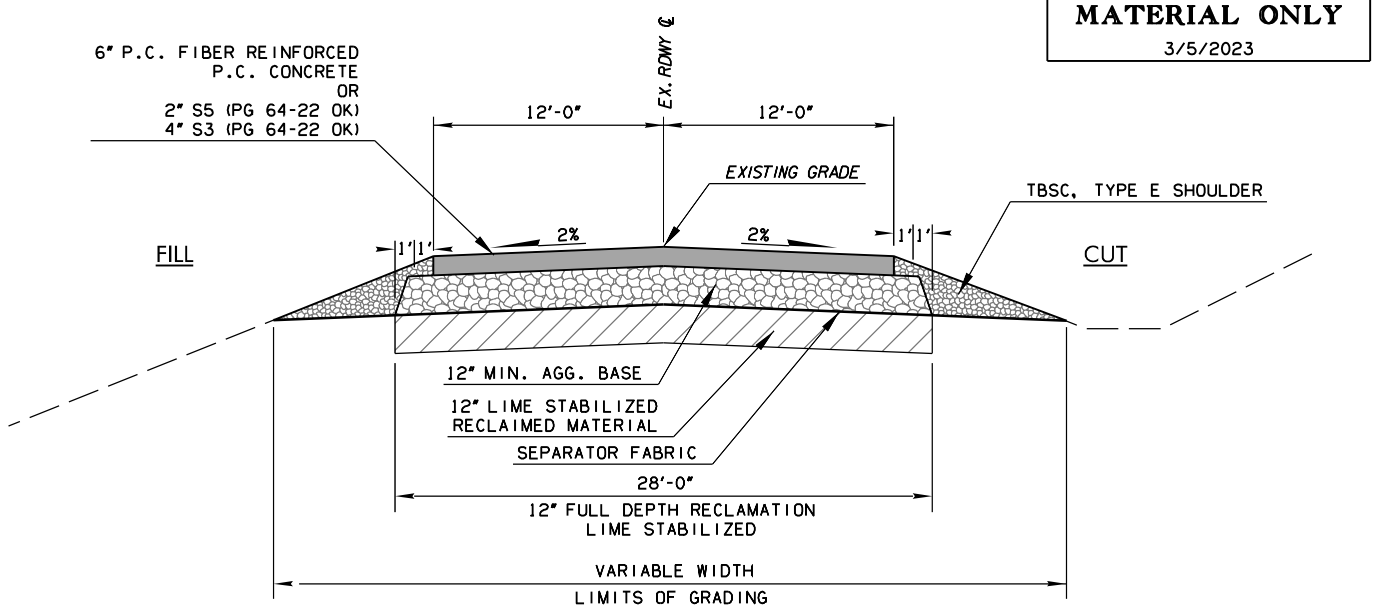
POE & ASSOCIATES, OKLAHOMA CITY, OK.

INFORMATION MATERIAL ONLY
3/5/2023



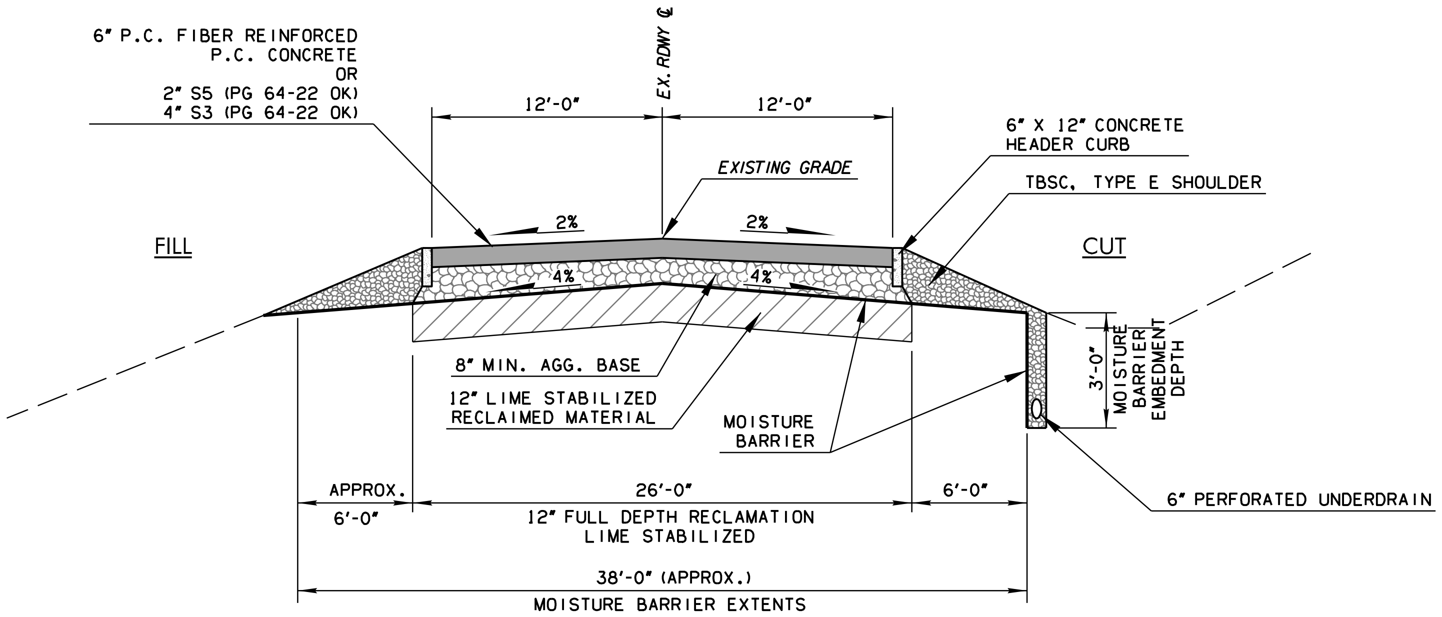
TYPICAL SECTION – ALTERNATIVE 1 – AGG. BASE W/ MOISTURE BARRIER

WM-0342 - ENTIRE PROJECT
WM-0343 - ENTIRE PROJECT EXCLUDING AREA OF HEAVY PAVEMENT DISTRESS



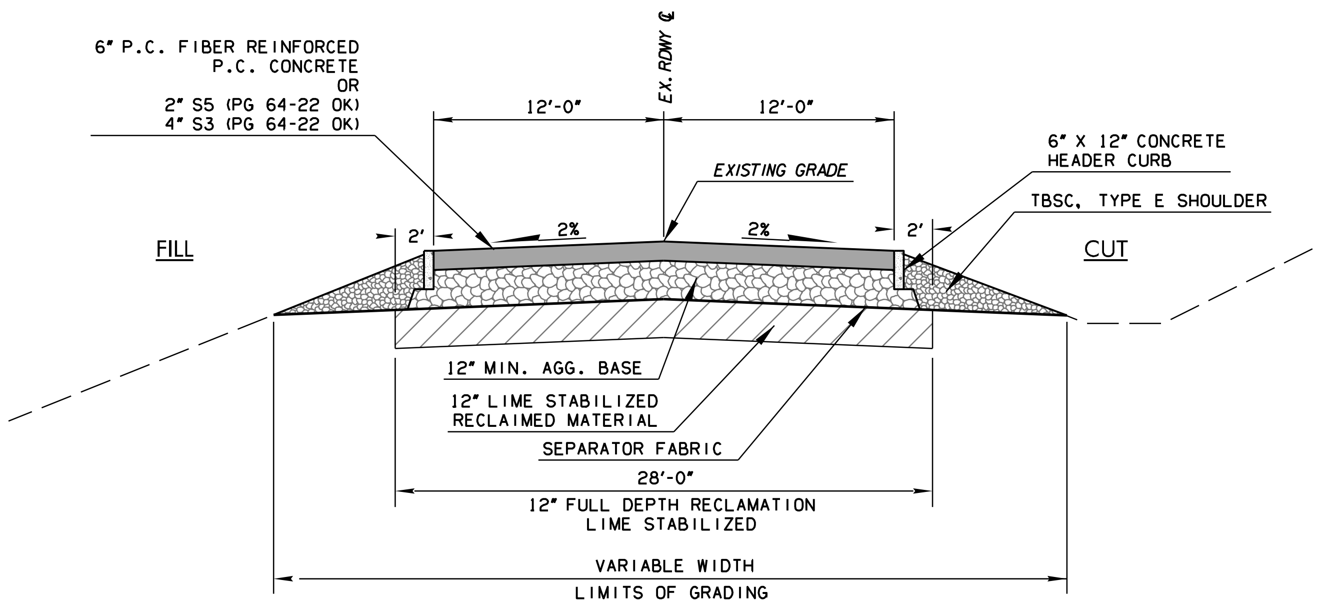
TYPICAL SECTION – ALTERNATIVE 2 – AGGREGATE BASE ONLY

WM-0342 - ENTIRE PROJECT
WM-0343 - ENTIRE PROJECT EXCLUDING AREA OF HEAVY PAVEMENT DISTRESS



TYPICAL SECTION – ALTERNATIVE 1A – AGG. BASE W/ MOISTURE BARRIER W/ HEADER CURB

WM-0342 - ENTIRE PROJECT
WM-0343 - ENTIRE PROJECT EXCLUDING AREA OF HEAVY PAVEMENT DISTRESS



TYPICAL SECTION – ALTERNATIVE 2A – AGGREGATE BASE ONLY W/ HEADER CURB

WM-0342 - ENTIRE PROJECT
WM-0343 - ENTIRE PROJECT EXCLUDING AREA OF HEAVY PAVEMENT DISTRESS

DESIGN	-	-
DRAWN	-	-
CHECKED	-	-
APPROVED	-	-
SQUAD	POE	

TYPICAL SECTION ALTERNATIVES

PROJECT NO. WM-0342 & WM-0343 SHEET NO. 2

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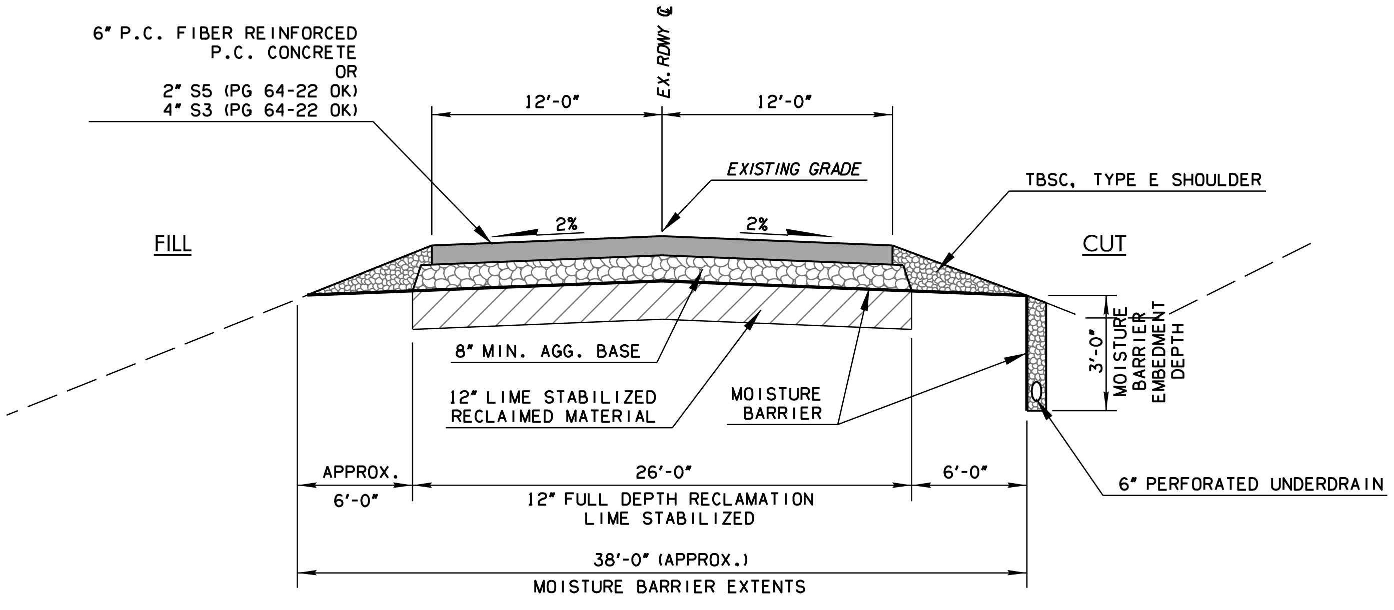
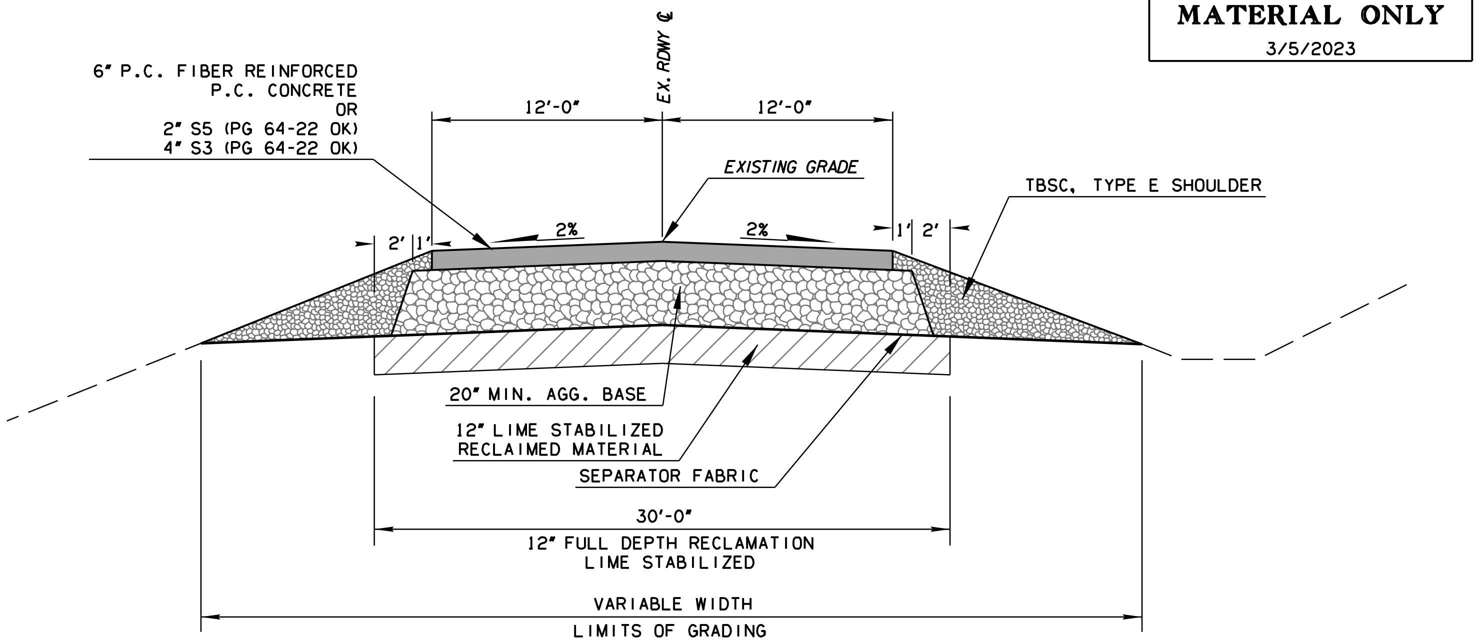
POE & ASSOCIATES, OKLAHOMA CITY, OK.

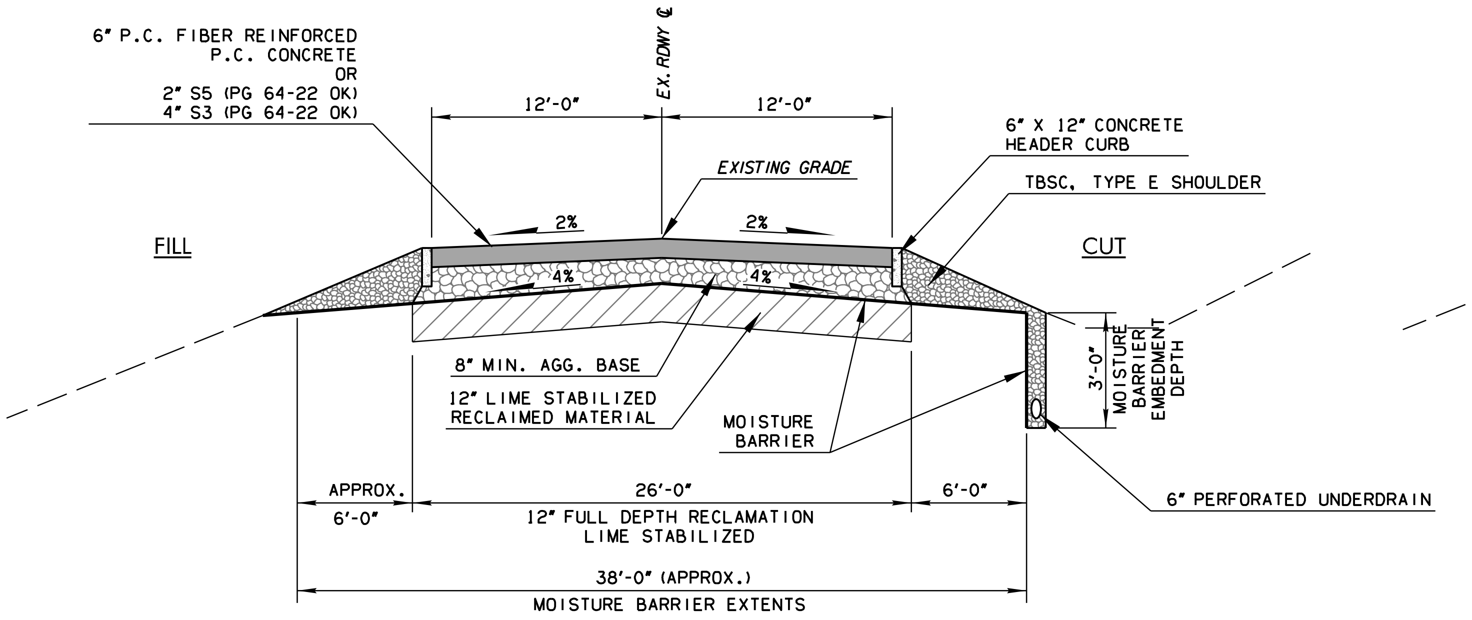
INFORMATION MATERIAL ONLY
3/5/2023



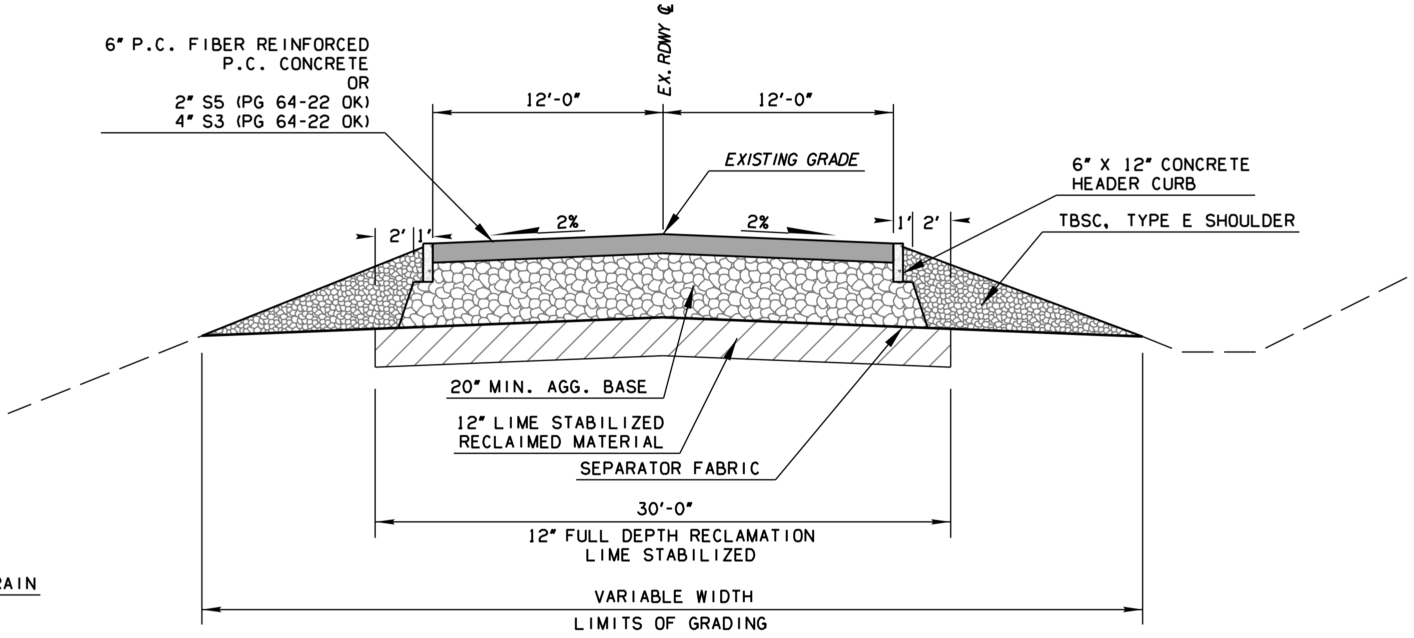
TYPICAL SECTION – ALTERNATIVE 1 – AREA OF HEAVY PAVEMENT DISTRESS
MOISTURE BARRIER OPTION
WM-0343 ONLY - 1000' LENGTH IN AREA OF HEAVY PAVEMENT DISTRESS



TYPICAL SECTION – ALTERNATIVE 2 – AREA OF HEAVY PAVEMENT DISTRESS
DEEP BASE REPLACEMENT
WM-0343 ONLY - 1000' LENGTH IN AREA OF HEAVY PAVEMENT DISTRESS



TYPICAL SECTION – ALTERNATIVE 1A – AREA OF HEAVY PAVEMENT DISTRESS
MOISTURE BARRIER OPTION W/ HEADER CURB
WM-0343 ONLY - 1000' LENGTH IN AREA OF HEAVY PAVEMENT DISTRESS



TYPICAL SECTION – ALTERNATIVE 2 – AREA OF HEAVY PAVEMENT DISTRESS
DEEP BASE REPLACEMENT W/ HEADER CURB
WM-0343 ONLY - 1000' LENGTH IN AREA OF HEAVY PAVEMENT DISTRESS

DESIGN	-	-
DRAWN	-	-
CHECKED	-	-
APPROVED	-	-
SQUAD	POE	

TYPICAL SECTIONS

PROJECT NO. WM-0342 & WM-0343 SHEET NO. 2

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APPENDIX B

PROJECT COST ESTIMATE

ESTIMATE OF PROBABLE CONSTRUCTION COST
WM-0342 WM-0343
LAKE ATOKA ROAD IMPROVEMENTS

					ASPHALT				CONCRETE			
WM-0342 - LAKE ATOKA ROAD (SOUTH 2 MILES)					MOISTURE BARRIER, 6" AGG BASE		12" AGG BASE		MOISTURE BARRIER, 6" AGG BASE		12" AGG BASE	
	BID ITEM	DESCRIPTION	UNIT	UNIT PRICE	QUANTITY	TOTAL ITEM COST	QUANTITY	TOTAL ITEM COST	QUANTITY	TOTAL ITEM COST	QUANTITY	TOTAL ITEM COST
	201(A)1200	CLEARING AND GRUBBING	LSUM	$ 25,000.00	1	$ 25,000.00	1	$ 25,000.00	1	$ 25,000.00	1	$ 25,000.00
	205(A)6200	TYPE A-SALVAGED TOPSOIL	LSUM	$ 16,052.00	1	$ 16,052.00	1	$ 16,052.00	1	$ 16,052.00	1	$ 16,052.00
	221(B)2300	TEMPORARY SILT FENCE	LF	$ 3.00	10401.6	$ 31,204.80	10401.6	$ 31,204.80	10401.6	$ 31,204.80	10401.6	$ 31,204.80
	230(A)7200	SOLID SLAB SODDING	SY	$ 3.00	11557	$ 34,671.00	11557	$ 34,671.00	11557	$ 34,671.00	11557	$ 34,671.00
	311(D)6500	PROCESS EXISTING BASE & SURFACE,METHOD D	LF	$ 7.50	10401.6	$ 78,012.00	10401.6	$ 78,012.00	10401.6	$ 78,012.00	10401.6	$ 78,012.00
	402(E)2600	TRAFFIC BOUND SURFACE COURSE TYPE E	TON	$ 35.00	4291	$ 150,185.00	9096	$ 318,360.00	4291	$ 150,185.00	9096	$ 318,360.00
	623(A)1200	BEAM GUARDRAIL W-BEAM SINGLE	LF	$ 40.00	500	$ 20,000.00	500	$ 20,000.00	500	$ 20,000.00	500	$ 20,000.00
Agg. Base	202(A)2200	UNCLASSIFIED EXCAVATION	CY	$ 12.00	12713	$ 152,556.00	18877	$ 226,524.00	12713	$ 152,556.00	18877	$ 226,524.00
	303(A)1200	AGGREGATE BASE TYPE A	CY	$ 65.00	5586	$ 363,090.00	10787	$ 701,155.00	5586	$ 363,090.00	10787	$ 701,155.00
	307(E)3600	CEMENTITIOUS STABILIZED SUBGRADE	SY	$ 7.50	30049	$ 225,367.50	32361	$ 242,707.50	30049	$ 225,367.50	32361	$ 242,707.50
	325 0100	SEPARATOR FABRIC	SY	$ 1.50			48541	$ 72,811.50			48541	$ 72,811.50
	325 0110	MOISTURE BARRIER MEMBRANE	SY	$ 6.00	48541	$ 291,246.00		$ -	48541	$ 291,246.00		$ -
	426(B)1300	PORTLAND CEMENT	TON	$ 250.00	730	$ 182,500.00	786	$ 196,500.00	730	$ 182,500.00	786	$ 196,500.00
	613(H)6200	6" PERFORATED PIPE UNDERDRAIN ROUND	LF	$ 20.00	10401.6	$ 208,032.00			10401.6	$ 208,032.00		
Asphalt	407(B)7300	TACK COAT	GAL	$ 4.00	4161	$ 16,644.00	4161	$ 16,644.00		$ -		$ -
	411(B)1330	SUPERPAVE, TYPE S3(PG 64-22 OK)	TON	$ 90.00	6213	$ 559,170.00	6213	$ 559,170.00		$ -		$ -
	411(C)1430	SUPERPAVE, TYPE S4(PG 64-22 OK)	TON	$ 120.00	3107	$ 372,840.00	3107	$ 372,840.00		$ -		$ -
	609(C)4410	CONCRETE HEADER CURB (8"X 18")	LF	$ 25.00	20803.2	$ 520,080.00	20803.2	$ 520,080.00		$ -		$ -
Conc	414(A)5200	P.C.CONCRETE PAVEMENT(PLACEMENT)	SY	$ 25.00		$ -		$ -	27738	$ 693,450.00	27738	$ 693,450.00
	414(G)5800	P.C. CONCRETE FOR PAVEMENT	CY	$ 200.00		$ -		$ -	4623	$ 924,600.00	4623	$ 924,600.00
	641 2110	MOBILIZATION	LSUM		1	$ 187,332.52	1	$ 196,586.59	1	$ 194,798.32	1	$ 204,052.39
	642(B)3300	CONSTRUCTION STAKING LEVEL II	LSUM	$ 25,000.00	1	$ 25,000.00	1	$ 25,000.00	1	$ 25,000.00	1	$ 25,000.00
	220 1100	SWPPP DOCUMENTATION AND MANAGEMENT	LSUM	$ 8,000.00	1	$ 8,000.00	1	$ 8,000.00	1	$ 8,000.00	1	$ 8,000.00
					TOTAL	**$ 3,466,982.82**	**TOTAL**	**$ 3,661,318.39**	**TOTAL**	**$ 3,623,764.62**	**TOTAL**	**$ 3,818,100.19**

					ASPHALT				CONCRETE			
WM-0343 - LAKE ATOKA ROAD (NORTH 2 MILES)					MOISTURE BARRIER, 6" AGG BASE		12" AGG BASE		MOISTURE BARRIER, 6" AGG BASE		12" AGG BASE	
	BID ITEM	DESCRIPTION	UNIT		QUANTITY	TOTAL ITEM COST	QUANTITY	TOTAL ITEM COST	QUANTITY	TOTAL ITEM COST	QUANTITY	TOTAL ITEM COST
	201(A)1200	CLEARING AND GRUBBING	LSUM	$ 25,000.00	1	$ 25,000.00	1	$ 25,000.00	1	$ 25,000.00	1	$ 25,000.00
	205(A)6200	TYPE A-SALVAGED TOPSOIL	LSUM	$ 15,074.00	1	$ 15,074.00	1	$ 15,074.00	1	$ 15,074.00	1	$ 15,074.00
	221(B)2300	TEMPORARY SILT FENCE	LF	$ 3.00	9768	$ 29,304.00	9768	$ 29,304.00	9768	$ 29,304.00	9768	$ 29,304.00
	230(A)7200	SOLID SLAB SODDING	SY	$ 3.00	10853	$ 32,559.00	10853	$ 32,559.00	10853	$ 32,559.00	10853	$ 32,559.00
	311(D)6500	PROCESS EXISTING BASE & SURFACE,METHOD D	LF	$ 7.50	9768	$ 73,260.00	9768	$ 73,260.00	9768	$ 73,260.00	9768	$ 73,260.00
	402(E)2600	TRAFFIC BOUND SURFACE COURSE TYPE E	TON	$ 35.00	4029	$ 141,015.00	8542	$ 298,970.00	4029	$ 141,015.00	8542	$ 298,970.00
	623(A)1200	BEAM GUARDRAIL W-BEAM SINGLE	LF	$ 40.00	1000	$ 40,000.00	1000	$ 40,000.00	1000	$ 40,000.00	1000	$ 40,000.00
Agg. Base	202(A)2200	UNCLASSIFIED EXCAVATION	CY	$ 12.00	11939	$ 143,268.00	17727	$ 212,724.00	11939	$ 143,268.00	17727	$ 212,724.00
	303(A)1200	AGGREGATE BASE TYPE A	CY	$ 65.00	5788	$ 376,220.00	10130	$ 658,450.00	5788	$ 376,220.00	10130	$ 658,450.00
	307(E)3600	CEMENTITIOUS STABILIZED SUBGRADE	SY	$ 7.50	28219	$ 211,642.50	30389	$ 227,917.50	28219	$ 211,642.50	30389	$ 227,917.50
	325 0100	SEPARATOR FABRIC	SY	$ 1.50			45584	$ 68,376.00			45584	$ 68,376.00
	325 0110	MOISTURE BARRIER MEMBRANE	SY	$ 6.00	45584	$ 273,504.00		$ -	45584	$ 273,504.00		$ -
	426(B)1300	PORTLAND CEMENT	TON	$ 250.00	686	$ 171,500.00	738	$ 184,500.00	686	$ 171,500.00	738	$ 184,500.00
	613(H)6200	6" PERFORATED PIPE UNDERDRAIN ROUND	LF	$ 20.00	9768	$ 195,360.00			9768	$ 195,360.00		
Asphalt	407(B)7300	TACK COAT	GAL	$ 4.00	3907	$ 15,628.00	3907	$ 15,628.00		$ -		$ -
	411(B)1330	SUPERPAVE, TYPE S3(PG 64-22 OK)	TON	$ 95.00	5835	$ 554,325.00	5835	$ 554,325.00		$ -		$ -
	411(C)1430	SUPERPAVE, TYPE S4(PG 64-22 OK)	TON	$ 115.00	2917	$ 335,455.00	2917	$ 335,455.00		$ -		$ -
	609(C)4410	CONCRETE HEADER CURB (8"X 18")	LF	$ 25.00	19536	$ 488,400.00	19536	$ 488,400.00		$ -		$ -
Conc	414(A)5200	P.C.CONCRETE PAVEMENT(PLACEMENT)	SY	$ 25.00		$ -		$ -	26048	$ 651,200.00	26048	$ 651,200.00
	414(G)5800	P.C. CONCRETE FOR PAVEMENT	CY	$ 200.00		$ -		$ -	4341	$ 868,200.00	4341	$ 868,200.00
	641 2110	MOBILIZATION	LSUM		1	$ 181,075.73	1	$ 187,997.13	1	$ 187,355.33	1	$ 194,276.73
	642(B)3300	CONSTRUCTION STAKING LEVEL II	LSUM	$ 20,000.00	1	$ 20,000.00	1	$ 20,000.00	1	$ 20,000.00	1	$ 20,000.00
	220 1100	SWPPP DOCUMENTATION AND MANAGEMENT	LSUM	$ 8,000.00	1	$ 8,000.00	1	$ 8,000.00	1	$ 8,000.00	1	$ 8,000.00
					TOTAL	**$ 3,330,590.23**	**TOTAL**	**$ 3,475,939.63**	**TOTAL**	**$ 3,462,461.83**	**TOTAL**	**$ 3,607,811.23**

APPENDIX C

GEOTECHNICAL REPORTS

Pavement Design Report

Lake Access Road Improvements
Atoka Lake – South Section
Near Stringtown, Oklahoma
April 8, 2022
Terracon Project No. 03215254

Prepared for:
Poe and Associates, Inc.
Oklahoma City, Oklahoma

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

April 8, 2022

Poe and Associates, Inc.
1601 Northwest Expressway, Suite 400
Oklahoma City, Oklahoma 73118

Attn: Mr. Todd Cochran, P.E.
P: [405] 949 1962
F: [405] 608 0380
E: Todd.Cochran@poeandassociates.com

Re: Pavement Design Report
Lake Access Road Improvements
Atoka Lake – South Section
Near Stringtown, Oklahoma
Terracon Project No. 03215254

Dear Mr. Cochran:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. These services were performed in general accordance with our Proposal No. P03215254 dated November 17, 2021. This geotechnical engineering report presents the results of the subsurface exploration and provides recommendations for the pavement typical sections and subgrade preparations for the proposed project.

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. 6/30/23

Jeff Dean, P.E.	Norman K. Tan, Ph.D., P.E.
Oklahoma No. 16998	Geotechnical Manager

JD:NT\kld\n:\projects\2021\03215254\project documents\apr2022

Copies to: Addressee (1 via email)

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TABLE OF CONTENTS - (Cont'd.)

APPENDIX A - FIELD EXPLORATION

APPENDIX B - LABORATORY TESTING

APPENDIX C - SUPPORTING DOCUMENTS

EXECUTIVE SUMMARY

A geotechnical exploration has been performed for the planned rehabilitation of the lake access roads along the east shoreline of Atoka Lake near Stringtown, Oklahoma. This report covers the south section which includes approximately two miles of pavement extending south from the dam. The scope of Terracon's field investigation includes evaluating the pavement at ten locations. This evaluation included coring the pavement and hand augered borings approximately 36 inches deep at each location. The scope also included testing the subgrade stiffness with a Kessler dynamic cone penetrometer (DCP).

The following conditions are indicated by our subsurface exploration:

- Soils encountered in, and extending to the bottom, of the hand augered borings consisted of moderate to high plasticity lean to fat clays with varying amounts of sand and occasional gravels. Auger refusal was encountered at a depth of approximately 15 inches in boring B-6.

- A surface layer of chemically treated subgrade, approximately 6 inches thick, was encountered in six of the ten borings.

- The existing pavement was asphalt nine of the ten locations and ranged in thickness from 2-1/2 to 5-1/8 inches. The road surface at boring B-6 was crushed aggregate.

- The DCP values provide an indication of the stiffness of the subgrade soil profile. The DCP plots generally indicate a stiffer upper layer in 5 of the 6 borings where chemical stabilization was indicated. The stiffness of the subgrade generally decreased below this stiffer upper layer in 7 of the borings. Refusal with the DCP was reached at depths of approximately 16, 13 and 31 inches at borings B-6, B-8 and B-10 respectively.

- Groundwater was not encountered in any of the borings during our field investigation.

- The moisture contents of the soils samples retrieved from each hand augered boring were generally at or well above the soil's plastic limit in several of the borings. This is the moisture content at which a clayey soil can be molded and begins to lose strength.

This geotechnical executive summary should be used in conjunction with the entire report for design and/or construction purposes. It should be recognized that specific details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled General Comments should be read for an understanding of the report limitations.

PAVEMENT DESIGN REPORT
LAKE ACCESS ROAD IMPROVEMENTS
ATOKA LAKE – SOUTH SECTION
NEAR STRINGTOWN, OKLAHOMA

Terracon Project No. 03215254
April 8, 2022

1.0 INTRODUCTION

This report presents the results of our geotechnical engineering services performed for the proposed rehabilitation of the lake access roads along the east shoreline of Atoka Lake near Stringtown, Oklahoma. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- subgrade strength values for pavement design
- groundwater conditions
- earthwork
- pavement typical sections

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Site layout	See Appendix A, Exhibits A-1 to A-4
Proposed development	The project will involve the rehabilitation of the lake access roads along the east shoreline of Atoka Lake near Stringtown, Oklahoma.
Grading	Grade changes for the proposed new construction are not anticipated.
Traffic loading	A traffic estimate of 1,000 vehicles per day including occasional trucks was provided for development of the pavement designs.

3.0 SUBSURFACE CONDITIONS

3.1 Pavement Cores

Ten pavement cores were collected from the existing pavement for evaluation. The pavement cores were 6 inches in diameter and penetrated the bound layers of the pavement. A diamond impregnated core barrel was used to cut the cores. Water was used to flush cuttings to the surface and cool the core barrel. Subgrade soil samples were also retrieved for laboratory testing. After collecting the pavement cores and subgrade samples, the core locations were backfilled with similar materials.

An engineer examined each of the pavement cores in the laboratory to evaluate the thickness and condition of each pavement layer. The cores were observed for the presence of stripping, deterioration, and layer separation in the asphaltic concrete.

The existing pavement was full depth asphalt was at nine of the ten locations and ranged in thickness from 2-1/2 to 5-1/8 inches. The road surface at boring B-6 was crushed aggregate. Photographic logs of the pavement cores are presented in Appendix A.

3.2 Subgrade Soils

The subgrade beneath the pavement at each core location was hand augered to a depth of approximately 36 inches. Auger refusal was encountered at a depth of approximately 15 inches in boring B-6. Subgrade soil samples were retrieved from each boring for laboratory testing. After collecting the subgrade samples, the borings were backfilled with similar materials. Stratification boundaries in the boring logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual. Indicator solution tests revealed a surface layer of chemically treated subgrade, approximately 6 inches thick, in six of the ten borings. Based upon the results of the borings, subsurface conditions on the project site can be generalized as follows:

Core Locations C-1 through C-10			
Description	**Approximate Depth to Bottom of Stratum (inches)**	**Material Encountered**	**Consistency/Density**
Stratum 1	6 (borings B-1, B-2, B-3, B-5, B-7, B-9)	Chemically Stabilized subgrade	Moderately stiff to stiff
Stratum 1	8 (boring B-6)	Crushed aggregate	N/A
Stratum 1	Not Determined (Borings B-4, B-8, B-10	Moderate to high plasticity lean to fat clays with varying amounts of sand	Soft to very stiff
Stratum 2	Not Determined (borings B-1, B-2, B-3, B-5, B-7, B-8, B-9)	Moderate to high plasticity lean to fat clays with varying amounts of sand	Soft to very stiff

The laboratory testing program is described in Appendix B. Test results are reported on the boring logs in Appendix A.

As illustrated in the boring logs, the moisture content of the subgrade samples that were tested, generally were at or in some instances well above the plastic limit of the clay soil in many of the borings. This is the moisture content at which a clay soil can be molded and begins to lose strength.

3.3 Subgrade Properties

The subsurface exploration program is described in Appendix A. Specific conditions encountered at each boring location are indicated in the individual boring logs, also included in Appendix A.

The Dynamic Cone Penetration (DCP) test results indicated the stiffness of the subgrade soil profiles along the proposed pavement alignment. California Bearing Ratio, CBR, values developed from the DCP tests are a means of comparing penetration values of soils to that of densely compacted crushed rock. A CBR value of 100 is used as the standard reference to indicate excellent material with resistance and support properties similar to a well graded crushed rock. In general, CBR values used for pavement design are listed in the following table.

CBR	Material
80 to 100	Good quality crushed rock
30 to 60	Chemically stabilized subgrade*
20 to 30	Very good subgrade
10 to 20	Fair to good subgrade
5 to 10	Questionable to fair subgrade
<5	Poor subgrade

* CBR values will vary according to chemical admixture

DCP tests were conducted at all core locations. The DCP values provide an indication of the stiffness of the subgrade soil profile. The DCP plots generally indicate a stiffer upper layer in 5 of the 6 borings where chemical stabilization was indicated. The stiffness of the subgrade generally decreased below this stiffer upper layer in 7 of the borings. Refusal with the DCP was reached at depths of approximately 16, 13 and 31 inches at borings B-6, B-8 and B-10 respectively. Overall, the DCP plots generally indicate subgrade ranging from very soft to very stiff. Plots of the DCP tests at each core location are included in Exhibits A-25 to A-34 in Appendix A.

Subgrade soil samples were obtained from all borings to determine the subgrade parameters for developing the pavement designs. Tests conducted on these samples include classification, gradation, and moisture content. These tests were used to evaluate the subgrade design criteria for the new pavement sections.

The laboratory testing program is described in Appendix B. Test results are reported on the boring logs in Appendix A.

3.4 Groundwater

The borings were monitored while hand augering and immediately after completion for the presence and level of groundwater. Water was not encountered in any of the borings during our investigation.

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 groundwater levels occur due to seasonal variations in the amount of rainfall, runoff, altered natural drainage paths, and other factors not evident at the time the borings were advanced.

4.0 PAVEMENT DESIGN RECOMMENDATIONS

4.1 Pavement Design Parameters

It is our understanding that both flexible and rigid options are to be considered for rehabilitating the pavement for this project. AASHTO Pavement Design software was used to design the overlay for the pavement section. The pavement designs are based upon a 30 year design life.

A bulk sample of the existing subgrade was collected from the borings to perform laboratory moisture/density test and resilient modulus tests to develop the design subgrade parameters required for the pavement designs. A summary of these test results are presented in the following table.

Soil Sample	Resilient Modulus, psi		Max Density/ Opt M.C. pcf / %	AASHTO Class	LL	PI	Passing #200
	OMC	OMC+2%					
Bulk 1	10,927	4,646	108.0 / 17.4	A-7-6(15)	47	21	66.3

Historical resilient modulus test values for highly plastic clay soil types range from 3,500 to 4,500 psi. For the pavement sections, a design resilient modulus value of 4,000 psi was used. The following is a summary of the design parameters used to design the pavement typical sections:

Atoka Lake Access Road – section south of the dam

- Average Annual Daily Traffic, AADT, 1,000
- Percent Trucks, 0.5%
- Directional Distribution, 55%
- Reliability value, 90%
- Design resilient modulus value – 4,000 psi.
- Annual Growth Rate, 2%

The full depth typical sections are based upon a 30-year design life. The design AADT used in the pavement designs include occasional class 9 vehicles and a combination of cars, pickup trucks, school buses, dump trucks, and various types of delivery trucks. If these design traffic parameters are inconsistent with those desired by the client, the revised traffic information should be submitted for our review to evaluate any potential changes to our design recommendations.

4.2 Pavement Typical Section Recommendations

Based upon the parameters listed above, the following pavement sections may be considered for the project.

Flexible Options – 30 Year Design

Option 1

2.0 in. S4 PG 64-22OK
4.0 in. S3 PG 64-22OK
12.0 in. FDR existing pavement and subgrade with lime added to control the expansive soils (Could use PC cement if a mix deign is performed)

Or

2.0 in. S4 PG 64-22OK
4.0 in. S3 PG 64-22OK
8.0 in. AggregateBase Type A – sholder with TBSC type E
8 oz/SY non-woven separator fabric
8.0 in. Stabilized Subgrade[1]

Rigid Options – 30 Year Design

Rigid Option

5.5 in. PC Concrete (recommend fiber reinforce concrete w/ saw joints every 6 ft laterally & longitudinally)
12.0 in. FDR existing pavement and subgrade with lime added to control the expansive soils (Could use PC cement if a mix deign is performed)

Or

5.5 in. PC Concrete (recommend fiber reinforce concrete w/ saw joints every 6 ft laterally & longitudinally)
8.0 in. AggregateBase Type A – sholder with TBSC type E
8 oz/SY non-woven separator fabric
8.0 in. Stabilized Subgrade[1]

Notes:

1 – Per ODOT Specifications 307 - at the rate specified for the appropriate soil classification according to OHD L-50

5.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

5.1 Geotechnical Considerations

The borings generally encountered moderate to high plasticity lean to fat clays with varying amounts of sand. These soils generally have low permeability and will tend to increase in moisture content and decrease in strength over time as the pavement is in service. This is evident by the high moisture contents of the several of the soil samples that were tested. The Kessler DCP test revealed several locations with deep, soft subgrade profiles.

Geotechnical engineering recommendations for earthwork and pavement design and construction are outlined below. The recommendations contained in this report are based upon the results of field and laboratory testing located in the boring logs and DCP tests, which are presented in Appendix A, engineering analyses, and our current understanding of the proposed project.

5.2 Earthwork

The following presents recommendations for site and subgrade preparation, including chemical treatment and placement of engineered fills. Later recommendations presented for design and construction of pavements are contingent upon implementing the recommendations outlined in this section.

Earthwork, including subgrade preparation, fill placement and chemical soil treatment, should be observed and tested by Terracon.

5.3 Subgrade Preparation

After the removal of selected pavement sections, the exposed subgrade should be probed with either a T-probe or Kessler DCP to identify the depth and lateral extent of any soft materials. In broader extents, it may be necessary to proof roll the subgrade with a loaded, tandem-axle dump truck weighing at least 25 tons (under the observation of Terracon personnel) to locate any soft or unstable zones. The proofrolling should involve overlapping passes of the equipment. Where rutting or pumping is observed during proofrolling, the unstable soils should be over excavated and replaced with an approved soil as described in following sections if it cannot be effectively dried and compacted in-place. The extent of this unstable soil will not become evident until construction begins, but this condition should be anticipated and planned for accordingly. We expect the subgrade soils beneath the existing pavement to accumulate moisture over the life of the pavement. Therefore, it is probable that wet or unstable areas will be encountered during probing or proofrolling.

After probing the subgrade and removal of soft subgrade, the exposed subgrade in areas to receive new fill should be scarified to a depth of 8 inches, adjusted to a workable moisture content within 2 percent of its optimum value and be compacted to at least 95 percent of the material's maximum dry density as determined by test method ASTM D698 (Standard Proctor).

5.4 Subgrade Stabilization

If the Full Depth Reclaimation, FDR, option is selected, to reduce potential strength loss and improve the long-term subgrade support, we recommend that the top 12 inches of the processed pavement and subgrade soils be chemically stabilized. If the existing pavement is removed, we recommend stabilizing the top 8 inches of the subgrade. The type of additive should be determined at the time of construction by the geotechnical engineer. We recommend following ODOT's OHD L-50 for determining the actual type and percentage of chemical used as indicated in the table below .

Soil Stabilization Table

Additive (Expressed as a percentage added on oven dry basis)	**Soil Group Classification - AASHTO M145**											
	A-1		A-1				A-3	A-4	A-5	A-6	A-7	
	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7					A-7-5	A-7-6
Portland Cement	4	4	4	4	4	4	5	√	√	√		
Fly Ash					12	12	13	14	14	14		
Cement Kiln Dust (Pre-Calciner Plants)	5	5	5	5	5	5	6	√	√			
Cement Kiln Dust (Other Type Plants)	10	10	10	11	11	11	12	12	12			
Hydrated Lime*										4	5**	5**

A blank in the table indicates the additive is not recommended for that soil group. Recommended amounts include a safety factor for loss due to wind, grading, and/or mixing. Pre-Calciner plants are identified on the ODOT Materials Division approved list for cement kiln dust.
√ = Mix Design required
*= Reduce quantity by 20 percent when quick lime is used, i.e. 4% x 0.8 = 3.2%, 5% x 0.8 = 4.0%, 6% x 0.8 = 4.8%.
**= use 6% when liquid limit is greater than 50.

Before compaction, the stabilized soil layer should be adjusted to within 2 percent of the material's optimum moisture as determined by test method ASTM D698. After conditioning the soil to the required moisture content, the stabilized subgrade should be compacted to at least 98 percent of the material's maximum dry density as determined by test method ASTM D698. Compaction should be completed within about two hours after initially mixing the soil and stabilizing agent to optimize the stabilization benefit. Chemically treated subgrade and engineered fill should be placed and compacted in accordance with the recommendation in the following sections.

5.5 Fill Materials

All fill required to replace exposed soft subgrade areas should be an approved material that is free of organic matter and debris as outlined in the following table.

Fill Type [1,2]	Acceptable Location for Placement
Imported Cohesive Soils (Clay soils with LL<40, 8<PI<20)	All engineered fill areas
On-site soils	All engineered fill areas

1. Prior to placing fill, a sample of the proposed material should be obtained for laboratory testing to confirm compliance with Atterberg limits and gradation requirements, and to determine moisture-density relationship. The tests will provide a basis for evaluating suitability of the material and in-place compacted density.
2. Per pavement design recommendations, the top 12 inches will be chemically stabilized.

5.6 Placement and Compaction Requirements

Recommended placement, compaction and moisture content criteria for engineered fill materials are as follows:

ITEM	DESCRIPTION
Fill Lift Thickness[1]	8-inches or less in loose thickness
Compaction Requirements[2, 3]	**Native Soils:** At least 95% of the material's maximum standard Proctor dry density, ASTM D-698 **Chemically Treated Soils:** At least 98% of the material's maximum standard Proctor dry density, ASTM D-698
Moisture Content[2]	**Native Soils:** Workable moisture content that is 2% below to 2% above its optimum standard Proctor value **Chemically Treated Soils:** 2% below to 2% above its optimum standard Proctor value

[1] Engineered fill should be placed and compacted in horizontal lifts.

[2] Compaction equipment and procedures should uniformly produce recommended moisture contents and densities throughout the lift.

[3] A qualified soil technician should perform sufficient in-place density tests during the filling operations to evaluate that proper levels of compaction, including dry unit weight and moisture content, are being attained.

5.7 Trench Backfill

Care should be taken to properly backfill utility trench cuts within the pavement areas. All trenches created for utility access under the pavement should be effectively sealed to restrict water intrusion into the pavement subgrade. We recommend using a clay soil to construct a trench plug that extends at least 5 feet out from the edge of the pavements. The clay should have a minimum plasticity index (PI) of 15 and be placed in controlled lifts not exceeding 9 inches in loose thickness so as to surround the utility line and fill the trench. Each lift of clay backfill should be compacted to at least 95 percent of the material's maximum standard Proctor dry density (ASTM D-698), at a moisture content that is 2 percentage points above the optimum value.

5.8 Drainage

Developing and maintaining effective surface drainage is critical to the satisfactory long-term performance of pavements. The pavement surface should be crowned sufficiently to rapidly drain surface water to the gutters and into drainage inlets. Paved shoulders and earth slopes should be adequately sloped to promote effective drainage of surface water away from the pavement edge. Ditches and other drainage structures should effectively collect and discharge runoff to prevent standing water that could saturate and soften the subgrade soils.

5.9 Maintenance

Periodic maintenance extends the service life of the pavement and should include crack sealing, joint sealing, and patching of any deteriorated areas. Also, thicker pavement sections could be used to reduce the required maintenance and extend the service life of the pavement. Failure to follow these recommendations could result in premature pavement distress and higher maintenance costs.

6.0 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, subgrade treatment 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 or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential of such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of *Poe and Associates, Inc.* for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, express 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

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Project Manager: JLD	Project No. 03215254
Drawn by: CAN	Scale: AS SHOWN
Checked by: JLD	File Name: A1-A4
Approved by: NKT	Date: APR 2022

Terracon

4701 N Stiles Ave
Oklahoma City, OK 73105-3330

SITE LOCATION

Lake Access Road Improvements
Access Road on east side of Atoka Lake
Stringtown, OK

Exhibit

A-1

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

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Project Manager: JLD	Project No. 03215254
Drawn by: CAN	Scale: AS SHOWN
Checked by: JLD	File Name: A1-A4
Approved by: NKT	Date: APR 2022

Terracon

4701 N Stiles Ave
Oklahoma City, OK 73105-3330

EXPLORATION PLAN

Lake Access Road Improvements

Access Road on east side of Atoka Lake
Stringtown, OK

Exhibit

A-2

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

AERIAL PHOTOGRAPHY PROVIDED
BY MICROSOFT BING MAPS

Project Manager: JLD	Project No. 03215254
Drawn by: CAN	Scale: AS SHOWN
Checked by: JLD	File Name: A1-A4
Approved by: NKT	Date: APR 2022

Terracon
4701 N Stiles Ave
Oklahoma City, OK 73105-3330

EXPLORATION PLAN

Lake Access Road Improvements
Access Road on east side of Atoka Lake
Stringtown, OK

Exhibit
A-3

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

AERIAL PHOTOGRAPHY PROVIDED
BY MICROSOFT BING MAPS

Project Manager: JLD	Project No. 03215254
Drawn by: CAN	Scale: AS SHOWN
Checked by: JLD	File Name: A1-A4
Approved by: NKT	Date: APR 2022

Terracon
4701 N Stiles Ave
Oklahoma City, OK 73105-3330

EXPLORATION PLAN

Lake Access Road Improvements
Access Road on east side of Atoka Lake
Stringtown, OK

Exhibit
A-4

Field Exploration Description

Ten pavement borings were drilled along the project site on February 18, 2022 at the approximate locations shown on the attached Exploration Plan, Exhibits A-2 to A-4.

Terracon personnel located the borings in the field by use of a hand held GPS device within the project extents provided by the Client. The locations of the borings should be considered accurate only to the degree implied by the methods used to define them.

A diamond-tipped core barrel was used to extract 6-inch diameter samples of the pavement. Soil borings were hand augered at each of the fifteen core locations. Subgrade soil samples were retrieved from each boring for laboratory testing.

The stiffness/relative density of the subgrade materials was assessed with a Kessler dynamic cone penetrometer (DCP) at the four street borings, and disturbed samples were obtained from the auger cuttings of all fifteen core locations. The DCP consists of a 17.6 pound slide hammer falling 22.6 inches onto an anvil driving a 0.79 inch diameter cone into the soil. The number of blows required to drive the cone is recorded along with the penetration depth and roughly corresponds to the California Bearing Ratio, CBR. The CBR is a strength measure comparing the penetration resistance of compacted soil to that of densely compacted crushed rock.

The sampling depths, soil descriptions, and laboratory test results are reported on the boring logs. The samples were tagged for identification, sealed to reduce moisture loss and returned to the laboratory for further examination, testing and classification.

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

BORING LOG NO. B-1

Page 1 of 1

PROJECT: **Atoka Lake Access Road Improvements - South Section**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **Access Road East side of Atoka Lake**
Stringtown, OK

GRAPHIC LOG	LOCATION See Exhibits A-2 to A-4 Latitude: 34.4224° Longitude: -96.0948° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**TREATED SUBGRADE (CLAYEY SAND - SC)**, brown 0.5					11.5		
▨	**LEAN TO FAT CLAY (CL/CH)**, brown 1.5	1				19.6		
▨	**FAT CLAY (CH)**, brown and gray 3.0	2 3				20.4 19.9		
	Boring Terminated at 3 Feet							

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 2 3/4" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-18-2022	Boring Completed: 02-18-2022
Drill Rig: 747	Driller: RP
Project No.: 03215254	Exhibit: A-6

BORING LOG NO. B-2

PROJECT: Atoka Lake Access Road Improvements - South Section

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Access Road East side of Atoka Lake
Stringtown, OK

GRAPHIC LOG	LOCATION See Exhibits A-2 to A-4 Latitude: 34.4239° Longitude: -96.0930°	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**TREATED SUBGRADE (CLAYEY SAND WITH GRAVEL - SC)**, dark brown	0.5					8.1	31-21-10	14
▨	**FAT CLAY (CH)**, brown						10.4		
▨			1						
▨							11.6		
▨			2						
▨	-gray and brown below 2.5'	3.0					22.1		
	Boring Terminated at 3 Feet		3						

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 5 1/8" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-18-2022	Boring Completed: 02-18-2022
Drill Rig: 747	Driller: RP
Project No.: 03215254	Exhibit: A-7

BORING LOG NO. B-3

Page 1 of 1

PROJECT: **Atoka Lake Access Road Improvements - South Section**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **Access Road East side of Atoka Lake**
Stringtown, OK

LOCATION See Exhibits A-2 to A-4

Latitude: 34.4269° Longitude: -96.0929°

GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	0.5	**TREATED SUBGRADE (CLAYEY SAND WITH GRAVEL - SC)**, dark brown					25.6		
▨		**FAT CLAY (CH)**, brown and grayish brown	1				32.7	58-29-29	
▨									
▨			2				32.7		
▨									
▨	3.0	-grayish brown below 2.5'	3				23.3		
		Boring Terminated at 3 Feet							

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 2 3/4" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-18-2022	Boring Completed: 02-18-2022
Drill Rig: 747	Driller: RP
Project No.: 03215254	Exhibit: A-8

BORING LOG NO. B-4

PROJECT: Atoka Lake Access Road Improvements - South Section

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Access Road East side of Atoka Lake
Stringtown, OK

GRAPHIC LOG	LOCATION See Exhibits A-2 to A-4 Latitude: 34.4294° Longitude: -96.0908° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**FAT CLAY WITH GRAVEL (CH)**, grayish brown			▌		19.5	59-21-38	
▨	-brown below 0.5'			▌		27.1		
▨		1						
▨				▌		25.5		
▨		2						
▨	3.0			▌		24.9		
	Boring Terminated at 3 Feet	3						

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 2 1/2" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-18-2022	Boring Completed: 02-18-2022
Drill Rig: 747	Driller: RP
Project No.: 03215254	Exhibit: A-9

BORING LOG NO. B-5

Page 1 of 1

PROJECT: Atoka Lake Access Road Improvements - South Section

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Access Road East side of Atoka Lake
Stringtown, OK

LOCATION See Exhibits A-2 to A-4

Latitude: 34.4318° Longitude: -96.0884°

DEPTH		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	TREATED SUBGRADE (LEAN CLAY WITH SAND - CL), brown					14.4		
0.5	**LEAN CLAY (CL)**, brown					16.1	34-19-15	
		1						
						30.8		
		2						
						27.6		
3.0	*Boring Terminated at 3 Feet*	3						

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 3 3/4" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-18-2022	Boring Completed: 02-18-2022
Drill Rig: 747	Driller: RP
Project No.: 03215254	Exhibit: A-10

BORING LOG NO. B-6

PROJECT: **Atoka Lake Access Road Improvements - South Section**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **Access Road East side of Atoka Lake**
Stringtown, OK

GRAPHIC LOG	LOCATION See Exhibits A-2 to A-4 Latitude: 34.4348° Longitude: -96.0865° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**FAT CLAY (CH)**, brown					26.2		
▨		1				25.4		
	1.3							
	Boring Terminated at Auger Refusal at 1.3 Feet							

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 8" Crushed Aggregate at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-18-2022	Boring Completed: 02-18-2022
Drill Rig: 747	Driller: RP
Project No.: 03215254	Exhibit: A-11

BORING LOG NO. B-7

Page 1 of 1

PROJECT: Atoka Lake Access Road Improvements - South Section

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Access Road East side of Atoka Lake
Stringtown, OK

LOCATION See Exhibits A-2 to A-4

Latitude: 34.4376° Longitude: -96.0868°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	TREATED SUBGRADE (CLAYEY SAND WITH GRAVEL - SC), brown					9.9		
	0.5							
	CLAYEY SAND WITH GRAVEL (SC), brown					7.6	30-21-9	17
		1						
	-reddish brown below 1.5'					8.9		
		2						
						11.8		
	3.0	3						
	Boring Terminated at 3 Feet							

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 3" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-18-2022	Boring Completed: 02-18-2022
Drill Rig: 747	Driller: RP
Project No.: 03215254	Exhibit: A-12

BORING LOG NO. B-8

PROJECT: Atoka Lake Access Road Improvements - South Section

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Access Road East side of Atoka Lake
Stringtown, OK

LOCATION See Exhibits A-2 to A-4

Latitude: 34.4405° Longitude: -96.0874°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	CLAYEY SAND (SC), brown			▮		9.9		
				▮		12.7		
		1						
	1.5							
	SANDY LEAN CLAY WITH GRAVEL (CL), brown			▮		10.5		
		2						
				▮		8.6		
	3.0	3						
	Boring Terminated at 3 Feet							

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 3 1/2" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-18-2022	Boring Completed: 02-18-2022
Drill Rig: 747	Driller: RP
Project No.: 03215254	Exhibit: A-13

BORING LOG NO. B-9

Page 1 of 1

PROJECT: Atoka Lake Access Road Improvements - South Section

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Access Road East side of Atoka Lake
Stringtown, OK

GRAPHIC LOG	LOCATION See Exhibits A-2 to A-4 Latitude: 34.4430° Longitude: -96.0877° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**TREATED SUBGRADE (CLAYEY SAND WITH GRAVEL - SC)**, brown 0.5			▮		15.8		
▨	**FAT CLAY (CH)**, brown			▮		19.1	56-23-33	
▨		1						
▨				▮		21.2		
▨		2						
▨	3.0			▮		25.8		
	Boring Terminated at 3 Feet	3						

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 3 1/4" Asphalt Concrete over 6" Aggregate base at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon

4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-18-2022	Boring Completed: 02-18-2022
Drill Rig: 747	Driller: RP
Project No.: 03215254	Exhibit: A-14

BORING LOG NO. B-10

Page 1 of 1

PROJECT: Atoka Lake Access Road Improvements - South Section

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Access Road East side of Atoka Lake
Stringtown, OK

GRAPHIC LOG	LOCATION See Exhibits A-2 to A-4 Latitude: 34.4444° Longitude: -96.0858° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**LEAN TO FAT CLAY WITH GRAVEL (CL/CH)**, brown and gray					10.8		
▨	-brown below 6'					14.4		
▨		1						
▨						11.4		
▨		2						
▨	3.0					8.9		
	Boring Terminated at 3 Feet	3						

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-3 for description of field procedures.

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 3 1/4" Asphalt Concrete over 4" Aggregate Base at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-18-2022	Boring Completed: 02-18-2022
Drill Rig: 747	Driller: RP
Project No.: 03215254	Exhibit: A-15

03215254 - Core 1

TOP

Terracon CORE LOG

CORE NUMBER	C-1
DATE CORED	2/18/2022
LOCATION	Atoka Lake Access Road- South Section Pavement Evaluation Access Road East side of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4224 LONGITUDE -96.0948

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☑ Yes ☐ No ☐ Unknown

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	2 3/4	
	Total Core Thickness	**2 3/4**	

Exhibit A-16

TOP


03215254 - Core 2

Terracon CORE LOG

CORE NUMBER	C-2
DATE CORED	2/18/2022
LOCATION	Atoka Lake Access Road- South Section Pavement Evaluation Access Road East side of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4239 LONGITUDE -96.0930

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☑ Yes ☐ No ☐ Unknown

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	5 1/8	
	Total Core Thickness	**5 1/8**	

Exhibit A-17

TOP

CORE LOG

CORE NUMBER	C-3
DATE CORED	2/18/2022
LOCATION	Atoka Lake Access Road- South Section Pavement Evaluation Access Road East side of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4269 LONGITUDE -96.0929

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☑ Yes ☐ No ☐ Unknown

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	2 3/4	
	Total Core Thickness	**2 3/4**	

Exhibit A-18

TOP

Terracon **CORE LOG**

CORE NUMBER	C-4
DATE CORED	2/18/2022
LOCATION	Atoka Lake Access Road- South Section Pavement Evaluation Access Road East side of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4294 LONGITUDE -96.0908

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	2 1/2	
	Total Core Thickness	**2 1/2**	Fractured

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☐ Yes ☑ No ☐ Unknown

Exhibit A-19

TOP

CORE LOG

CORE NUMBER	C-5
DATE CORED	2/18/2022
LOCATION	Atoka Lake Access Road- South Section Pavement Evaluation Access Road East side of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4318 LONGITUDE -96.0884

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☑ Yes ☐ No ☐ Unknown

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	3 3/4	
	Total Core Thickness	**3 3/4**	

Exhibit A-20

TOP

CORE LOG

CORE NUMBER C-7
DATE CORED 2/18/2022
LOCATION Atoka Lake Access Road- South Section
Pavement Evaluation
Access Road East side of Atoka Lake
Stringtown, Oklahoma

GPS LATITUDE 34.4376 LONGITUDE -96.0868

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☑ Yes ☐ No ☐ Unknown

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	3	
	Total Core Thickness	**3**	

Exhibit A-21

03215254 - Core 8

TOP

Terracon CORE LOG

CORE NUMBER	C-8
DATE CORED	2/18/2022
LOCATION	Atoka Lake Access Road- South Section Pavement Evaluation Access Road East side of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4405 LONGITUDE -96.0874

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☐ Yes ☑ No ☐ Unknown

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	3 1/2	
	Total Core Thickness	**3 1/2**	Fractured

Exhibit A-22

TOP

CORE LOG

CORE NUMBER	C-9
DATE CORED	2/18/2022
LOCATION	Atoka Lake Access Road- South Section Pavement Evaluation Access Road East side of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4430 LONGITUDE -96.0877

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☑ Yes ☐ No ☐ Unknown

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	3 1/4	
1	Aggregate Base	6	
	Total Core Thickness	**9 1/4**	

Exhibit A-23

TOP

CORE LOG

CORE NUMBER C-10
DATE CORED 2/18/2022
LOCATION Atoka Lake Access Road- South Section
Pavement Evaluation
Access Road East side of Atoka Lake
Stringtown, Oklahoma

GPS LATITUDE 34.4444 LONGITUDE -96.0858

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	3 1/4	
1	Aggregate Base	4	
	Total Core Thickness	**7 1/4**	

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

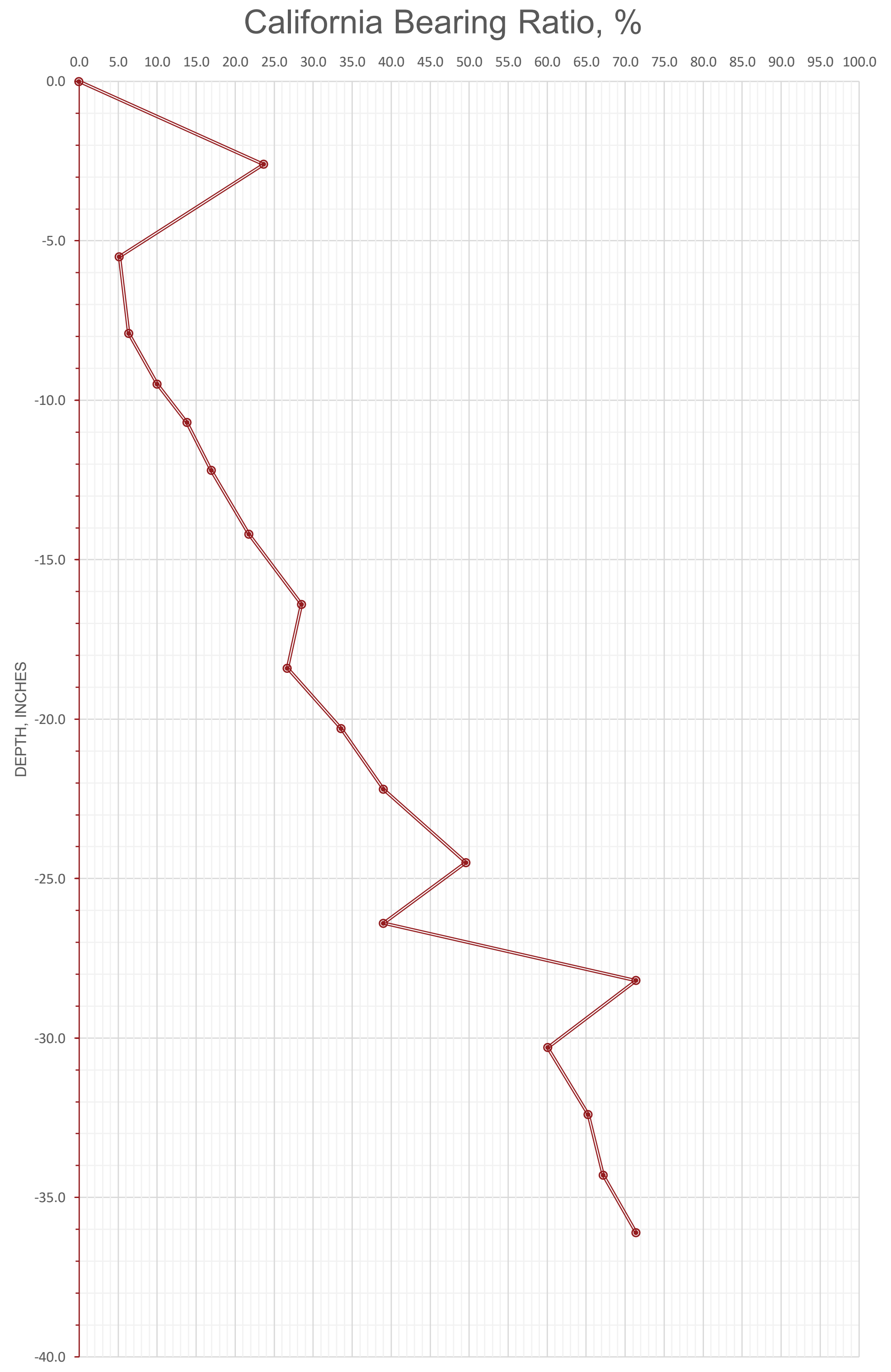
Stabilized Subgrade Beneath Pavement or Sub-base? ☐ Yes ☑ No ☐ Unknown

Exhibit A-24

California Bearing Ratio from DCP - Boring No. B-1

PROJECT:	**03215254**	**SITE:**	**Atoka Lake South Access Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
7	-2.6	23.6
2	-5.5	5.1
2	-7.9	6.4
2	-9.5	10.0
2	-10.7	13.8
3	-12.2	16.9
5	-14.2	21.8
7	-16.4	28.5
6	-18.4	26.7
7	-20.3	33.6
8	-22.2	39.0
12	-24.5	49.6
8	-26.4	39.0
13	-28.2	71.4
13	-30.3	60.1
14	-32.4	65.3
13	-34.3	67.2
13	-36.1	71.4



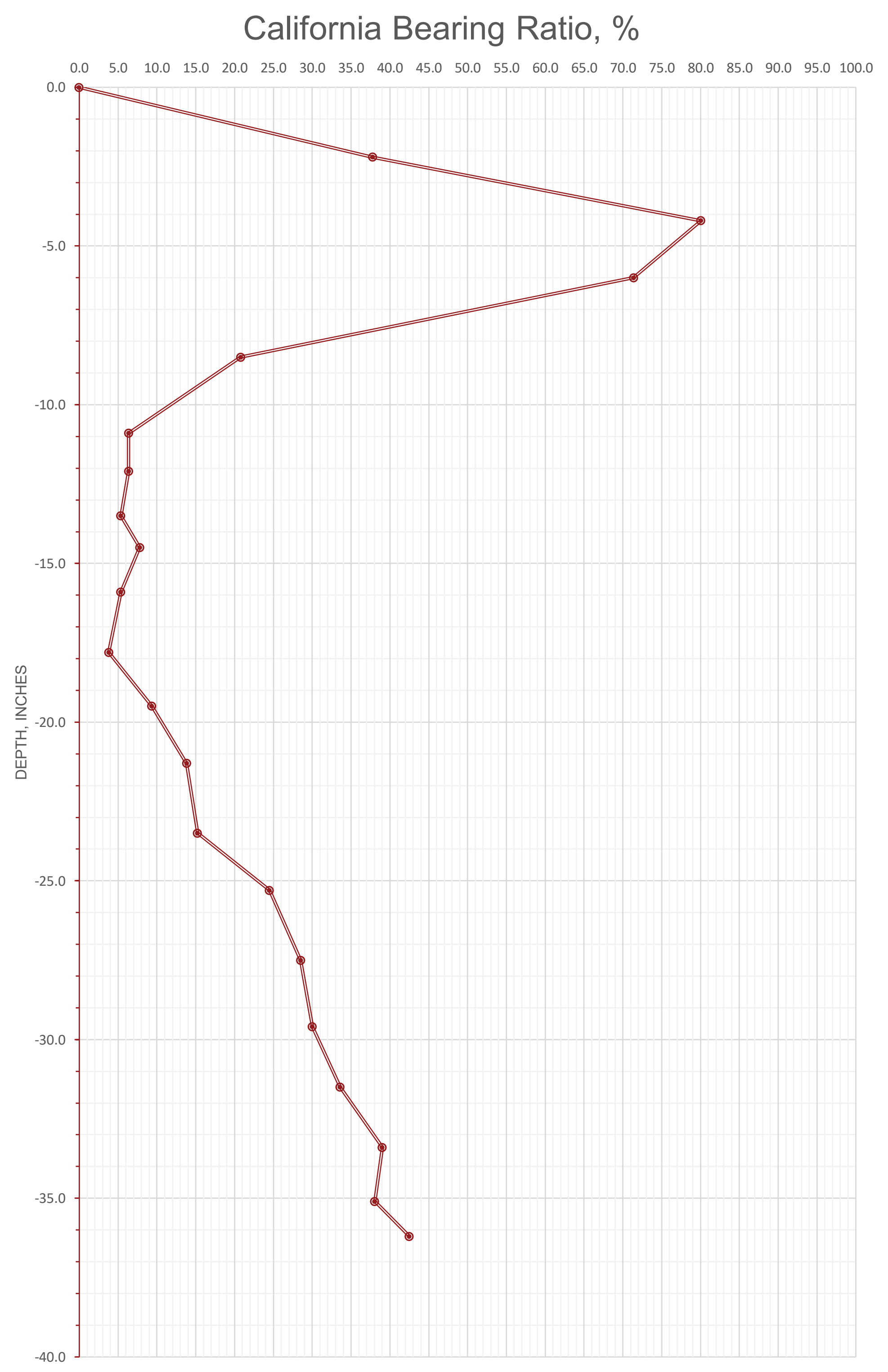
Notes:

DRILLING DATE:	2/18/2022
Project No.:	03215254
Exhibit:	A-25

California Bearing Ratio from DCP - Boring No. B-2

PROJECT:	**03215254**	**SITE:**	**Atoka Lake South Access Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
9	-2.2	37.8
16	-4.2	80.1
13	-6.0	71.4
6	-8.5	20.8
2	-10.9	6.4
1	-12.1	6.4
1	-13.5	5.3
1	-14.5	7.8
1	-15.9	5.3
1	-17.8	3.8
2	-19.5	9.4
3	-21.3	13.8
4	-23.5	15.2
5	-25.3	24.5
7	-27.5	28.5
7	-29.6	30.0
7	-31.5	33.6
8	-33.4	39.0
7	-35.1	38.1
5	-36.2	42.5



Terracon

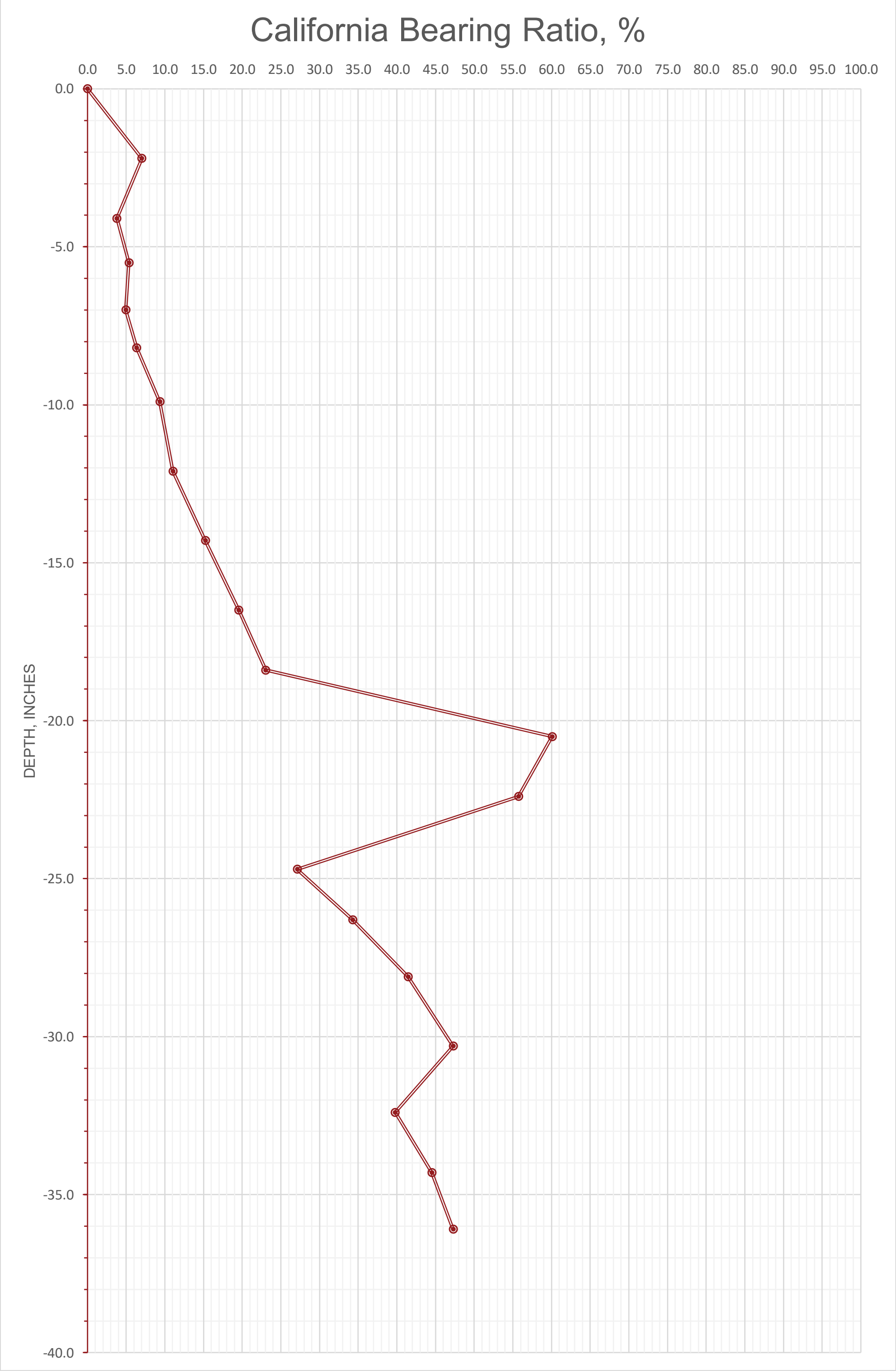
Notes:

DRILLING DATE:	2/18/2022
Project No.:	03215254
Exhibit:	A-26

California Bearing Ratio from DCP - Boring No. B-3

PROJECT:	**03215254**	**SITE:**	**Atoka Lake South Access Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
2	-2.2	7.0
1	-4.1	3.8
1	-5.5	5.3
1	-7.0	5.0
1	-8.2	6.4
2	-9.9	9.4
3	-12.1	11.0
4	-14.3	15.2
5	-16.5	19.6
5	-18.4	23.0
13	-20.5	60.1
11	-22.4	55.7
7	-24.7	27.1
6	-26.3	34.3
8	-28.1	41.5
11	-30.3	47.3
9	-32.4	39.8
9	-34.3	44.5
9	-36.1	47.3



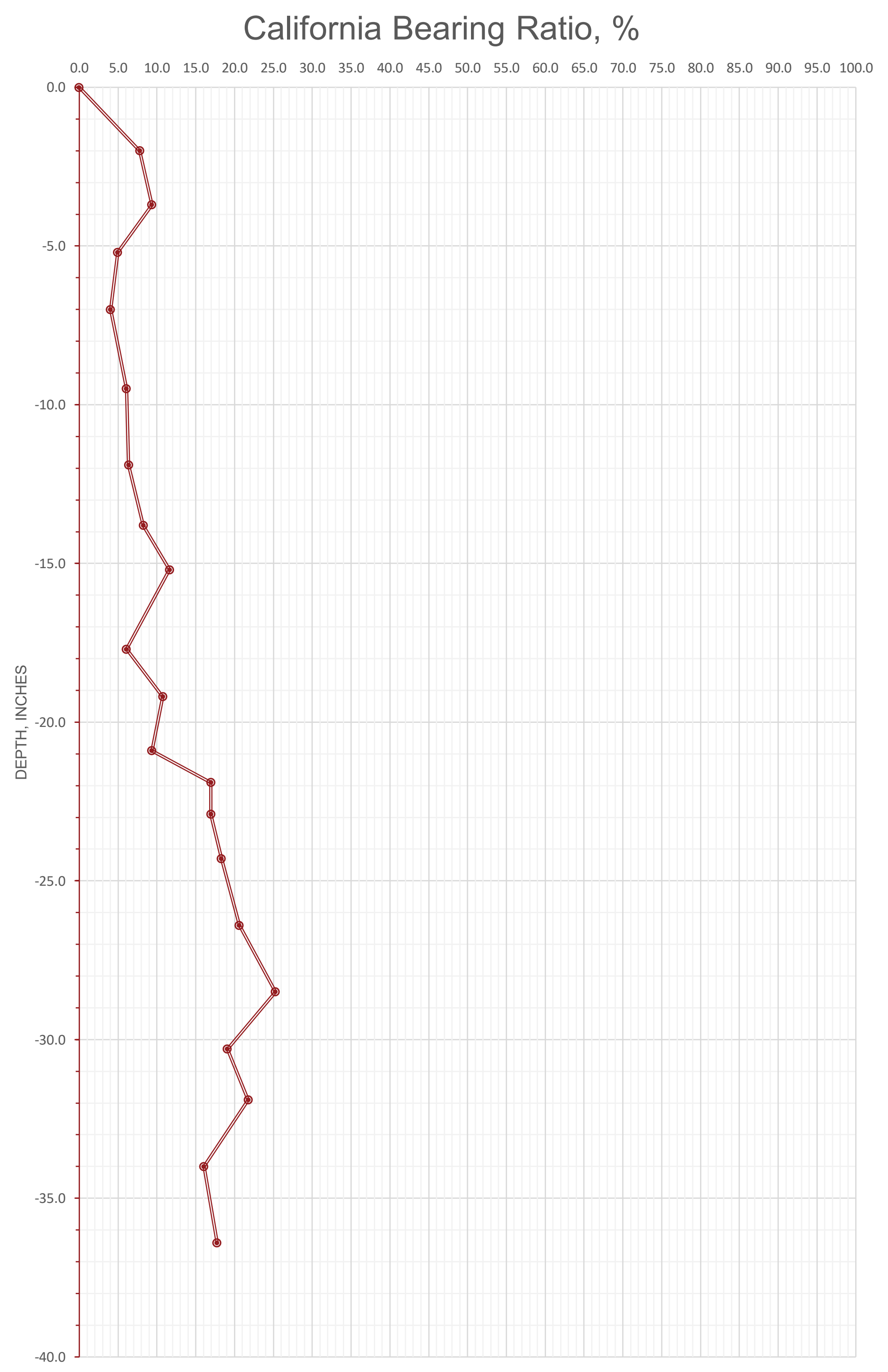
Notes:

DRILLING DATE:	2/18/2022
Project No.:	03215254
Exhibit:	A-27

California Bearing Ratio from DCP - Boring No. B-4

PROJECT:	**03215254**	**SITE:**	**Atoka Lake South Access Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
2	-2.0	7.8
2	-3.7	9.4
1	-5.2	5.0
1	-7.0	4.0
2	-9.5	6.1
2	-11.9	6.4
2	-13.8	8.3
2	-15.2	11.6
2	-17.7	6.1
2	-19.2	10.8
2	-20.9	9.4
2	-21.9	16.9
2	-22.9	16.9
3	-24.3	18.3
5	-26.4	20.6
6	-28.5	25.3
4	-30.3	19.1
4	-31.9	21.8
4	-34.0	16.0
5	-36.4	17.7



Terracon

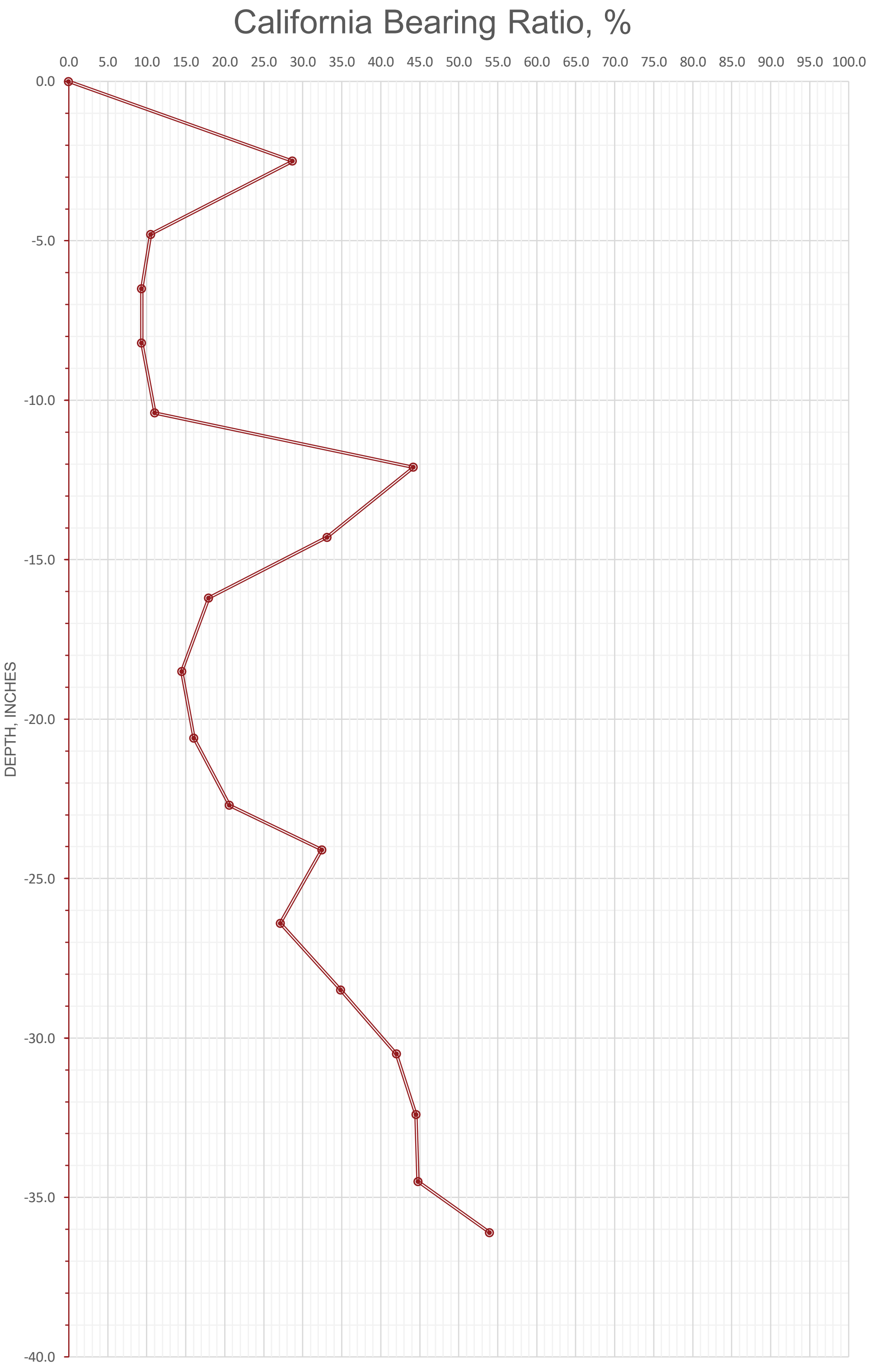
Notes:

DRILLING DATE:	2/18/2022
Project No.:	03215254
Exhibit:	A-28

California Bearing Ratio from DCP - Boring No. B-5

PROJECT:	**03215254**	**SITE:**	**Atoka Lake South Access Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
8	-2.5	28.7
3	-4.8	10.5
2	-6.5	9.4
2	-8.2	9.4
3	-10.4	11.0
8	-12.1	44.2
8	-14.3	33.1
4	-16.2	18.0
4	-18.5	14.5
4	-20.6	16.0
5	-22.7	20.6
5	-24.1	32.4
7	-26.4	27.1
8	-28.5	34.9
9	-30.5	42.0
9	-32.4	44.5
10	-34.5	44.8
9	-36.1	54.0



Terracon

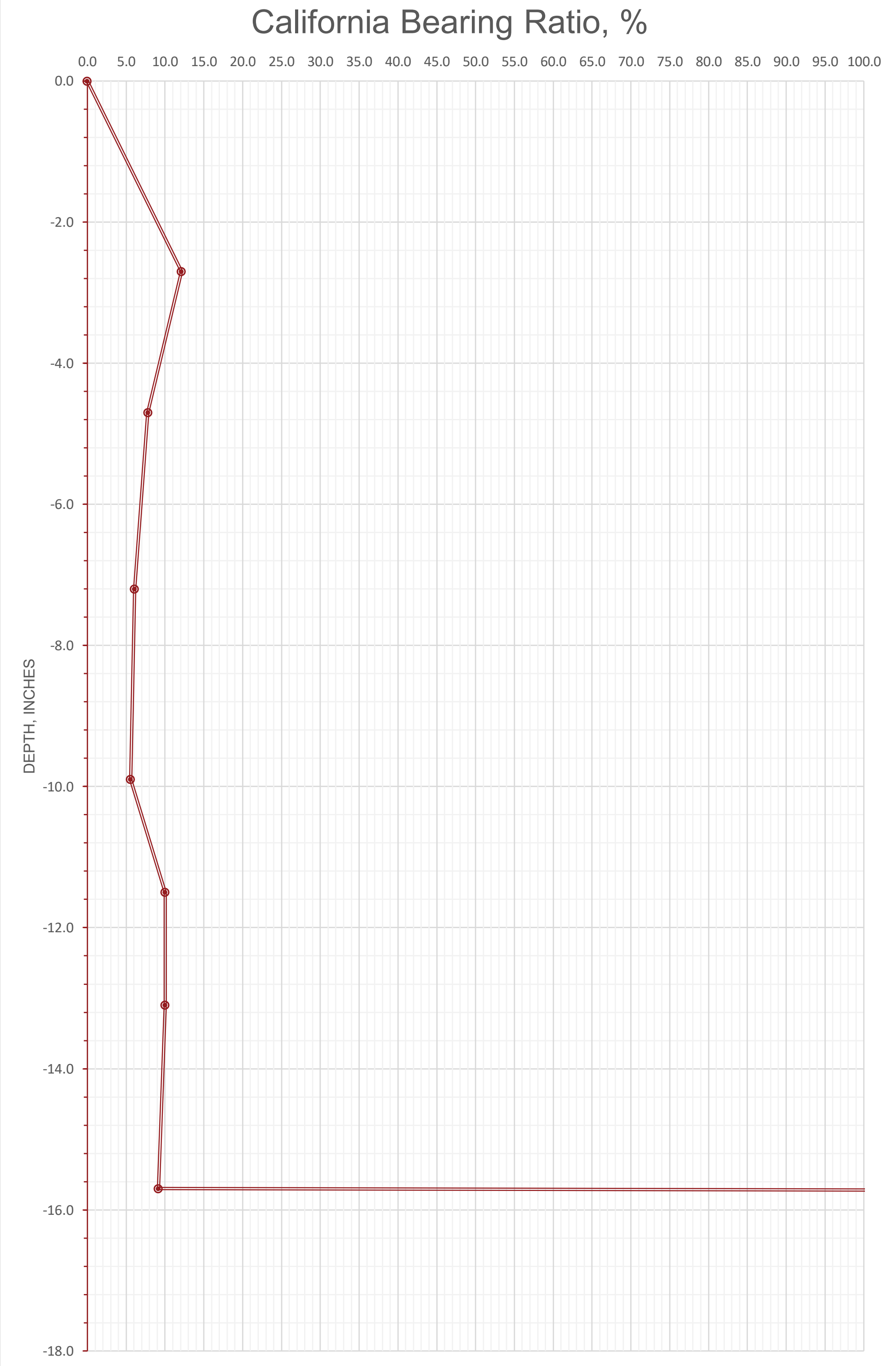
Notes:

DRILLING DATE:	2/18/2022
Project No.:	03215254
Exhibit:	A-29

California Bearing Ratio from DCP - Boring No. B-6

PROJECT:	**03215254**	**SITE:**	**Atoka Lake South Access Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
4	-2.7	12.1
2	-4.7	7.8
2	-7.2	6.1
2	-9.9	5.6
2	-11.5	10.0
2	-13.1	10.0
3	-15.7	9.2
50	-16.1	1739.8



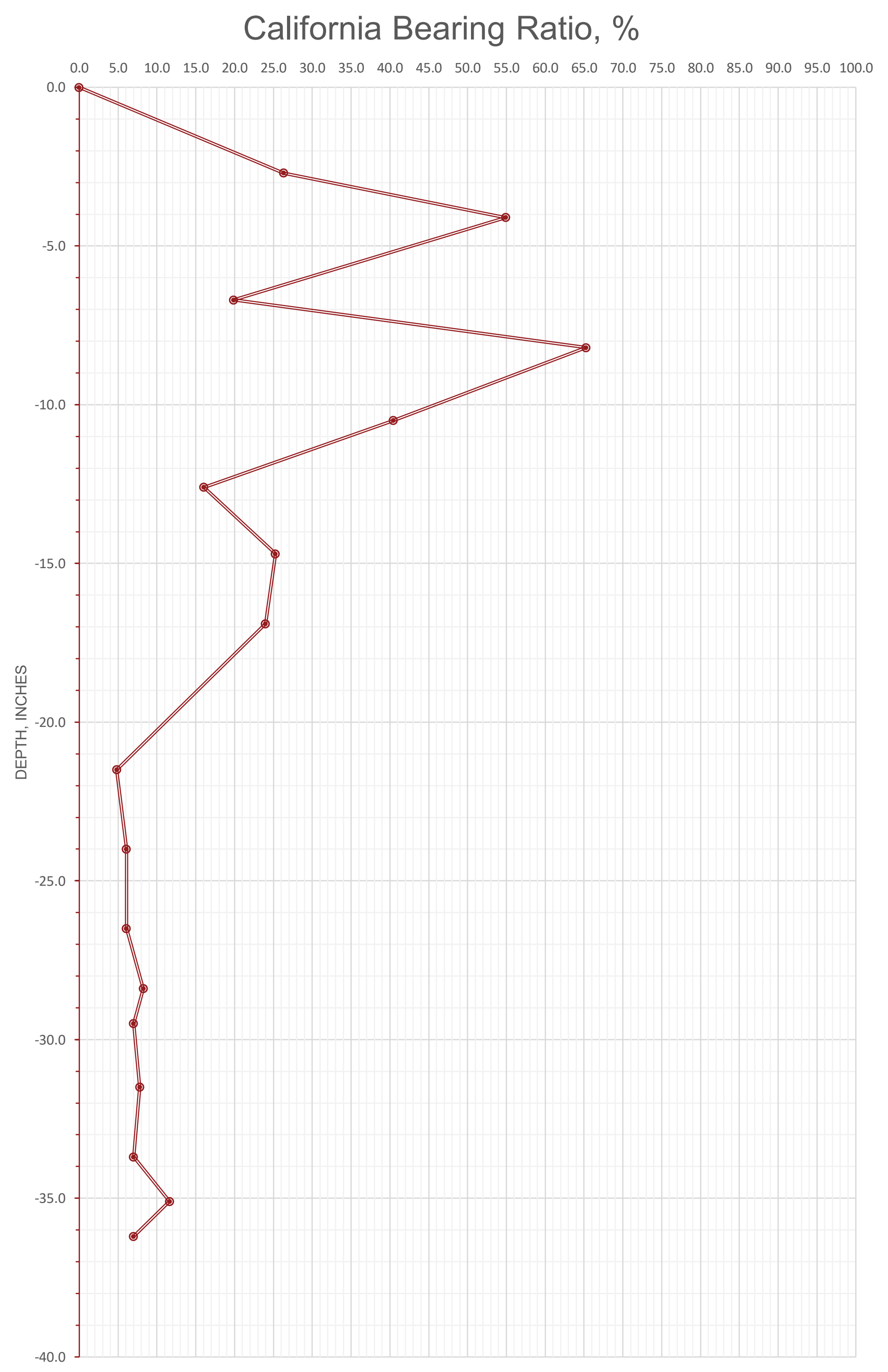
Notes:

DRILLING DATE:	2/18/2022
Project No.:	03215254
Exhibit:	A-30

California Bearing Ratio from DCP - Boring No. B-7

PROJECT:	**03215254**	**SITE:**	**Atoka Lake South Access Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
8	-2.7	26.3
8	-4.1	54.9
6	-6.7	19.9
10	-8.2	65.3
10	-10.5	40.4
4	-12.6	16.0
6	-14.7	25.3
6	-16.9	24.0
3	-21.5	4.8
2	-24.0	6.1
2	-26.5	6.1
2	-28.4	8.3
1	-29.5	7.0
2	-31.5	7.8
2	-33.7	7.0
2	-35.1	11.6
1	-36.2	7.0



Terracon

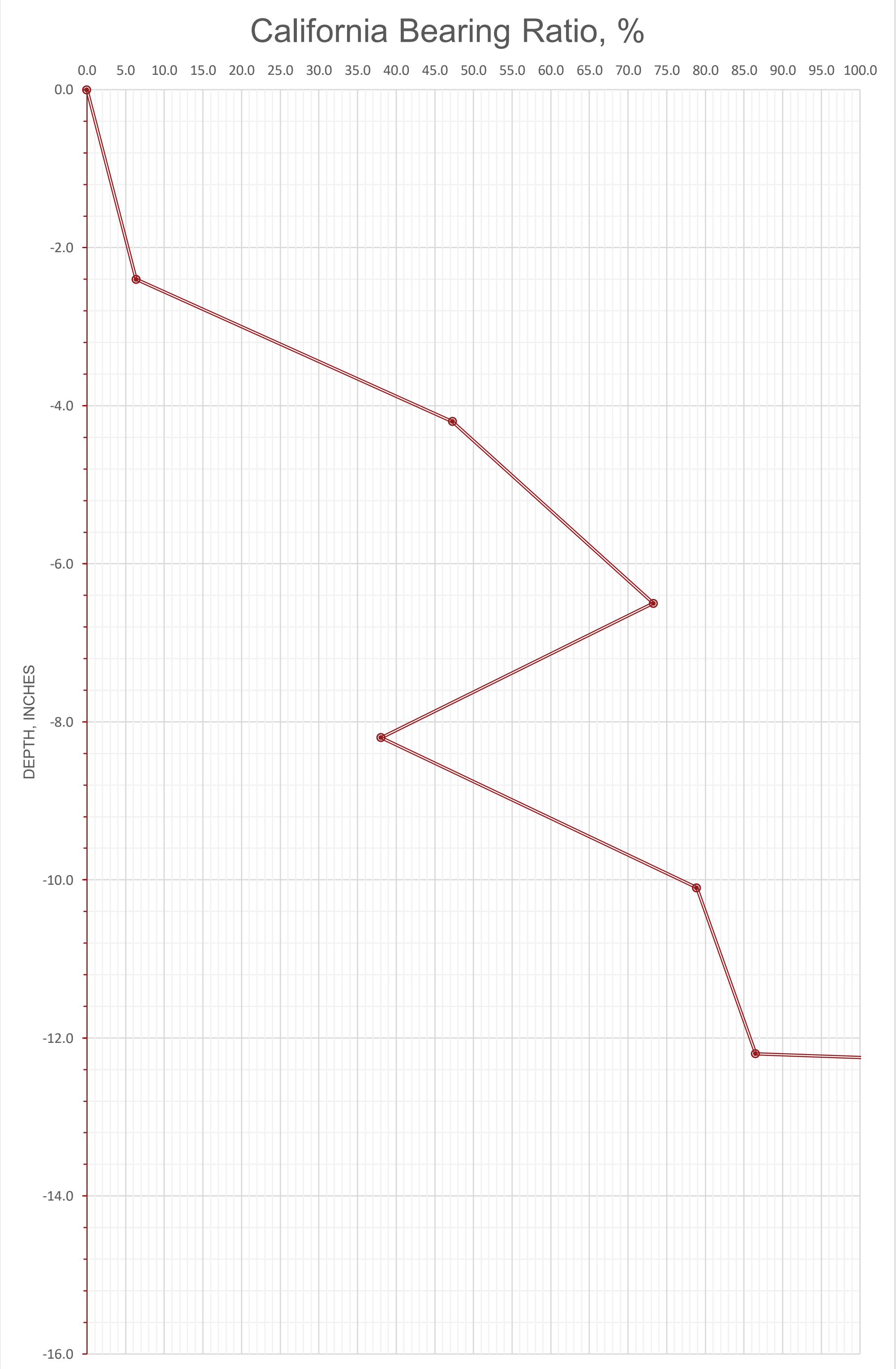
Notes:

DRILLING DATE:	2/18/2022
Project No.:	03215254
Exhibit:	A-31

California Bearing Ratio from DCP - Boring No. B-8

PROJECT:	**03215254**	**SITE:**	**Atoka Lake South Access Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
2	-2.4	6.4
9	-4.2	47.3
17	-6.5	73.3
7	-8.2	38.1
15	-10.1	78.9
18	-12.2	86.5
50	-13.5	464.7



Terracon

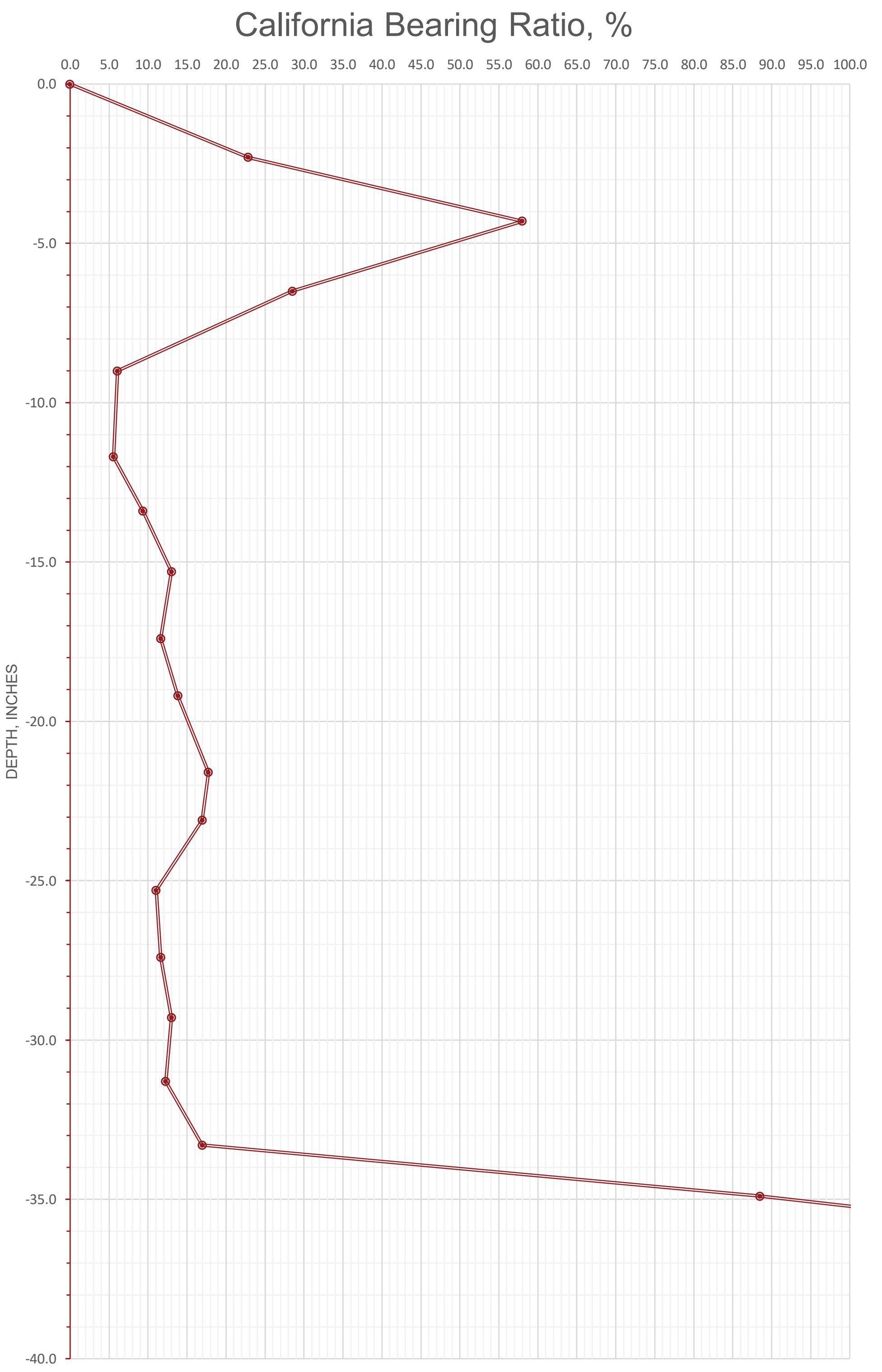
Notes:

DRILLING DATE:	2/18/2022
Project No.:	03215254
Exhibit:	A-32

California Bearing Ratio from DCP - Boring No. B-9

PROJECT:	**03215254**	**SITE:**	**Atoka Lake South Access Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
6	-2.3	22.8
12	-4.3	58.0
7	-6.5	28.5
2	-9.0	6.1
2	-11.7	5.6
2	-13.4	9.4
3	-15.3	13.0
3	-17.4	11.6
3	-19.2	13.8
5	-21.6	17.7
3	-23.1	16.9
3	-25.3	11.0
3	-27.4	11.6
3	-29.3	13.0
3	-31.3	12.3
4	-33.3	16.9
14	-34.9	88.5
15	-36.1	132.0



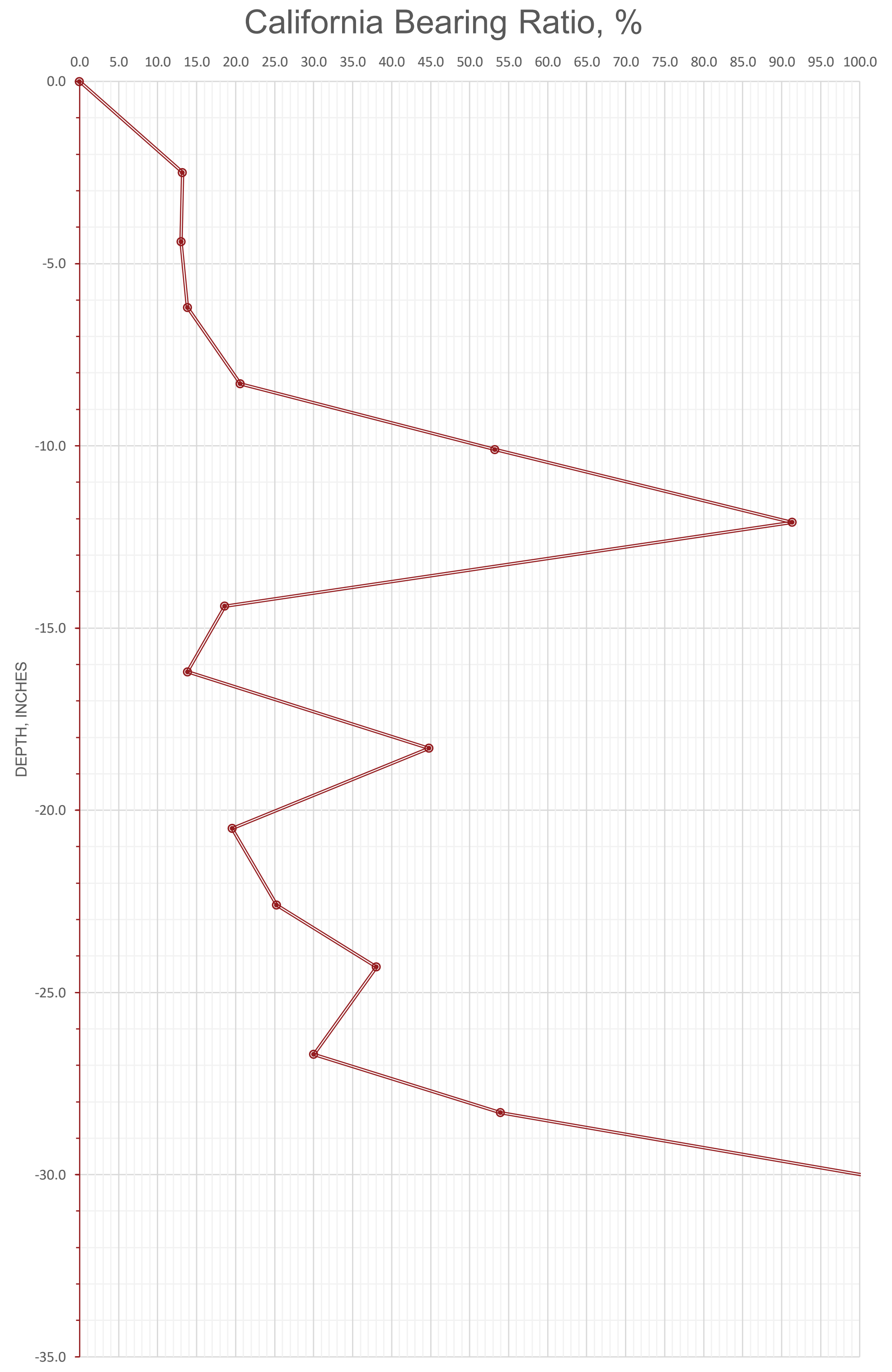
Notes:

DRILLING DATE:	2/18/2022
Project No.:	03215254
Exhibit:	A-33

California Bearing Ratio from DCP - Boring No. B-10

PROJECT:	**03215254**	**SITE:**	**Atoka Lake South Access Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
4	-2.5	13.2
3	-4.4	13.0
3	-6.2	13.8
5	-8.3	20.6
10	-10.1	53.2
18	-12.1	91.4
5	-14.4	18.6
3	-16.2	13.8
10	-18.3	44.8
5	-20.5	19.6
6	-22.6	25.3
7	-24.3	38.1
8	-26.7	30.0
9	-28.3	54.0
18	-30.1	102.8
50	-31.2	560.3



Terracon

Notes:

DRILLING DATE:	2/18/2022
Project No.:	03215254
Exhibit:	A-34

APPENDIX B
LABORATORY TESTING

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS) described in Appendix C. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

Laboratory tests were conducted on selected soil samples and the test results are presented on the boring logs in Appendix A and on report forms in this appendix. The laboratory test results were used for the geotechnical engineering analyses, and the development of foundation, earthwork, and pavement design recommendations. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

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

- In-situ water content
- Atterberg Limits
- Gradation
- Moisture Density
- Resilient Modulus

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 judgement.

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-1	0 - 6												11		
B-1	6 - 12												20		
B-1	18 - 24												20		
B-1	30 - 36												20		
B-2	0 - 6	CLAYEY SAND with GRAVEL(SC)	A-2-4 (0)		31	21	10	14.2	20.9	64.9			8		
B-2	6 - 12												10		
B-2	18 - 24												12		
B-2	30 - 36												22		
B-3	0 - 6												26		
B-3	6 - 12				58	29	29						33		
B-3	18 - 24												33		
B-3	30 - 36												23		
B-4	0 - 6				59	21	38						20		
B-4	6 - 12												27		
B-4	18 - 24												26		
B-4	30 - 36												25		
B-5	0 - 6												14		
B-5	6 - 12				34	19	15						16		
B-5	18 - 24												31		
B-5	30 - 36												28		
B-6	0 - 6												26		
B-6	6 - 12												25		
B-7	0 - 6												10		
B-7	6 - 12	CLAYEY SAND with GRAVEL(SC)	A-2-4 (0)		30	21	9	16.9	29.8	53.3			8		
B-7	18 - 24												9		

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Atoka Lake Access Road- South Section

SITE: Access Road East side of Atoka Lake
Stringtown, OK

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PH. 405-525-0453 FAX. 405-557-0549

PROJECT NUMBER: 03215254

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT_LAB_SUMMARY 03215254 ATOKA LAKE SOUTH.GPJ TERRACON_DATATEMPLATE.GDT 3/15/22

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-7	30 - 36												12		
B-8	0 - 6												10		
B-8	6 - 12												13		
B-8	18 - 24												10		
B-8	30 - 36												9		
B-9	0 - 6												16		
B-9	6 - 12				56	23	33						19		
B-9	18 - 24												21		
B-9	30 - 36												26		
B-10	0 - 6												11		
B-10	6 - 12												14		
B-10	18 - 24												11		
B-10	30 - 36												9		
Comp Bulk OMC	0 - 3	SANDY LEAN CLAY(CL)	A-7-6 (15)		47	21	26	65.3	7.5	27.0				17.4	108.0

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Atoka Lake Access Road- South Section

SITE: Access Road East side of Atoka Lake
Stringtown, OK

Terracon
4701 N Stiles Ave
Oklahoma City, OK
PH. 405-525-0453 FAX. 405-557-0549

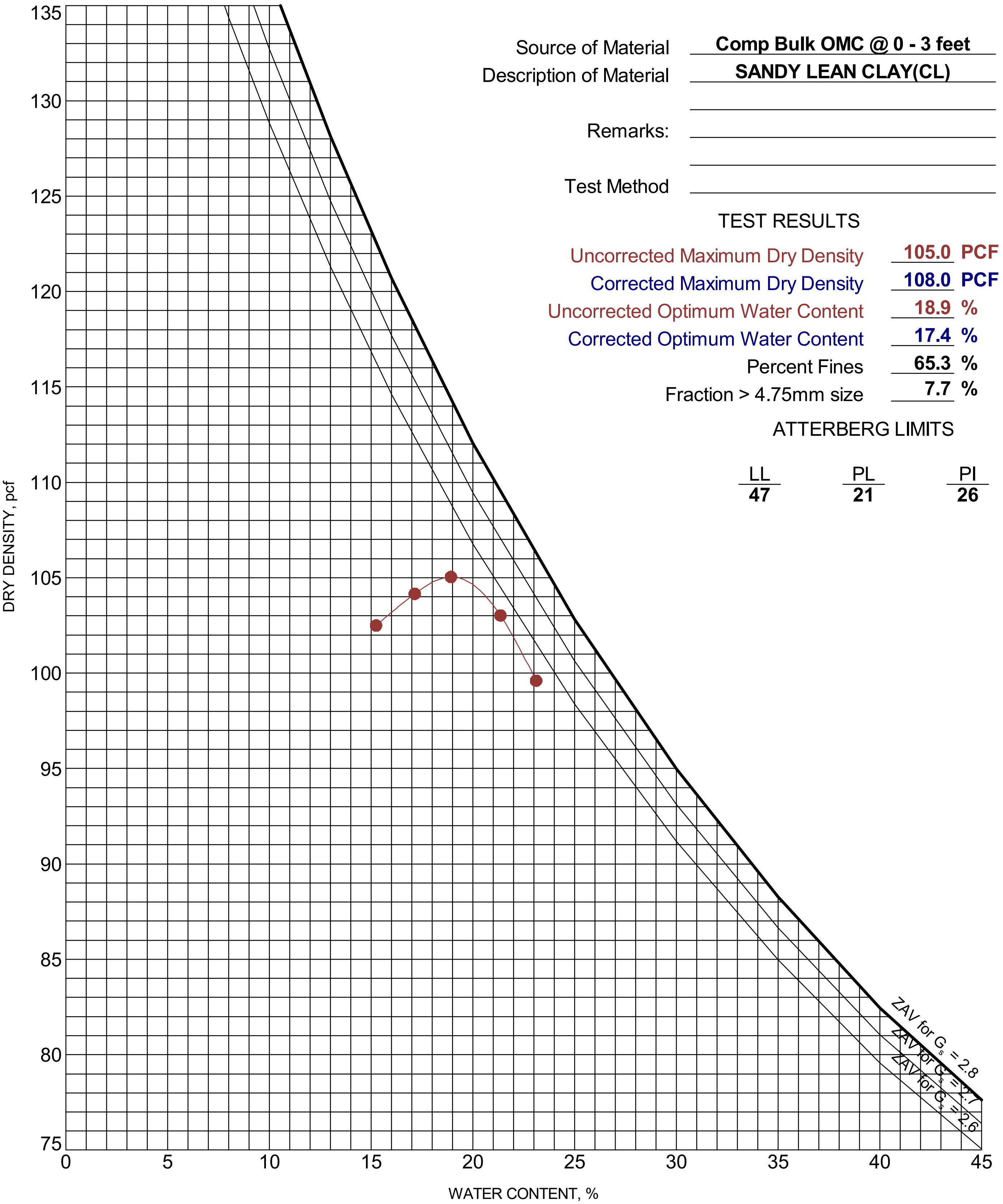
PROJECT NUMBER: 03215254

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-3

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material **Comp Bulk OMC @ 0 - 3 feet**

Description of Material **SANDY LEAN CLAY(CL)**

Remarks:

Test Method

TEST RESULTS

Uncorrected Maximum Dry Density	105.0	PCF
Corrected Maximum Dry Density	108.0	PCF
Uncorrected Optimum Water Content	18.9	%
Corrected Optimum Water Content	17.4	%
Percent Fines	65.3	%
Fraction > 4.75mm size	7.7	%

ATTERBERG LIMITS

LL	PL	PI
47	21	26

PROJECT: Atoka Lake Access Road
Improvements - South Section

SITE: Access Road East side of Atoka Lake
Stringtown, OK

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03215254

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-4

Resilient Modulus Testing - AASHTO T 307-99 English Units

Report Date: 08-Apr-22
Lab No.: Lab 52 RM 7 OMC
Project No.: 03215254

Soil Map Unit: Comp Bulk OMC
Soil Symbol: CL / A-7-6
Depth (ft.) 0 - 3.0
Compaction Method Static
Max. Dry Density (pcf) 105.0
Opt. Moisture Content (%) 18.9
Inside Mold Diameter (in) 3.94

Weight of Wet Soil (lb) 6.58
Initial Sample Diameter (in) 3.94
Initial Sample Height (in) 7.87
Initial Sample Area (in^2) 12.17
Sample Volume (in^3) 95.86
Compacted Moisture Content(%) 19.4
Wet Density (pcf) 118.7
Dry Density (pcf) 99.4

Test Date: March 5, 2022

Final Sample Height (in) 7.9
Final Sample Wet Weight (lb) 6.58
Final Moisture Content (%) 19.3
Accumulated Strain (%) 0.08

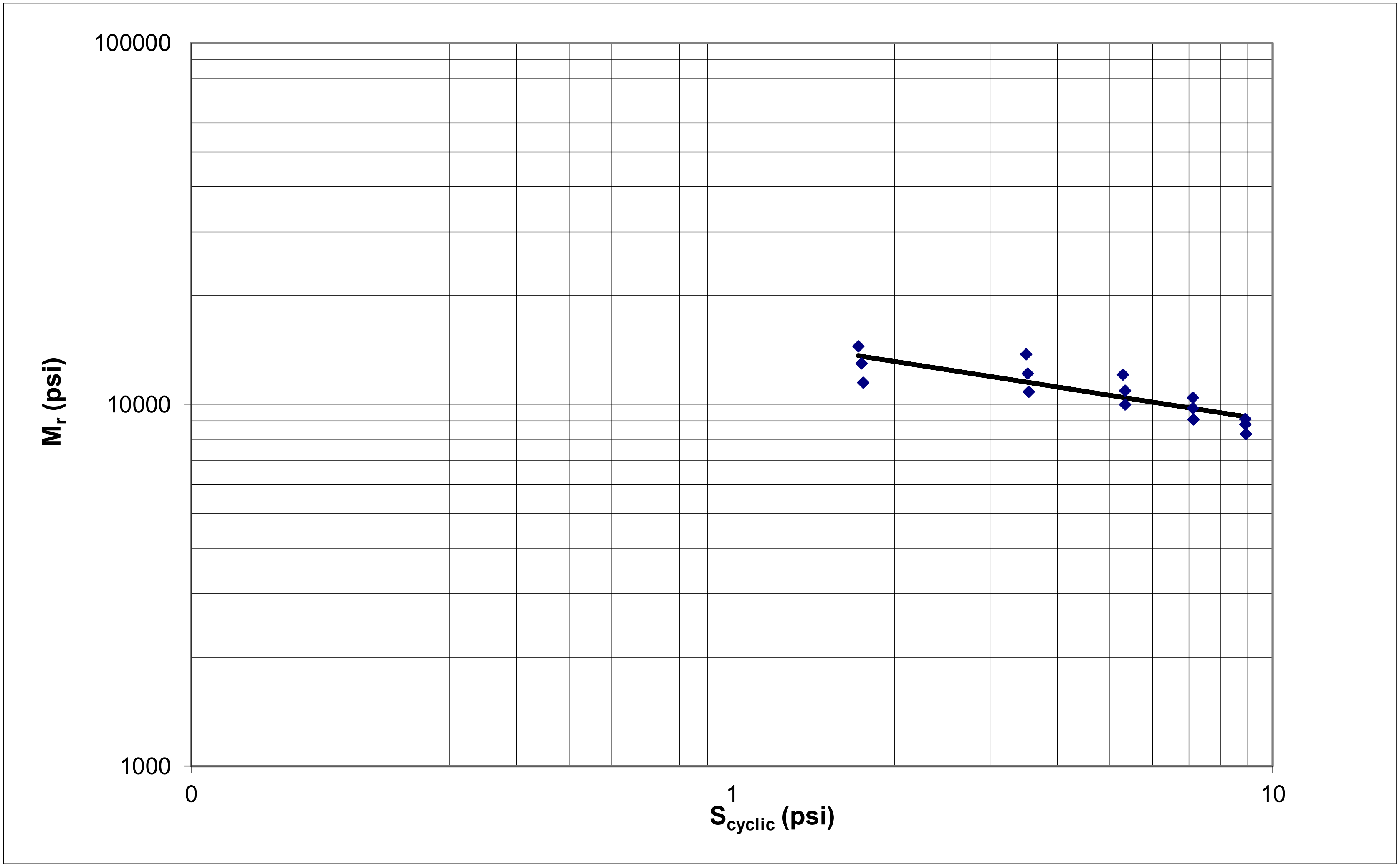
Percent Passing No. 10 86
Percent Passing No. 200 65.3
Liquid Limit 47
Plasticity Index 26

Chamber Confining Pressure (S_3) psi	Nominal Maximum Axial Stress (S_{cyclic}) psi	Actual Applied Max. Axial Load (P_{max}) lb	Actual Applied Cyclic Load (P_{cyclic}) lb	Actual Applied Contact Load ($P_{contact}$) lb	Actual Applied Max. Axial (S_{max}) psi	Actual Applied Cyclic Stress (S_{cyclic}) psi	Actual Applied Contact Stress ($S_{contact}$) psi	Recov. Def. LVDT #1 Reading (H_1) in	Recov. Def. LVDT #2 Reading (H_2) in	Average Recov. Def. LVDT 1 (H_{avg}) in	Resilient Strain (ϵ_r) in/in	Resilient Modulus (M_r) psi
6.00	2.00	23.0	20.8	2.2	1.89	1.71	0.179	0.0010	0.0009	0.0009	0.000118	14,502
6.00	4.00	47.1	42.6	4.5	3.87	3.50	0.372	0.0021	0.0019	0.0020	0.000254	13,782
6.00	6.00	71.6	64.4	7.3	5.88	5.29	0.597	0.0035	0.0033	0.0034	0.000436	12,110
6.00	8.00	96.1	86.7	9.4	7.90	7.12	0.776	0.0055	0.0052	0.0054	0.000680	10,468
6.00	10.00	120.5	108.5	12.0	9.90	8.91	0.989	0.0079	0.0075	0.0077	0.000978	9,110
4.01	2.00	23.2	21.1	2.1	1.91	1.74	0.171	0.0011	0.0010	0.0011	0.000133	13,012
4.01	4.00	47.5	42.9	4.6	3.90	3.53	0.378	0.0023	0.0022	0.0023	0.000290	12,174
4.01	6.00	71.8	65.0	6.8	5.90	5.34	0.561	0.0040	0.0037	0.0038	0.000488	10,927
4.01	8.00	96.3	86.8	9.5	7.91	7.13	0.779	0.0059	0.0056	0.0057	0.000730	9,773
4.01	10.00	120.4	108.5	12.0	9.89	8.91	0.981	0.0081	0.0078	0.0080	0.001010	8,819
2.01	2.00	23.0	21.3	1.7	1.89	1.75	0.136	0.0013	0.0011	0.0012	0.000152	11,497
2.00	4.00	47.3	43.1	4.2	3.88	3.54	0.343	0.0026	0.0025	0.0026	0.000326	10,860
2.00	6.00	71.5	64.9	6.6	5.87	5.33	0.538	0.0043	0.0041	0.0042	0.000533	10,007
2.00	8.00	96.0	86.9	9.1	7.88	7.13	0.749	0.0064	0.0060	0.0062	0.000786	9,075
2.00	10.00	120.2	108.7	11.5	9.87	8.93	0.945	0.0087	0.0083	0.0085	0.001076	8,297

Exhibit B-5

Terracon

Date Reported: 4/8/2022 Comp Bulk OMC
Terracon Lab No. Lab 52 RM 7 OMC
Project No. 03215254



$Mr = K1 \times S_{cylic}^{k2}$

S3 (psi)	K1	K2	R^2
6	17940.1	-0.274	0.86
4	15465.8	-0.233	0.91
2	13305.6	-0.195	0.90
All	15484.4	-0.235	0.70

Exhibit B-5

Date Reported:	4/8/2022	Comp Bulk OMC
Terracon Lab No.	Lab 52 RM 7 OMC	
Project No.	03215254	

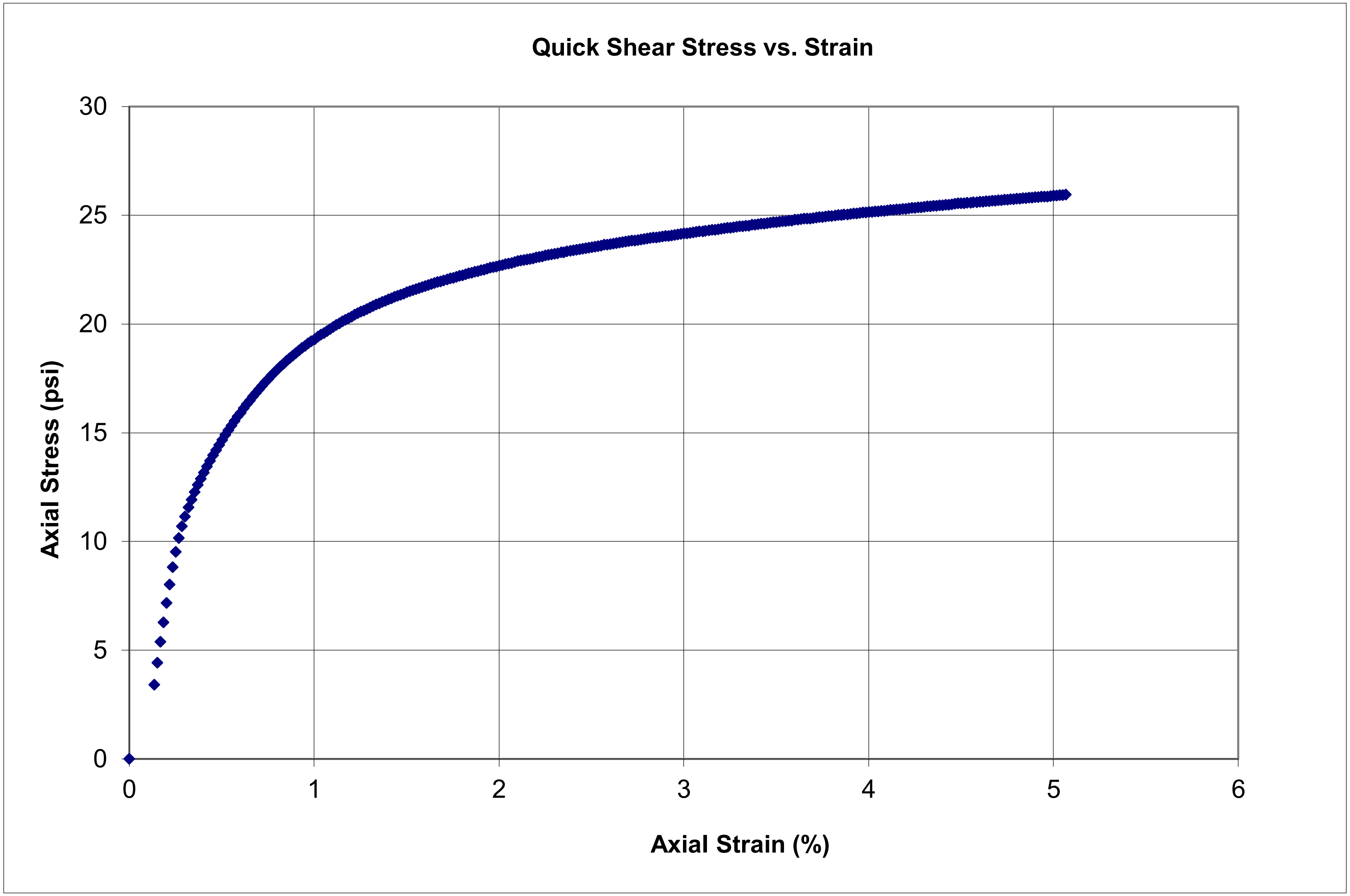


Exhibit B-5

Resilient Modulus Testing - AASHTO T 307-99 English Units

Report Date:	08-Apr-22
Lab No.:	Lab 52 RM 7 OMC+
Project No.:	03215254
Test Date:	March 5, 2022

Soil Map Unit:	Comp Bulk OMC+
Soil Symbol:	CL / A-7-6
Depth (ft.)	0 - 3.0
Compaction Method	Static
Max. Dry Density (pcf)	105.0
Opt. Moisture Content (%)	18.9
Inside Mold Diameter (in)	3.94

Weight of Wet Soil (lb)	6.80
Initial Sample Diameter (in)	3.94
Initial Sample Height (in)	7.87
Initial Sample Area (in^2)	12.17
Sample Volume (in^3)	95.86
Compacted Moisture Content(%)	23.3
Wet Density (pcf)	122.6
Dry Density (pcf)	99.4

Final Sample Height (in)	7.8
Final Sample Wet Weight (lb)	6.80
Final Moisture Content (%)	23.3
Accumulated Strain (%)	0.98
Percent Passing No. 10	86
Percent Passing No. 200	65.3
Liquid Limit	47
Plasticity Index	26

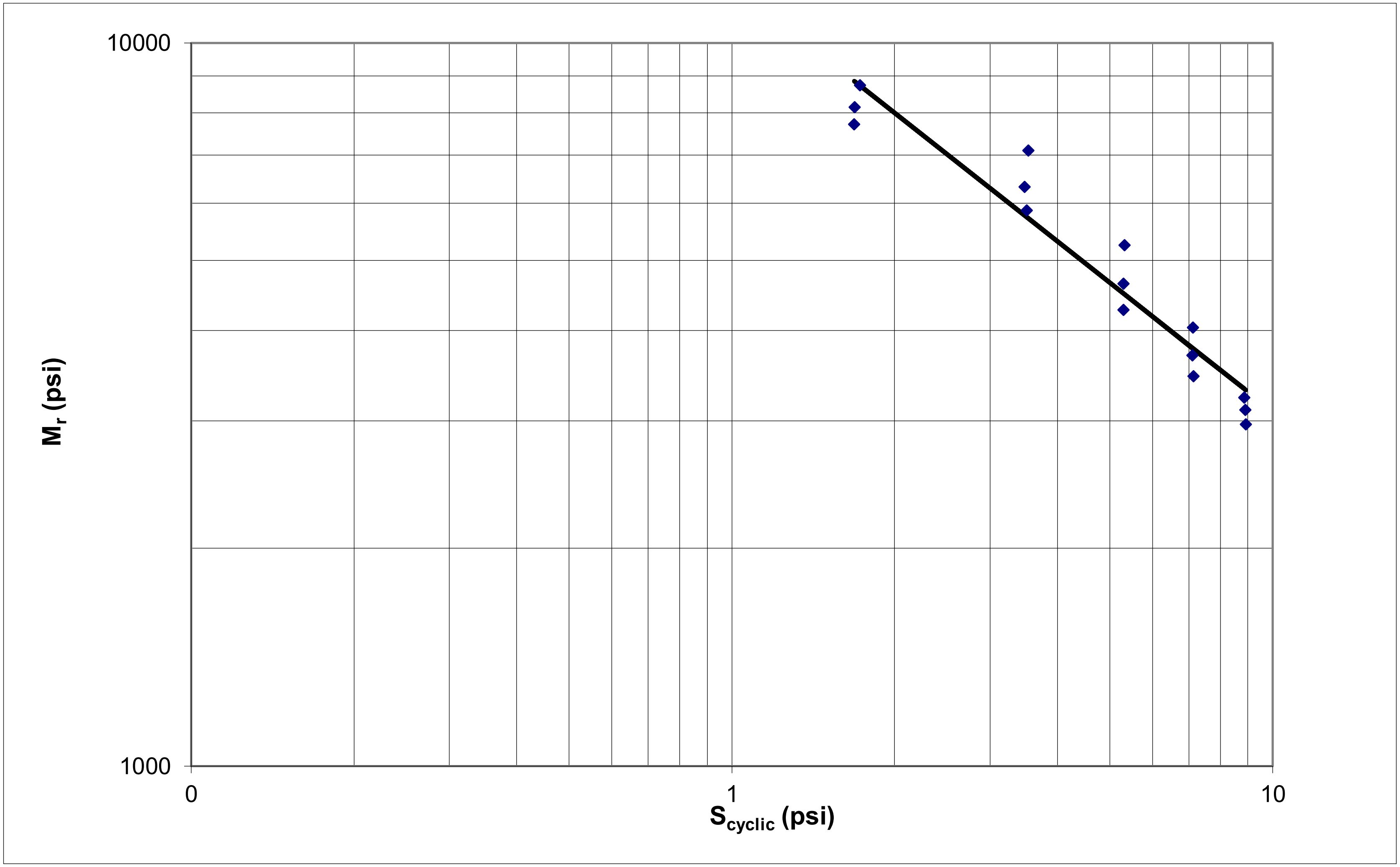
Chamber Confining Pressure (S_3) psi	Nominal Maximum Axial Stress (S_{cyclic}) psi	Actual Applied Max. Axial Load (P_{max}) lb	Actual Applied Cyclic Load (P_{cyclic}) lb	Actual Applied Contact Load ($P_{contact}$) lb	Actual Applied Max. Axial (S_{max}) psi	Actual Applied Cyclic Stress (S_{cyclic}) psi	Actual Applied Contact Stress ($S_{contact}$) psi	Recov. Def. LVDT #1 Reading (H_1) in	Recov. Def. LVDT #2 Reading (H_2) in	Average Recov. Def. LVDT 1 (H_{avg}) in	Resilient Strain (ϵ_r) in/in	Resilient Modulus (M_r) psi
6.00	2.00	23.2	21.0	2.2	1.90	1.73	0.177	0.0016	0.0015	0.0016	0.000197	8,737
6.00	4.00	47.6	43.0	4.6	3.91	3.53	0.376	0.0040	0.0038	0.0039	0.000497	7,101
6.00	6.00	71.9	64.8	7.1	5.91	5.32	0.585	0.0082	0.0078	0.0080	0.001012	5,256
6.00	8.00	96.5	86.7	9.8	7.93	7.12	0.805	0.0139	0.0139	0.0139	0.001762	4,043
6.00	10.00	120.7	108.0	12.7	9.91	8.87	1.043	0.0211	0.0221	0.0216	0.002743	3,233
4.01	2.00	23.1	20.5	2.6	1.90	1.69	0.215	0.0015	0.0018	0.0016	0.000207	8,145
4.01	4.00	47.5	42.4	5.1	3.90	3.48	0.421	0.0041	0.0045	0.0043	0.000550	6,323
4.01	6.00	72.0	64.6	7.4	5.91	5.30	0.608	0.0089	0.0090	0.0090	0.001142	4,646
4.01	8.00	96.5	86.5	10.0	7.92	7.10	0.821	0.0150	0.0152	0.0151	0.001920	3,699
4.01	10.00	120.8	108.5	12.4	9.92	8.91	1.017	0.0224	0.0228	0.0226	0.002867	3,107
2.00	2.00	22.7	20.5	2.2	1.86	1.68	0.178	0.0016	0.0018	0.0017	0.000218	7,717
2.00	4.00	47.3	42.7	4.5	3.88	3.51	0.371	0.0045	0.0049	0.0047	0.000599	5,863
2.01	6.00	71.6	64.6	7.0	5.88	5.30	0.573	0.0097	0.0098	0.0098	0.001242	4,271
2.00	8.00	96.3	86.9	9.4	7.91	7.13	0.775	0.0162	0.0163	0.0162	0.002062	3,460
2.00	10.00	120.6	108.6	12.0	9.90	8.92	0.984	0.0238	0.0235	0.0237	0.003005	2,967

Exhibit B-6

Date Reported: 4/8/2022 Comp Bulk OMC+

Terracon Lab No. Lab 52 RM 7 OMC+

Project No. 03215254



$Mr = K1 \times S_{cylic}^{k2}$

S3 (psi)	K1	K2	R^2
6	13362.0	-0.604	0.94
4	11834.7	-0.585	0.97
2	11078.2	-0.583	0.98
All	12043.7	-0.590	0.93

Exhibit B-6

Date Reported: 4/8/2022

Terracon Lab No. Lab 52 RM 7 OMC+

Project No. 03215254

Comp Bulk OMC+

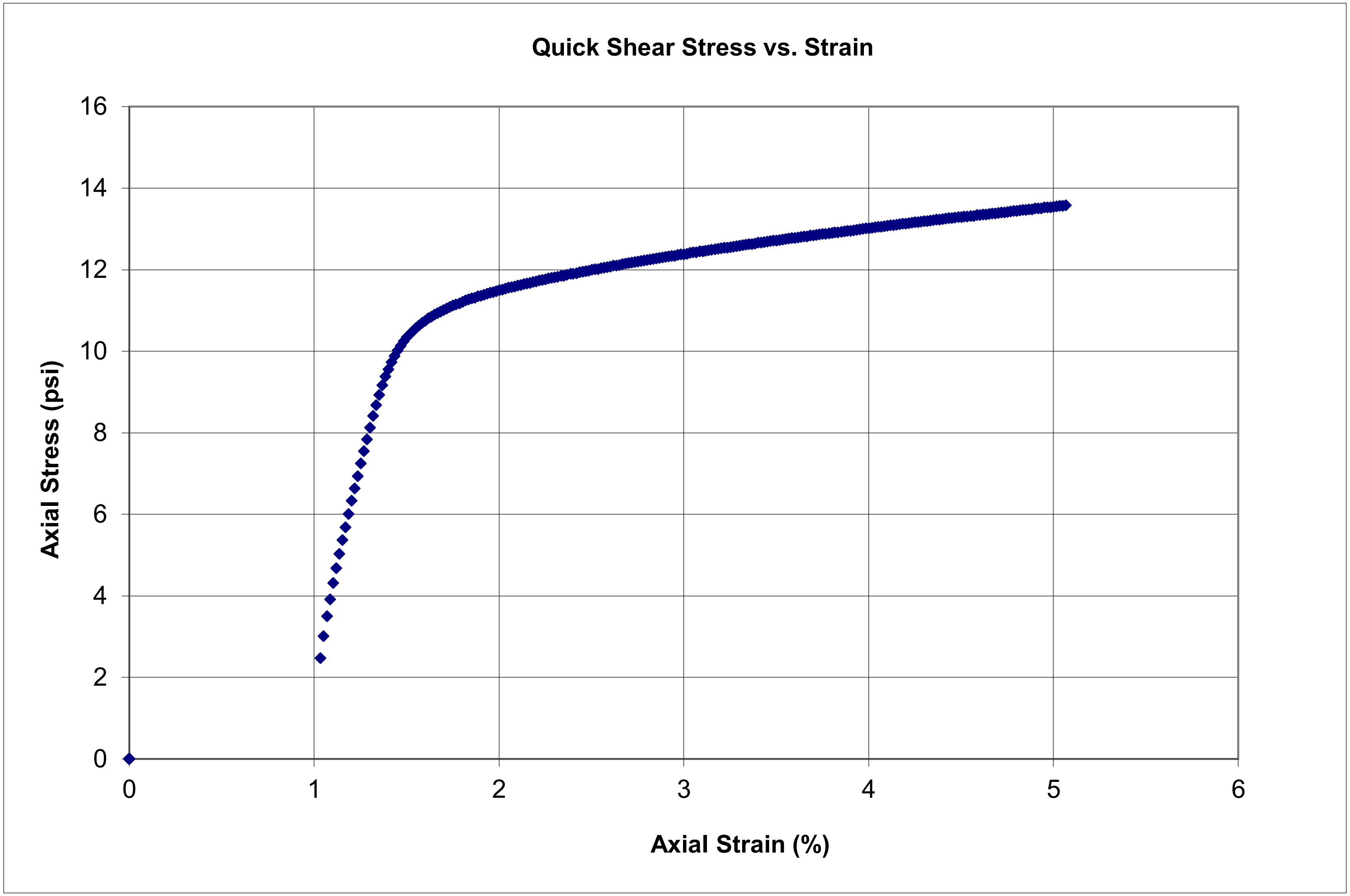


Exhibit B-6

APPENDIX C
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

Terracon

UNIFIED SOIL CLASSIFICATION SYSTEM

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

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

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

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

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

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

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

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

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

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

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

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

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

[Q] PI plots below "A" line.

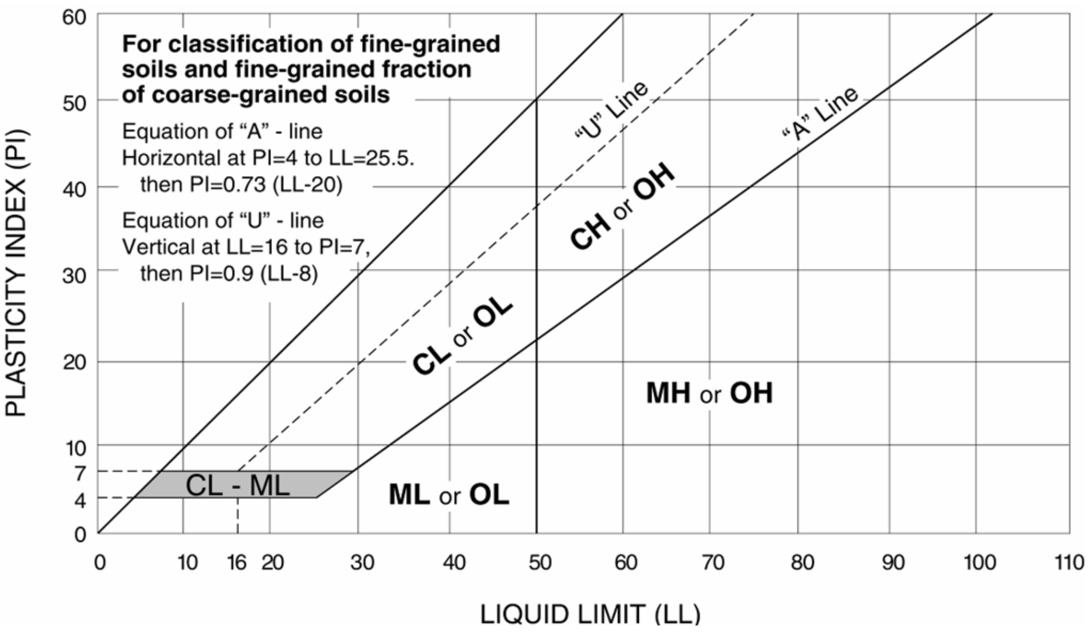


Exhibit C-2

Pavement Design Report

Lake Access Road Improvements
Atoka Lake – North Section
Near Stringtown, Oklahoma
April 8, 2022
Terracon Project No. 03215255

Prepared for:
Poe and Associates, Inc.
Oklahoma City, Oklahoma

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

terracon.com

Terracon

Environmental ■ Facilities ■ Geotechnical ■ Materials

April 8, 2022

Poe and Associates, Inc.
1601 Northwest Expressway, Suite 400
Oklahoma City, Oklahoma 73118

Attn: Mr. Todd Cochran, P.E.
P: [405] 949 1962
F: [405] 608 0380
E: Todd.Cochran@poeandassociates.com

Re: Pavement Design Report
Lake Access Road Improvements
Atoka Lake – North Section
Near Stringtown, Oklahoma
Terracon Project No. 03215255

Dear Mr. Cochran:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. These services were performed in general accordance with our Proposal No. P03215255 dated November 17, 2021. This geotechnical engineering report presents the results of the subsurface exploration and provides recommendations for the pavement typical sections and subgrade preparations for the proposed project and repair recommendations for the slide that has occurred.

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. 6/30/23

Jeff Dean, P.E.	Norman K. Tan, Ph.D., P.E.
Oklahoma No. 16998	Geotechnical Manager

JD:NT\kld\n:\projects\2021\03215254\project documents\apr2022

Copies to: Addressee (1 via email)

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APPENDIX A - FIELD EXPLORATION

APPENDIX B - LABORATORY TESTING

APPENDIX C - SUPPORTING DOCUMENTS

EXECUTIVE SUMMARY

A geotechnical exploration has been performed for the planned rehabilitation of the lake access roads along the east shoreline of Atoka Lake near Stringtown, Oklahoma. This report covers the north section which includes approximately two miles of pavement extending north from the dam. The scope of Terracon's field investigation includes evaluating the pavement at eight locations which included coring the pavement and hand augered borings approximately 36 inches deep at each location and testing the subgrade stiffness with a Kessler dynamic cone penetrometer (DCP). The scope also included six deep borings to evaluate the slide that has developed within the pavement beginning approximately 0.8 miles north of the dam.

The following conditions are indicated by our subsurface exploration:

- Soils encountered in, and extending to the bottom, of the hand augered borings consisted of moderate to high plasticity lean to fat clays with varying amounts of sand and occasional gravels. Auger refusal was encountered at a depth of approximately 21 inches in boring B-2.

- A surface layer of chemically treated subgrade, ranging in thickens from approximately 6 to 18 inches, was encountered in the ten pavement borings.

- The existing pavement was asphalt and ranged in thickness from 2-1/4 to 7 inches.

- The DCP values provide an indication of the stiffness of the subgrade soil profile. The DCP plots generally indicate a stiffer upper layer in 3 of the 8 borings where chemical stabilization was indicated. The stiffness of the subgrade generally decreased below this stiffer upper layer in 2 of the 3 borings. The DCP indicated very soft subgrade ranging to depths of 10 to 36 inches in 5 of the borings. Refusal with the DCP was reached at a depth of approximately 21 inches at boring B-2.

- Groundwater was encountered only in boring B-10 at a depth of 36 inches at the time of our field investigation.

- The moisture contents of the soils samples retrieved from each hand augered boring were generally at or in some instances well above the soil's plastic limit in several of the borings. This is the moisture content at which a clayey soil can be molded and begins to lose strength.

- Six deep borings were drilled across the pavement section to evaluate the landslide that has occurred along the north road section. Three borings near station 547+25 and three borings near station 556+25. The three borings, B-5, B5A, and B-5B, near station 547+25 were drilled to a depth of 24 feet and encountered lean to fat clay ranging in depth from 11 to 15 feet below which the soil profile transitioned to highly weathered shale. The three borings, B-7, B-7A, and B-7B, near station 556+25 were drilled to a depth of 34.5 to 39.5 feet and encountered lean to fat clay ranging in depth from 18 to 28.5 feet deep below which the soil profile transitioned to highly weathered shale.

- Groundwater was not encountered in any of the deep borings during our field investigation.

This geotechnical executive summary should be used in conjunction with the entire report for design and/or construction purposes. It should be recognized that specific details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled General Comments should be read for an understanding of the report limitations.

PAVEMENT DESIGN REPORT
LAKE ACCESS ROAD IMPROVEMENTS
ATOKA LAKE – NORTH SECTION
NEAR STRINGTOWN, OKLAHOMA
Terracon Project No. 03215255
April 8, 2022

1.0 INTRODUCTION

This report presents the results of our geotechnical engineering services performed for the proposed rehabilitation of the lake access roads along the east shoreline of Atoka Lake near Stringtown, Oklahoma. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- subgrade strength values for
- landslide repair
- groundwater conditions
- earthwork
- pavement typical sections

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Site layout	See Appendix A, Exhibits A-1 to A-5
Proposed development	The project will involve the rehabilitation of the lake access roads along the east shoreline of Atoka Lake near Stringtown, Oklahoma.
Grading	Grade changes for the proposed new construction are not anticipated.
Traffic loading	A traffic estimate of 1,000 vehicles per day including occasional trucks was provided for development of the pavement designs.

3.0 SUBSURFACE CONDITIONS

3.1 Pavement Cores

The pavement was cored at eight locations for evaluation. The pavement thickness was measured in the field at the two deep boring locations. The pavement cores were 6 inches in diameter and penetrated the bound layers of the pavement. A diamond impregnated core barrel was used to cut the cores. Water was used to flush cuttings to the surface and cool the core barrel. Subgrade soil samples were also retrieved for laboratory testing. After collecting the pavement cores and subgrade samples, the core locations were backfilled with similar materials.

An engineer examined each of the pavement cores in the laboratory to evaluate the thickness and condition of each pavement layer. The cores were observed for the presence of stripping, deterioration, and layer separation in the asphaltic concrete.

The existing pavement was full depth asphalt was at nine of the ten locations and ranged in thickness from 2-1/4 to 7 inches. Photographic logs of the pavement cores are presented in Appendix A.

3.2 Subgrade Soils

The subgrade beneath the pavement at each core location was hand augered to a depth of approximately 36 inches. Auger refusal was encountered at a depth of approximately 21 inches in boring B-2. Subgrade soil samples were retrieved from each boring for laboratory testing. After collecting the subgrade samples, the borings were backfilled with similar materials. Stratification boundaries in the boring logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual. Indicator solution tests revealed a surface layer of chemically treated subgrade ranging from approximately 6 to 18 inches thick beneath the pavement at the ten boring locations. Based upon the results of the borings, subsurface conditions on the project site can be generalized as follows:

Pavement Core Locations C-1 through C-10			
Description	**Approximate Depth to Bottom of Stratum (inches)**	**Material Encountered**	**Consistency/Density**
Stratum 1	6 to 18	Chemically Stabilized subgrade	Very soft to very stiff
Stratum 2	Below termination depth	Moderate to high plasticity lean to fat clays with varying amounts of sand	Very soft to very stiff

Landslide Borings B-5, B-5A, B-5B, B-7, B-7A, and B-7B			
Description	**Approximate Depth to Bottom of Stratum (feet)**	**Material Encountered**	**Consistency/Density**
Stratum 1	11 to 28.5	Moderate to high plasticity lean to fat clays with varying amounts of sand	Medium stiff to hard
Stratum 2	Below termination depth	Highly weathered to weathered shale	Soft to hard

The laboratory testing program is described in Appendix B. Test results are reported on the boring logs in Appendix A.

As illustrated in the boring logs, the moisture content of the subgrade samples that were tested, generally were at or in some instances well above the plastic limit of the clay soil in many of the borings. This is the moisture content at which a clay soil can be molded and begins to lose strength.

3.3 Subgrade Properties

The subsurface exploration program is described in Appendix A. Specific conditions encountered at each boring location are indicated in the individual boring logs, also included in Appendix A.

The Dynamic Cone Penetration (DCP) test results indicated the stiffness of the subgrade soil profiles along the proposed pavement alignment. California Bearing Ratio, CBR, values developed from the DCP tests are a means of comparing penetration values of soils to that of densely compacted crushed rock. A CBR value of 100 is used as the standard reference to indicate excellent material with resistance and support properties similar to a well graded crushed rock. In general, CBR values used for pavement design are listed in the following table.

CBR	Material
80 to 100	Good quality crushed rock
30 to 60	Chemically stabilized subgrade*
20 to 30	Very good subgrade
10 to 20	Fair to good subgrade
5 to 10	Questionable to fair subgrade
<5	Poor subgrade

* CBR values will vary according to chemical admixture

DCP tests were conducted at 8 pavement coring locations. The DCP values provide an indication of the stiffness of the subgrade soil profile. The DCP plots generally indicate a stiffer upper layer at boring locations B-2, B-4, and B-9 where chemical stabilization was indicated. The stiffness of the subgrade generally decreased below this stiffer upper layer in 2 of the borings. The DCP test indicated deep, soft subgrade at boring locations B-1, B-3, B-4, B-6, and B-8. Overall, the DCP plots generally indicate subgrade ranging from very soft to very stiff. Plots of the DCP tests at each core location are included in Exhibits A-29 to A-36 in Appendix A.

Subgrade soil samples were obtained from all borings to determine the subgrade parameters for developing the pavement designs. Tests conducted on these samples include classification, gradation, and moisture content. These tests were used to evaluate the subgrade design criteria for the new pavement sections.

The laboratory testing program is described in Appendix B. Test results are reported on the boring logs in Appendix A.

3.4 Groundwater

The borings were monitored while hand augering and immediately after completion for the presence and level of groundwater. Water was not encountered in any of the borings during our investigation.

Groundwater was not observed in the borings while drilling, or for the short duration the borings could remain open. However, this does not necessarily mean the borings terminated above groundwater. Due to the low permeability of the soils encountered in the borings, a relatively long period may be necessary for a groundwater level to develop and stabilize in a borehole.

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 groundwater levels occur due to seasonal variations in the amount of rainfall, runoff, altered natural drainage paths, and other factors not evident at the time the borings were advanced.

4.0 PAVEMENT DESIGN RECOMMENDATIONS

4.1 Pavement Design Parameters

It is our understanding that both flexible and rigid options are to be considered for rehabilitating the pavement for this project. AASHTO Pavement Design software was used to design the overlay for the pavement section. The pavement designs are based upon a 30 year design life.

A bulk sample of the existing subgrade was collected from the borings to perform a laboratory moisture/density test and resilient modulus tests to develop the design subgrade parameters required for the pavement designs. A summary of these test results are presented in the following table.

Soil Sample	Resilient Modulus, psi		Max Density/ Opt M.C. pcf / %	AASHTO Class	LL	PI	Passing #200
	OMC	OMC+2%					
Bulk 1	11,502	8,757	100.6 / 21.5	A-7-5(13)	60	25	58.1

Historical resilient modulus test values for highly plastic soils range from 3,000 to 4,000 psi. For the pavement sections, a design resilient modulus value of 3,500 psi was used. The following is a summary of the design parameters used to design the pavement typical sections:

Atoka Lake Access Road – section north of the dam

- Average Annual Daily Traffic, AADT, 1,000
- Percent Trucks, 0.5%
- Directional Distribution, 55%
- Reliability value, 90%
- Design resilient modulus value – 3,500 psi
- Annual Growth Rate, 2%

The full depth typical sections are based upon a 30-year design life. The design AADT used in the pavement designs include occasional class 9 vehicles and a combination of cars, pickup trucks, school buses, dump trucks, and various types of delivery trucks. If these design traffic parameters are inconsistent with those desired by the client, the revised traffic information should be submitted for our review to evaluate any potential changes to our design recommendations.

4.2 Pavement Typical Section Recommendations

Based upon the parameters listed above, the following pavement sections may be considered for the project.

Flexible Options – 30 Year Design

Option 1

2.0 in. S4 PG 64-22OK
4.0 in. S3 PG 64-22OK
12.0 in. FDR existing pavement and subgrade with lime added to control the expansive soils (Could use PC cement if a mix deign is performed)

Or

2.0 in. S4 PG 64-22OK
4.0 in. S3 PG 64-22OK
8.0 in. AggregateBase Type A – sholder with TBSC type E
8 oz/SY non-woven separator fabric
8.0 in. Stabilized Subgrade[1]

Rigid Options – 30 Year Design

Rigid Option

5.5 in. PC Concrete (recommend fiber reinforce concrete w/ saw joints every 6 ft laterally & longitudinally)
12.0 in. FDR existing pavement and subgrade with lime added to control the expansive soils (Could use PC cement if a mix deign is performed)

Or

5.5 in. PC Concrete (recommend fiber reinforce concrete w/ saw joints every 6 ft laterally & longitudinally)

8.0 in. AggregateBase Type A – sholder with TBSC type E
8 oz/SY non-woven separator fabric
8.0 in. Stabilized Subgrade[1]

Notes:

1 – Per ODOT Specifications 307 - at the rate specified for the appropriate soil classification according to OHD L-50

5.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

5.1 Geotechnical Considerations

The borings generally encountered moderate to high plasticity lean to fat clays with varying amounts of sand. These soils generally have low permeability and will tend to increase in moisture content and decrease in strength over time as the pavement is in service. This is evident by the high moisture contents of the several of the soil samples that were tested. The Kessler DCP test revealed several locations with deep, soft subgrade profiles.

Geotechnical engineering recommendations for earthwork and pavement design and construction are outlined below. The recommendations contained in this report are based upon the results of field and laboratory testing located in the boring loges and DCP tests, which are presented in Appendix A, engineering analyses, and our current understanding of the proposed project.

5.2 Earthwork

The following presents recommendations for site and subgrade preparation, including chemical treatment and placement of engineered fills. Later recommendations presented for design and construction of pavements are contingent upon implementing the recommendations outlined in this section.

Earthwork, including subgrade preparation, fill placement and chemical soil treatment, should be observed and tested by Terracon.

5.3 Subgrade Preparation

After the removal of selected pavement sections, the exposed subgrade should be probed with either a T-probe or Kessler DCP to identify the depth and lateral extent of any soft materials. In broader extents, it may be necessary to proof roll the subgrade with a loaded, tandem-axle dump truck weighing at least 25 tons (under the observation of Terracon personnel) to locate any soft or unstable zones. The proofrolling should involve overlapping passes of the equipment. Where rutting or pumping is observed during proofrolling, the unstable soils should be over excavated and replaced with an approved soil as described in following sections if it cannot be effectively dried and compacted in-place. The extent of this unstable soil will not become evident until construction begins, but this condition should be anticipated and planned for accordingly. We expect the subgrade soils beneath the existing pavement to accumulate moisture over the life of the pavement. Therefore, it is probable that wet or unstable areas will be encountered during probing or proofrolling.

After probing the subgrade and removal of soft subgrade, the exposed subgrade in areas to receive new fill should be scarified to a depth of 8 inches, adjusted to a workable moisture content within 2 percent of its optimum value and be compacted to at least 95 percent of the material's maximum dry density as determined by test method ASTM D698 (Standard Proctor).

5.4 Subgrade Stabilization

If the Full Depth Reclaimation, FDR, option is selected, to reduce potential strength loss and improve the long-term subgrade support, we recommend that the top 12 inches of the processed pavement and subgrade soils be chemically stabilized. If the existing pavement is removed, we recommend stabilizing the top 8 inches of the subgrade. The type of additive should be determined at the time of construction by the geotechnical engineer. We recommend following ODOT's OHD L-50 for determining the actual type and percentage of chemical used as indicated in the table below .

Soil Stabilization Table												
Additive (Expressed as a percentage added on oven dry basis)	**Soil Group Classification - AASHTO M145**											
	A-1		A-1				A-3	A-4	A-5	A-6	A-7	
	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7					A-7-5	A-7-6
Portland Cement	4	4	4	4	4	4	5	√	√	√		
Fly Ash					12	12	13	14	14	14		
Cement Kiln Dust (Pre-Calciner Plants)	5	5	5	5	5	5	6	√	√			
Cement Kiln Dust (Other Type Plants)	10	10	10	11	11	11	12	12	12			
Hydrated Lime*										4	5**	5**

A blank in the table indicates the additive is not recommended for that soil group. Recommended amounts include a safety factor for loss due to wind, grading, and/or mixing. Pre-Calciner plants are identified on the ODOT Materials Division approved list for cement kiln dust.

√ = Mix Design required

*= Reduce quantity by 20 percent when quick lime is used, i.e. 4% x 0.8 = 3.2%, 5% x 0.8 = 4.0%, 6% x 0.8 = 4.8%.

**= use 6% when liquid limit is greater than 50.

Before compaction, the stabilized soil layer should be adjusted to within 2 percent of the material's optimum moisture as determined by test method ASTM D698. After conditioning the soil to the required moisture content, the stabilized subgrade should be compacted to at least 98 percent of the material's maximum dry density as determined by test method ASTM D698. Compaction should be completed within about two hours after initially mixing the soil and stabilizing agent to optimize the stabilization benefit. Chemically treated subgrade and engineered fill should be placed and compacted in accordance with the recommendation in the following sections.

5.5 Fill Materials

All fill required to replace exposed soft subgrade areas should be an approved material that is free of organic matter and debris as outlined in the following table.

Fill Type [1,2]	Acceptable Location for Placement
Imported Cohesive Soils (Clay soils with LL<40, 8<PI<20)	All engineered fill areas
On-site soils	All engineered fill areas

1. Prior to placing fill, a sample of the proposed material should be obtained for laboratory testing to confirm compliance with Atterberg limits and gradation requirements, and to determine moisture-density relationship. The tests will provide a basis for evaluating suitability of the material and in-place compacted density.
2. Per pavement design recommendations, the top 12 inches will be chemically stabilized.

5.6 Placement and Compaction Requirements

Recommended placement, compaction and moisture content criteria for engineered fill materials are as follows:

ITEM	DESCRIPTION
Fill Lift Thickness[1]	8-inches or less in loose thickness
Compaction Requirements[2, 3]	**Native Soils:** At least 95% of the material's maximum standard Proctor dry density, ASTM D-698 **Chemically Treated Soils:** At least 98% of the material's maximum standard Proctor dry density, ASTM D-698
Moisture Content[2]	**Native Soils:** Workable moisture content that is 2% below to 2% above its optimum standard Proctor value **Chemically Treated Soils:** 2% below to 2% above its optimum standard Proctor value

[1] Engineered fill should be placed and compacted in horizontal lifts.

[2] Compaction equipment and procedures should uniformly produce recommended moisture contents and densities throughout the lift.

[3] A qualified soil technician should perform sufficient in-place density tests during the filling operations to evaluate that proper levels of compaction, including dry unit weight and moisture content, are being attained.

5.7 Trench Backfill

Care should be taken to properly backfill utility trench cuts within the pavement areas. All trenches created for utility access under the pavement should be effectively sealed to restrict water intrusion into the pavement subgrade. We recommend using a clay soil to construct a trench plug that extends at least 5 feet out from the edge of the pavements. The clay should have a minimum plasticity index (PI) of 15 and be placed in controlled lifts not exceeding 9 inches in loose thickness so as to surround the utility line and fill the trench. Each lift of clay backfill should be compacted to at least 95 percent of the material's maximum standard Proctor dry density (ASTM D-698), at a moisture content that is 2 percentage points above the optimum value.

5.8 Drainage

Developing and maintaining effective surface drainage is critical to the satisfactory long-term performance of pavements. The pavement surface should be crowned sufficiently to rapidly drain surface water to the gutters and into drainage inlets. Paved shoulders and earth slopes should be adequately sloped to promote effective drainage of surface water away from the pavement edge. Ditches and other drainage structures should effectively collect and discharge runoff to prevent standing water that could saturate and soften the subgrade soils.

5.9 Maintenance

Periodic maintenance extends the service life of the pavement and should include crack sealing, joint sealing, and patching of any deteriorated areas. Also, thicker pavement sections could be used to reduce the required maintenance and extend the service life of the pavement. Failure to follow these recommendations could result in premature pavement distress and higher maintenance costs.

6.0 LANDSLIDE ANAYSIS AND REPAIR RECOMMENDATIONS

6.1 Data Analysis

The Atoka Lake Access roads along the east shoreline of the lake are generally formed from a sidehill cut into the existing hill slope. The slopes of the north road appear to be relatively shallow ranging from approximately 7H:1V to about 8H:1V. Clay slopes constructed of moderate to high plasticity clays, such as those along these access roads, although stable when originally constructed, experience shrink and swell movements during alternating wet / dry weather cycles. This shrink / swell activity tends to form cracks along the surface which allow more water into the near surface zone along the slope causing it to swell and soften to a greater depth. This swelling/softening activity forms a weaker zone of soil along the surface of the embankment.

The soils in this zone of the slope become progressively more normally consolidated and can approach what is termed a "fully softened" condition. Creep and further weathering can reduce the shear strength of the soil in this zone further, causing progressive strain-softening, leading to a residual strength condition in portions of the slope. Slopes of this nature can begin to fail progressively, either in a bottom-up, or top-down fashion, leading to full mobilization of the entire slope. In the case of these slopes along the access roads, it appears that the failure is a top-down progression. The tension cracks that formed along the road slope likely served to introduce additional water seepage into the shear surface causing further shear strength reduction and downslope progression.

Estimated ranges of fully softened and residual shear strength parameters for use in our analyses were developed for the embankment fill and native soils based on the index test results using the correlations developed by Dr. Timothy Stark of the University of Illinois. Using the provided cross sections, the as-built/failed condition was modeled using the slope stability software, Slope/W in order to back-calculate the likely existing failure surface location.

The parameters for each material and zone were estimated based the soil boring data, laboratory tests, the estimated shear strength parameter ranges discussed previously, previous experience with soil slopes in this region, and observations at the site.

The tension cracks observed in the pavement were used to define the approximate location of the slip surface at each of the slides that were analyzed. For the back-calculation analysis of each of the failed slopes, a target safety factor of 1 was used to analyze the existing slope. Soil parameters for each material and zone were varied within the anticipated ranges of fully softened and/or residual strength conditions until the factor of safety for the analyzed model reached approximately 1. The results of this back-calculation analysis are shown in Figures 1 and 2. The results of this analysis indicate a residual strength condition along the failure surface and normally consolidated (fully softened) conditions in the underlying native foundation soils. Although not shown in Figures 1 and 2, it is likely that the central core of the slope (away from the likely failure surface zone) still possesses apparent overconsolidated shear strength (higher cohesion and friction) due to the original compaction process and lack of weathering exposure.

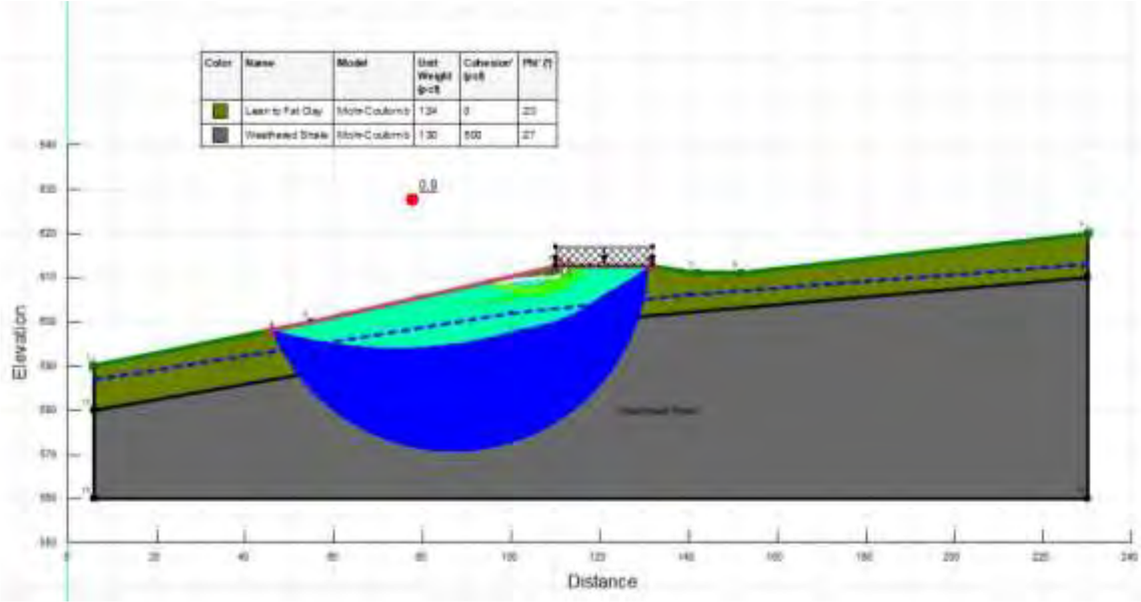


Figure 1 – Estimated Failure Plane of Slide near Borings B-5, B-5A, & B-5B.
Approximate Station 547+20

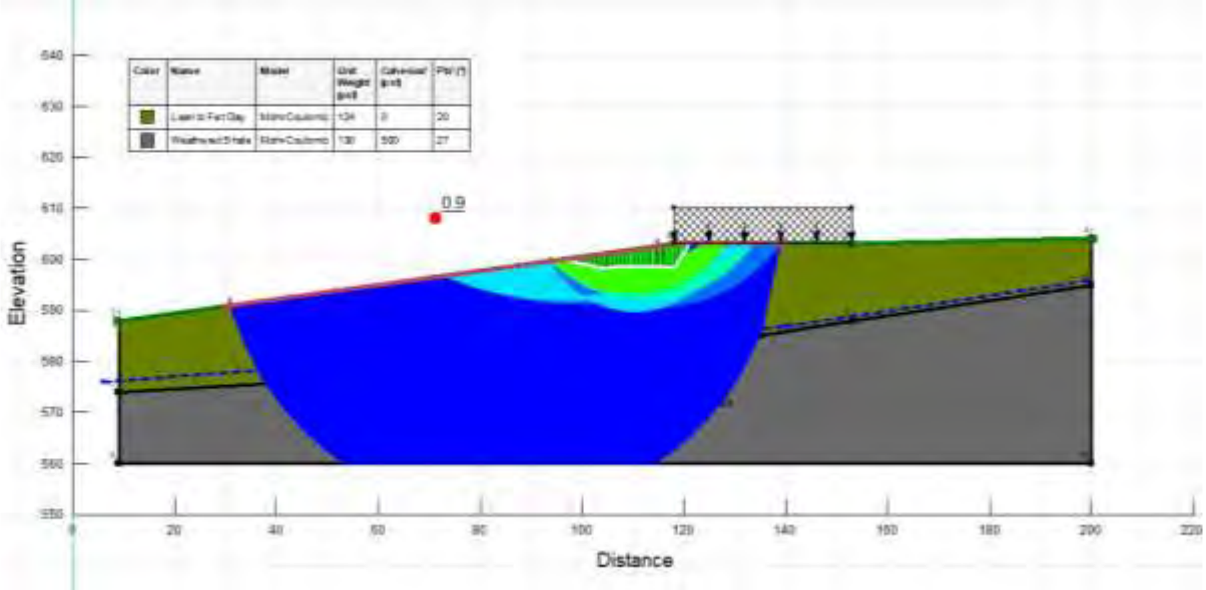


Figure 2 – Estimated Failure Plane of Slide near Borings B-&, B-7A, & B-7B.
Approximate Station 556+20

The back-calculation results displayed in Figures 1 and 2 provide our best estimate of the most likely location of the failure surfaces within the slope based upon the embankment soil parameters used and the slope geometry at each location. It should be noted that only one point on the failure surface (the tension crack in the pavement) is known. The actual location (depth and downslope extent) of the failure surface likely varies from the locus shown in each figure due to variations in material property, weathering and other variables not accounted for in the analysis. A test trench into the slope at each location would be required to accurately identify the depth, extent and actual location of the failure surface

6.2 Repair Alternatives

As requested, slope repair alternatives were analyzed for the occurring slides. A common approach to mitigate steep slopes, that have failed, is to flatten the slope. These slopes already lie at a relatively shallow slope angle, approximately 7H:1V to about 8H:1V.

A repair option, often considered, is to reinforce the slope. This can be achieved by excavating the failed material in and around each of the slides and placing it back in controlled layers of soil of specified maximum thickness. Each lift would be compacted to a targeted density and moisture content. Reinforcement, in the form of a high strength geotextile, would be placed between each of the layers of compacted soil. This type of reinforcement option would require extensive removal of the pavement and portions of the slope to a depth below the slippage plain of the slide. The slope would be reconstructed from this point with reinforced layers as described previously. The final step would be to reconstruct the pavement sections that have been removed. This option again requires considerable earthwork and would effectively close the north access road for the duration of the project.

Another slope reinforcement option is available that does not require the extensive reconstruction described in the previous approach. This option uses soil nails or soil anchors to stabilize the slope in place. The advantage of this approach is that it can be achieved without closing the road for extensive periods of time and may possibly be conducted with one lane of traffic open during operations. In this reinforcement method, soil nails or anchors composed of high strength steel rods or tubes are either driven or drilled to a specified depth beyond the slippage plane into stable strata within the slope. They are placed along the slope in a grid pattern with spacing typical ranging from 3 to 6 feet. A reinforcing mesh of steel wire or cable is also placed along the slope and fastened to the anchors to reinforce the soil between the soil nails or anchor rods. This approach has the advantage of saving considerable time and the expense over other methods requiring extensive earthwork operations. This option was analyzed for feasibility at each of the two slide locations where borings were drilled. They are illustrated in Figures 3 and 4 below.

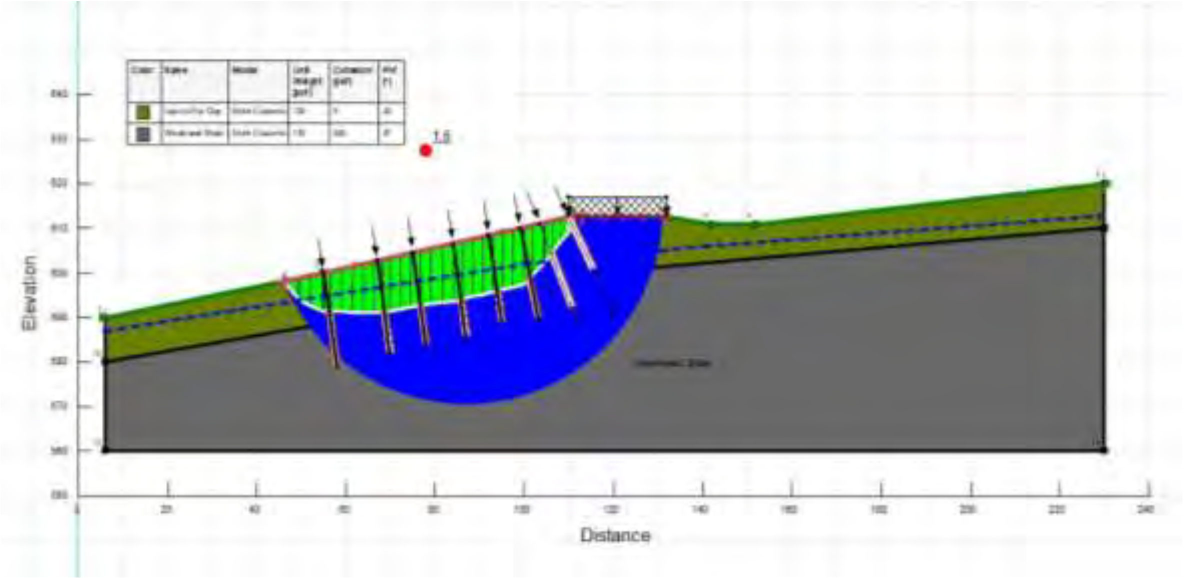


Figure 3. Slide near borings B-5, B-5A, & B-5B reinforced with soil nails into the existing slope. Approximate Station 547+20

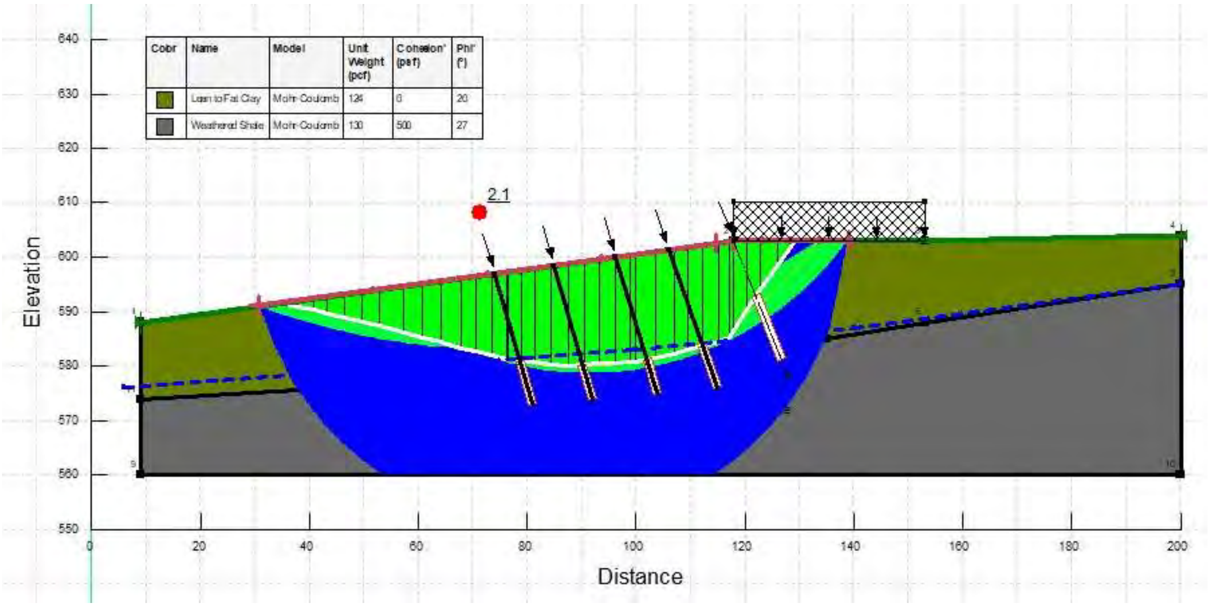


Figure 4. Soil nail reinforced slide near borings B-7, B-7A, & B-7B. Approximate Station 556+20

Figures 3 and 4 indicate that soil nails and/or soil anchors can be used to successfully stabilize the slopes, in place, without the requirement of extensive earthwork. **The final designs for this option should be developed by a contractor which specializes in this type of stabilization approach.** That design will be based upon the information detailed in our boring logs, the slope geometry, and the engineering properties of the anchorage system that is used. This approach has been used successfully in recent years to stabilize problem slopes that have plagued ODOT Maintenance personnel for several years. We can provide contact information for contractors that specialize in this type of work if needed. We recommend completing all slope stabilization work prior to starting the rehabilitation of the north lake access road.

7.0 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, subgrade treatment 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 or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential of such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of *Poe and Associates, Inc.* for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, express 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

AERIAL PHOTOGRAPHY PROVIDED
BY MICROSOFT BING MAPS

Project Manager: JLD	Project No. 03215255
Drawn by: CAN	Scale: AS SHOWN
Checked by: JLD	File Name: A1-A5
Approved by: NKT	Date: APR 2022

Terracon

4701 N Stiles Ave
Oklahoma City, OK 73105-3330

SITE LOCATION

Atoka Lake Access Road
Improvements – North Section
Stringtown, OK

Exhibit

A-1

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

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Project Manager: JLD	Project No. 03215255
Drawn by: CAN	Scale: AS SHOWN
Checked by: JLD	File Name: A1-A5
Approved by: NKT	Date: APR 2022

Terracon

4701 N Stiles Ave
Oklahoma City, OK 73105-3330

EXPLORATION PLAN

Atoka Lake Access Road Improvements – North Section
Stringtown, OK

Exhibit
A-2

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

AERIAL PHOTOGRAPHY PROVIDED
BY MICROSOFT BING MAPS

Project Manager: JLD	Project No. 03215255
Drawn by: CAN	Scale: AS SHOWN
Checked by: JLD	File Name: A1-A5
Approved by: NKT	Date: APR 2022

Terracon
4701 N Stiles Ave
Oklahoma City, OK 73105-3330

EXPLORATION PLAN

Atoka Lake Access Road Improvements – North Section

Stringtown, OK

Exhibit

A-3

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

AERIAL PHOTOGRAPHY PROVIDED
BY MICROSOFT BING MAPS

Project Manager: JLD	Project No. 03215255
Drawn by: CAN	Scale: AS SHOWN
Checked by: JLD	File Name: A1-A5
Approved by: NKT	Date: APR 2022

Terracon
4701 N Stiles Ave
Oklahoma City, OK 73105-3330

EXPLORATION PLAN

Atoka Lake Access Road Improvements – North Section
Stringtown, OK

Exhibit
A-4

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

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Project Manager: JLD
Drawn by: CAN
Checked by: JLD
Approved by: NKT

Project No. 03215255
Scale: AS SHOWN
File Name: A1-A5
Date: APR 2022

Terracon
4701 N Stiles Ave
Oklahoma City, OK 73105-3330

EXPLORATION PLAN

Atoka Lake Access Road Improvements – North Section

Stringtown, OK

Exhibit

A-5

Field Exploration Description

Eight pavement borings were drilled along the project site on February 16 to 19, 2022 at the approximate locations shown on the attached Exploration Plan, Exhibits A-2 to A-5.

Terracon personnel located the borings in the field by use of a hand held GPS device within the project extents provided by the Client. The locations of the borings should be considered accurate only to the degree implied by the methods used to define them.

A diamond-tipped core barrel was used to extract 6-inch diameter samples of the pavement. Soil borings were hand augered at each of the fifteen core locations. Subgrade soil samples were retrieved from each boring for laboratory testing.

The stiffness/relative density of the subgrade materials in the pavement borings was assessed with a Kessler dynamic cone penetrometer (DCP) at the four street borings, and disturbed samples were obtained from the auger cuttings of all fifteen core locations. The DCP consists of a 17.6 pound slide hammer falling 22.6 inches onto an anvil driving a 0.79 inch diameter cone into the soil. The number of blows required to drive the cone is recorded along with the penetration depth and roughly corresponds to the California Bearing Ratio, CBR. The CBR is a strength measure comparing the penetration resistance of compacted soil to that of densely compacted crushed rock.

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

A truck mounted, rotary drill rig equipped with continuous flight augers was used to advance the deep boreholes(B-5, B-5A, B-5B, B-7, B-7A and B-7B). Representative samples were obtained by the split-barrel sampling procedures.

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

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

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

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

The sampling depths, soil descriptions, and laboratory test results are reported on the boring logs. The samples were tagged for identification, sealed to reduce moisture loss and returned to the laboratory for further examination, testing and classification.

BORING LOG NO. B-1

Page 1 of 1

PROJECT: **Atoka Lake North Access Road**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **East Access Road**
Stringtown, OK

LOCATION See Exhibit A-2

Latitude: 34.4462° Longitude: -96.0812°

DEPTH		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.5	**TREATED SUBGRADE (CLAYEY SAND WITH GRAVEL - SC)**, brown								12.5			
	FAT CLAY WITH SAND (CH), brown and grayish brown										62-23-39	85
									19.8			
3.0									15.3			

Boring Terminated at 3 Feet

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 2 3/8" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-19-2022	Boring Completed: 02-19-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-7

BORING LOG NO. B-2

PROJECT: Atoka Lake North Access Road

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: East Access Road
Stringtown, OK

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 34.4490° Longitude: -96.0808° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	0.5 **TREATED SUBGRADE (CLAYEY SAND WITH GRAVEL - SC)**, brown			▮					11.0			
▨	**FAT CLAY WITH SAND (CH)**, yellow and brown			▮					15.5			
▨	1.8			▮					13.5			
	Boring Terminated at Auger Refusal at 1.8 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 2 1/4" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-19-2022	Boring Completed: 02-19-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-8

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 03215255 ATOKA LAKE NORTH.GPJ TERRACON_DATATEMPLATE.GDT 4/8/22

BORING LOG NO. B-3

Page 1 of 1

PROJECT: Atoka Lake North Access Road

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: East Access Road
Stringtown, OK

LOCATION See Exhibit A-2

Latitude: 34.4506° Longitude: -96.0783°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5 **TREATED SUBGRADE (CLAYEY SAND WITH GRAVEL - SC)**, brown								12.4			
	FAT CLAY (CH), yellow and brown								26.4		65-27-38	
									20.9			
	3.0 -yellowish brown and grayish brown below 2.5'								19.8			
	Boring Terminated at 3 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 3 5/8" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-19-2022	Boring Completed: 02-19-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-9

BORING LOG NO. B-4

Page 1 of 1

PROJECT: Atoka Lake North Access Road

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: East Access Road
Stringtown, OK

LOCATION See Exhibits A-2 to A-5

Latitude: 34.4524° Longitude: -96.0753°

GRAPHIC LOG	DEPTH		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5	**TREATED SUBGRADE (CLAYEY SAND WITH GRAVEL - SC)**, brown								20.9			
▨		**FAT CLAY (CH)**, brown								18.6 21.5			
	3.0	-brown and red below 2.5'								26.1			
		Boring Terminated at 3 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 5 1/4" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-19-2022	Boring Completed: 02-19-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-10

BORING LOG NO. B-5

Page 1 of 1

PROJECT: Atoka Lake North Access Road

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: East Access Road
Stringtown, OK

LOCATION See Exhibits A-2 to A-5

Latitude: 34.4540° Longitude: -96.0739°

DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	LEAN CLAY WITH GRAVEL (CL), brown, medium stiff			☒	3-3-5 N=8				17.3			
	-stiff below 1.5'			☒	6-6-5 N=11						45-20-25	77
	-brown, pale brown, very stiff below 3'			☒	8-10-12 N=22				11.8			
		5		☒	6-8-13 N=21				15.0			
	-hard below 6'			☒	8-13-29 N=42				15.5			
9.0				☒	10-15-25 N=40				18.8			
	LEAN CLAY (CL), brown, hard	10		☒	7-13-25 N=38				16.3			
				☒	13-14-24 N=38				12.6			
				☒	14-15-26 N=41				14.3			
15.0				☒	21-25-29 N=54				11.5			
	HIGHLY WEATHERED SHALE, brown, soft	15		☒	19-30-50/6"				12.2			
	-brown and yellowish brown below 16.5'			☒	19-25-44 N=69				13.0			
19.5	-soft to hard below 18'			☒	19-35-50/2"				11.7			
	WEATHERED SHALE, brown, hard	20		☒	50/2"				11.6			
	-soft below 21'			☒	16-50/6"				10.8			
24.0	-moderately hard below 23.5'			☒	50/4"				10.4			
	Boring Terminated at 24 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-16-2022	Boring Completed: 02-16-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-11

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 03215255 ATOKA LAKE NORTH.GPJ TERRACON_DATATEMPLATE.GDT 4/8/22

BORING LOG NO. B-5A

Page 1 of 1

PROJECT: Atoka Lake North Access Road

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: East Access Road
Stringtown, OK

GRAPHIC LOG	LOCATION See Exhibits A-2 to A-5 Latitude: 34.4540° Longitude: -96.0739° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**TREATED SUBGRADE (LEAN CLAY WITH ASPHALT PIECES - CL)**, brown with black, medium stiff 1.5			☒	4-3-4 N=7				17.5			
▨	**LEAN TO FAT CLAY (CL/CH)**, brown, medium stiff			☒	2-3-4 N=7				6.6			
▨	-red, brown, stiff below 3'			☒	3-4-8 N=12				22.6			
▨	-medium stiff below 4.5' 6.0	5		☒	3-5-3 N=8				29.6			
▨	**FAT CLAY (CH)**, brown and gray, very stiff			☒	5-7-22 N=29				17.7			
▨	-brown, hard below 7.5'			☒	5-17-24 N=41				20.5			
▨		10		☒	9-15-22 N=37				12.5			
▨				☒	9-40-42 N=82				12.7			
▨	13.5			☒	17-18-36 N=54				13.8			
☰	**HIGHLY WEATHERED SHALE**, brown, soft			☒	18-50/6"				12.8			
☰	16.5	15		☒	16-26-41 N=67				10.5			
☰	**WEATHERED SHALE**, brown, soft to moderately hard			☒	50/4"				10.5			
☰				☒	50/6"				8.9			
☰		20		☒	50/4"				7.5			
☰				☒	41-50/4"				10.5			
☰	24.0			☒	50/3"				11.0			
	Boring Terminated at 24 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 3" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-16-2022	Boring Completed: 02-16-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-12

BORING LOG NO. B-5B

Page 1 of 1

PROJECT: Atoka Lake North Access Road

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: East Access Road
Stringtown, OK

GRAPHIC LOG	LOCATION See Exhibits A-2 to A-5 Latitude: 34.4540° Longitude: -96.0739° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**LEAN TO FAT CLAY (CL/CH)**, trace gravel, brown, stiff			☒	5-6-7 N=13				19.3			
▨	-medium stiff below 1.5'			☒	3-3-4 N=7				16.7			
▨	-very stiff below 3'			☒	12-10-12 N=22				13.8			
▨	4.5 **FAT CLAY (CH)**, brown and red, stiff	5		☒	3-4-5 N=9				22.7			
▨	-brown, very stiff below 6'			☒	5-7-22 N=29				14.2			
▨	-brown, grayish brown, hard below 7.5'			☒	9-17-21 N=38				14.3			
▨		10		☒	18-31-44 N=75				13.1			
▤	11.0 **HIGHLY WEATHERED SHALE**, brown, grayish brown and yellow, soft to moderately hard			☒	15-32-50/6"				12.1			
▤				☒	38-50/5"				14.5			
▤				☒	32-50/3"				10.3			
▤		15		☒	50/6"				13.5			
▤				☒	16-31-50/3"				13.3			
▤				☒	16-38-50/4"				11.6			
▤		20		☒	38-50/5"				12.5			
▤	21.0 **WEATHERED SHALE**, brown, soft to moderately hard			☒	50/5"				11.7			
▤	24.0			☒	50/4"				10.8			
	Boring Terminated at 24 Feet											

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

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 3" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-17-2022	Boring Completed: 02-17-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-13

BORING LOG NO. B-6

Page 1 of 1

PROJECT: **Atoka Lake North Access Road**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **East Access Road**
Stringtown, OK

GRAPHIC LOG	DEPTH	LOCATION See Exhibits A-2 to A-5 Latitude: 34.4550° Longitude: -96.0732°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5	**TREATED SUBGRADE (LEAN CLAY WITH SAND - CL)**, brown								11.1			
										26.0			
		FAT CLAY (CH), brown -red and brown below 1.5'								35.0			
	3.0	brown below 2.5'								31.2			
		Boring Terminated at 3 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 3 5/8" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-18-2022	Boring Completed: 02-18-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-14

BORING LOG NO. B-7

Page 1 of 2

PROJECT: Atoka Lake North Access Road

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: East Access Road
Stringtown, OK

LOCATION See Exhibits A-2 to A-5

Latitude: 34.4560° Longitude: -96.0727°

DEPTH	Description
1.5	**TREATED SUBGRADE (LEAN CLAY WITH GRAVEL - CL)**, brown, stiff to very stiff
4.0	**CLAYEY SAND WITH GRAVEL (SC)**, brown and red, stiff -very stiff below 3'
6.0	**SANDY FAT CLAY (CH)**, brown and red, very stiff
18.0	**FAT CLAY (CH)**, gray, brown and yellowish brown, hard -grayish brown, yellowish brown, and gray below 13.5'
	HIGHLY WEATHERED SHALE, grayish brown and yellow, soft

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		☒	5-6-9 N=15				11.5			
		☒	5-6-6 N=12						59-24-35	44
		☒	8-10-12 N=22				20.5			
5		☒	7-8-12 N=20				19.5			
		☒	12-19-26 N=45				19.2		73-34-39	
		☒	15-21-29 N=50				18.8			
10		☒	17-25-31 N=56				19.0			
		☒	15-21-35 N=56				18.2			
		☒	32-30-39 N=69				18.0			
		☒	15-27-25 N=52				19.1			
15		☒	19-26-37 N=63				17.7			
		☒	10-20-29 N=49				20.6			
		☒	25-35-50/6"				18.2			
20		☒	17-27-31 N=58				18.8			
		☒	15-21-25 N=46				19.5			
25		☒	15-21-31 N=52				20.7			

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-16-2022	Boring Completed: 02-16-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-15

BORING LOG NO. B-7

PROJECT: Atoka Lake North Access Road

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: East Access Road
Stringtown, OK

LOCATION See Exhibits A-2 to A-5

Latitude: 34.4560° Longitude: -96.0727°

DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
HIGHLY WEATHERED SHALE, grayish brown and yellow, soft *(continued)*											
-dark gray below 28.5'	30		☒	17-25-32 N=57				20.0			
-yellowish brown with dark grayish brown below 33.5'	35		☒	17-21-32 N=53				39.3			
-dark grayish brown below 38.5'			☒	21-50/5"				19.3			
39.5 **Boring Terminated at 39.5 Feet**											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-16-2022	Boring Completed: 02-16-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-15

BORING LOG NO. B-7A

Page 1 of 2

PROJECT: Atoka Lake North Access Road

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: East Access Road
Stringtown, OK

LOCATION See Exhibits A-2 to A-5

Latitude: 34.4560° Longitude: -96.0727°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**FAT CLAY (CH)**, brown, medium stiff			☒	3-3-5 N=8				27.1			
▨	-very stiff below 1.5'			☒	5-7-12 N=19				21.1			
▨	-yellowish brown, hard below 3'			☒	12-15-18 N=33				17.2			
▨	-yellowish brown, brown, very stiff below 4.5'	5		☒	8-8-12 N=20				17.8			
▨	-brown, yellowish brown, grayish brown, hard below 6'			☒	15-20-23 N=43				19.1			
▨				☒	12-12-21 N=33				18.3			
▨		10		☒	14-21-22 N=43				19.4			
▨				☒	12-17-22 N=39				18.4			
▨				☒	13-17-17 N=34				18.8			
▨				☒	22-27-29 N=56				16.2			
▨		15		☒	17-21-29 N=50							
▨				☒	23-26-28 N=54				21.4			
▨				☒	13-17-31 N=48				17.8			
▨		20		☒	16-22-20 N=42				18.7			
▨				☒	14-16-21 N=37							
▨	23.5											
▤	**HIGHLY WEATHERED SHALE**, brown and yellowish brown with dark gray, soft to moderately hard			☒	31-48-50/3"				19.0			
▤		25										

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 4" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-17-2022	Boring Completed: 02-17-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-16

BORING LOG NO. B-7A

Page 2 of 2

PROJECT: **Atoka Lake North Access Road**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **East Access Road**
Stringtown, OK

LOCATION See Exhibits A-2 to A-5

Latitude: 34.4560° Longitude: -96.0727°

DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
HIGHLY WEATHERED SHALE, brown and yellowish brown with dark gray, soft to moderately hard *(continued)*											
-soft below 28.5'			☒	17-21-35 N=56				18.2			
	30										
-soft to moderately hard below 33.5'			☒	31-50/3"				17.1			
34.5											
Boring Terminated at 34.5 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-17-2022	Boring Completed: 02-17-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-16

BORING LOG NO. B-7B

PROJECT: Atoka Lake North Access Road

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: East Access Road
Stringtown, OK

LOCATION See Exhibits A-2 to A-5

Latitude: 34.4560° Longitude: -96.0727°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**FAT CLAY (CH)**, brown, medium stiff			☒	3-3-3 N=6				21.2			
▨	-stiff below 1.5'			☒	3-5-4 N=9				21.0		56-31-25	
▨	-very stiff below 3'			☒	5-8-11 N=19				20.4			
▨	-hard below 4.5'	5		☒	4-12-20 N=32				19.1			
▨	-very stiff below 6'			☒	4-11-16 N=27				19.5			
▨	-hard below 7.5'			☒	7-16-21 N=37				18.1			
▨		10		☒	12-16-20 N=36				18.5			
▨	-brown with yellowish brown, hard below 10.5'			☒	18-20-25 N=45				18.4			
▨				☒	25-36-42 N=78				16.1			
▨				☒	19-26-43 N=69				15.9			
▨		15		☒	18-25-32 N=57				15.2			
▨	-dark gray below 16.5'			☒	16-22-42 N=64				16.5			
▨				☒	19-31-40 N=71				15.0			
▨	-brown, yellowish brown below 19.5'	20		☒	16-22-20 N=42				15.0			
▨				☒	25-31-33 N=64				15.4			
▨												
▨	-brown below 23.5'			☒	15-20-25 N=45				16.1			
		25										

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-17-2022	Boring Completed: 02-17-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-17

BORING LOG NO. B-7B

PROJECT: **Atoka Lake North Access Road**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **East Access Road**
Stringtown, OK

LOCATION See Exhibits A-2 to A-5

Latitude: 34.4560° Longitude: -96.0727°

GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	28.5	**FAT CLAY (CH)**, brown, medium stiff *(continued)*											
▤		**HIGHLY WEATHERED SHALE**, brown, soft	30		☒	17-26-42 N=68				16.4			
▤	34.5				☒	26-50/5"				14.7			
		Boring Terminated at 34.5 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-17-2022	Boring Completed: 02-17-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-17

BORING LOG NO. B-8

Page 1 of 1

PROJECT: Atoka Lake North Access Road

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: East Access Road
Stringtown, OK

LOCATION See Exhibits A-2 to A-5

Latitude: 34.4590° Longitude: -96.0712°

GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5	**TREATED SUBGRADE (LEAN CLAY WITH SAND - CL)**, trace gravel, brown								14.7			
▨		**FAT CLAY (CH)**, brown								22.7		59-25-34	
▨										25.1			
▨	3.0									17.3			
		Boring Terminated at 3 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 4 3/8" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-19-2022	Boring Completed: 02-19-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-18

BORING LOG NO. B-9

Page 1 of 1

PROJECT: **Atoka Lake North Access Road**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **East Access Road**
Stringtown, OK

LOCATION See Exhibits A-2 to A-5

Latitude: 34.4615° Longitude: -96.0695°

GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.5	**TREATED SUBGRADE (SANDY LEAN CLAY - CL)**, trace gravel, brown								13.9			
	3.0	**FAT CLAY (CH)**, brown								25.4 25.4 19.6			
		Boring Terminated at 3 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 6" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-18-2022	Boring Completed: 02-18-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-19

BORING LOG NO. B-10

Page 1 of 1

PROJECT: **Atoka Lake North Access Road**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **East Access Road**
Stringtown, OK

LOCATION See Exhibits A-2 to A-5

Latitude: 34.4618° Longitude: -96.0647°

GRAPHIC LOG	DEPTH		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨		**TREATED SUBGRADE (SANDY LEAN CLAY - CL)**, trace			▮					8.0		35-29-6	
▨	1.0	gravel, brown			▮					9.9			
▨		**FAT CLAY WITH SAND (CH)**, brown											
▨					▮					15.6			
▨	3.0			▽	▮								

Boring Terminated at 3 Feet

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-6 for description of field procedures

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

See Appendix C for explanation of symbols and abbreviations.

Notes:

Approx. 7" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

▽ *3' While drilling*

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-18-2022	Boring Completed: 02-18-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255	Exhibit: A-20

TOP

CORE LOG

CORE NUMBER	C-1
DATE CORED	2/19/2022
LOCATION	Atoka Lake North Access Road Pavement Evaluation Access Road East of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4462 LONGITUDE -96.0812

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☑ Yes ☐ No ☐ Unknown

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	2 3/8	
	Total Core Thickness	**2 3/8**	Fractured

Exhibit A-21

TOP

Terracon **CORE LOG**

CORE NUMBER	C-2
DATE CORED	2/19/2022
LOCATION	Atoka Lake North Access Road Pavement Evaluation Access Road East of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4490 LONGITUDE -96.0808

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☑ Yes ☐ No ☐ Unknown

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	2 1/4	
	Total Core Thickness	**2 1/4**	

Exhibit A-22

TOP

Terracon **CORE LOG**

CORE NUMBER	C-3
DATE CORED	2/19/2022
LOCATION	Atoka Lake North Access Road Pavement Evaluation Access Road East of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4506 LONGITUDE -96.0783

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	1 1/4	Fabric on bottom of core
	Asphaltic Concrete	**2 3/8**	
	Total Core Thickness	**3 5/8**	

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☑ Yes ☐ No ☐ Unknown

Exhibit A-23

CORE LOG

CORE NUMBER	C-4
DATE CORED	2/19/2022
LOCATION	Atoka Lake North Access Road Pavement Evaluation Access Road East of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4524 LONGITUDE -96.0753

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	2 1/8	
	Asphaltic Concrete	3 1/8	Fabric on bottom of core
	Total Core Thickness	**5 1/4**	

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☑ Yes ☐ No ☐ Unknown

Exhibit A-24

TOP

Terracon

CORE LOG

CORE NUMBER	C-5
DATE CORED	2/18/2022
LOCATION	Atoka Lake North Access Road Pavement Evaluation Access Road East of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4550 LONGITUDE -96.0732

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	1	
	Asphaltic Concrete	**2 5/8**	Fabric on bottom of core
	Total Core Thickness	**3 5/8**	

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☑ Yes ☐ No ☐ Unknown

Exhibit A-25

TOP

CORE LOG

CORE NUMBER	C-8
DATE CORED	2/19/2022
LOCATION	Atoka Lake North Access Road Pavement Evaluation Access Road East of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4590 LONGITUDE -96.0712

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☑ Yes ☐ No ☐ Unknown

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	1 7/8	
	Asphaltic Concrete	2 1/2	Fabric on bottom of core
	Total Core Thickness	**4 3/8**	

Exhibit A-26

TOP

CORE LOG

CORE NUMBER	C-9
DATE CORED	2/18/2022
LOCATION	Atoka Lake North Access Road Pavement Evaluation Access Road East of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4615 LONGITUDE -96.0695

CORE LAYER DATA (FROM TOP TO BOTTOM):

Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	2 3/8	
	Asphaltic Concrete	3 5/8	Fabric on bottom of core
	Total Core Thickness	**6**	

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☑ Yes ☐ No ☐ Unknown

Exhibit A-27

TOP

Terracon CORE LOG

CORE NUMBER	C-10
DATE CORED	2/18/2022
LOCATION	Atoka Lake North Access Road Pavement Evaluation Access Road East of Atoka Lake Stringtown, Oklahoma

GPS LATITUDE 34.4618 LONGITUDE -96.0647

CORE DATA

Surface Material Type: ☑ A.C. ☐ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☐ Stripping ☐ Separation ☑ N/A

Honeycomb or "D" Cracking in PCC: ☐ Honeycomb ☐ "D" Cracking ☑ N/A

Stabilized Subgrade Beneath Pavement or Sub-base? ☑ Yes ☐ No ☐ Unknown

CORE LAYER DATA (FROM TOP TO BOTTOM):

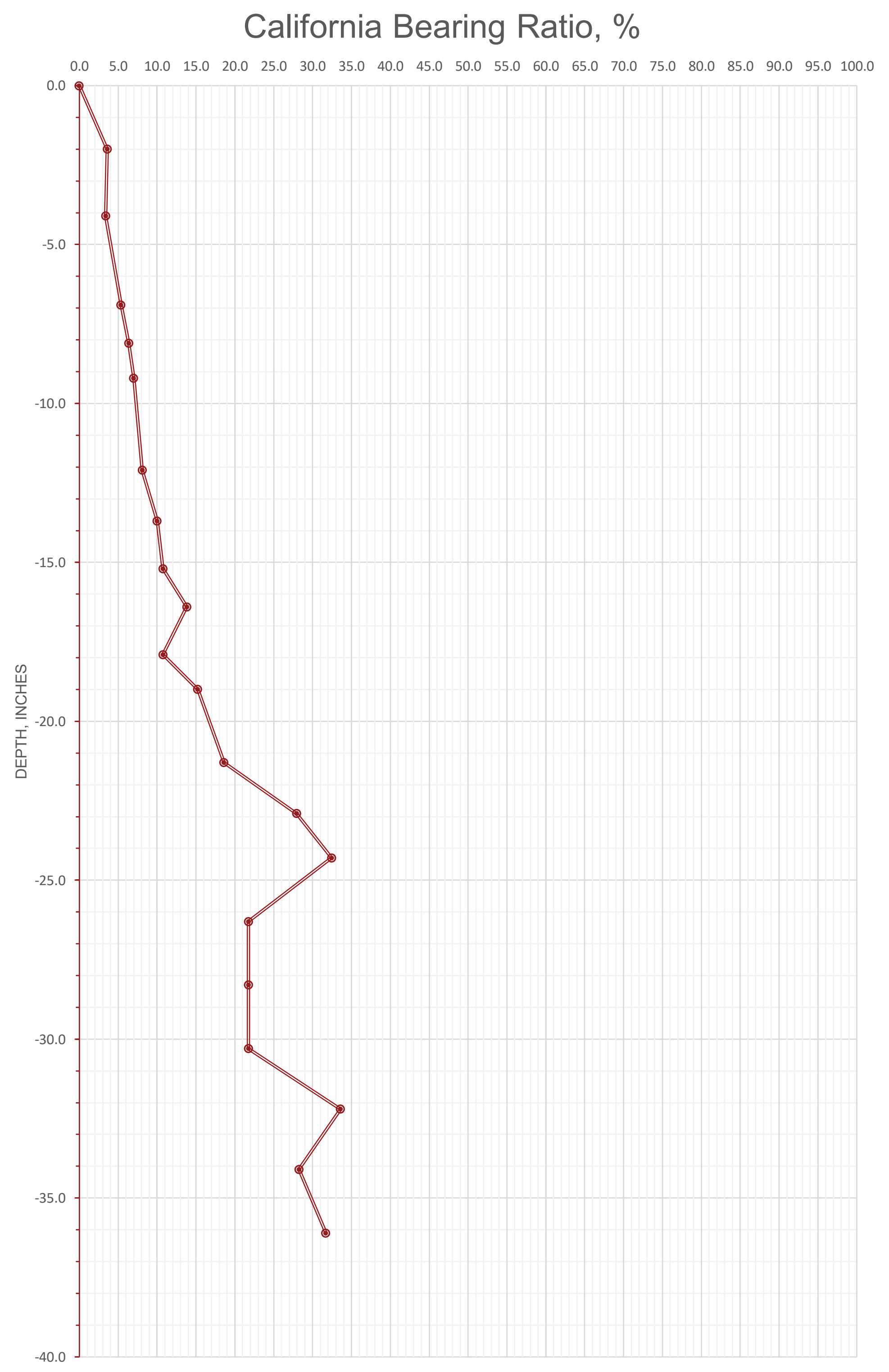
Sample No	Layer Type	Layer Thickness (in.)	Layer Characteristics
1	Asphaltic Concrete	2	
	Asphaltic Concrete	2	
	Asphaltic Concrete	3	
	Total Core Thickness	**7**	

Exhibit A-28

California Bearing Ratio from DCP - Boring No. B-1

PROJECT:	**03215255**	**SITE:**	**Atoka Lake North Acccess Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
1	-2.0	3.6
1	-4.1	3.4
2	-6.9	5.3
1	-8.1	6.4
1	-9.2	7.0
3	-12.1	8.1
2	-13.7	10.0
2	-15.2	10.8
2	-16.4	13.8
2	-17.9	10.8
2	-19.0	15.2
5	-21.3	18.6
5	-22.9	27.9
5	-24.3	32.4
5	-26.3	21.8
5	-28.3	21.8
5	-30.3	21.8
7	-32.2	33.6
6	-34.1	28.3
7	-36.1	31.7



Terracon

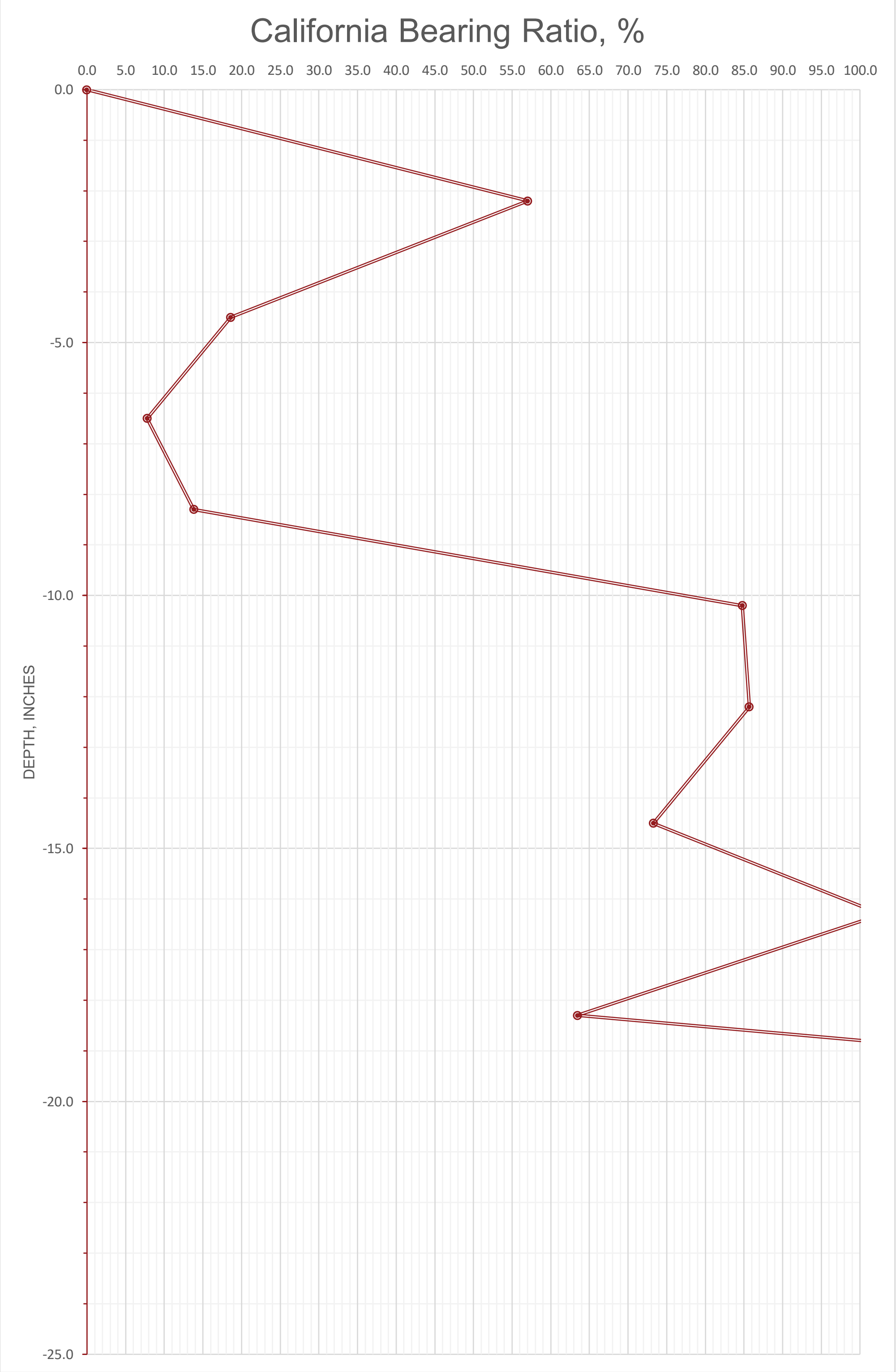
Notes:

DRILLING DATE:	2/20/2022
Project No.:	03215255
Exhibit:	A-29

California Bearing Ratio from DCP - Boring No. B-2

PROJECT:	**03215255**	**SITE:**	**Atoka Lake North Acccess Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
13	-2.2	57.0
5	-4.5	18.6
2	-6.5	7.8
3	-8.3	13.8
16	-10.2	84.8
17	-12.2	85.7
17	-14.5	73.3
18	-16.3	102.8
13	-18.3	63.5
38	-20.3	210.9
50	-20.9	1104.8



Terracon

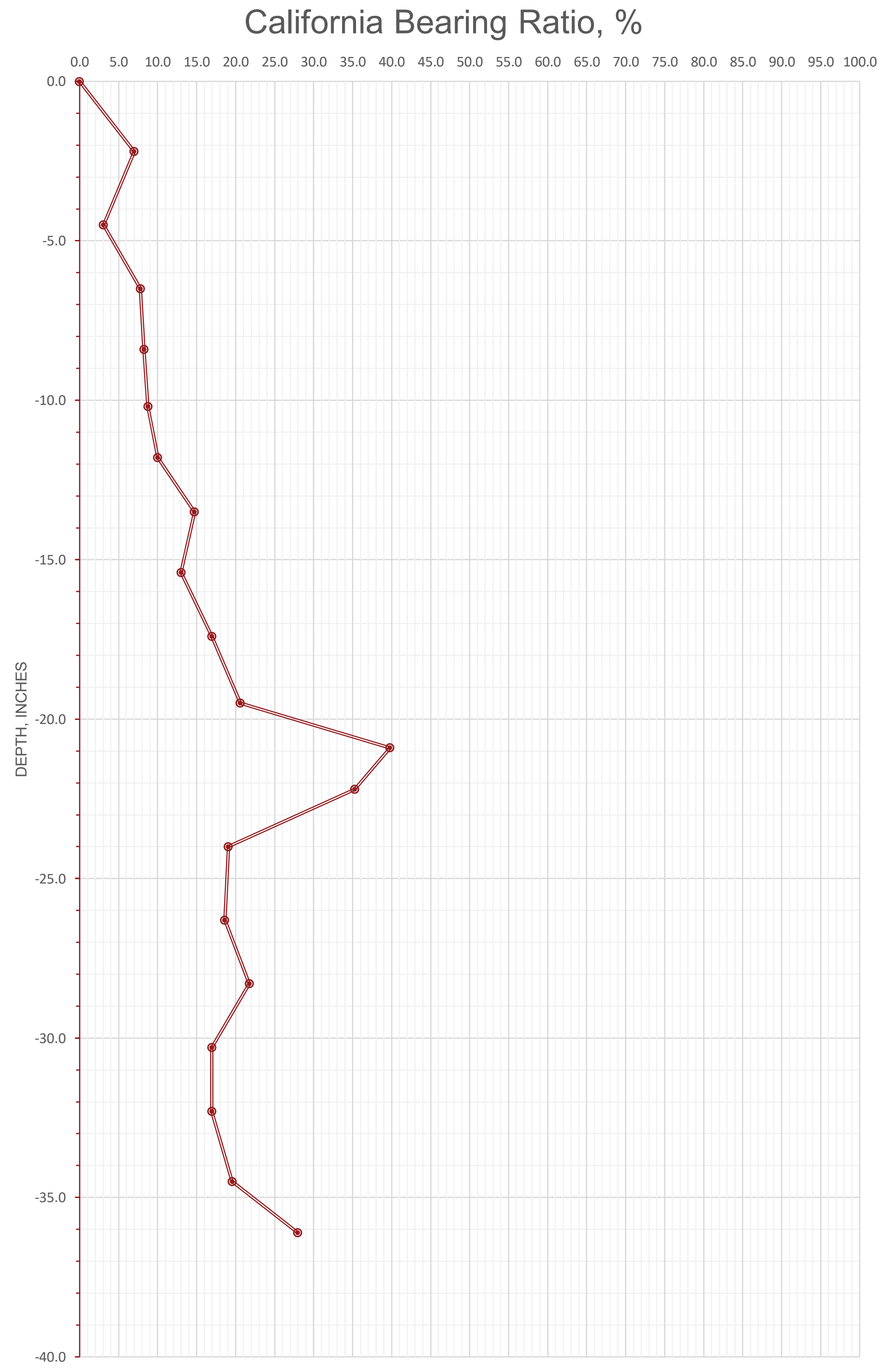
Notes:

DRILLING DATE:	2/20/2022
Project No.:	03215255
Exhibit:	A-30

California Bearing Ratio from DCP - Boring No. B-3

PROJECT:	**03215255**	**SITE:**	**Atoka Lake North Acccess Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
2	-2.2	7.0
1	-4.5	3.1
2	-6.5	7.8
2	-8.4	8.3
2	-10.2	8.8
2	-11.8	10.0
3	-13.5	14.7
3	-15.4	13.0
4	-17.4	16.9
5	-19.5	20.6
6	-20.9	39.8
5	-22.2	35.3
4	-24.0	19.1
5	-26.3	18.6
5	-28.3	21.8
4	-30.3	16.9
4	-32.3	16.9
5	-34.5	19.6
5	-36.1	27.9



Terracon

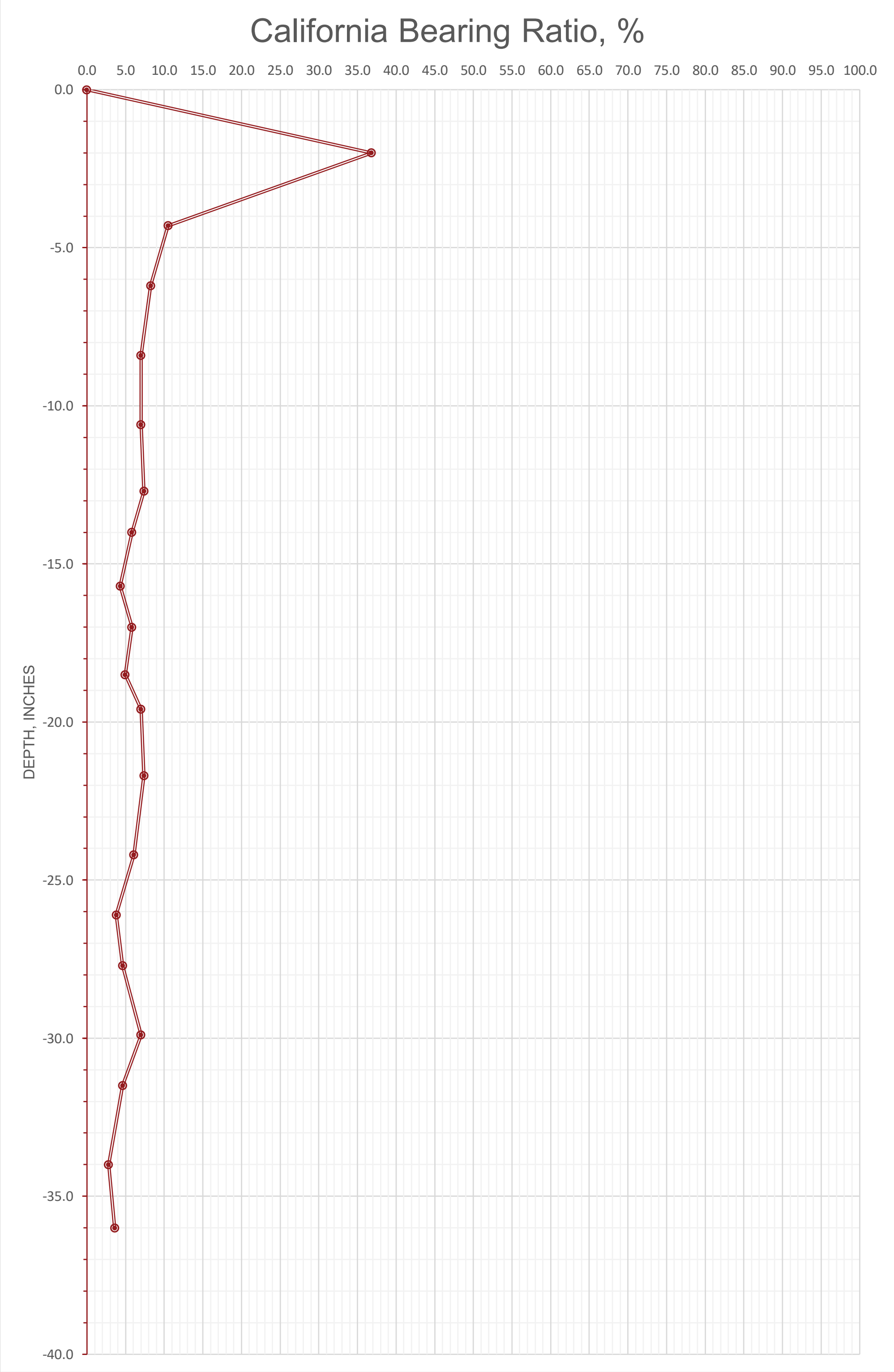
Notes:

DRILLING DATE:	2/20/2022
Project No.:	03215255
Exhibit:	A-31

California Bearing Ratio from DCP - Boring No. B-4

PROJECT:	**03215255**	**SITE:**	**Atoka Lake North Acccess Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
8	-2.0	36.8
3	-4.3	10.5
2	-6.2	8.3
2	-8.4	7.0
2	-10.6	7.0
2	-12.7	7.4
1	-14.0	5.8
1	-15.7	4.3
1	-17.0	5.8
1	-18.5	5.0
1	-19.6	7.0
2	-21.7	7.4
2	-24.2	6.1
1	-26.1	3.8
1	-27.7	4.6
2	-29.9	7.0
1	-31.5	4.6
1	-34.0	2.8
1	-36.0	3.6



Terracon

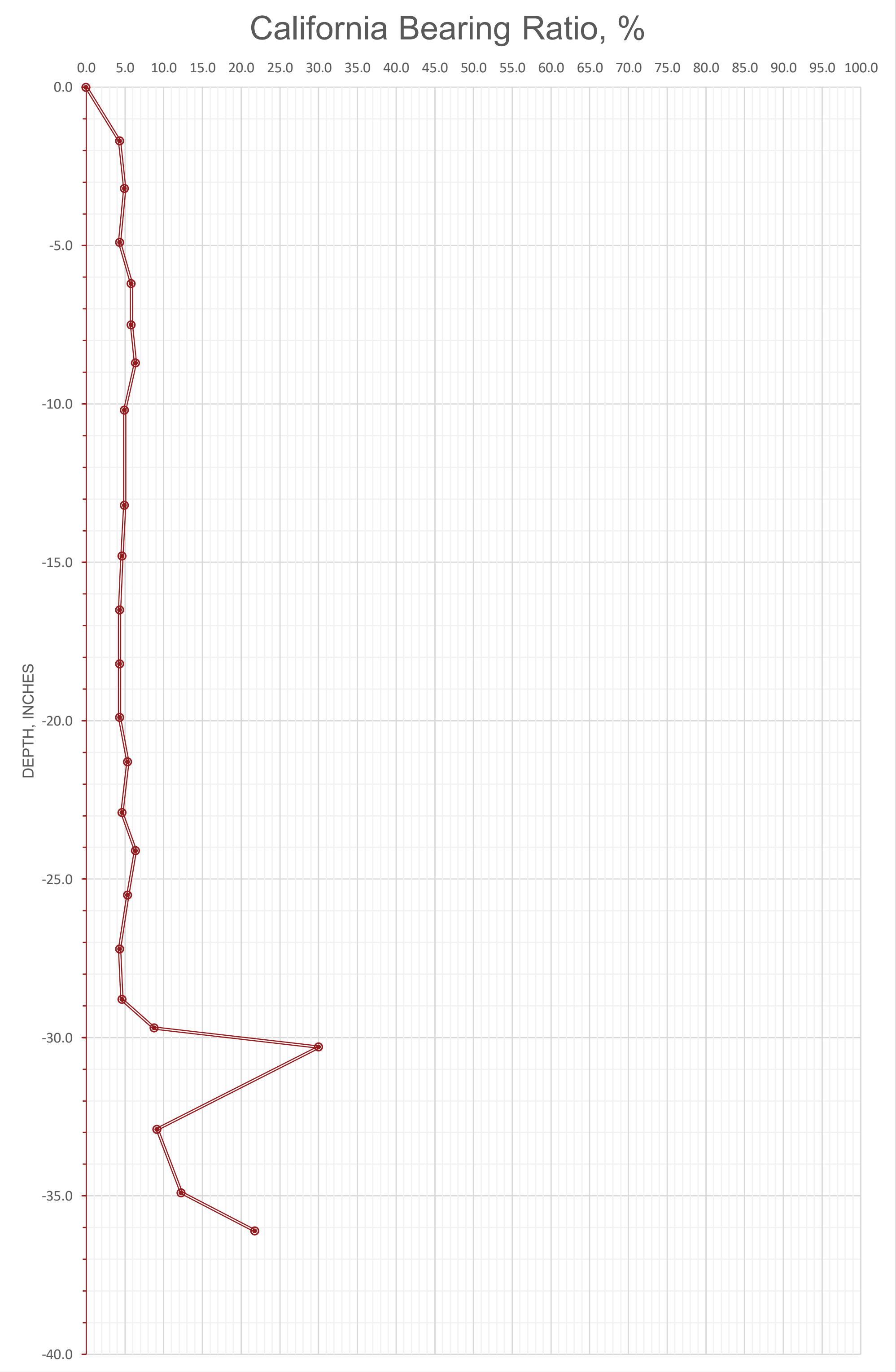
Notes:

DRILLING DATE:	2/20/2022
Project No.:	03215255
Exhibit:	A-32

California Bearing Ratio from DCP - Boring No. B-6

PROJECT:	**03215255**	**SITE:**	**Atoka Lake North Acccess Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
1	-1.7	4.3
1	-3.2	5.0
1	-4.9	4.3
1	-6.2	5.8
1	-7.5	5.8
1	-8.7	6.4
1	-10.2	5.0
2	-13.2	5.0
1	-14.8	4.6
1	-16.5	4.3
1	-18.2	4.3
1	-19.9	4.3
1	-21.3	5.3
1	-22.9	4.6
1	-24.1	6.4
1	-25.5	5.3
1	-27.2	4.3
1	-28.8	4.6
1	-29.7	8.8
2	-30.3	30.0
3	-32.9	9.2
3	-34.9	12.3
3	-36.1	21.8



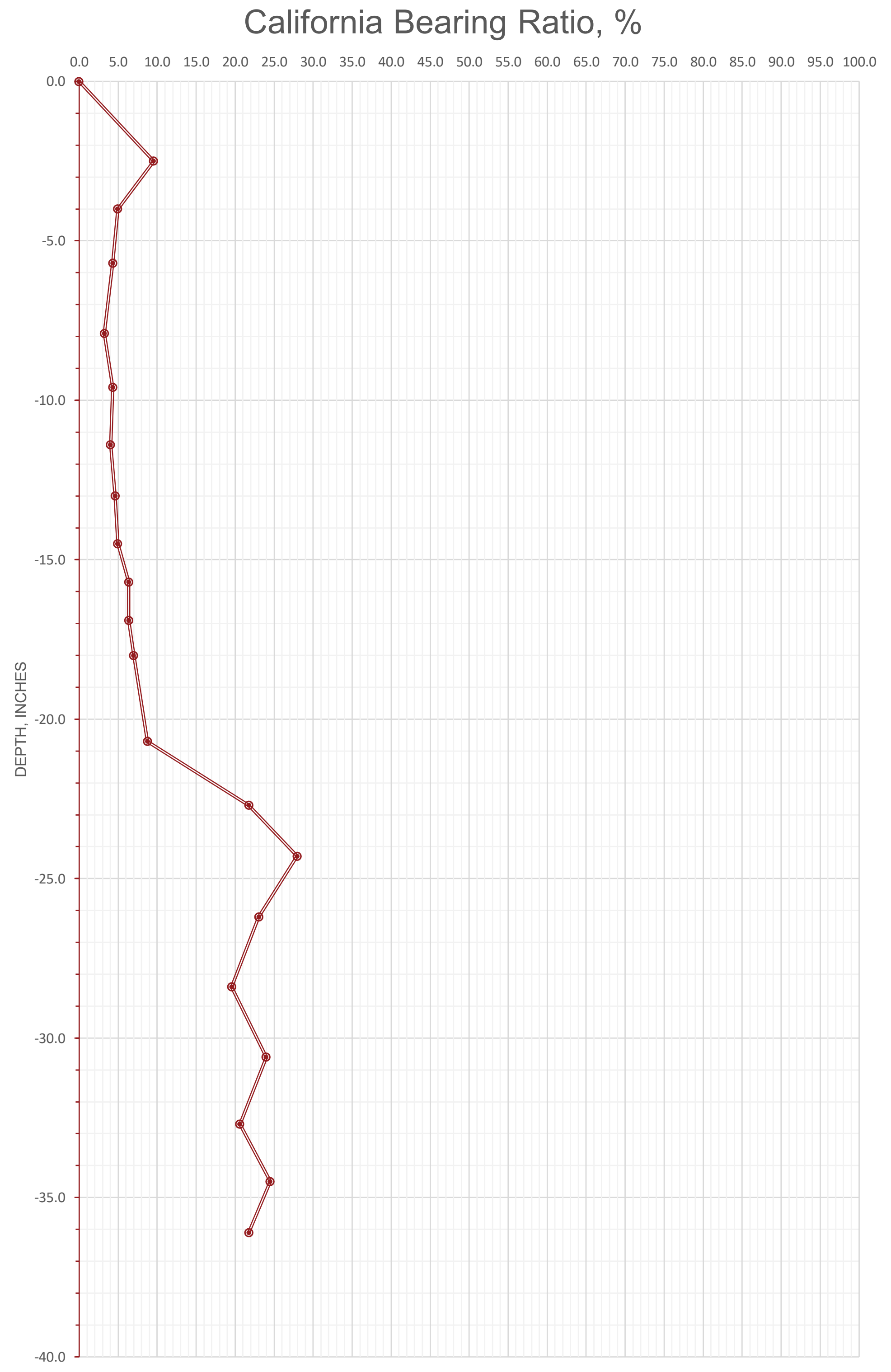
Notes:

DRILLING DATE:	2/20/2022
Project No.:	03215255
Exhibit:	A-33

California Bearing Ratio from DCP - Boring No. B-8

PROJECT:	03215255	SITE:	Atoka Lake North Acccess Road

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
3	-2.5	9.6
1	-4.0	5.0
1	-5.7	4.3
1	-7.9	3.2
1	-9.6	4.3
1	-11.4	4.0
1	-13.0	4.6
1	-14.5	5.0
1	-15.7	6.4
1	-16.9	6.4
1	-18.0	7.0
3	-20.7	8.8
5	-22.7	21.8
5	-24.3	27.9
5	-26.2	23.0
5	-28.4	19.6
6	-30.6	24.0
5	-32.7	20.6
5	-34.5	24.5
4	-36.1	21.8



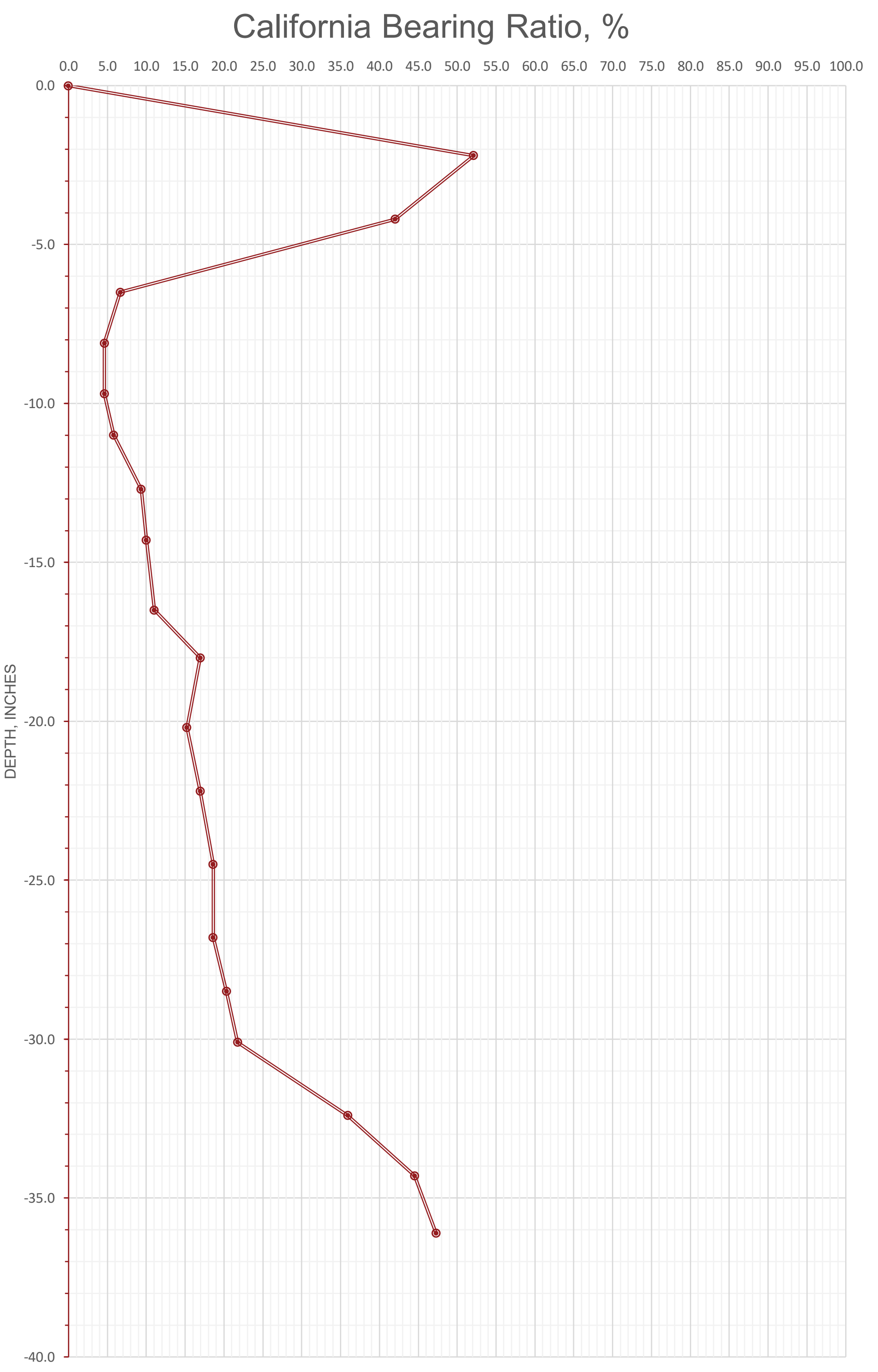
Notes:

DRILLING DATE:	2/20/2022
Project No.:	03215255
Exhibit:	A-34

California Bearing Ratio from DCP - Boring No. B-9

PROJECT:	**03215255**	**SITE:**	**Atoka Lake North Acccess Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
12	-2.2	52.1
9	-4.2	42.0
2	-6.5	6.7
1	-8.1	4.6
1	-9.7	4.6
1	-11.0	5.8
2	-12.7	9.4
2	-14.3	10.0
3	-16.5	11.0
3	-18.0	16.9
4	-20.2	15.2
4	-22.2	16.9
5	-24.5	18.6
5	-26.8	18.6
4	-28.5	20.3
4	-30.1	21.8
9	-32.4	35.9
9	-34.3	44.5
9	-36.1	47.3



Terracon

Notes:

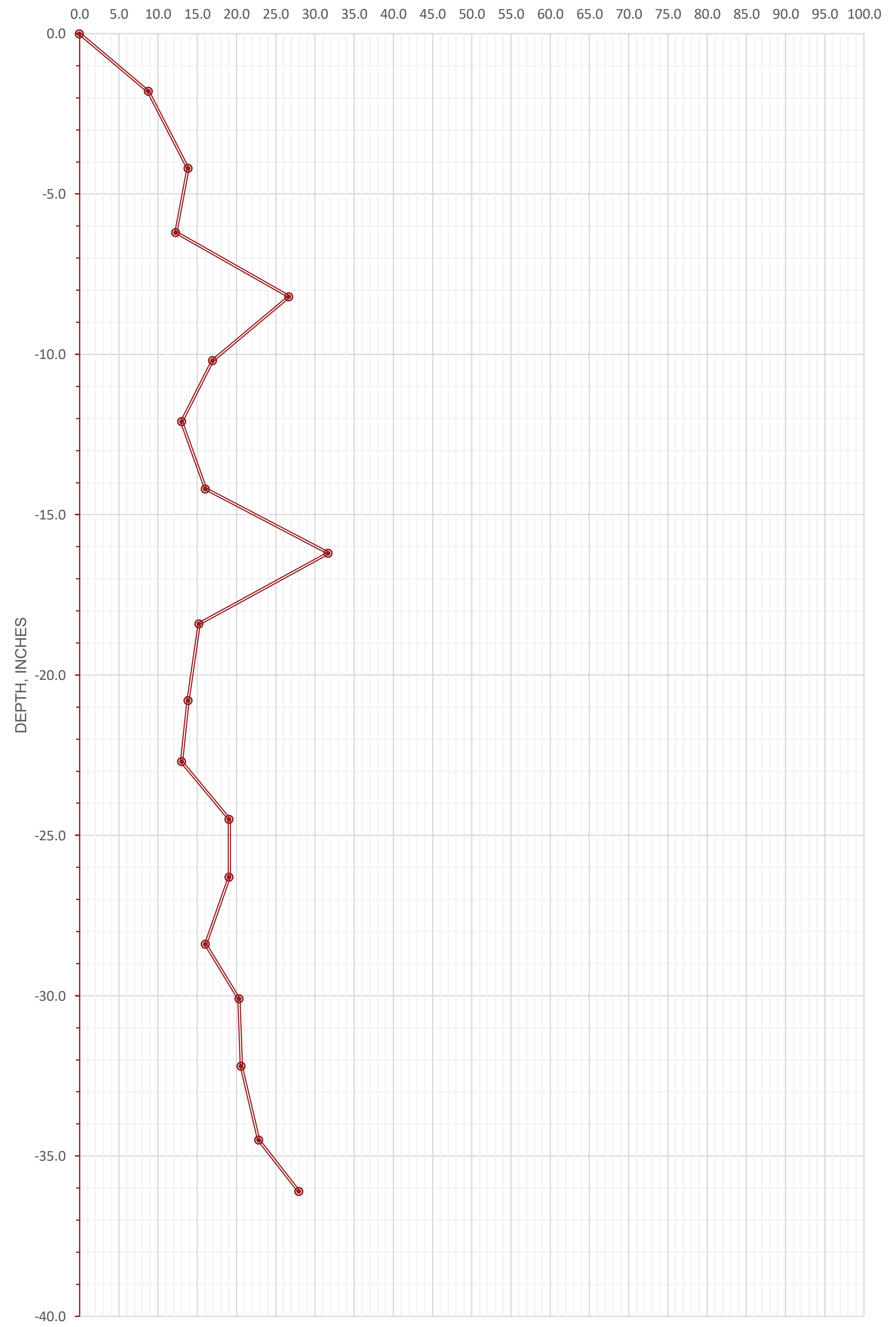
DRILLING DATE:	2/18/2022
Project No.:	03215255
Exhibit:	A-35

California Bearing Ratio from DCP - Boring No. B-10

PROJECT:	**03215255**	**SITE:**	**Atoka Lake North Acccess Road**

Number of Blows	Depth (In)	CBR (%)
0	0.0	0.0
2	-1.8	8.8
4	-4.2	13.8
3	-6.2	12.3
6	-8.2	26.7
4	-10.2	16.9
3	-12.1	13.0
4	-14.2	16.0
7	-16.2	31.7
4	-18.4	15.2
4	-20.8	13.8
3	-22.7	13.0
4	-24.5	19.1
4	-26.3	19.1
4	-28.4	16.0
4	-30.1	20.3
5	-32.2	20.6
6	-34.5	22.8
5	-36.1	27.9

California Bearing Ratio, %



Terracon

Notes:

DRILLING DATE:	2/18/2022
Project No.:	03215255
Exhibit:	A-36

APPENDIX B
LABORATORY TESTING

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS) described in Appendix C. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

Laboratory tests were conducted on selected soil samples and the test results are presented on the boring logs in Appendix A and on report forms in this appendix. The laboratory test results were used for the geotechnical engineering analyses, and the development of foundation, earthwork, and pavement design recommendations. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

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

- In-situ water content
- Atterberg Limits
- Gradation
- Moisture Density
- Resilient Modulus
- Triaxial Strength

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 judgement.

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-1	0 - 6												13		
B-1	6 - 12	FAT CLAY with SAND(CH)	A-7-6 (36)		62	23	39	84.7	3.0	12.3					
B-1	18 - 24												20		
B-1	30 - 36												15		
B-2	0 - 6												11		
B-2	6 - 12												16		
B-2	18 - 21												14		
B-3	0 - 6												12		
B-3	6 - 12				65	27	38						26		
B-3	18 - 24												21		
B-3	30 - 36												20		
B-4	0 - 6												21		
B-4	6 - 12												19		
B-4	18 - 24												22		
B-4	30 - 36												26		
B-5	0 - 1.5												17		
B-5	1.5 - 3	LEAN CLAY with GRAVEL(CL)	A-7-6 (19)		45	20	25	77.4	13.3	9.3					
B-5	3 - 4.5												12		
B-5	4														
B-5	4.5 - 6												15		
B-5	6 - 7.5												16		
B-5	7.5 - 9												19		
B-5	9 - 10.5												16		
B-5	10.5 - 12												13		
B-5	12 - 13.5												14		

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Atoka Lake North Access Road	Terracon 4701 N Stiles Ave Oklahoma City, OK	PROJECT NUMBER: 03215255
SITE: East Access Road Stringtown, OK		CLIENT: Poe & Associates Inc Oklahoma City, OK
	PH. 405-525-0453 FAX. 405-557-0549	EXHIBIT: B-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT_LAB_SUMMARY 03215255 ATOKA LAKE NORTH.GPJ TERRACON_DATATEMPLATE.GDT 3/15/22

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-5	13.5 - 15												12		
B-5	15 - 16.49												12		
B-5	16.5 - 18												13		
B-5	18 - 19.17												12		
B-5	19.5 - 19.67												12		
B-5	21 - 21.99												11		
B-5	23.5 - 23.83												10		
B-5A	0 - 1.5												18		
B-5A	1.5 - 3												7		
B-5A	3 - 4.5												23		
B-5A	4.5 - 6												30		
B-5A	6 - 7.5												18		
B-5A	7.5 - 9												21		
B-5A	9 - 10.5												12		
B-5A	10.5 - 12												13		
B-5A	12 - 13.5												14		
B-5A	13.5 - 14.49												13		
B-5A	15 - 16.5												11		
B-5A	16.5 - 16.83												11		
B-5A	18 - 18.49												9		
B-5A	19.5 - 19.83												7		
B-5A	21 - 21.83												10		
B-5A	23.5 - 23.75												11		
B-5B	0 - 1.5												19		
B-5B	1.5 - 3												17		

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Atoka Lake North Access Road

SITE: East Access Road
Stringtown, OK

Terracon
4701 N Stiles Ave
Oklahoma City, OK
PH. 405-525-0453 FAX. 405-557-0549

PROJECT NUMBER: 03215255

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-3

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-5B	3 - 4.5												14		
B-5B	4.5 - 6												23		
B-5B	6 - 7.5												14		
B-5B	7.5 - 9												14		
B-5B	9 - 10.5												13		
B-5B	10.5 - 11.99												12		
B-5B	12 - 12.92												15		
B-5B	13.5 - 14.25												10		
B-5B	15 - 15.49												14		
B-5B	16.5 - 17.75												13		
B-5B	18 - 19.33												12		
B-5B	19.5 - 20.42												12		
B-5B	21 - 21.42												12		
B-5B	23.5 - 23.83												11		
B-6	0 - 6												11		
B-6	6 - 12												26		
B-6	18 - 24												35		
B-6	30 - 36												31		
B-7	0 - 1.5												12		
B-7	1.5 - 3	CLAYEY SAND with GRAVEL(SC)	A-7-6 (10)		59	24	35	44.2	20.0	35.8					
B-7	2														
B-7	3 - 4.5												21		
B-7	4.5 - 6												19		
B-7	6 - 7.5					73	34	39					19		
B-7	7.5 - 9												19		

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Atoka Lake North Access Road

SITE: East Access Road
Stringtown, OK

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PH. 405-525-0453 FAX. 405-557-0549

PROJECT NUMBER: 03215255

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-4

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-7	9 - 10.5												19		
B-7	10.5 - 12												18		
B-7	12 - 13.5												18		
B-7	13.5 - 15												19		
B-7	15 - 16.5												18		
B-7	16.5 - 18												21		
B-7	18 - 19.49												18		
B-7	19.5 - 21												19		
B-7	21 - 22.5												19		
B-7	23.5 - 25												21		
B-7	28.5 - 30												20		
B-7	33.5 - 35												39		
B-7	38.5 - 39.42												19		
B-7A	0 - 1.5												27		
B-7A	1.5 - 3												21		
B-7A	3 - 4.5												17		
B-7A	4.5 - 6												18		
B-7A	6 - 7.5												19		
B-7A	7.5 - 9												18		
B-7A	9 - 10.5												19		
B-7A	10.5 - 12												18		
B-7A	12 - 13.5												19		
B-7A	13.5 - 15												16		
B-7A	15 - 16.5														
B-7A	16.5 - 18												21		

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Atoka Lake North Access Road

SITE: East Access Road
Stringtown, OK

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PH. 405-525-0453 FAX. 405-557-0549

PROJECT NUMBER: 03215255

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-5

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-7A	18 - 19.5												18		
B-7A	19.5 - 21												19		
B-7A	21 - 22.5														
B-7A	23.5 - 24.75												19		
B-7A	28.5 - 30												18		
B-7A	33.5 - 34.25												17		
B-7B	0 - 1.5												21		
B-7B	1.5 - 3				56	31	25						21		
B-7B	3 - 4.5												20		
B-7B	4.5 - 6												19		
B-7B	6 - 7.5												19		
B-7B	7.5 - 9												18		
B-7B	9 - 10.5												18		
B-7B	10.5 - 12												18		
B-7B	12 - 13.5												16		
B-7B	13.5 - 15												16		
B-7B	15 - 16.5												15		
B-7B	16.5 - 18												16		
B-7B	18 - 19.5												15		
B-7B	19.5 - 21												15		
B-7B	21 - 22.5												15		
B-7B	23.5 - 25												16		
B-7B	28.5 - 30												16		
B-7B	33.5 - 34.42												15		
B-8	0 - 6												15		

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Atoka Lake North Access Road

SITE: East Access Road
Stringtown, OK

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PH. 405-525-0453 FAX. 405-557-0549

PROJECT NUMBER: 03215255

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT_LAB_SUMMARY 03215255 ATOKA LAKE NORTH.GPJ TERRACON_DATATEMPLATE.GDT 3/15/22

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-8	6 - 12				59	25	34						23		
B-8	18 - 24												25		
B-8	30 - 36												17		
B-9	0 - 6												14		
B-9	6 - 12												25		
B-9	18 - 24												25		
B-9	30 - 36												20		
B-10	0 - 6				35	29	6						8		
B-10	6 - 12												10		
B-10	18 - 24												16		
B-10	30 - 36														
B-5 Tubes	0 - 2														
B-5 Tubes	2 - 4														
B-5 Tubes	4 - 6												12		
B-7 Tubes	0 - 2														
B-7 Tubes	2 - 4												24		
B-7 Tubes	4 - 6														
Comp Bulk OMC	0 - 3	SANDY ELASTIC SILT(MH)	A-7-5 (13)		60	35	25	58.1	13.5	28.4				21.5	100.6

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Atoka Lake North Access Road

SITE: East Access Road
Stringtown, OK

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PH. 405-525-0453 FAX. 405-557-0549

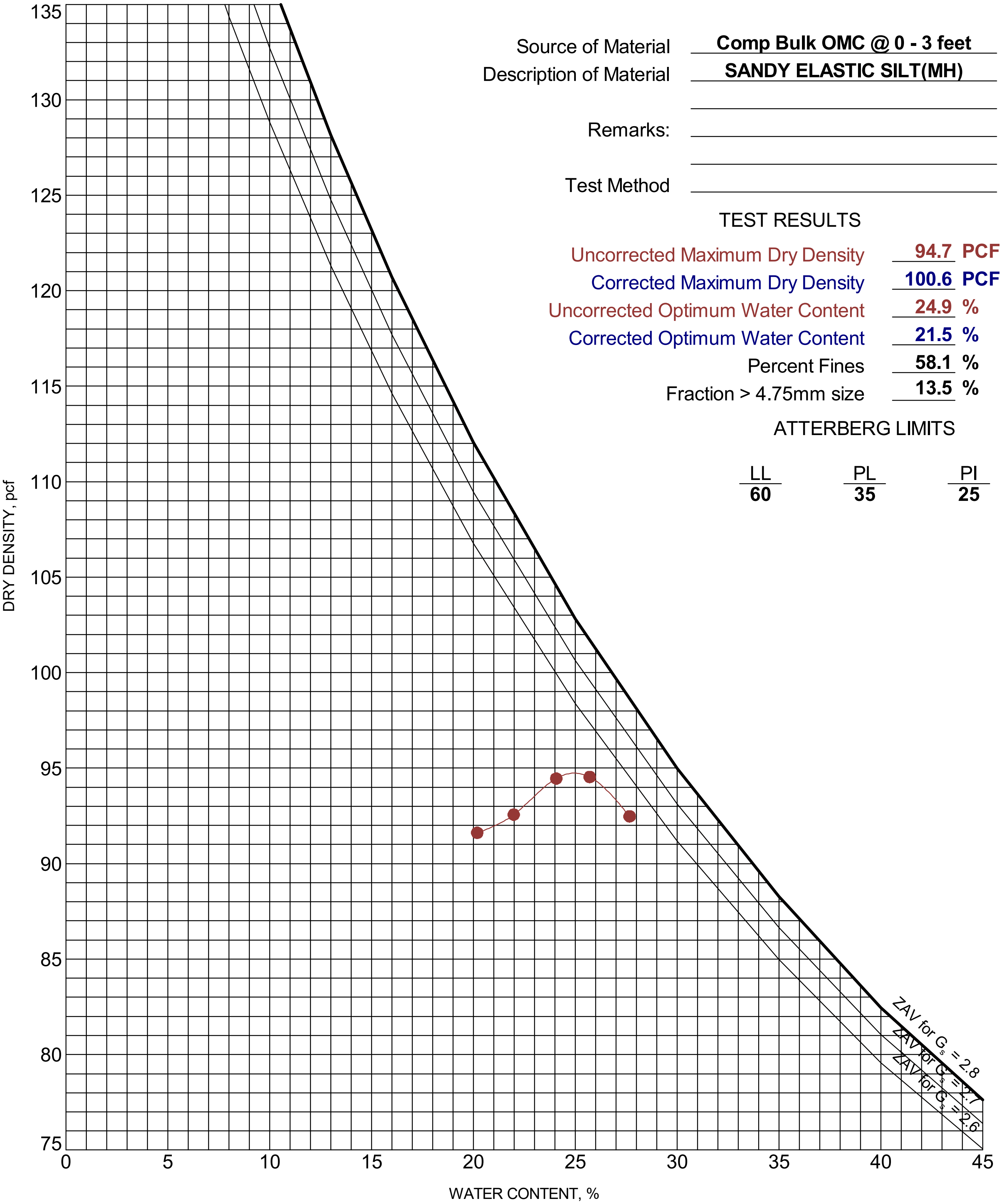
PROJECT NUMBER: 03215255

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-7

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material **Comp Bulk OMC @ 0 - 3 feet**

Description of Material **SANDY ELASTIC SILT(MH)**

Remarks:

Test Method

TEST RESULTS

Uncorrected Maximum Dry Density	94.7	PCF
Corrected Maximum Dry Density	100.6	PCF
Uncorrected Optimum Water Content	24.9	%
Corrected Optimum Water Content	21.5	%
Percent Fines	58.1	%
Fraction > 4.75mm size	13.5	%

ATTERBERG LIMITS

LL	PL	PI
60	35	25

PROJECT: Atoka Lake North Access Road

SITE: East Access Road
Stringtown, OK

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PROJECT NUMBER: 03215255

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-8

Resilient Modulus Testing - AASHTO T 307-99 English Units

Report Date: 08-Apr-22
Lab No.: Lab 53 RM 8 OMC
Project No.: 03215255

Soil Map Unit: Comp Bulk OMC
Soil Symbol: CH / A-7-5
Depth (ft.): 0 - 3.0
Compaction Method: Static
Max. Dry Density (pcf): 94.7
Opt. Moisture Content (%): 24.9
Inside Mold Diameter (in): 3.94

Weight of Wet Soil (lb): 6.23
Initial Sample Diameter (in): 3.94
Initial Sample Height (in): 7.87
Initial Sample Area (in^2): 12.17
Sample Volume (in^3): 95.86
Compacted Moisture Content(%): 25.4
Wet Density (pcf): 112.3
Dry Density (pcf): 89.5

Test Date: March 5, 2022

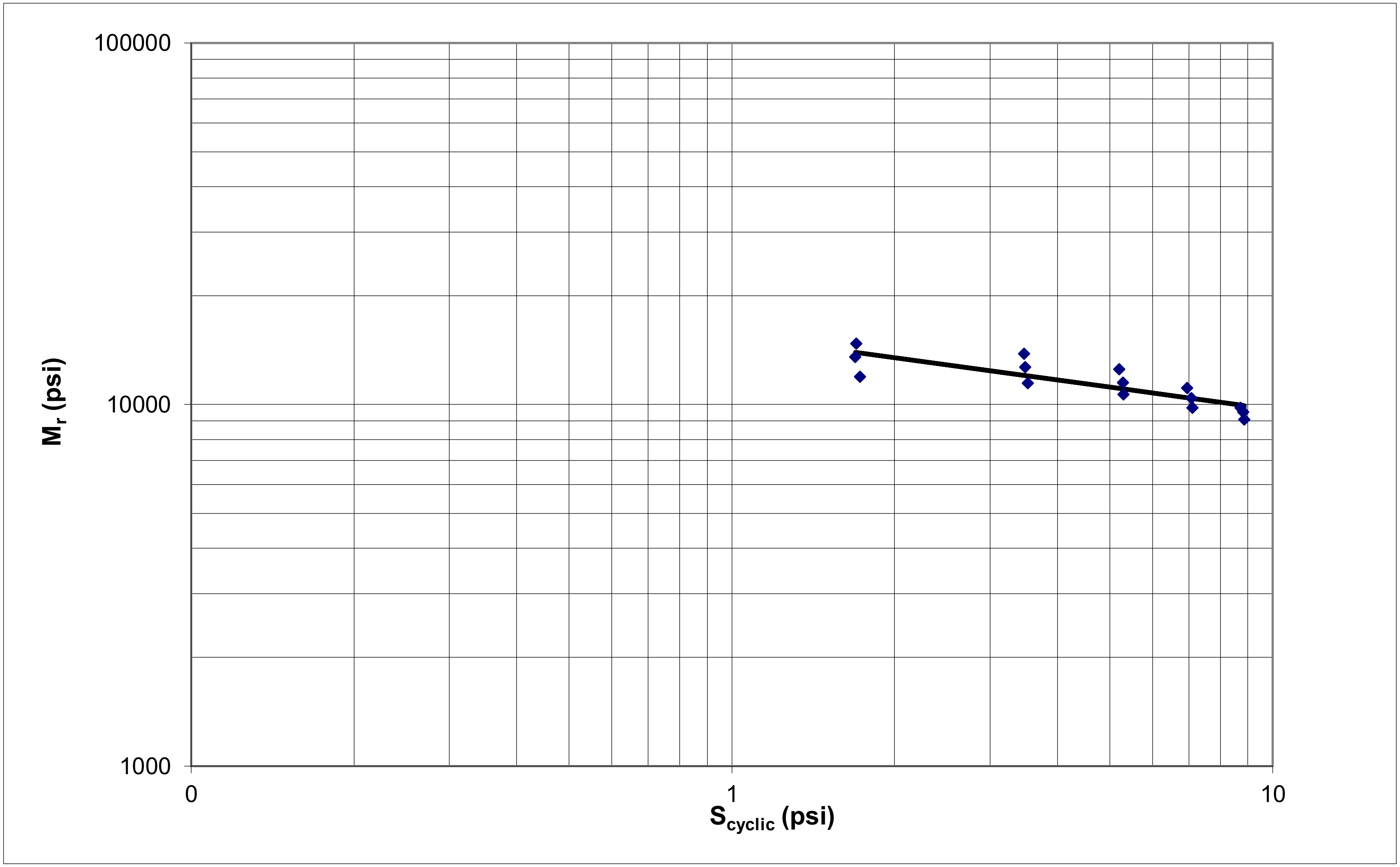
Final Sample Height (in): 7.9
Final Sample Wet Weight (lb): 6.23
Final Moisture Content (%): 25.4
Accumulated Strain (%): 0.03

Percent Passing No. 10: 77
Percent Passing No. 200: 58.1
Liquid Limit: 60
Plasticity Index: 25

Chamber Confining Pressure (S_3) psi	Nominal Maximum Axial Stress (S_{cyclic}) psi	Actual Applied Max. Axial Load (P_{max}) lb	Actual Applied Cyclic Load (P_{cyclic}) lb	Actual Applied Contact Load ($P_{contact}$) lb	Actual Applied Max. Axial (S_{max}) psi	Actual Applied Cyclic Stress (S_{cyclic}) psi	Actual Applied Contact Stress ($S_{contact}$) psi	Recov. Def. LVDT #1 Reading (H_1) in	Recov. Def. LVDT #2 Reading (H_2) in	Average Recov. Def. LVDT 1 (H_{avg}) in	Resilient Strain (ϵ_r) in/in	Resilient Modulus (M_r) psi
6.00	2.00	22.9	20.7	2.3	1.88	1.70	0.186	0.0009	0.0009	0.0009	0.000115	14,724
6.00	4.00	46.6	42.2	4.4	3.83	3.47	0.363	0.0020	0.0020	0.0020	0.000251	13,838
6.01	6.00	70.4	63.3	7.1	5.78	5.20	0.585	0.0033	0.0032	0.0033	0.000415	12,526
6.00	8.00	94.5	84.6	9.8	7.76	6.95	0.807	0.0050	0.0048	0.0049	0.000626	11,097
6.01	10.00	118.9	106.2	12.7	9.76	8.72	1.044	0.0072	0.0068	0.0070	0.000889	9,809
4.01	2.00	23.1	20.6	2.5	1.90	1.69	0.206	0.0010	0.0010	0.0010	0.000125	13,546
4.01	4.00	47.3	42.5	4.8	3.89	3.49	0.398	0.0022	0.0022	0.0022	0.000275	12,675
4.01	6.00	71.5	64.4	7.1	5.87	5.29	0.583	0.0037	0.0036	0.0036	0.000460	11,502
4.01	8.00	95.8	86.2	9.6	7.86	7.08	0.785	0.0054	0.0053	0.0054	0.000681	10,400
4.01	10.00	119.6	107.3	12.3	9.82	8.81	1.008	0.0074	0.0071	0.0073	0.000924	9,538
2.00	2.00	23.0	21.0	2.0	1.89	1.72	0.168	0.0011	0.0011	0.0011	0.000144	11,944
2.00	4.00	47.3	42.9	4.4	3.88	3.52	0.360	0.0024	0.0024	0.0024	0.000308	11,450
2.00	6.00	71.4	64.5	6.9	5.86	5.30	0.567	0.0039	0.0039	0.0039	0.000497	10,650
2.00	8.00	95.8	86.5	9.3	7.87	7.10	0.767	0.0058	0.0057	0.0057	0.000725	9,798
2.00	10.00	119.7	108.0	11.7	9.83	8.87	0.961	0.0078	0.0076	0.0077	0.000977	9,078

Exhibit B-9

Date Reported: 4/8/2022 Comp Bulk OMC
Terracon Lab No. Lab 53 RM 8 OMC
Project No. 03215255



Mr = K1 x S_{cylic}^{k2}

S3 (psi)	K1	K2	R^2
6	17571.5	-0.239	0.88
4	15693.9	-0.209	0.91
2	13500.9	-0.163	0.89
All	15532.3	-0.205	0.71

Exhibit B-9

Date Reported: 4/8/2022

Terracon Lab No. Lab 53 RM 8 OMC

Project No. 03215255

Comp Bulk OMC

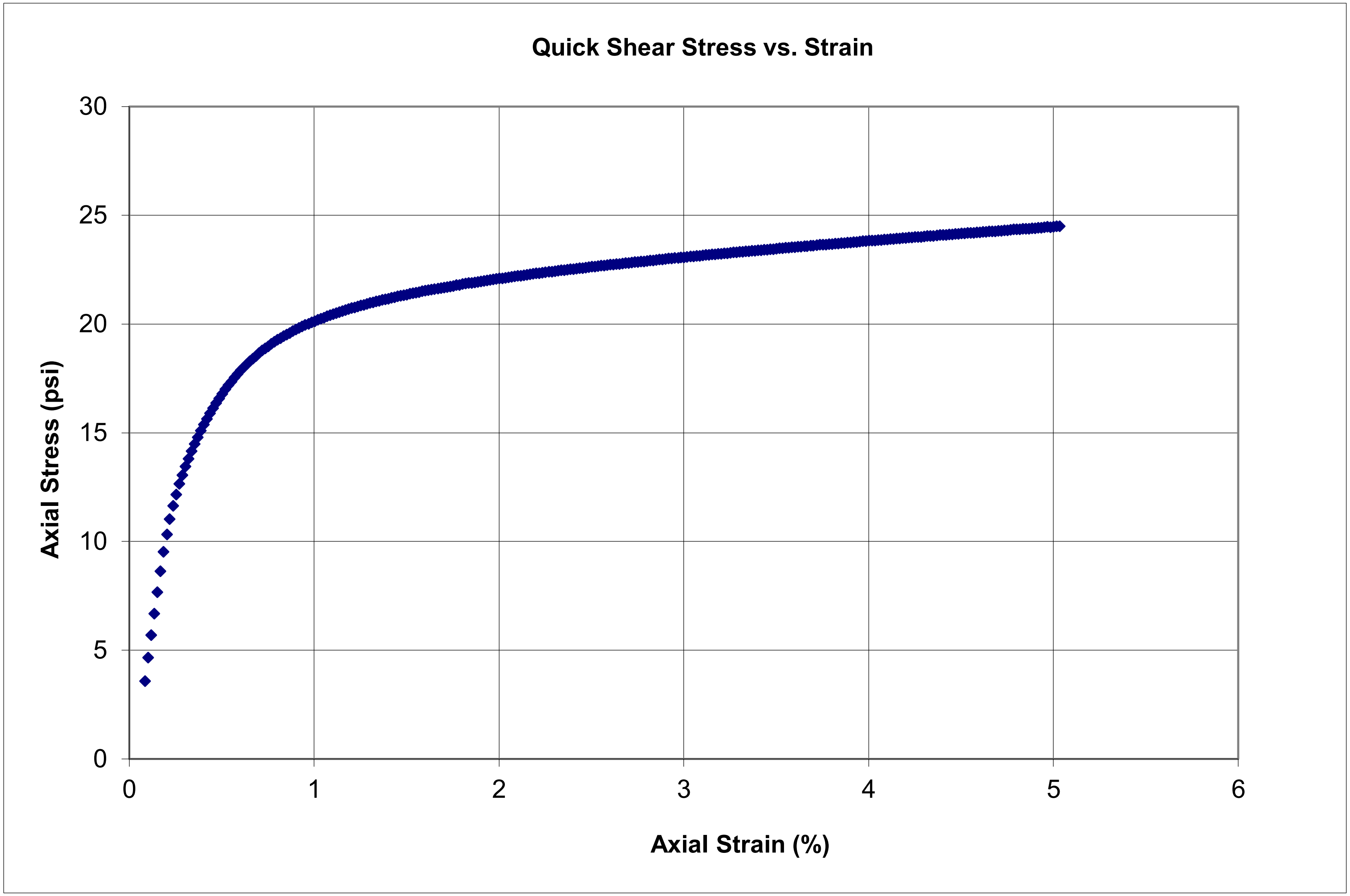


Exhibit B-9

Resilient Modulus Testing - AASHTO T 307-99 English Units

Report Date: 08-Apr-22
Lab No.: Lab 53 RM 8 OMC+
Project No.: 03215255

Soil Map Unit: Comp Bulk OMC+
Soil Symbol: CH / A-7-5
Depth (ft.): 0 - 3.0
Compaction Method: Static
Max. Dry Density (pcf): 94.7
Opt. Moisture Content (%): 24.9
Inside Mold Diameter (in): 3.94

Weight of Wet Soil (lb): 6.44
Initial Sample Diameter (in): 3.94
Initial Sample Height (in): 7.87
Initial Sample Area (in^2): 12.17
Sample Volume (in^3): 95.86
Compacted Moisture Content(%): 29.2
Wet Density (pcf): 116.0
Dry Density (pcf): 89.8

Test Date: March 5, 2022

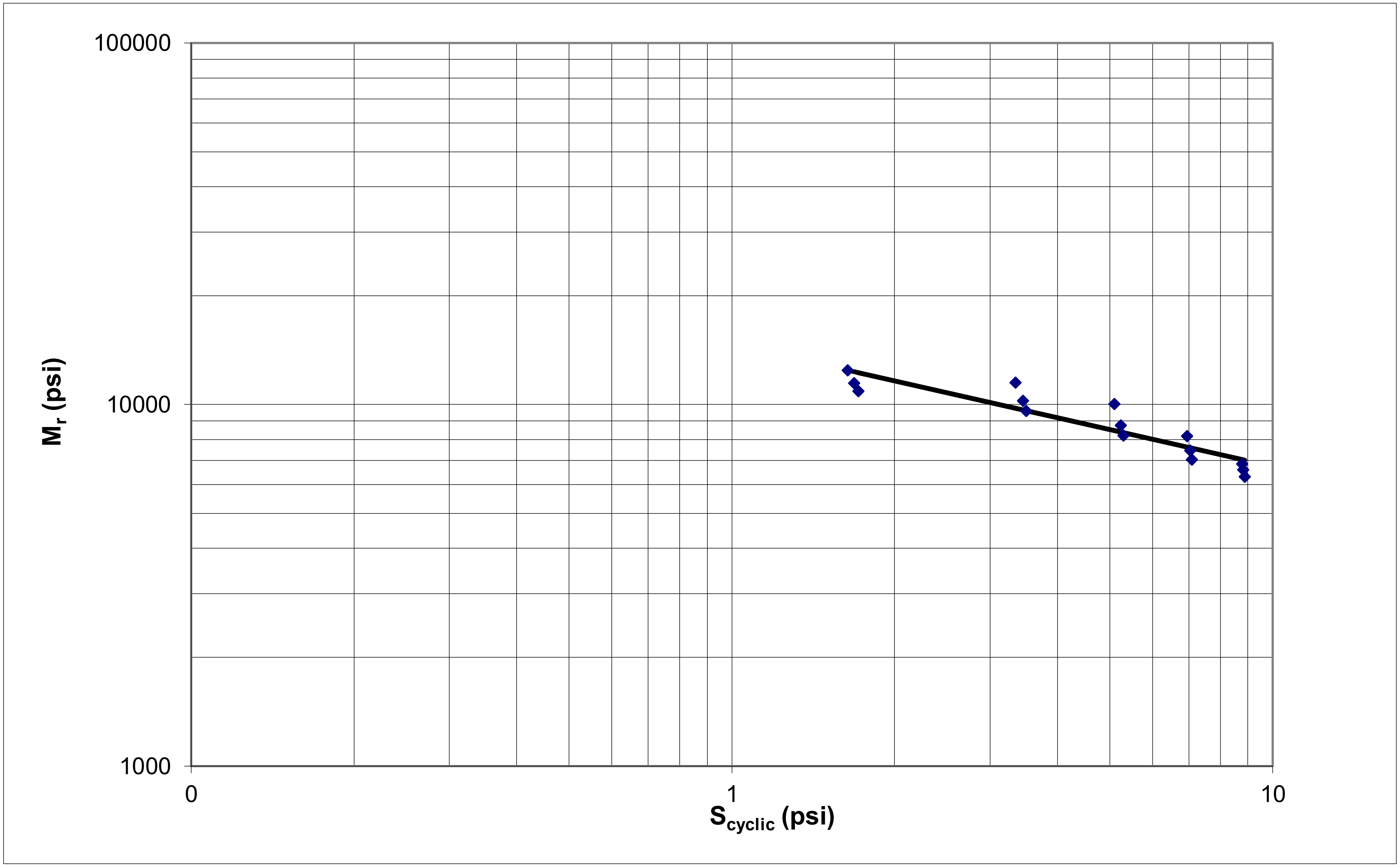
Final Sample Height (in): 7.9
Final Sample Wet Weight (lb): 6.44
Final Moisture Content (%): 29.2
Accumulated Strain (%): 0.07

Percent Passing No. 10: 77
Percent Passing No. 200: 58.1
Liquid Limit: 60
Plasticity Index: 25

Chamber Confining Pressure (S_3) psi	Nominal Maximum Axial Stress (S_{cyclic}) psi	Actual Applied Max. Axial Load (P_{max}) lb	Actual Applied Cyclic Load (P_{cyclic}) lb	Actual Applied Contact Load ($P_{contact}$) lb	Actual Applied Max. Axial (S_{max}) psi	Actual Applied Cyclic Stress (S_{cyclic}) psi	Actual Applied Contact Stress ($S_{contact}$) psi	Recov. Def. LVDT #1 Reading (H_1) in	Recov. Def. LVDT #2 Reading (H_2) in	Average Recov. Def. LVDT 1 (H_{avg}) in	Resilient Strain (ϵ_r) in/in	Resilient Modulus (M_r) psi
6.00	2.00	22.5	19.9	2.6	1.85	1.64	0.214	0.0010	0.0010	0.0010	0.000132	12,441
6.01	4.00	45.6	40.7	4.9	3.74	3.34	0.399	0.0023	0.0023	0.0023	0.000291	11,503
6.00	6.00	69.6	62.1	7.5	5.72	5.10	0.614	0.0041	0.0039	0.0040	0.000508	10,045
6.00	8.00	94.6	84.5	10.1	7.77	6.94	0.831	0.0068	0.0066	0.0067	0.000847	8,191
6.00	10.00	119.4	106.8	12.6	9.81	8.77	1.034	0.0102	0.0100	0.0101	0.001282	6,845
4.01	2.00	23.1	20.5	2.6	1.89	1.68	0.210	0.0012	0.0012	0.0012	0.000147	11,448
4.01	4.00	47.1	42.1	5.0	3.87	3.46	0.413	0.0027	0.0026	0.0027	0.000338	10,237
4.01	6.00	71.2	63.8	7.4	5.85	5.24	0.612	0.0048	0.0047	0.0047	0.000598	8,757
4.01	8.00	95.4	85.6	9.7	7.83	7.03	0.801	0.0075	0.0074	0.0074	0.000944	7,447
4.01	10.00	119.7	107.5	12.2	9.83	8.83	1.004	0.0106	0.0105	0.0105	0.001337	6,602
2.00	2.00	22.9	20.8	2.0	1.88	1.71	0.168	0.0012	0.0012	0.0012	0.000157	10,887
2.00	4.00	47.1	42.7	4.5	3.87	3.50	0.368	0.0029	0.0029	0.0029	0.000366	9,584
2.00	6.00	71.3	64.5	6.8	5.85	5.29	0.558	0.0051	0.0050	0.0051	0.000645	8,213
2.00	8.00	95.6	86.4	9.2	7.85	7.09	0.757	0.0080	0.0079	0.0079	0.001007	7,044
2.01	10.00	119.9	108.2	11.7	9.84	8.88	0.961	0.0112	0.0110	0.0111	0.001409	6,303

Exhibit B-10

Date Reported: 4/8/2022 Comp Bulk OMC+
Terracon Lab No. Lab 53 RM 8 OMC+
Project No. 03215255



Mr = K1 x S_{cylic}^{k2}

S3 (psi)	K1	K2	R^2
6	15979.9	-0.344	0.86
4	14373.4	-0.331	0.93
2	13648.1	-0.332	0.95
All	14688.0	-0.338	0.85

Exhibit B-10

Terracon

Date Reported: 4/8/2022

Terracon Lab No. Lab 53 RM 8 OMC+

Project No. 03215255

Comp Bulk OMC+

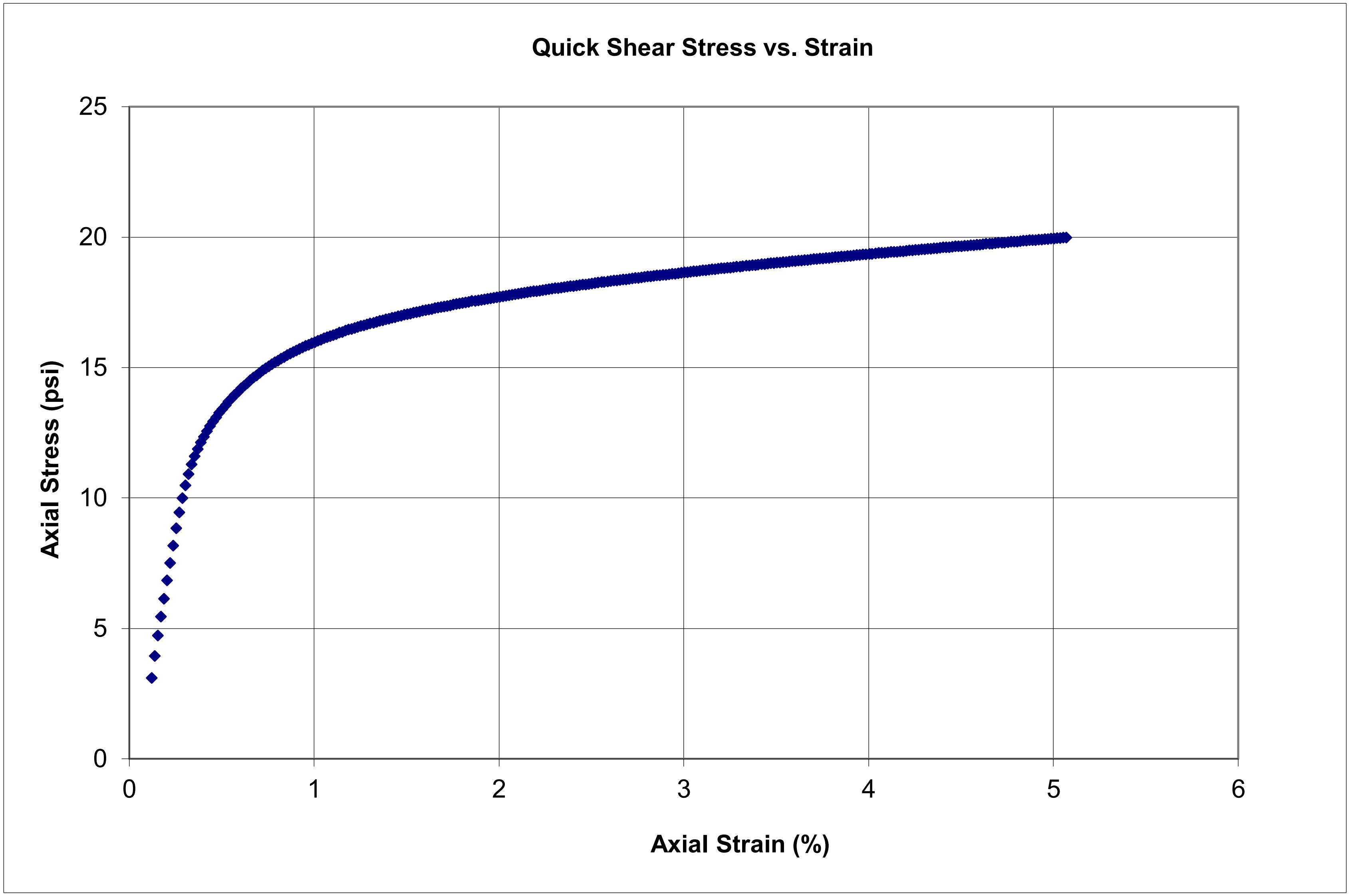


Exhibit B-10

APPENDIX C
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

Exhibit C-1

UNIFIED SOIL CLASSIFICATION SYSTEM

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

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

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

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

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

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

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

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

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

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

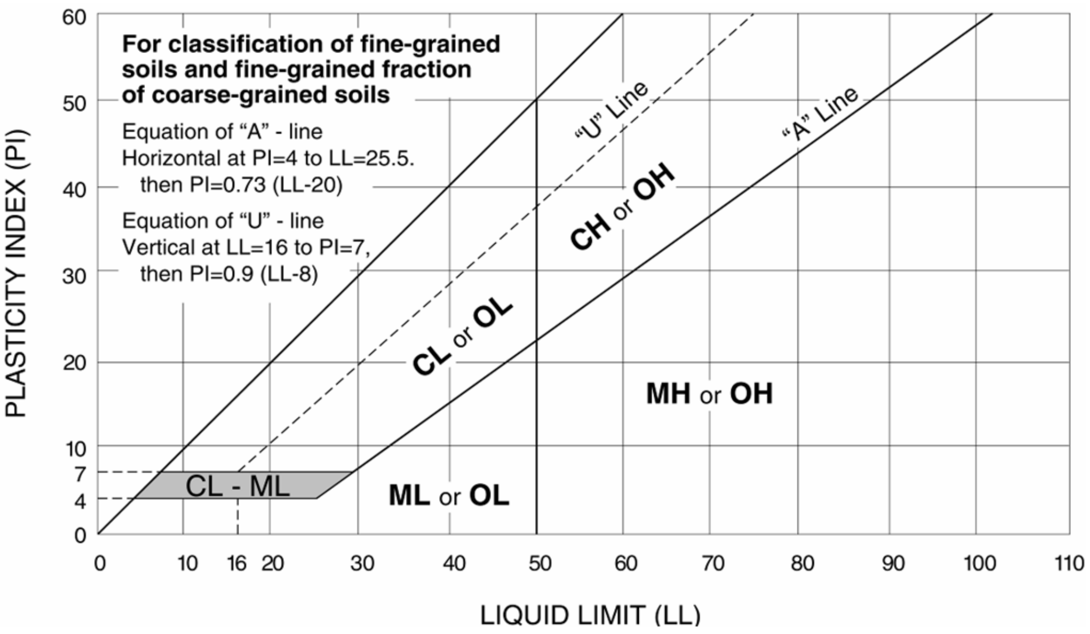
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

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

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

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

[Q] PI plots below "A" line.



Terracon

Exhibit C-2

GENERAL NOTES

Sedimentary Rock Classification

DESCRIPTIVE ROCK CLASSIFICATION:

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

LIMESTONE	Light to dark colored, crystalline to fine-grained texture, composed of $CaCo_3$, reacts readily with HCl.
DOLOMITE	Light to dark colored, crystalline to fine-grained texture, composed of $CaMg(CO_3)_2$, harder than limestone, reacts with HCl when powdered.
CHERT	Light to dark colored, very fine-grained texture, composed of micro-crystalline quartz (SiO_2), brittle, breaks into angular fragments, will scratch glass.
SHALE	Very fine-grained texture, composed of consolidated silt or clay, bedded in thin layers. The unlaminated equivalent is frequently referred to as siltstone, claystone or mudstone.
SANDSTONE	Usually light colored, coarse to fine texture, composed of cemented sand size grains of quartz, feldspar, etc. Cement usually is silica but may be such minerals as calcite, iron-oxide, or some other carbonate.
CONGLOMERATE	Rounded rock fragments of variable mineralogy varying in size from near sand to boulder size but usually pebble to cobble size (½ inch to 6 inches). Cemented together with various cementing agents. Breccia is similar but composed of angular, fractured rock particles cemented together.

PHYSICAL PROPERTIES:

DEGREE OF WEATHERING

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

HARDNESS AND DEGREE OF CEMENTATION

Limestone and Dolomite:

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

Shale, Siltstone and Claystone

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

Sandstone and Conglomerate

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

BEDDING AND JOINT CHARACTERISTICS

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

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

SOLUTION AND VOID CONDITIONS

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

Terracon

Form 110—6-85

Exhibit C-3

Supplemental Report

Lake Access Road Improvements (Phase II)
Atoka Lake – North Section
Near Stringtown, Oklahoma

February 6, 2023
Terracon Project No. 03215255A

Prepared for:
Poe and Associates, Inc.
Oklahoma City, Oklahoma

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

terracon.com
Terracon
Environmental ■ Facilities ■ Geotechnical ■ Materials

February 6, 2023

Poe and Associates, Inc.
1601 Northwest Expressway, Suite 400
Oklahoma City, Oklahoma 73118

Attn: Mr. Todd Cochran, P.E.
P: [405] 949 1962
F: [405] 608 0380
E: Todd.Cochran@poeandassociates.com

Re: Supplemental Report
Lake Access Road Improvements (Phase II)
Atoka Lake – North Section
Near Stringtown, Oklahoma
Terracon Project No. 03215255A

Dear Mr. Cochran:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. These services were performed in general accordance with Phase II of our Proposal No. P03215255 dated November 17, 2021. This geotechnical engineering report presents the results of the subsurface exploration and provides recommendations for the pavement typical sections and subgrade preparations for the proposed project and repair recommendations for the slide that has occurred.

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. 6/30/23

Jeff Dean, P.E.	Norman K. Tan, Ph.D., P.E.
Oklahoma No. 16998	Geotechnical Manager

JD:NT\kld\n:\projects\2021\03215254\project documents\Feb2023

Copies to: Addressee (1 via email)

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APPENDIX D - SUPPORTING DOCUMENTS

EXECUTIVE SUMMARY

Supplemental borings were drilled along the north lake access road along the east shoreline of Atoka Lake near Stringtown, Oklahoma to collect additional soil samples for more in-depth analysis to determine the cause of the distresses that have developed in the pavement. This report covers the supplemental analysis of the north section which includes approximately two miles of pavement extending north from the dam. The scope of Terracon's field investigation included fourteen supplemental borings spaced along the length of the pavement section. Twelve of the borings were drilled through the pavement and subgrade to collect split-barrel and thin-walled tube samples. Two additional borings were focused in the two areas where slides appeared to have developed.

The following conditions are indicated by our subsurface exploration:

- Soils encountered in, and extending to the bottom, of the borings consisted primarily of moderate to very high plasticity lean to fat clays with varying amounts of sand and occasional gravels. Sandstone bedrock was encountered at a depth of approximately 30 inches in boring B-1B and a depth of approximately 78 inches at boring B-5E. Highly weathered shale was encountered at a depth of 78 inches in boring B-7C. Hand Auger refusal was encountered in boring B-5C at a depth of about 18 inches.

- The existing asphalt pavement was asphalt and ranged in thickness from 2 to 4 inches.

- Groundwater was not encountered in any of the borings at the time of our field investigation.

- The measured moisture contents of the soil samples retrieved from each boring ranged from moderately low to high and in some locations were well above the soil's plastic limit. This is the moisture content at which a clayey soil can be molded and begins to lose strength.

- A site visit was conducted at the project on August 9, 2022 to better evaluate the pavement condition and topography along the access road. The crack patterns that have developed throughout the road in combination with the high plasticity clays discovered in the first phase borings and the relatively shallow slopes and tend to indicate the pavement distresses are due more to shrink-swell activity rather than movement due to a continuous slope failure. Examination of the slopes during the site visit did not reveal any evidence of movement along the slope between the road and the lake shore.

This geotechnical executive summary should be used in conjunction with the entire report for design and/or construction purposes. It should be recognized that specific details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled General Comments should be read for an understanding of the report limitations.

SUPPLEMENTAL REPORT
LAKE ACCESS ROAD IMPROVEMENTS (PHASE II)
ATOKA LAKE – NORTH SECTION
NEAR STRINGTOWN, OKLAHOMA

Terracon Project No. 03215255A
February 6, 2023

1.0 INTRODUCTION

This report presents the results of our supplemental drilling and laboratory testing performed for the proposed rehabilitation of the north lake access road along the east shoreline of Atoka Lake near Stringtown, Oklahoma. The purpose of these services is to provide additional information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- subgrade strength values
- landslide repair
- groundwater conditions
- earthwork
- pavement typical sections

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION
Site layout	See Appendix A, Exhibits A-1 to A-3.
Proposed development	The project involves the rehabilitation of the lake access roads along the east shoreline of Atoka Lake near Stringtown, Oklahoma.
Grading	Grade changes for the proposed new construction are not anticipated.
Traffic loading	A traffic estimate of 1,000 vehicles per day including occasional trucks was provided for development of the pavement designs.

3.0 PAVEMENT AND SUBSURFACE CONDITIONS

3.1 Supplemental Borings

Fourteen supplemental borings were drilled or hand-augered, in this investigation, at the locations illustrated in Exhibits A-2 and A-3 in Appendix A. These borings were drilled/augered at selected locations between the previous borings drilled in our initial investigation of the north access road to acquire additional information in terms of soil properties and variability in the soil profile between the various borings. Twelve borings were drilled through the pavement. Nine of the twelve borings were drilled to collect soil samples by the split barrel method for classification tests and three borings were drilled at selected locations adjacent to the split barrel borings to collect thin-walled tube samples for additional laboratory tests. Two additional borings, B-5C and B-7C, were drilled near the previous borings B-5, B-5A, B-5B, and B-7, B-7A, B-7B that had been drilled to investigate potential slides had developed between the road and the lake.

3.2 Pavement Condition

Based upon information collected from the pavement borings, the pavement thickness measurements ranged from approximately 2 to 4 inches. A site visit was conducted at the project on August 9, 2022 to better evaluate the pavement condition and topography along the north access road. The crack patterns that have developed vary in frequency and severity throughout the pavement. Photographs taken during this site visit are included as Exhibits C-1 to C-3 in Appendix C of this report. Examination of these cracks in combination with the highly plastic clays that were discovered in the first phase borings and the relatively shallow slopes and tend to indicate the pavement distresses are due more to shrink-swell activity in the subgrade rather than movement due to a developing slope failure.

3.3 Subgrade Properties

The subgrade beneath the pavement, in most areas, can be generally described as deep deposits of high plasticity clays with varying amounts of sand. Groundwater was not encountered in any of the borings at the time of our investigation. Review of the recorded moisture contents, in the boring logs, revealed several locations where the in-situ moisture content was much lower than the soils plastic limit indicating somewhat dry conditions. The moisture contents at other areas were at or near the plastic limit of the soil which is the moisture content at which a clayey soil can be molded and begins to lose strength. The information collected from these borings also revealed considerable variability in the subgrade soils between boring locations along the north access road alignment. The liquid limit values, of those representative soil samples tested, ranged from 20 to 78 with many samples in the range of 50’s and 60’s. The plasticity indices ranged from 7 to 46 with most ranging in the upper 20’s and 30’s. These values are presented in the supplemental boring logs included as Exhibits A-5 to A-18 in Appendix A.

Clay soils having high plasticity values such as many of those tested are prone to high shrink-swell activity. In an effort to quantify this shrink-swell activity, these soils were evaluated, under varied conditions, using PVR version 9.3 which is a software program that uses TxDOT Method Tex-124-E, developed by Chester McDowell to estimate the Potential Vertical Rise, PVR, of the subgrade. For this evaluation, we looked at two conditions: the subgrade with no applied surcharge, which allowed maximum swell in the subgrade to occur; and then we looked at the estimated surcharge required to restrict swell in the subgrade to less than 1 inch. The results using the soils information collected from all pavement borings drilled to date are presented in the Table below. This program provides reasonable swell values based upon the soil data used but by no means are these values exact. They should be considered very good for estimating purposes only.

PVR Estimates from Representative Soil Samples

Boring(s)	PVR with No Surcharge (in.)	Surcharge* Required for <1" Swell (ft.)	PVR (in.)
B-1 / B-1A	2.2	3	0.9
B-2 / B-3	2.0	3	0.7
B-3A	1.3	1.5	0.8
B-4A	0.6	1	0.5
B-5D	2.4	4	0.9
B-5E	1.7	3	0.8
B-6 / B-7E	2.9	4.5	0.9
B-8A	0.8	1	0.6
B-8 / B-10	1.8	2	0.99

*Surcharge is equivalent to a unit weight of 120 pcf.

These PVR estimates in conjunction with the information included in the boring logs provide an indication of how severe swelling can occur at specific locations as well as the variability in the soil properties along the project extents in terms of shrink-swell potential.

Laboratory swell tests were performed on selected thin-walled tube samples to verify the estimates developed from the PVR calculations. These swell tests were conducted on two soil samples, one each from boring B-5D and boring B-7E, which are areas where the PVR estimates were greatest. The tests on these two samples were conducted to evaluate the pressure or surcharge required to prevent swell from occurring. The swell tests began with the samples at the in-situ moisture content at the time they were collected. As pressure was applied to the sample, water was added to induce swelling. The pressure was then increased, as needed, to maintain a relative zero strain in the sample. The swell test results are included as Exhibits B-12 and B-13 in Appendix B. A summary of the results from these two swell tests is presented in the table below.

Swell Pressure Test Results

Sample	Depth (ft)	Liquid Limit	Plastic Limit	Initial Moisture Content (%)	Final Moisture Content (%)	Swell Pressure for Zero Swell (psf)
B-5D	3 to 4.5	53	28	20.6	27.4	401.5
B-7E	3 to 4.5	70	46	27.6	30.3	1805.9

The swell tests provide valuable information regarding how the behavior of the clay samples is affected in terms of plasticity and changes in moisture content. The sample from boring B-5D with a plasticity index of 28, had an increase in moisture content of 6.8%, over the course of the test, and required a swell pressure or surcharge of 401.5 psf to maintain zero swell. This would be equivalent to approximately 3.4 feet of soil compacted to 120 pcf. The sample from boring B-7E with a plasticity index of 46 had a much lower increase in moisture content of 2.7% yet required a surcharge pressure of 1805 psf. which would be equivalent to about 15 feet of 120 pcf. surcharge. This amount of surcharge would, of course, be very impractical for most projects. These tests provide an indication of the impact that changes in moisture content have on the clay soils. They also bring into question about what an acceptable PVR value would be for this pavement section. Many state agencies allow a maximum PVR of 1.5 inches for mainline pavement sections and 2 inches for lower traffic volume roads. The traffic estimated for this project was approximately 1000 vehicles per day which would indicate that a PVR of 2 inches would be acceptable. Under this criteria, additional analysis of the PVR calculations from the boring log data produces the recommended surcharge estimates as presented in the table below.

PVR Estimates from Representative Soil Samples

Boring(s)	PVR with No Surcharge (in.)	Surcharge* Required for < 2" Swell (ft.)	PVR (in.)
B-1 / B-1A	2.2	1	1.7
B-2 / B-3	2.0	1	1.5
B-3A	1.3	1**	1.0
B-4A	0.6	1**	0.5
B-5D	2.4	1	2.0
B-5E	1.7	1**	1.3
B-6 / B-7E	2.9	2	1.8
B-8A	0.8	1**	0.6
B-8 / B-10	1.8	1**	1.3

*Surcharge is equivalent to a unit weight of 120 pcf.

**1 Ft. of surcharge was included for consistency in the modified pavement section.

As indicated in the table above, the PVR estimates show that 1 foot of surcharge would be required to keep the PVR values below 2 inches at most locations except for the areas near boring B-6 and the B-7 borings. The subgrade in these areas will require a minimum surcharge of 2 feet to maintain a maximum PVR of 2 inches. Based upon this analysis we recommend revising the earlier pavement design typical sections to reflect this.

4.0 PAVEMENT DESIGN RECOMMENDATIONS

4.1 Pavement Design Parameters

In Terracon's initial report 03215255 dated April 7, 2022, both flexible and rigid options were considered for rehabilitating the pavement for this project. AASHTO Pavement Design software was used to design the overlay for the pavement section. All pavement design options are based upon a 30-year design life.

The following is a summary of the design parameters used to design the pavement typical sections:

<u>Atoka Lake Access Road – section north of the dam</u>

- Average Annual Daily Traffic, AADT, 1,000
- Percent Trucks, 0.5%
- Directional Distribution, 55%
- Reliability value, 90%
- Design resilient modulus value – 3,500 psi
- Annual Growth Rate, 2%

The full depth typical sections are based upon a 30-year design life. The design AADT used in the pavement designs include occasional class 9 vehicles and a combination of cars, pickup trucks, school buses, dump trucks, and various types of delivery trucks. If these design traffic parameters are inconsistent with those desired by the client, the revised traffic information should be submitted for our review to evaluate any potential changes to our design recommendations.

4.2 Pavement Typical Section Recommendations

Based upon the parameters listed above, and in consideration of the surcharge requirements to limit the PVR to 2 inches in the subgrade, the following <u>revised</u> pavement sections, which include a surcharge layer to control swell, may be considered for the project.

Flexible Options – 30 Year Design

<u>Option 1</u>

2.0 in. S4 PG 64-22OK
4.0 in. S3 PG 64-22OK
12.0 in. Aggregate Base type A – shoulder w/ TBSC-Type E (**SURCHARGE**[2])
8 oz/SY non-woven separator fabric beneath Aggregate Base & TBSC
12.0 in. FDR existing pavement and subgrade with lime added to control the expansive soils (Could use PC cement if a mix design is performed)

Or

Option 2

2.0 in. S4 PG 64-22OK
4.0 in. S3 PG 64-22OK
8.0 in. Aggregate Base Type A – shoulder with TBSC type E
12.0 in. Aggregate Base Type A – shoulder with TBSC type E (**SURCHARGE**[2])
8 oz/SY non-woven separator fabric beneath Aggregate Base & TBSC
12.0 in. Stabilized Subgrade[1]

Rigid Options – 30 Year Design

Option 1

5.5 in. PC Concrete (recommend fiber reinforce concrete w/ saw joints every 6 ft laterally & longitudinally)
12.0 in Aggregate Base type A – shoulder w/ TBSC-Type E (**SURCHARGE**[2])
8 oz/SY non-woven separator fabric beneath Aggregate Base & TBSC
12.0 in. FDR existing pavement and subgrade with lime added to control the expansive soils (Could use PC cement if a mix deign is performed)

Or

Option 2

5.5 in. PC Concrete (recommend fiber reinforce concrete w/ saw joints every 6 ft laterally & longitudinally)
8.0 in. Aggregate Base Type A – shoulder with TBSC Type E
12.0 in. Aggregate Base Type A – shoulder w/ TBSC-Type E (**SURCHARGE**[2])
8 oz/SY non-woven separator fabric beneath Aggregate Base & TBSC
12.0 in. Stabilized Subgrade[1]

Notes:

1 – Per ODOT Specifications 307 - at the rate specified for the appropriate soil classification according to OHD L-50.

2 – Due to the variability in the subgrade properties between boring locations, we recommend a minimum surcharge of 1 ft of Type A aggregate base at all locations except for those locations near boring B-6 and the B-7 borings. To control PVR in those areas we recommend increasing the thickness of aggregate base to 24 inches. We recommend beginning this section approximately 100 feet south of the boring B-6 location and extending it to 100 feet beyond the B-7 borings. This extent is estimated to be approximately 670 feet in length.

5.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

5.1 Geotechnical Considerations

The borings generally encountered moderate to high plasticity lean to fat clays with varying amounts of sand. These soils generally have low permeability and will tend to increase in moisture content and decrease in strength over time as the pavement is in service. The Kessler DCP tests, conducted in Phase I, revealed several locations with deep, soft subgrade profiles. Additional areas of soft subgrade may be encountered, once pavement reconstruction begins, and may require replacement as described in **Section 5.3 Subgrade Preparation** below.

Geotechnical engineering recommendations for earthwork and pavement design and construction are outlined below. The recommendations contained in this report are based upon the results of field and laboratory testing located in the boring loges and DCP tests, which are presented in Appendix A, engineering analyses, and our current understanding of the proposed project.

5.2 Earthwork

The following presents recommendations for site and subgrade preparation, including chemical treatment and placement of engineered fills. Later recommendations presented for design and construction of pavements are contingent upon implementing the recommendations outlined in this section.

Earthwork, including subgrade preparation, fill placement and chemical soil treatment, should be observed and tested by Terracon.

5.3 Subgrade Preparation

After the removal of selected pavement sections, the exposed subgrade should be probed with either a T-probe or Kessler DCP to identify the depth and lateral extent of any soft subgrade encountered. In broader extents, it may be necessary to proof roll the subgrade with a loaded, tandem-axle dump truck weighing at least 25 tons (under the observation of Terracon personnel) to locate any soft or unstable zones. The proofrolling should involve overlapping passes of the equipment. Where rutting or pumping is observed during proofrolling, the unstable soils should be over excavated and replaced with an approved soil as described in following sections if it cannot be effectively dried and compacted in-place. The extent of this unstable soil will not become evident until construction begins, but this condition should be anticipated and planned for accordingly. We expect the subgrade soils beneath the existing pavement to accumulate moisture over the life of the pavement. Therefore, it is probable that wet or unstable areas will be encountered during probing or proofrolling.

After probing the subgrade and removal of soft subgrade, the exposed subgrade in areas to receive new fill should be scarified to a depth of 8 inches, adjusted to a workable moisture content. Given the high plasticity of the clays in several sections of the project extent, we recommend a workable moisture content of about 2 percent above the optimum value and be compacted to at least 95 percent of the material's maximum dry density as determined by test method ASTM D698 (Standard Proctor). It is important to avoid compacting these clays dry of optimum to minimize potential swell.

5.4 Subgrade Stabilization

If the Full Depth Reclamation, FDR, option is selected, to reduce potential strength loss and improve the long-term subgrade support, we recommend that the top 12 inches of the processed pavement and subgrade soils be chemically stabilized. If the existing pavement is removed, we recommend stabilizing the top 12 inches of the subgrade. The type of additive should be determined at the time of construction by the geotechnical engineer. We recommend following ODOT's OHD L-50 for determining the actual type and percentage of chemical used as indicated in the table below.

Soil Stabilization Table

Additive (Expressed as a percentage added on oven dry basis)	**Soil Group Classification - AASHTO M145**											
	A-1		A-1				A-3	A-4	A-5	A-6	A-7	
	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7					A-7-5	A-7-6
Portland Cement	4	4	4	4	4	4	5	√	√	√		
Fly Ash					12	12	13	14	14	14		
Cement Kiln Dust (Pre-Calciner Plants)	5	5	5	5	5	5	6	√	√			
Cement Kiln Dust (Other Type Plants)	10	10	10	11	11	11	12	12	12			
Hydrated Lime*										4	5**	5**

A blank in the table indicates the additive is not recommended for that soil group. Recommended amounts include a safety factor for loss due to wind, grading, and/or mixing. Pre-Calciner plants are identified on the ODOT Materials Division approved list for cement kiln dust.

√ = Mix Design required

*= Reduce quantity by 20 percent when quick lime is used, i.e. 4% x 0.8 = 3.2%, 5% x 0.8 = 4.0%, 6% x 0.8 = 4.8%.

**= use 6% when liquid limit is greater than 50.

Before compaction, the stabilized soil layer should be adjusted to 2 percent above the material's optimum moisture as determined by test method ASTM D698. After conditioning the soil to the required moisture content, the stabilized subgrade should be compacted to at least 98 percent of the material's maximum dry density as determined by test method ASTM D698. If cement kiln dust or Portland cement is used, compaction should be completed within about two hours after initially mixing the soil and stabilizing agent to optimize the stabilization benefit. If lime is used a second mixing will be required before compaction begins as outlined in ODOT Specifications, Section 307 - Subgrade Treatment. Chemically treated subgrade and the surcharge fill should be placed and compacted in accordance with the recommendation in the following sections.

5.5 Fill Materials

All fill required to replace exposed soft subgrade areas should be an approved material that is free of organic matter and debris as outlined in the following table.

Fill Type [1,2]	Acceptable Location for Placement
Imported Cohesive Soils[1,2] (Clay soils with LL<40, 8<PI<20)	All engineered fill areas
ODOT Type A Aggregate Base	Surcharge layer

1. Prior to placing fill, a sample of the proposed material should be obtained for laboratory testing to confirm compliance with Atterberg limits and gradation requirements, and to determine moisture-density relationship. The tests will provide a basis for evaluating suitability of the material and in-place compacted density.
2. Per pavement design recommendations, the top 12 inches will be chemically stabilized.

5.6 Placement and Compaction Requirements

Recommended placement, compaction and moisture content criteria for engineered fill materials are as follows:

ITEM	DESCRIPTION
Fill Lift Thickness[1]	8-inches or less in loose thickness
Compaction Requirements[2, 3]	**Native Soils:** At least 95% of the material's maximum standard Proctor dry density, ASTM D-698 **Chemically Treated Soils:** At least 98% of the material's maximum standard Proctor dry density, ASTM D-698 **Aggregate Base:** At least 95% of the material's maximum standard Proctor dry density, ASTM D-698
Moisture Content[2]	**Native Soils:** Workable moisture content that is 2% above its optimum standard Proctor value **Chemically Treated Soils:** 2% below to 2% above its optimum standard Proctor value **Aggregate Base:** Workable moisture content that is around 2% above its optimum standard Proctor value

[1] Engineered fill should be placed and compacted in horizontal lifts.

[2] Compaction equipment and procedures should uniformly produce recommended moisture contents and densities throughout the lift.

[3] A qualified soil technician should perform sufficient in-place density tests during the filling operations to evaluate that proper levels of compaction, including dry unit weight and moisture content, are being attained.

5.7 Trench Backfill

Care should be taken to properly backfill utility trench cuts within the pavement areas. All trenches created for utility access under the pavement should be effectively sealed to restrict water intrusion into the pavement subgrade. We recommend using a clay soil to construct a trench plug that extends at least 5 feet out from the edge of the pavements. The clay should have a plasticity index (PI) range of 15 to 25 and be placed in controlled lifts not exceeding 9 inches in loose thickness to surround the utility line and fill the trench. Each lift of clay backfill should be compacted to at least 95 percent of the material's maximum standard Proctor dry density (ASTM D-698), at a moisture content that is 2 percentage points above the optimum value.

5.8 Drainage

Developing and maintaining effective surface drainage is critical to the satisfactory long-term performance of pavements. The pavement surface should be crowned sufficiently to rapidly drain surface water to the gutters and into drainage inlets. Paved shoulders and earth slopes should be adequately sloped to promote effective drainage of surface water away from the pavement edge. Ditches and other drainage structures should effectively collect and quickly discharge runoff to prevent standing water that could saturate and soften the subgrade soils.

5.9 Maintenance

Periodic maintenance extends the service life of the pavement and should include crack sealing, joint sealing, and patching of any deteriorated areas. Also, thicker pavement sections could be used to reduce the required maintenance and extend the service life of the pavement. Failure to follow these recommendations could result in premature pavement distress and higher maintenance costs.

6.0 SLOPE STABILITY ANAYSIS

6.1 Data Analysis

The Atoka Lake Access roads along the east shoreline of the lake are generally formed from a sidehill cut into the existing hill slope. The slopes of the north road appear to be relatively shallow ranging from approximately 7H:1V to about 8H:1V. Clay slopes constructed of moderate to high plasticity clays, such as those along encountered along this access road, although stable when originally constructed, experience shrink and swell movements during alternating wet / dry weather cycles. This shrink / swell activity tends to form cracks along the surface which allow more water into the near surface zone along the slope causing it to swell and soften to a greater depth. This swelling/softening activity forms a weaker zone of soil along the surface of the embankment. The soils in this zone of the slope become progressively more normally consolidated and can approach what is termed a “fully softened” condition. Creep and further weathering can reduce the shear strength of the soil in this zone further, causing progressive strain-softening, leading to a residual strength condition in portions of the slope. Slopes of this nature can begin to fail progressively, either in a bottom-up, or top-down fashion, leading to full mobilization of the entire slope. In the case of these slopes along the access roads, it appears that the failure is a top-down progression. The tension cracks that formed in the pavement likely served to introduce additional water seepage into the shear surface causing further shear strength reduction and downslope progression.

Estimated ranges of fully softened and residual shear strength parameters for use in our analyses were developed for the embankment fill and native soils based on the index test results using the correlations developed by Dr. Timothy Stark of the University of Illinois. Using the provided cross sections, the as-built/failed condition was modeled using the slope stability software, Slope/W in order to back-calculate the likely existing failure surface location.

The parameters for each material and zone were estimated based the soil boring data, laboratory tests, the estimated shear strength parameter ranges discussed previously, previous experience with soil slopes in this region, and observations at the site. Our initial analysis was based upon the three borings that were drilled across the access road near stations 546+20 and 556+20. For our supplemental investigation, we included two additional borings drilled or hand-augered on the slope between the road and the lake near each of these stations. These are included as borings B-5C and B-7C in Appendix A. The information from these two borings on the slope allowed us to revise the previous borings B-5, B-5A, B-5B, and B-7, B-7A, B-7B to better define the rock parameters in our slope stability models. The revised borings are included as Exhibits A-19 to A-24 in Appendix A. The updated slope models were re-analyzed to evaluate the stability of the slopes and develop revised safety factors of 1.5 and 1.3 at these two locations. These are illustrated in Figures 1 and 2 below.

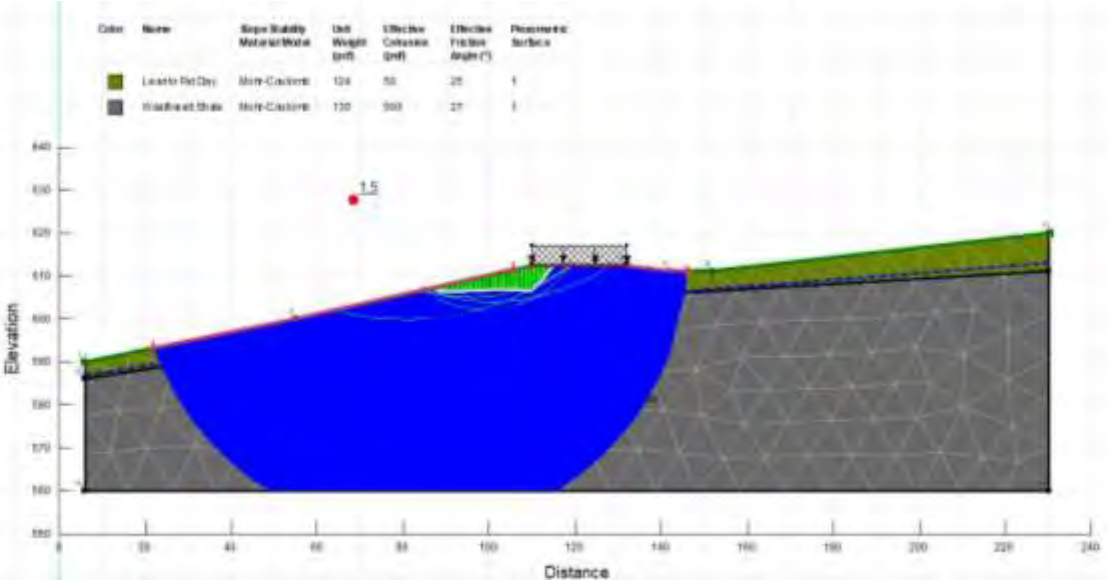


Figure 1 – Estimated Failure Plane of Slide near Borings B-5, B-5A, B-5B and B-5C. Approximate Station 547+20

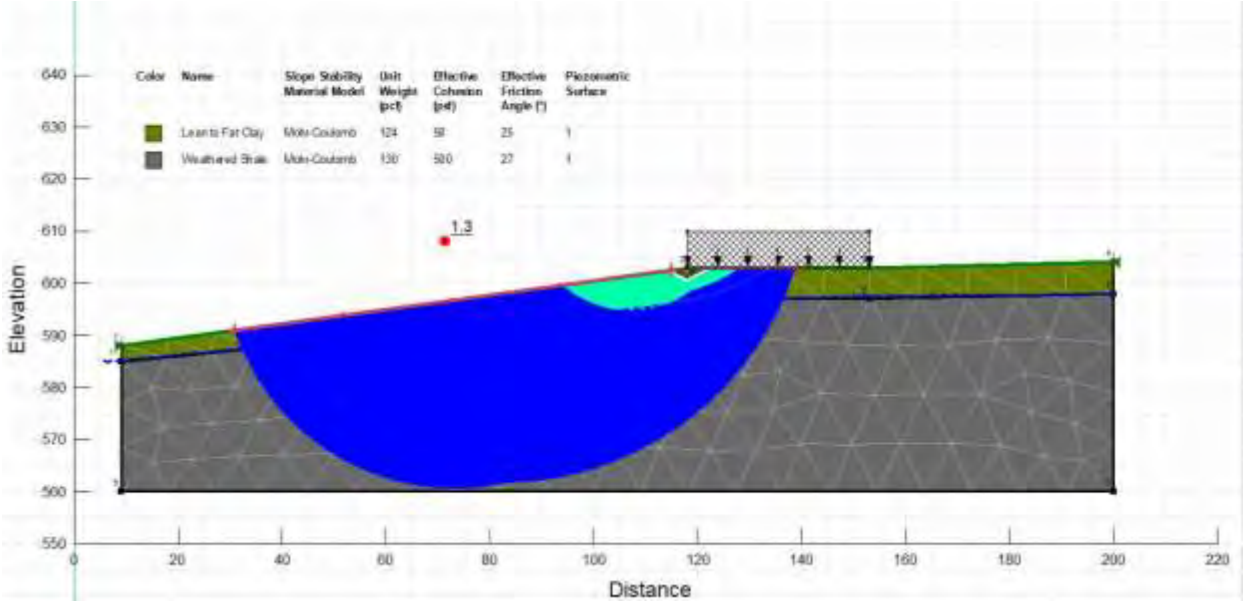


Figure 2 – Estimated Failure Plane of Slide near Borings B-&, B-7A, B-7B and B-7C. Approximate Station 556+20

The slope stability results displayed in Figures 1 and 2 are reasonable and appear to be more in line with what should be expected along these shallow slopes. Additionally, observations made during the August 2022 site visit found no indication of a scarp or slippage plane development along any of the slopes. We recommend monitoring these areas for the development of any slippage or cracks, especially after a heavy rain event which could saturate the subgrade and trigger a slide. The elimination of the open cracks in the pavement through the completed repair / reconstruction of the access road should minimize the infiltration of surface runoff into the slope and reduce the chances of future slide development.

7.0 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, subgrade treatment 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 or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential of such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of *Poe and Associates, Inc.* for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, express 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

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Project Manager: JLD	Project No. 03215255A
Drawn by: CAN	Scale: AS SHOWN
Checked by: JLD	File Name: A1-A3
Approved by: NKT	Date: JAN 2023

Terracon
4701 N Stiles Ave
Oklahoma City, OK 73105-3330

SITE LOCATION

Atoka Lake Access Road Improvements
North Section (Phase II)
Stringtown, Oklahoma

Exhibit
A-1

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

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Project Manager: JLD	Project No. 03215255
Drawn by: CAN	Scale: AS SHOWN
Checked by: JLD	File Name: A1-A3
Approved by: NKT	Date: JAN 2023

Terracon

4701 N Stiles Ave
Oklahoma City, OK 73105-3330

EXPLORATION PLAN

Atoka Lake Access Road Improvements
North Section (Phase II)
Stringtown, Oklahoma

Exhibit

A-2

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

AERIAL PHOTOGRAPHY PROVIDED
BY MICROSOFT BING MAPS

Project Manager: JLD	Project No. 03215255
Drawn by: CAN	Scale: AS SHOWN
Checked by: JLD	File Name: A1-A3
Approved by: NKT	Date: JAN 2023

Terracon

4701 N Stiles Ave
Oklahoma City, OK 73105-3330

EXPLORATION PLAN

Atoka Lake Access Road Improvements
North Section (Phase II)
Stringtown, Oklahoma

Exhibit

A-3

Field Exploration Description

Fourteen supplemental borings were drilled or hand-augered, in this investigation, on November 28 and 29, at the locations illustrated in Exhibits A-2 and A-3 in Appendix A.

Terracon personnel located the borings in the field by use of a handheld GPS device within the project extents provided by the Client. The locations of the borings should be considered accurate only to the degree implied by the methods used to define them.

Soil borings were drilled or hand augered at each of the fourteen locations. Subgrade soil samples were retrieved from each boring for laboratory testing.

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

A truck mounted, rotary drill rig equipped with continuous flight augers was used to advance the deep boreholes (B-5, B-5A, B-5B, B-7, B-7A and B-7B). Representative samples were obtained by the split-barrel sampling procedures.

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

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

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

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

The sampling depths, soil descriptions, and laboratory test results are reported on the boring logs. The samples were tagged for identification, sealed to reduce moisture loss and returned to the laboratory for further examination, testing and classification.

BORING LOG NO. B-1A

Page 1 of 1

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4462° Longitude: -96.0812°

GRAPHIC LOG	DEPTH		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
	0.2	**APPROX. 2" OF ASPHALT PAVEMENT**											
▨		**FAT CLAY (CH)**, tan, stiff			☒	3-4-10 N=14				24.0		59-24-35	94
▨		-very stiff below 2.5'			☒	5-9-10 N=19				14.7			
▨	4.5	**LEAN CLAY (CL)**, tan, hard	5		☒	10-14-20 N=34				14.9		49-21-28	
	6.0	***Boring Terminated at 6 Feet***											

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

Hammer Type: Automatic

Advancement Method: Power Auger	See Exhibit A-4 for description of field procedures See Appendix B for description of laboratory procedures and additional data (if any).	Notes:
Abandonment Method: Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.	See Appendix D for explanation of symbols and abbreviations.	

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-28-2022	Boring Completed: 11-28-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-5

BORING LOG NO. B-1B

Page 1 of 1

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4471° Longitude: -96.0814°

GRAPHIC LOG	DEPTH		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS	PERCENT FINES
							TEST TYPE	COMPRESSIVE STRENGTH (psf)	STRAIN (%)			LL-PL-PI	
	0.2	**APPROX. 2" OF ASPHALT PAVEMENT**											
		LEAN CLAY WITH SAND (CL), tan, hard			☒	4-22-47 N=69				13.9		32-18-14	74
	2.5	**WEATHERED SANDSTONE**, tan, poorly cemented			☒	29-50/5"				5.2		24-16-8	
			5		☒	25-28-44 N=72				11.6			
	6.0	***Boring Terminated at 6 Feet***											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-28-2022	Boring Completed: 11-28-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 03215255 ATOKA LAKE NORTH.GPJ TERRACON_DATATEMPLATE.GDT 2/6/23

BORING LOG NO. B-3A

Page 1 of 1

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4506° Longitude: -96.0783°

GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.2	**APPROX. 2" OF ASPHALT PAVEMENT**											
▨		**CLAYEY SAND WITH SANDSTONE FRAGMENTS (SC)**, tan, loose			☒	6-3-5 N=8				20.3		54-29-25	49
▨		-medium dense below 2.5'			☒	5-7-11 N=18				15.6			
▨	6.0		5		☒	8-11-15 N=26				12.2		45-23-22	67

Boring Terminated at 6 Feet

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

Hammer Type: Automatic

Advancement Method: Power Auger	See Exhibit A-4 for description of field procedures See Appendix B for description of laboratory procedures and additional data (if any). See Appendix D for explanation of symbols and abbreviations.	Notes:
Abandonment Method: Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.		

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-28-2022	Boring Completed: 11-28-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-7

BORING LOG NO. B-4A

Page 1 of 1

PROJECT: **Lake Access Road Improvements (Phase II)**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **Atoka Lake - North Section**
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4525° Longitude: -96.0751°

GRAPHIC LOG	DEPTH		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.2	**APPROX. 2" OF ASPHALT PAVEMENT**											
		SANDSTONE FRAGMENTS INTERMIXED WITH CLAY, tan, medium dense			☒	6-19-9 N=28				12.6		38-28-10	8
	4.5				☒	8-6-4 N=10				4.6			
	6.0	**FAT CLAY (CH)**, tan, stiff	5		☒	4-5-6 N=11				27.4		50-22-28	
		Boring Terminated at 6 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-28-2022	Boring Completed: 11-28-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-8

BORING LOG NO. B-5C

Page 1 of 1

PROJECT: **Lake Access Road Improvements (Phase II)**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **Atoka Lake - North Section**
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4540° Longitude: -96.0740°

GRAPHIC LOG	DEPTH		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST TEST TYPE	STRENGTH TEST COMPRESSIVE STRENGTH (psf)	STRENGTH TEST STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨		**SANDY SILTY CLAY (CL-ML)**, tan			▮					9.8			
▨	1.0				▮					13.4		20-13-7	56
▨	1.5	**SANDY LEAN CLAY (CL)**, tan			▮					14.5		22-14-8	
		Boring Terminated at Auger Refusal at 1.5 Feet											

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

Advancement Method:
Hand Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-29-2022	Boring Completed: 11-29-2022
Drill Rig: Hand Auger	Driller: RP
Project No.: 03215255A	Exhibit: A-9

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 03215255 ATOKA LAKE NORTH.GPJ TERRACON_DATATEMPLATE.GDT 2/6/23

BORING LOG NO. B-5D

Page 1 of 1

PROJECT: **Lake Access Road Improvements (Phase II)**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **Atoka Lake - North Section**
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4541° Longitude: -96.0738°

DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.3	**APPROX. 4" OF ASPHALT PAVEMENT**											
	CLAYEY SAND (SC), tan, loose			☒	3-2-2 N=4				12.2		56-21-35	21
2.5	**FAT CLAY WITH SAND (CH)**, tan, medium stiff			☒	2-3-4 N=7				30.1		53-25-28	81
	-stiff below 4.5'	5		☒	4-5-5 N=10				32.2		67-26-41	
	-gray, tan, olive, and medium stiff below 6.5'			☒	3-5-7 N=12				18.6		64-28-36	
8.0	***Boring Terminated at 8 Feet***											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-29-2022	Boring Completed: 11-29-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-10

BORING LOG NO. B-5D-T

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4541° Longitude: -96.0738°

GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
■	0.3	**APPROX. 4" OF ASPHALT PAVEMENT**											
▨	2.5	**CLAYEY SAND (SC)**, tan											
▨	4.5	**FAT CLAY WITH SAND (CH)**, tan			■					20.6	96	53-25-28	81
		Boring Terminated at 4.5 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-29-2022	Boring Completed: 11-29-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-11

BORING LOG NO. B-5E

Page 1 of 1

PROJECT: **Lake Access Road Improvements (Phase II)**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **Atoka Lake - North Section**
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4538° Longitude: -96.0740°

GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
■	0.3	**APPROX. 4" OF ASPHALT PAVEMENT**											
▨		**FAT CLAY WITH SAND (CH)**, gray and tan, medium stiff			☒	16-4-3 N=7				11.3			
▨		-gray, tan, olive, and stiff below 2'			☒	5-6-8 N=14				17.4		55-25-30	84
▨		-gray, tan, and very stiff below 3.5'			☒	6-8-10 N=18				16.7		56-24-32	
▨	6.5	-reddish brown, gray, and very stiff below 5'	5		☒	10-10-11 N=21				14.8		54-22-32	
⁚		**HIGHLY WEATHERED CLAYEY SANDSTONE**, tan and gray, poorly cemented			☒	18-29-24 N=53				17.4			
⁚	9.5	-tan and very stiff below 8'			☒	14-14-15 N=29				12.3			
		Boring Terminated at 9.5 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-28-2022	Boring Completed: 11-28-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-12

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 03215255 ATOKA LAKE NORTH.GPJ TERRACON_DATATEMPLATE.GDT 2/6/23

BORING LOG NO. B-7C

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

GRAPHIC LOG	LOCATION See Exhibits A-2 & A-3 Latitude: 34.4561° Longitude: -96.0728° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**FAT CLAY WITH SANDSTONE FRAGMENTS (CH)**, tan, stiff			☒	5-8-2 N=10				25.8			
▨	-gray, olive, and very stiff below 2.5'			☒	8-11-13 N=24				21.9		73-28-45	85
▨	-hard below 4.5'	5		☒	11-15-30 N=45				19.1			
▤	6.5 **HIGHLY WEATHERED SHALE**, gray, brown and olive, soft			☒	15-35-45 N=80				19.7			
▤	-gray and brown below 8.5'	10		☒	18-22-28 N=50				17.2		68-31-37	96
▤				☒	19-30-50/6"				15.8		67-29-38	
▤	-gray and tan below 12.5'			☒	17-24-27 N=51				19.9		72-28-44	
▤		15		☒	16-26-32 N=58				18.2			
▤				☒	30-37-50 N=87				18.3			
▤	-gray and brown below 18.5'	20		☒	15-24-30 N=54				19.2			
▤	-gray below 20.5'			☒	15-30-40 N=70				20.7		78-35-43	
▤	-gray and brown below 22.5'			☒	38-50/5"				19.5			

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-29-2022	Boring Completed: 11-29-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-13

BORING LOG NO. B-7C

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

GRAPHIC LOG	LOCATION See Exhibits A-2 & A-3 Latitude: 34.4561° Longitude: -96.0728° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS	PERCENT FINES
						TEST TYPE	COMPRESSIVE STRENGTH (psf)	STRAIN (%)			LL-PL-PI	
	HIGHLY WEATHERED SHALE, gray, brown and olive, soft *(continued)*											
		25		☒	15-30-50/6"				19.1			
				☒	35-37-50/5"				21.6			
	28.0											
	Boring Terminated at 28 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-29-2022	Boring Completed: 11-29-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-13

BORING LOG NO. B-7D

Page 1 of 1

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4562° Longitude: -96.0726°

GRAPHIC LOG DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.3	**APPROX. 4" OF ASPHALT PAVEMENT**											
	SANDY ELASTIC SILT WITH GRAVEL (MH), tan and olive brown, loose			☒	3-4-3 N=7				17.6		55-31-24	69
	-tan, gray, olive brown and medium dense below 2.5'			☒	3-5-8 N=13				19.1			
4.5	**CLAYEY SAND (SC)**, tan and brown, medium dense	5		☒	11-10-9 N=19				12.6		31-21-10	53
				☒	7-8-9 N=17				16.1			
8.0	***Boring Terminated at 8 Feet***											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-29-2022	Boring Completed: 11-29-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-14

BORING LOG NO. B-7E

Page 1 of 1

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4558° Longitude: -96.0728°

GRAPHIC LOG DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0.3	**APPROX. 4" OF ASPHALT PAVEMENT**											
	SANDY FAT CLAY (CH), tan, soft			☒	2-2-2 N=4				25.1			
	-olive, gray, and stiff below 2.5'			☒	3-4-5 N=9				19.4		66-27-39	93 65
		5		☒	4-5-8 N=13				16.2			
	-tan, very stiff below 6.5'			☒	9-12-17 N=29				16.9		53-29-24	
8.0	***Boring Terminated at 8 Feet***											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-29-2022	Boring Completed: 11-29-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-15

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 03215255 ATOKA LAKE NORTH.GPJ TERRACON_DATATEMPLATE.GDT 2/6/23

BORING LOG NO. B-7E-T

Page 1 of 1

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4558° Longitude: -96.0728°

GRAPHIC LOG	DEPTH		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
■	0.3	**APPROX. 4" OF ASPHALT PAVEMENT**											
▨		**FAT CLAY (CH)**, tan											
▨		-olive and gray below 2.5'			■					23.6	95	70-24-46	93
▨	4.5												
		Boring Terminated at 4.5 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-29-2022	Boring Completed: 11-29-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-16

BORING LOG NO. B-8A

Page 1 of 1

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4576° Longitude: -96.0719°

GRAPHIC LOG	DEPTH		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST TEST TYPE	STRENGTH TEST COMPRESSIVE STRENGTH (psf)	STRENGTH TEST STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	0.3	**APPROX. 4" OF ASPHALT PAVEMENT**											
		CLAYEY SAND (SC), gray, olive and dark brown, loose			☒	3-2-4 N=6				16.4		43-23-20	37
		-gray and reddish brown, medium stiff below 2.5'			☒	5-5-5 N=10				30.3			
		-gray and brown below 4.5'	5		☒	3-4-6 N=10				24.0			
	6.0	***Boring Terminated at 6 Feet***											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-29-2022	Boring Completed: 11-29-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-17

BORING LOG NO. B-8A-T

Page 1 of 1

PROJECT: **Lake Access Road Improvements (Phase II)**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **Atoka Lake - North Section**
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4576° Longitude: -96.0719°

GRAPHIC LOG	DEPTH		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST			WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS	PERCENT FINES
							TEST TYPE	COMPRESSIVE STRENGTH (psf)	STRAIN (%)			LL-PL-PI	
	0.3	**APPROX. 4" OF ASPHALT PAVEMENT**											
		CLAYEY SAND (SC), gray, olive and dark brown -gray and reddish brown below 2.5'			■								
	4.5	***Boring Terminated at 4.5 Feet***											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

Abandonment Method:
Boring backfilled with auger cuttings upon completion. Surface capped with asphalt.

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 11-29-2022	Boring Completed: 11-29-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-18

BORING LOG NO. B-5 Revised

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4540° Longitude: -96.0739°

DEPTH	DESCRIPTION	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	LEAN CLAY WITH GRAVEL (CL), brown, medium stiff	3-3-5 N=8				17.3			
	-stiff below 1.5'	6-6-5 N=11						45-20-25	77
	-brown, pale brown, very stiff below 3'	8-10-12 N=22				11.8			
		6-8-13 N=21				15.0			
6.0	**HIGHLY WEATHERED SHALE**, brown, soft	8-13-29 N=42				15.5			
		10-15-25 N=40				18.8			
		7-13-25 N=38				16.3			
		13-14-24 N=38				12.6			
		14-15-26 N=41				14.3			
		21-25-29 N=54				11.5			
		19-30-50/6"				12.2			
	-brown and yellowish brown below 16.5'	19-25-44 N=69				13.0			
	-soft to hard below 18'	19-35-50/2"				11.7			
19.5	**WEATHERED SHALE**, brown, hard	50/2"				11.6			
	-soft below 21'	16-50/6"				10.8			

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-16-2022	Boring Completed: 02-16-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-19

BORING LOG NO. B-5 Revised

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

GRAPHIC LOG	LOCATION See Exhibits A-2 & A-3 Latitude: 34.4540° Longitude: -96.0739° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	24.0 -moderately hard below 23.5'			⊠	50/4"				10.4			
	Boring Terminated at 24 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-16-2022	Boring Completed: 02-16-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-19

BORING LOG NO. B-5A Revised

PROJECT: **Lake Access Road Improvements (Phase II)**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **Atoka Lake - North Section**
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4540° Longitude: -96.0739°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
⁘	**TREATED SUBGRADE (LEAN CLAY WITH ASPHALT PIECES - CL)**, brown with black, medium stiff			☒	4-3-4 N=7				17.5			
	1.5											
▨	**LEAN TO FAT CLAY (CL/CH)**, brown, medium stiff			☒	2-3-4 N=7				6.6			
	-red, brown, stiff below 3'			☒	3-4-8 N=12				22.6			
	-medium stiff below 4.5'	5		☒	3-5-3 N=8				29.6			
	6.0											
▨	**FAT CLAY (CH)**, brown and gray, very stiff			☒	5-7-22 N=29				17.7			
	-brown, hard below 7.5'			☒	5-17-24 N=41				20.5			
		10		☒	9-15-22 N=37				12.5			
				☒	9-40-42 N=82				12.7			
				☒	17-18-36 N=54				13.8			
	13.5											
☰	**HIGHLY WEATHERED SHALE**, brown, soft			☒	18-50/6"				12.8			
		15		☒	16-26-41 N=67				10.5			
	16.5											
☰	**WEATHERED SHALE**, brown, soft to moderately hard			☒	50/4"				10.5			
				☒	50/6"				8.9			
		20		☒	50/4"				7.5			
				☒	41-50/4"				10.5			

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

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

Approx. 3" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-16-2022	Boring Completed: 02-16-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-20

BORING LOG NO. B-5A Revised

PROJECT: Lake Access Road Improvements (Phase II)	**CLIENT: Poe & Associates Inc** **Oklahoma City, OK**
SITE: Atoka Lake - North Section **Stringtown, Oklahoma**	

GRAPHIC LOG	LOCATION See Exhibits A-2 & A-3 Latitude: 34.4540° Longitude: -96.0739° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	24.0			☒	50/3"				11.0			
	Boring Terminated at 24 Feet											

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

Hammer Type: Automatic

Advancement Method: Power Auger	See Exhibit A-4 for description of field procedures See Appendix B for description of laboratory procedures and additional data (if any).	Notes:
Abandonment Method: Boring backfilled with cuttings above 4'; grouted 4' to 14'; backfilled with cuttings from 14' to termination depth. Surface capped with asphalt.	See Appendix D for explanation of symbols and abbreviations.	

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-16-2022	Boring Completed: 02-16-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-20

BORING LOG NO. B-5B Revised

Page 1 of 2

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

GRAPHIC LOG	LOCATION See Exhibits A-2 & A-3 Latitude: 34.4540° Longitude: -96.0739° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**LEAN TO FAT CLAY (CL/CH)**, trace gravel, brown, stiff			☒	5-6-7 N=13				19.3			
▨	-medium stiff below 1.5'			☒	3-3-4 N=7				16.7			
▨	-very stiff below 3'			☒	12-10-12 N=22				13.8			
▨	4.5 **FAT CLAY (CH)**, brown and red, stiff	5		☒	3-4-5 N=9				22.7			
▨	-brown, very stiff below 6'			☒	5-7-22 N=29				14.2			
▨	-brown, grayish brown, hard below 7.5'			☒	9-17-21 N=38				14.3			
▨		10		☒	18-31-44 N=75				13.1			
▤	11.0 **HIGHLY WEATHERED SHALE**, brown, grayish brown and yellow, soft to moderately hard			☒	15-32-50/6"				12.1			
▤				☒	38-50/5"				14.5			
▤				☒	32-50/3"				10.3			
▤		15		☒	50/6"				13.5			
▤				☒	16-31-50/3"				13.3			
▤				☒	16-38-50/4"				11.6			
▤		20		☒	38-50/5"				12.5			
▤	21.0 **WEATHERED SHALE**, brown, soft to moderately hard			☒	50/5"				11.7			

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

Approx. 3" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-17-2022	Boring Completed: 02-17-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-21

BORING LOG NO. B-5B Revised

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4540° Longitude: -96.0739°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS: LL-PL-PI	PERCENT FINES
	24.0			☒	50/4"				10.8			
	Boring Terminated at 24 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-17-2022	Boring Completed: 02-17-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-21

BORING LOG NO. B-7 Revised

Page 1 of 2

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4560° Longitude: -96.0727°

DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1.5	**TREATED SUBGRADE (LEAN CLAY WITH GRAVEL - CL)**, brown, stiff to very stiff			☒	5-6-9 N=15				11.5			
	CLAYEY SAND WITH GRAVEL (SC), brown and red, stiff			☒	5-6-6 N=12						59-24-35	44
4.0	-very stiff below 3'			☒	8-10-12 N=22				20.5			
6.0	**SANDY FAT CLAY (CH)**, brown and red, very stiff	5		☒	7-8-12 N=20				19.5			
	FAT CLAY (CH), gray, brown and yellowish brown, hard			☒	12-19-26 N=45				19.2		73-34-39	
				☒	15-21-29 N=50				18.8			
		10		☒	17-25-31 N=56				19.0			
				☒	15-21-35 N=56				18.2			
				☒	32-30-39 N=69				18.0			
	-grayish brown, yellowish brown, and gray below 13.5'	15		☒	15-27-25 N=52				19.1			
				☒	19-26-37 N=63				17.7			
18.0				☒	10-20-29 N=49				20.6			
	HIGHLY WEATHERED SHALE, grayish brown and yellow, soft			☒	25-35-50/6"				18.2			
		20		☒	17-27-31 N=58				18.8			
				☒	15-21-25 N=46				19.5			

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-16-2022	Boring Completed: 02-16-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-22

BORING LOG NO. B-7 Revised

PROJECT: **Lake Access Road Improvements (Phase II)**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **Atoka Lake - North Section**
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4560° Longitude: -96.0727°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST TEST TYPE	STRENGTH TEST COMPRESSIVE STRENGTH (psf)	STRENGTH TEST STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▤	**HIGHLY WEATHERED SHALE**, grayish brown and yellow, soft *(continued)*	25		☒	15-21-31 N=52				20.7			
▤	-dark gray below 28.5'	30		☒	17-25-32 N=57				20.0			
▤	-yellowish brown with dark grayish brown below 33.5'	35		☒	17-21-32 N=53				39.3			
▤	-dark grayish brown below 38.5' 39.5			☒	21-50/5"				19.3			
	Boring Terminated at 39.5 Feet											

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

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-16-2022	Boring Completed: 02-16-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-22

BORING LOG NO. B-7A Revised

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4560° Longitude: -96.0727°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**FAT CLAY (CH)**, brown, medium stiff			☒	3-3-5 N=8				27.1			
▨	-very stiff below 1.5'			☒	5-7-12 N=19				21.1			
▨	-yellowish brown, hard below 3'			☒	12-15-18 N=33				17.2			
▨	-yellowish brown, brown, very stiff below 4.5'	5		☒	8-8-12 N=20				17.8			
▨	-brown, yellowish brown, grayish brown, hard below 6'			☒	15-20-23 N=43				19.1			
▨				☒	12-12-21 N=33				18.3			
▨		10		☒	14-21-22 N=43				19.4			
▨				☒	12-17-22 N=39				18.4			
▨				☒	13-17-17 N=34				18.8			
▨				☒	22-27-29 N=56				16.2			
▨		15		☒	17-21-29 N=50							
▨				☒	23-26-28 N=54				21.4			
▨				☒	13-17-31 N=48				17.8			
▨		20		☒	16-22-20 N=42				18.7			
▨				☒	14-16-21 N=37							
▨	23.5											

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

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

Approx. 4" Asphalt Concrete at Surface

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-17-2022	Boring Completed: 02-17-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-23

BORING LOG NO. B-7A Revised

Page 2 of 2

PROJECT: **Lake Access Road Improvements (Phase II)**

CLIENT: **Poe & Associates Inc**
Oklahoma City, OK

SITE: **Atoka Lake - North Section**
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4560° Longitude: -96.0727°

DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
<u>HIGHLY WEATHERED SHALE</u>, brown and yellowish brown with dark gray, soft to moderately hard			☒	31-48-50/3"				19.0			
	25										
-soft below 28.5'			☒	17-21-35 N=56				18.2			
	30										
-soft to moderately hard below 33.5'			☒	31-50/3"				17.1			
34.5											
Boring Terminated at 34.5 Feet											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon

4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-17-2022	Boring Completed: 02-17-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-23

BORING LOG NO. B-7B Revised

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4560° Longitude: -96.0727°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**FAT CLAY (CH)**, brown, medium stiff			☒	3-3-3 N=6				21.2			
▨	-stiff below 1.5'			☒	3-5-4 N=9				21.0		56-31-25	
▨	-very stiff below 3'			☒	5-8-11 N=19				20.4			
▨	-hard below 4.5'	5		☒	4-12-20 N=32				19.1			
▨	-very stiff below 6'			☒	4-11-16 N=27				19.5			
▨	-hard below 7.5'			☒	7-16-21 N=37				18.1			
▨		10		☒	12-16-20 N=36				18.5			
▨	-brown with yellowish brown, hard below 10.5'			☒	18-20-25 N=45				18.4			
▨				☒	25-36-42 N=78				16.1			
▨				☒	19-26-43 N=69				15.9			
▨		15		☒	18-25-32 N=57				15.2			
▨	-dark gray below 16.5'			☒	16-22-42 N=64				16.5			
▨				☒	19-31-40 N=71				15.0			
▨	-brown, yellowish brown below 19.5'	20		☒	16-22-20 N=42				15.0			
▨				☒	25-31-33 N=64				15.4			

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

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-17-2022	Boring Completed: 02-17-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-24

BORING LOG NO. B-7B Revised

PROJECT: Lake Access Road Improvements (Phase II)

CLIENT: Poe & Associates Inc
Oklahoma City, OK

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

LOCATION See Exhibits A-2 & A-3

Latitude: 34.4560° Longitude: -96.0727°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
▨	**FAT CLAY (CH)**, brown, medium stiff *(continued)* -brown below 23.5'	25		☒	15-20-25 N=45				16.1			
▤	28.5 **HIGHLY WEATHERED SHALE**, brown, soft	30		☒	17-26-42 N=68				16.4			
▤				☒	26-50/5"				14.7			
	34.5 ***Boring Terminated at 34.5 Feet***											

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

Hammer Type: Automatic

Advancement Method:
Power Auger

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

See Exhibit A-4 for description of field procedures

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

See Appendix D for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
4701 N Stiles Ave
Oklahoma City, OK

Boring Started: 02-17-2022	Boring Completed: 02-17-2022
Drill Rig: 747	Driller: RP
Project No.: 03215255A	Exhibit: A-24

APPENDIX B
LABORATORY TESTING

Laboratory Testing

Samples retrieved during the field exploration were taken to the laboratory for further observation by the project geotechnical engineer and were classified in accordance with the Unified Soil Classification System (USCS) described in Appendix D. At that time, the field descriptions were confirmed or modified as necessary and an applicable laboratory testing program was formulated to determine engineering properties of the subsurface materials.

Laboratory tests were conducted on selected soil samples and the test results are presented on the boring logs in Appendix A and on report forms in this appendix. The laboratory test results were used for the geotechnical engineering analyses, and the development of foundation, earthwork, and pavement design recommendations. Laboratory tests were performed in general accordance with the applicable ASTM, local or other accepted standards.

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

- In-situ water content
- Atterberg Limits
- Gradation
- Moisture Density
- Swell Potential

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 judgement.

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-1	0 - 0.5			brown									13		
B-1	0.5 - 1	FAT CLAY with SAND(CH)	A-7-6 (36)	brown	62	23	39	84.7	3.0	12.3					
B-1	1.5 - 2												20		
B-1	2.5 - 3												15		
B-1	6														
B-1	18														
B-1	30														
B-10	0 - 0.5			brown	35	29	6						8		
B-10	0.5 - 1												10		
B-10	1.5 - 2												16		
B-10	2.5 - 3														
B-10	6														
B-10	18														
B-10	30														
B-2	0 - 0.5			brown									11		
B-2	0.5 - 1			yellow									16		
B-2	1.5 - 1.8												14		
B-2	6														
B-2	18														
B-3	0 - 0.5			brown									12		
B-3	0.5 - 1			yellow	65	27	38						26		
B-3	1.5 - 1.8												21		
B-3	2.5 - 3												20		
B-3	6														
B-3	18														

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Lake Access Road Improvements (Phase II)

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK
PH. 405-525-0453 **FAX. 405-557-0549**

PROJECT NUMBER: 03215255A

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-2

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT_LAB_SUMMARY 03215255 ATOKA LAKE NORTH.GPJ TERRACON_DATATEMPLATE.GDT 2/3/23

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-3	30														
B-4	0 - 0.5			brown									21		
B-4	0.5 - 1			brown									19		
B-4	1.5 - 1.8												22		
B-4	2.5 - 3												26		
B-4	6														
B-4	18														
B-4	30														
B-5 Tubes	0 - 2														
B-5 Tubes	2 - 4														
B-5 Tubes	4 - 6												12		
B-6	0 - 0.5			brown									11		
B-6	0.5 - 1			brown									26		
B-6	1.5 - 1.8												35		
B-6	2.5 - 3												31		
B-6	6														
B-6	18														
B-6	30														
B-7 Tubes	0 - 2														
B-7 Tubes	2 - 4												24		
B-7 Tubes	4 - 6														
B-8	0 - 0.5			brown									15		
B-8	0.5 - 1			brown	59	25	34						23		
B-8	1.5 - 2												25		
B-8	2.5 - 3												17		

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Lake Access Road Improvements (Phase II)

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PH. 405-525-0453 FAX. 405-557-0549

PROJECT NUMBER: 03215255A

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-3

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-8	6														
B-8	18														
B-8	30														
B-9	0 - 0.5			brown									14		
B-9	0.5 - 1			brown									25		
B-9	1.5 - 2												25		
B-9	2.5 - 3												20		
B-9	6														
B-9	18														
B-9	30														
Comp Bulk OMC	0 - 3	SANDY ELASTIC SILT(MH)	A-7-5 (13)		60	35	25	58.1	13.5	28.4				21.5	100.6
Comp Bulk OMC +2	0 - 3														
B-1A	0.5 - 2	FAT CLAY(CH)	A-7-6 (37)		59	24	35	94.2	0.0	2.2			24		
B-1A	2.5 - 4												15		
B-1A	4.5 - 6			tan	49	21	28						15		
B-1B	0.5 - 2	LEAN CLAY with SAND(CL)	A-6 (9)		32	18	14	73.9	0.0	6.1			14		
B-1B	2.5 - 3.416			tan	24	16	8						5		
B-1B	4.5 - 6												12		
B-3A	0.5 - 2	CLAYEY SAND(SC)	A-7-6 (9)		54	29	25	49.4	0.0	6.8			20		
B-3A	2.5 - 4												16		
B-3A	4.5 - 6	SANDY LEAN CLAY(CL)	A-7-6 (13)		45	23	22	67.2	0.0	3.4			12		
B-4A	0.5 - 2		A-2-4 (0)		38	28	10	7.9	0.0	10.8			13		
B-4A	2.5 - 4												5		
B-4A	4.5 - 6			tan	50	22	28						27		
B-5C	0 - 0.5			tan									10		

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Lake Access Road Improvements (Phase II)

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PH. 405-525-0453 FAX. 405-557-0549

PROJECT NUMBER: 03215255A

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-4

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-5C	0.5 - 1	SANDY SILTY CLAY(CL-ML)	A-4 (1)		20	13	7	55.6	0.0	15.2			13		
B-5C	1 - 1.5			tan	22	14	8						15		
B-5C	6														
B-5C	12														
B-5D	0.5 - 2	CLAYEY SAND(SC)	A-2-7 (2)		56	21	35	21.0	0.0	7.5			12		
B-5D	2.5 - 4			tan				81.0	0.0	0.0			30		
B-5D	3				53	25	28								
B-5D	4.5 - 6				67	26	41						32		
B-5D	6.5 - 8				64	28	36						19		
B-5D-T	3 - 4.5	FAT CLAY with SAND(CH)	A-7-6 (24)		53	25	28	80.7	0.0	7.3			21		
B-5E	0.5 - 2												11		
B-5E	2 - 3.5							84.3	0.0	4.5			17		
B-5E	2.5				55	25	30								
B-5E	3.5 - 5												17		
B-5E	4.5				56	24	32								
B-5E	5 - 6.5				54	22	32						15		
B-5E	6.5 - 8			tan									17		
B-5E	8 - 9.5												12		
B-7C	0.5 - 2												26		
B-7C	2.5 - 4	FAT CLAY with SAND(CH)	A-7-6 (43)		73	28	45	84.6	0.0	5.6			22		
B-7C	4.5 - 6												19		
B-7C	6.5 - 8			gray, brown									20		
B-7C	8.5 - 10	FAT CLAY(CH)	A-7-5 (43)		68	31	37	96.0	0.0	2.2			17		
B-7C	10.5 - 11.99				67	29	38						16		
B-7C	12.5 - 14				72	28	44						20		

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Lake Access Road Improvements (Phase II)

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PH. 405-525-0453 FAX. 405-557-0549

PROJECT NUMBER: 03215255A

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-5

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-7C	14.5 - 16												18		
B-7C	16.5 - 18												18		
B-7C	18.5 - 20												19		
B-7C	20.5 - 22				78	35	43						21		
B-7C	22.5 - 23.416												20		
B-7C	24.5 - 25.99												19		
B-7C	26.5 - 27.916												22		
B-7D	0.5 - 2	SANDY ELASTIC SILT(MH)	A-7-5 (17)		55	31	24	68.9	0.0	3.5			18		
B-7D	2.5 - 4												19		
B-7D	4.5 - 6	SANDY LEAN CLAY(CL)	A-4 (3)	tan	31	21	10	52.6	0.0	14.9			13		
B-7D	6.5 - 8												16		
B-7E	0.5 - 2												25		
B-7E	2.5 - 4	SANDY FAT CLAY(CH)	A-7-6 (24)		66	27	39	65.3	0.0	4.9			19		
B-7E	3							92.7	0.0	7.3					
B-7E	4.5 - 6												16		
B-7E	6.5 - 8				53	29	24						17		
B-7E-T	3 - 4.5	FAT CLAY(CH)	A-7-6 (48)		70	24	46	92.7	0.0	5.5			24		
B-8A	0.5 - 2	CLAYEY SAND(SC)	A-7-6 (3)		43	23	20	37.4	0.0	13.0			16		
B-8A	2.5 - 4												30		
B-8A	3														
B-8A	4.5 - 6												24		
B-8A	6.5														
B-8A-T	3 - 4.5														
B-5	0 - 1.5			brown									17		
B-5	1.5 - 3	LEAN CLAY with GRAVEL(CL)	A-7-6 (19)		45	20	25	77.4	13.3	9.3					

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Lake Access Road Improvements (Phase II)

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PH. 405-525-0453 FAX. 405-557-0549

PROJECT NUMBER: 03215255A

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-6

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-5	3 - 4.5												12		
B-5	4														
B-5	4.5 - 6												15		
B-5	6 - 7.5			brown									16		
B-5	7.5 - 9												19		
B-5	9 - 10.5												16		
B-5	10.5 - 12												13		
B-5	12 - 13.5												14		
B-5	13.5 - 15												12		
B-5	15 - 16.49												12		
B-5	16.5 - 18												13		
B-5	18 - 19.17												12		
B-5	19.5 - 19.67			brown									12		
B-5	21 - 21.99												11		
B-5	23.5 - 23.83												10		
B-5A	0 - 1.5			brown									18		
B-5A	1.5 - 3			brown									7		
B-5A	3 - 4.5												23		
B-5A	4.5 - 6												30		
B-5A	6 - 7.5			brown									18		
B-5A	7.5 - 9												21		
B-5A	9 - 10.5												12		
B-5A	10.5 - 12												13		
B-5A	12 - 13.5												14		
B-5A	13.5 - 14.49			brown									13		

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Lake Access Road Improvements (Phase II)

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PH. 405-525-0453 FAX. 405-557-0549

PROJECT NUMBER: 03215255A

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-7

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-5A	15 - 16.5												11		
B-5A	16.5 - 16.83			brown									11		
B-5A	18 - 18.49												9		
B-5A	19.5 - 19.83												7		
B-5A	21 - 21.83												10		
B-5A	23.5 - 23.75												11		
B-5B	0 - 1.5			brown									19		
B-5B	1.5 - 3												17		
B-5B	3 - 4.5												14		
B-5B	4.5 - 6			brown									23		
B-5B	6 - 7.5												14		
B-5B	7.5 - 9												14		
B-5B	9 - 10.5												13		
B-5B	10.5 - 11.99												12		
B-5B	12 - 12.92												15		
B-5B	13.5 - 14.25												10		
B-5B	15 - 15.49												14		
B-5B	16.5 - 17.75												13		
B-5B	18 - 19.33												12		
B-5B	19.5 - 20.42												12		
B-5B	21 - 21.42			brown									12		
B-5B	23.5 - 23.83												11		
B-7	0 - 1.5			brown									12		
B-7	1.5 - 3	CLAYEY SAND with GRAVEL(SC)	A-7-6 (10)	brown	59	24	35	44.2	20.0	35.8					
B-7	2														

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Lake Access Road Improvements (Phase II)

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

4701 N Stiles Ave
Oklahoma City, OK

PH. 405-525-0453 FAX. 405-557-0549

PROJECT NUMBER: 03215255A

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-8

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT_LAB_SUMMARY 03215255 ATOKA LAKE NORTH.GPJ TERRACON_DATATEMPLATE.GDT 2/3/23

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-7	3 - 4.5												21		
B-7	4.5 - 6												19		
B-7	6 - 7.5			gray, brown	73	34	39						19		
B-7	7.5 - 9												19		
B-7	9 - 10.5												19		
B-7	10.5 - 12												18		
B-7	12 - 13.5												18		
B-7	13.5 - 15												19		
B-7	15 - 16.5												18		
B-7	16.5 - 18												21		
B-7	18 - 19.49			grayish brown									18		
B-7	19.5 - 21												19		
B-7	21 - 22.5												19		
B-7	23.5 - 25												21		
B-7	28.5 - 30												20		
B-7	33.5 - 35												39		
B-7	38.5 - 39.42												19		
B-7A	0 - 1.5			brown									27		
B-7A	1.5 - 3												21		
B-7A	3 - 4.5												17		
B-7A	4.5 - 6												18		
B-7A	6 - 7.5												19		
B-7A	7.5 - 9												18		
B-7A	9 - 10.5												19		
B-7A	10.5 - 12												18		

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Lake Access Road Improvements (Phase II)

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

PH. 405-525-0453 FAX. 405-557-0549

PROJECT NUMBER: 03215255A

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-9

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-7A	12 - 13.5												19		
B-7A	13.5 - 15												16		
B-7A	15 - 16.5														
B-7A	16.5 - 18												21		
B-7A	18 - 19.5												18		
B-7A	19.5 - 21												19		
B-7A	21 - 22.5														
B-7A	23.5 - 24.75			brown and yellowish brown									19		
B-7A	28.5 - 30												18		
B-7A	33.5 - 34.25												17		
B-7B	0 - 1.5			brown									21		
B-7B	1.5 - 3				56	31	25						21		
B-7B	3 - 4.5												20		
B-7B	4.5 - 6												19		
B-7B	6 - 7.5												19		
B-7B	7.5 - 9												18		
B-7B	9 - 10.5												18		
B-7B	10.5 - 12												18		
B-7B	12 - 13.5												16		
B-7B	13.5 - 15												16		
B-7B	15 - 16.5												15		
B-7B	16.5 - 18												16		
B-7B	18 - 19.5												15		
B-7B	19.5 - 21												15		
B-7B	21 - 22.5												15		

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Lake Access Road Improvements (Phase II)

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK
PH. 405-525-0453 FAX. 405-557-0549

PROJECT NUMBER: 03215255A

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-10

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-7B	23.5 - 25												16		
B-7B	28.5 - 30			brown									16		
B-7B	33.5 - 34.42												15		

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Lake Access Road Improvements (Phase II)

SITE: Atoka Lake - North Section
Stringtown, Oklahoma

Terracon
4701 N Stiles Ave
Oklahoma City, OK

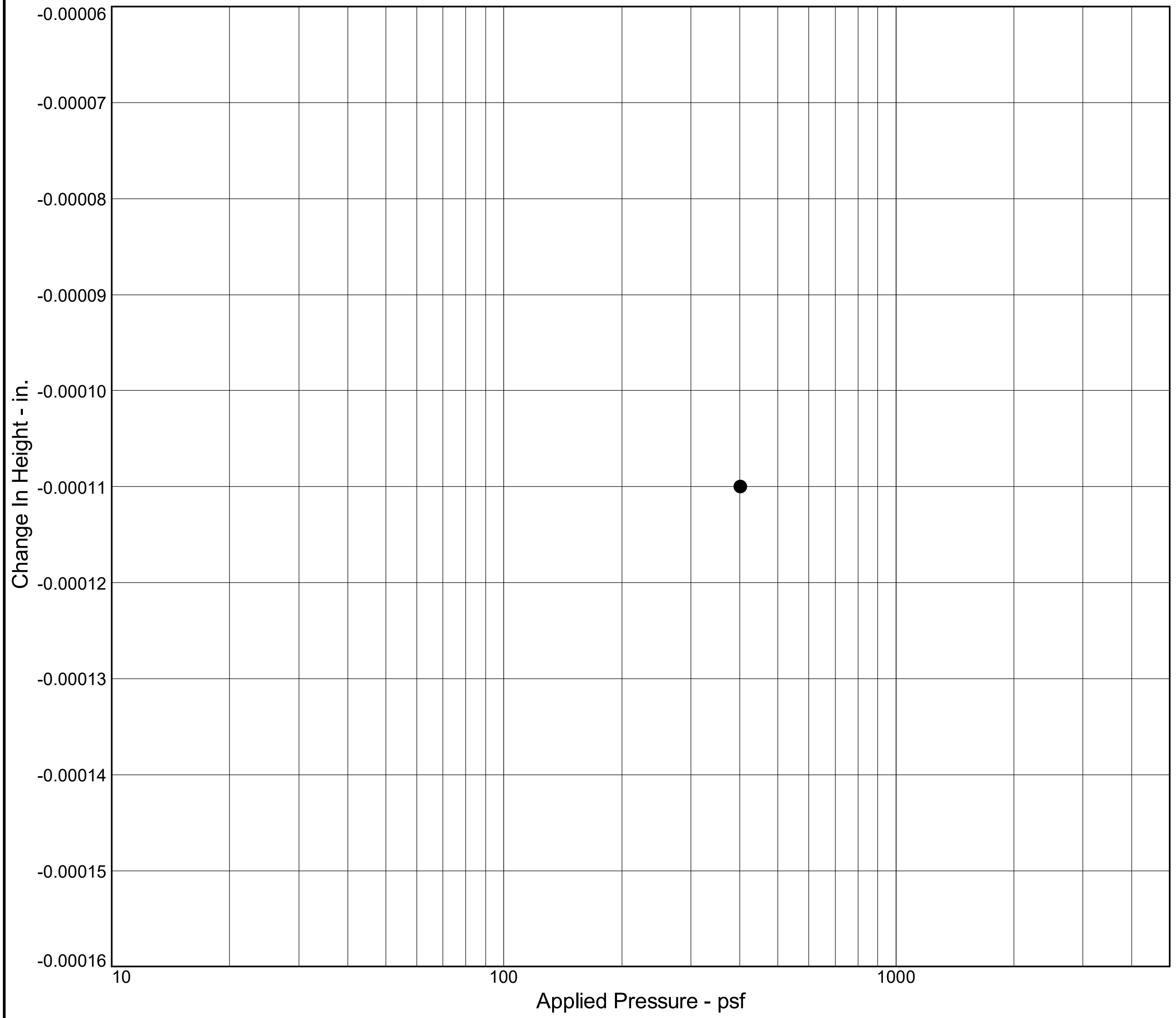
PH. 405-525-0453 FAX. 405-557-0549

PROJECT NUMBER: 03215255A

CLIENT: Poe & Associates Inc
Oklahoma City, OK

EXHIBIT: B-11

SWELL/COLLAPSE TEST REPORT



MATERIAL DESCRIPTION	USCS	AASHTO
Sandy Fat Clay	CH	

LL	PI	Sp. Gr.	Overburden (psf)	Dry Dens. (pcf)		Moisture		Saturation		Void Ratio		P_c (psf)	C_c
				Init.	Final	Init.	Final	Init.	Final	Init.	Final		
53	28	2.68		95.7	89.8	20.6 %	27.4 %	67.0 %	89.3 %	0.822	0.822		

Preparation Process:

Condition of Test:

D2435 Method	C_r	Swell Press. (psf)	Swell %
D4546			

Project No. 03215255A **Client:** Poe & Associates, Inc.

Project: Atoka Lake North Access Road
East Access Road, Stringtown, OK

Location: B-5D **Depth:** 3'-4.5'

Terracon Consultants, Inc.

Oklahoma City, OK

Remarks:
Swell Pressure= 401.5psf

Checked By: KS

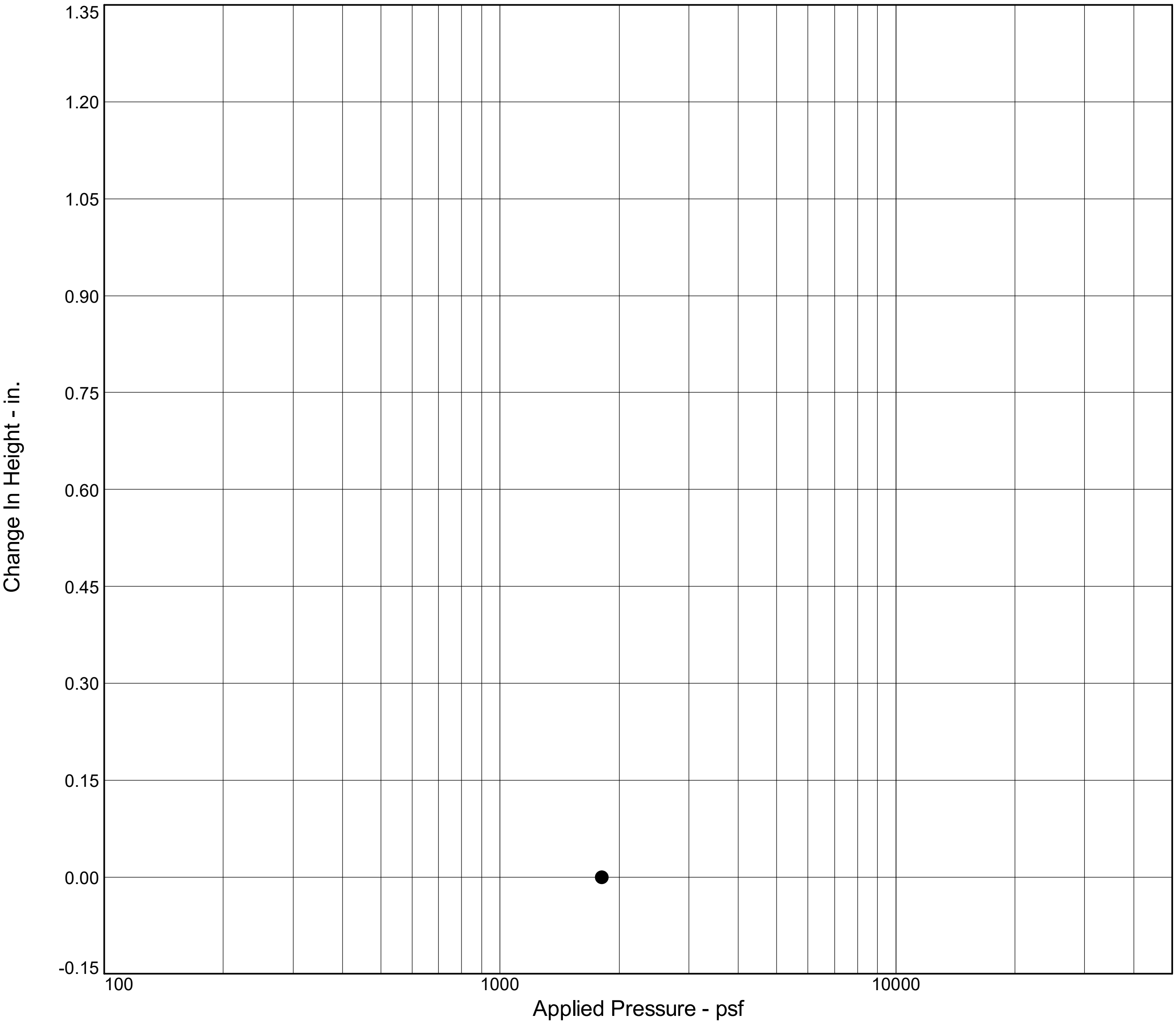
Title:

Figure

Tested By: CR

Exhibit B-12

SWELL/COLLAPSE TEST REPORT



MATERIAL DESCRIPTION	USCS	AASHTO
Fat Clay, light Brown	CH	

LL	PI	Sp. Gr.	Overburden (psf)	Dry Dens. (pcf)		Moisture		Saturation		Void Ratio		P_c (psf)	C_c
				Init.	Final	Init.	Final	Init.	Final	Init.	Final		
70	46	2.68	375	95.2	91.4	27.6 %	30.3 %	93.2 %	100.0 %	0.793	0.793		

Preparation Process:

Condition of Test:

D2435 Method	C_r	Swell Press. (psf)	Swell %
D4546			

Project No. 03215255A **Client:** Poe & Associates, Inc.

Project: Atoka Lake North Access Road
East Access Road, Stringtown, OK

Location: B-7E **Depth:** 3'-4.5'

Terracon Consultants, Inc.

Oklahoma City, OK

Remarks:
Swell Pressure=1805.9psf

Checked By: KS

Title:

Figure

Tested By: CR

Exhibit B-13

APPENDIX C
PAVEMENT PHOTOGRAPHS

Photo 1 – Pavement condition near approximate location of boring B-4A

Photo 2 – Pavement condition between borings B-7D & B-8A

Photo 3 – Pavement condition near approximate location of boring B-7E

Photo 4 – Pavement condition near approximate location of boring B-5E

Photo 5 – Pavement condition near approximate location of boring B-7D

APPENDIX D
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Auger	**Split Spoon**
Shelby Tube	**Pressure Meter**
Texas Cone	**Rock Core**
Grab Sample	**No Recovery**

WATER LEVEL

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

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

FIELD TESTS

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

DESCRIPTIVE SOIL CLASSIFICATION

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

LOCATION AND ELEVATION NOTES

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

STRENGTH TERMS

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

RELATIVE PROPORTIONS OF SAND AND GRAVEL

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

GRAIN SIZE TERMINOLOGY

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

RELATIVE PROPORTIONS OF FINES

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

PLASTICITY DESCRIPTION

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

Terracon

Exhibit D-1

UNIFIED SOIL CLASSIFICATION SYSTEM

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

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

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

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

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

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

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

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

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

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

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

[N] $PI \geq 4$ and plots on or above "A" line.

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

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

[Q] PI plots below "A" line.

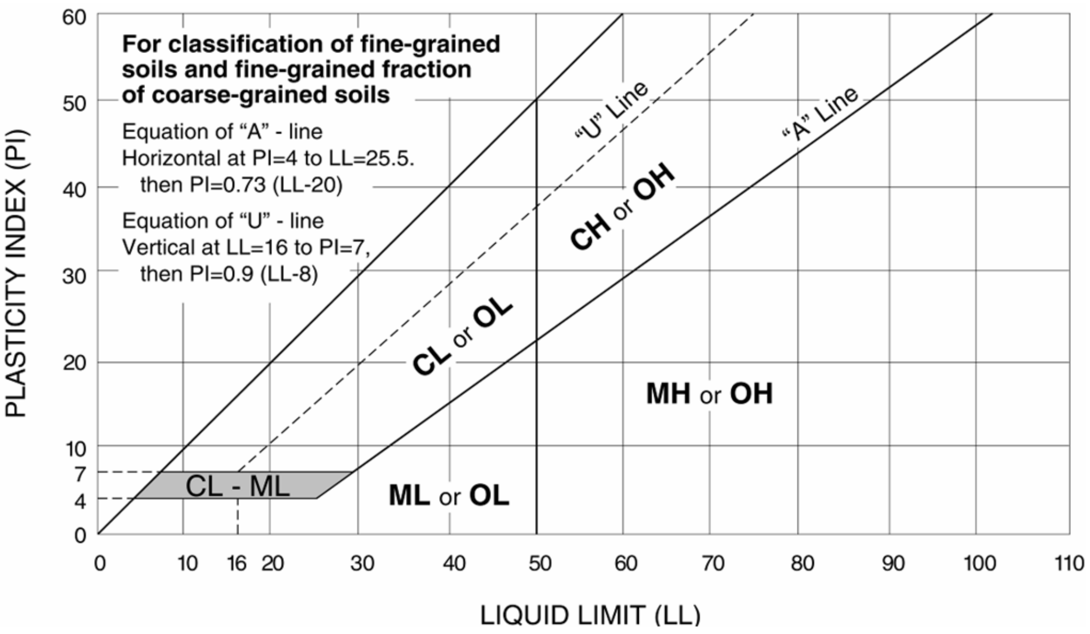


Exhibit D-2

GENERAL NOTES

Sedimentary Rock Classification

DESCRIPTIVE ROCK CLASSIFICATION:

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

LIMESTONE	Light to dark colored, crystalline to fine-grained texture, composed of $CaCo_3$, reacts readily with HCl.
DOLOMITE	Light to dark colored, crystalline to fine-grained texture, composed of $CaMg(CO_3)_2$, harder than limestone, reacts with HCl when powdered.
CHERT	Light to dark colored, very fine-grained texture, composed of micro-crystalline quartz (SiO_2), brittle, breaks into angular fragments, will scratch glass.
SHALE	Very fine-grained texture, composed of consolidated silt or clay, bedded in thin layers. The unlaminated equivalent is frequently referred to as siltstone, claystone or mudstone.
SANDSTONE	Usually light colored, coarse to fine texture, composed of cemented sand size grains of quartz, feldspar, etc. Cement usually is silica but may be such minerals as calcite, iron-oxide, or some other carbonate.
CONGLOMERATE	Rounded rock fragments of variable mineralogy varying in size from near sand to boulder size but usually pebble to cobble size (½ inch to 6 inches). Cemented together with various cementing agents. Breccia is similar but composed of angular, fractured rock particles cemented together.

PHYSICAL PROPERTIES:

DEGREE OF WEATHERING

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

HARDNESS AND DEGREE OF CEMENTATION

Limestone and Dolomite:

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

Shale, Siltstone and Claystone

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

Sandstone and Conglomerate

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

BEDDING AND JOINT CHARACTERISTICS

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

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

SOLUTION AND VOID CONDITIONS

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

Exhibit D-3

Terracon

Pavement Analysis Report

Atoka Lake Access Roads

Life Cycle Cost Analysis Report

Near Stringtown, Oklahoma

April 8, 2022
Terracon Project Nos. 03215254 / 03215255

Prepared for:
POE and Associates
Suite 400
1601 Northwest Expressway
Oklahoma City, OK 73118

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

terracon.com
Terracon
Environmental ■ Facilities ■ Geotechnical ■ Materials

April 8, 2022

POE and Associates
Suite 400
1601 Northwest Expressway
Oklahoma City, OK 73118

Attn: Mr. Todd Cochran, P.E.
P: [405] 949 1962
F: [405] 608 0380
E: Todd.Cochran@poeandassociates.com

Re: Life Cycle Cost Analysis, LCCA
Lake Access Road Improvements for Atoka Lake
Near Stringtown, Oklahoma
Terracon Proposal No. 03215254 / 03215255

Dear Mr. Cochran:

Terracon Consultants, Inc. has completed the geotechnical engineering services for the above-referenced project. These services were performed in general accordance with our Proposal Nos. P03215254 and P03215255 dated November 17, 2021.

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

Sincerely,
Terracon Consultants, Inc.
Cert. Of Auth. #CA-4531 exp. 6/30/23

Jeff Dean, P.E.
Oklahoma No. 16998

Norman K. Tan, Ph.D., P.E.
Geotechnical Manager

JD:NT\kld\n:\projects\2021\03215254-03215255\project documents\apr2022

Copies to: Addressee (1 via email)

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PAVEMENT ANALYSIS REPORT
PAVEMENT LIFE CYCLE COST ANALYSIS REPORT
LAKE ACCESS ROAD IMPROVEMENTS
ATOKA LAKE, NEAR STRINGTOWN, OKLAHOMA

Terracon Project No. 03215254 / 032152555
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1.0 INTRODUCTION

The analysis of the pavement typical section options designed for the north and south section of the Atoka Lake Access Roads project has been completed. This analysis includes the Life Cycle Cost Analysis, LCCA, of the flexible and rigid pavement options that are currently under consideration. This report includes the findings of a literature review of the LCCA approaches used by other state DOTs, the development of the estimated pavement maintenance/rehabilitation cycles, and the computation of the life cycle costs for each pavement option.

2.0 PROJECT INFORMATION

The Atoka Lake access roads extend approximately 2 miles north and 2 miles south from the Atoka Lake Dam along the eastern shoreline of Atoka Lake near Stringtown, Oklahoma. The total project length including both north and south sections is approximately 3.88 miles. Life-Cycle Cost Analysis, LCCA, were performed on the pavement design options provided in Terracon Reports 03215254 and 0325255 for the project. The LCCA was conducted in general accordance to the guidance provided by the FHWA Publication FHWA-SA-98-079, "Life Cycle Cost Analysis in Pavement Design". This life cycle cost analysis will be based upon the typical section estimates provided earlier which encompasses a project length of 20,500 feet or approximately 3.88 miles. The life cycle cost analysis period will cover 45 years in order to include multiple maintenance activities over the analysis period.

3.0 LITERATURE REVIEW OF LCCA APPROACHES

3.1 Basic LCCA Factors Considered

The FHWA Publication FHWA-SA-98-079, "Life Cycle Cost Analysis in Pavement Design", identifies eight procedural steps in conducting a life cycle cost analysis. These steps are:

1. Establish alternative pavement design options for the analysis period.
2. Determine performance periods and activity timing.
3. Estimate agency costs.
4. Estimate user costs.
5. Develop expenditures.
6. Compute net present value.
7. Analyze results.
8. Reevaluate design strategies.

Alternative pavement designs must be comparable for the given analysis period. They must be designed to provide equal benefits to the user or provide the same level of service for the required time period. Alternate pavement designs can be evaluated through the use of the AASHTO Pavement ME design approach which predicts the long term performance of each pavement type. These predictions can also provide a source for estimating the timing of periodic maintenance activities that will maintain a specified level of performance for each pavement option.

Agency maintenance records are a good source for estimating projected maintenance activity timing as well as the projected agency costs for the life span of each pavement option. Agency costs for the flexible pavement option could be established from maintenance records ranging from basic activities such as a wearing course mill and fill to a more in-depth rehabilitation such as a structural overlay. The rigid pavement option could look at the costs of cleaning and resealing joints, panel patching, and surface diamond grinding. Since Agency maintenance records were not available for these projects, projections of future maintenance activities were estimated from AASHTO Pavement ME performance timeline predictions.

User costs are the differential costs incurred by the highway user between completing highway improvement options and associated maintenance and rehabilitation strategies over the analysis period of the project. User costs can be viewed as an accumulation of vehicle operating costs, user delay costs, and crash costs. For this project user costs were not included due to the anticipated low volume of traffic along the project corridor and the absence of any maintenance records.

Expenditures are the accumulation of costs and benefits of each pavement option during the analysis period. Costs are viewed as negative expenditures and typically include the initial cost of construction and the costs of periodic maintenance and rehabilitation activities. Benefits are viewed as positive expenditures and may be the estimated salvage value or remaining service life of the pavement at the end of the analysis period. Use of a salvage value would indicate the intention that the use of the facility would be terminated at the end of the analysis period. The use of a remaining service life value indicates the pavement will continue to be in operation, possibly after a significant rehabilitation, if needed.

Since LCCA is a form of economic analysis used to evaluate the long term economic efficiency between pavement options, once all costs and their timing have been developed, future costs must be discounted to the base year and added to the initial cost to determine the Net Present Value, NPV for the pavement alternative. NPV may be calculated using the following formula:

$$\text{NPV} = \text{Initial Cost} + \sum \text{Rehab Costs} \left[1/\left(1+i\right)^{n}\right]$$

Where: i = discount rate
n = year of expenditure

The term $\left[1/\left(1+i\right)^{n}\right]$ component of the above formula is referred to the Present Value, PV.

Once the net present values of the individual components of each pavement option are tabulated, the results may be analyzed. Specific items typically evaluated are a comparison of Agency costs and a comparison of User costs incurred during the analysis period. Another issue that may be evaluated is the ability to make any trade-offs that will still provide the same level of service.

It should be stressed that LCCA is intended to be a decision support tool. The results of the LCCA are not intended to be decisions in and of themselves.

3.2 LCCA Approach for the Atoka Lake Access Roads

Given the absence of an established LCCA program within the Transportation Agencies in Oklahoma and the desire to present a thorough approach that would be fair to each of the paving industries involved, a decision was made to use a life cycle cost analysis approach that would be based upon the following factors:

1. Initial project construction costs
2. Projected maintenance costs
3. Remaining service life

Several assumptions were made to develop this approach and input from representatives from both paving industries was instrumental in providing essential details in the development of several of the factors.

The initial costs were those provided based upon the pavement typical sections developed in Terracon Reports 03215254 and 0325255 for the project. The LCCA analysis for each pavement typical section was based upon a period of 45 years.

The projected maintenance costs were based upon the unit rates provided in the pavement estimates for each typical section. Maintenance activity cycles were estimated using the pavement performance curves generated over the LCCA analysis period by the AASHTO Pavement ME software and input from industry representatives. The remaining service life was estimated using the design models produced by Pavement ME and assumptions based upon historical experience.

4.0 LIFE CYCLE COST ANALYSES

4.1 Initial Project Construction Costs

Upon completion of the pavement designs, estimates for each of the pavement options were provided. These were based upon the compilation of the individual pay items that comprise each typical section. The representative estimates for each pavement option were converted to a cost per lane-mile based upon the provided project length as shown in the following table.

PAVEMENT OPTION	INITIAL CONSTRUCTION COSTS	COST PER MILE (3.88 MILES)
Flexible Pavement	$2,349,892	$605,241
Rigid Pavement	$3,094,346	$796,983

4.2 Project Maintenance Costs

Maintenance costs were developed using the unit prices provided in the pavement cost estimates and the pavement performance over the LCCA analysis period projected by the AASHTO Pavement ME software.

4.2.1 Flexible Pavement Costs

Utilizing the properties of current hot mix asphalt, HMA, mixtures along with the performance projections from Pavement ME, the flexible pavement model indicates the majority of the distress in the pavement, throughout the 45 year analysis period, will be occurring at or near the surface. Bottom up cracking as predicted by the models appears to be minimal. It is our opinion that a reasonable maintenance cycle for the flexible pavement would be as shown below.

FLEXIBLE OPTION MAINTENANCE ACTIVITY	Activity Year
Coldmill and replace the top 2 inches of the pavement surface	20
Coldmill and replace the top 2 inches of the pavement surface	40

This estimated maintenance program would provide a smooth driving surface as well as the structural repairs or improvements as needed.

These maintenance cycle activities were based upon the pavement performance curves generated over the LCCA analysis period by the AASHTO Pavement ME software. Maintenance costs were estimated using the unit prices used in the final construction estimates for the flexible pavement typical section.

4.2.2 Rigid Pavement Costs

For the rigid pavement option, the Pavement ME model indicates minimal distress over the 45 year analysis period. The estimated percentage of cracked panels tends to increase over the design life and approaches the threshold of 15% set in the design parameters at year 35. This does not indicate that the pavement will be maintenance free. It is our opinion that a reasonable maintenance program would include cleaning and resealing the joints, occasional panel patching and a periodic diamond grind to maintain a smooth driving surface. The estimated maintenance schedule used for the rigid option is shown the in table below.

RIGID OPTION MAINTENANCE ACTIVITY	Activity Year
Clean & reseal 25% joints and repair 7% of the panels	20
Clean & reseal 25% joints, repair 7% of the panels, and diamond grind the surface.	40

Unit prices for each of the rigid pavement maintenance activities were provided by a local representative of the concrete paving industry. These rates are presented in the tables below.

RIGID OPTION MAINTENANCE ACTIVITY	UNIT PRICES
Joint Rehabilitation	$2.50/Linear Ft.
Panel replacement	$150/SY
Diamond Grinding	$2.75/SY

These maintenance cycle activities were based upon the pavement performance curves generated over the LCCA analysis period by the AASHTO Pavement ME software. Maintenance costs were estimated using the unit prices used in the final construction estimates for the rigid pavement typical section.

4.3 Remaining Service Life

Each design alternative has been evaluated over an equivalent analysis period. Many state agencies apply an arbitrary salvage value at the end of this period. This salvage value would indicate an estimated worth of the pavement materials at the end of the period. Since many pavements, if properly maintained, retain the ability to remain in service for several more years after the analysis period, a more realistic approach is to apply a Remaining Service Life, RSL to the pavement. This RSL can be estimated based upon the project cost and the percentage of design life remaining at the end of the analysis period. In recent years, it has been uncommon, in Oklahoma, to totally remove and reconstruct a modern pavement section. Many times, the existing pavement is not removed but used as a base for a new pavement section. A review of the Pavement ME models for each of the pavement typical sections indicate minimal structural, or full depth, failure during the 45 year analysis period making the estimation of RSL more difficult. The flexible pavement section was designed using the concepts of perpetual; pavement meaning minimizing the occurrence of bottom up cracking in the pavement Perpetual concept pavement sections are noted to retain much of the original structural integrity while typically needing periodic surface treatments to restore ride quality. Rigid pavement sections provide long service life while needing the occasional panel repair, joint seal, and diamond grind. Later in the life of the pavement, as traffic volumes continue to increase, these repairs may become more frequent and more costly. With these ideas in mind an assumption was made to estimate the remaining service life for each option as follows:

RSL for the flexible option = 0.75 x original construction cost
RSL for the rigid option = 0.5 x original construction cost.

4.4 LCCA Results

The calculated results of the initial construction costs, user costs, maintenance costs, and remaining service life results were converted to a per lane-mile cost. The maintenance costs for each pavement option activity were projected to reflect future values by means of implementing a discount factor tied to the year in which the activity will occur. A discount factor of 4% was used as recommended by the FHWA publication referenced earlier in this report. The per-mile costs for each option were then tabulated to formulate a Life Cycle Cost per mile in terms of present worth dollars. These costs were then amortized to an Average Annual Cost per mile. The results of the Life Cycle Cost Analysis are presented in the following table.

Pavement Alternatives (45 year analysis period)	Flexible Pavement (per-mile)	Rigid Pavement (per-mile)
Initial Costs (Present Worth)	$605,241	$796,983
Projected Maintenance Costs		

Pavement Alternatives (45 year analysis period)	**Flexible Pavement (per-mile)**	**Rigid Pavement (per-mile)**
Year 20	$372,649	$401,659
Year 40	$816,520	$1,065,978
Projected Total Maintenance Costs	$1,189,169	$1,487,201
Projected Total Maintenance Costs (Present Worth)	$203,584	$251,257
Remaining Service Life		
Percent of Original Cost	0.75	0.5
Remaining Service Life at End of Analysis Period	($453,930)	($398,491)
Total remaining Service Life (Present Worth)	($77,712)	($68,221)
LIFE CYCLE COSTS		
Total Present Worth	$731,112	$980,019
Average Annual Cost	$35,285	$47,298

5.0 GENERAL COMMENTS

The information and analyses presented in this report are based upon the material unit prices specific to the project, traffic information provided for the project for the purpose of designing the pavement typical sections, and from maintenance activity unit prices provided by local representatives of the paving industry in Oklahoma. Where historical information was deficient, assumptions were made for each pavement option in order to continue through the analysis process. These assumptions consisted of estimating the maintenance activities and their respective cycles and estimating the Remaining Service Life for each option. These assumptions were applied equally for both pavement options evaluated. This report does not reflect any variations which may occur between actual and assumed values. Should more detailed information become available, it may be necessary to reevaluate the analysis provided in this report.

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 engineering practices. No warranties, either express or implied are intended or made. In the event that any changes in the information or assumptions made, as outlined in this report, are required, the analysis and conclusions 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.