ARKANSAS DEPARTMENT OF TRANSPORTATION

SUBSURFACE INVESTIGATION

STATE JOB NO. **BR7615**

FEDERAL AID PROJECT NO. **STPB-0076(297)**

MULBERRY RIVER STR. & APPRS. (S)

COUNTY ROAD NO. **CRS 45 & 67**

IN **FRANKLIN** **COUNTY**

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ARKANSAS DEPARTMENT OF TRANSPORTATION
ARDOT.gov | IDriveArkansas.com | Lorie H. Tudor, P.E., Director
MATERIALS DIVISION
11301 West Baseline Road | P.O. Box 2261 | Little Rock, AR 72203-2261 | Phone: 501.569.2185 | Fax: 501.569.2368

March 24, 2021

TO: Mr. Rick Ellis, Bridge Engineer

SUBJECT: Job No. BR7615
Mulberry River Str. & Apprs. (S)
Crawford & Franklin Counties
County Road 67

Submitted herein are foundation recommendations for construction of the replacement bridge over Mulberry River and Mulberry Relief Creek on County Road 67 in Crawford and Franklin Counties. Recommendations for the approach embankments will be provided in a supplemental report.

This report includes a brief summary of the geology and site conditions, rock core unconfined compression test, and the logs of the borings conducted for the structures and approaches of the above referenced project. Following the summary are the foundation recommendations. D_{50} data for scour analysis is also included in this foundations report.

Introduction

This project consists of replacing two existing bridges on County Road 67 with a single bridge approximately 600 feet in length and 30.5 feet in width, that will span over the Mulberry River and Mulberry Relief Creek. The new replacement bridge will be constructed on an offset alignment and is located south of the existing bridges.

Field Investigation

A subsurface investigation was performed by ARDOT personnel to complete the requested borings. The borings were drilled between February 2, 2021 and March 2, 2021, using auger boring and rock coring methods. A total of five (5) borings were requested for this bridge and four (4) borings were completed. The boring in the river channel was not performed due to high water levels and inaccessibility to the planned location. Borings were slightly offset due to height restrictions and steep slopes. Groundwater was observed in Boring 3 and Boring 4. Groundwater was not observed in the other borings. Standard Penetration Test (SPT) was conducted for soil sampling and field testing. The approximate locations of the borings are presented on the Plan of Borings included in Attachment A. The boring logs are also included in Attachment A.

Lab Investigation

All samples were brought to the Materials laboratory for testing and classified by experience personnel in accordance with the United Soil Classification (USCS) and American Association of State Highway and Transportation Officials (AASHTO) soil classification system. Representative lab tests were performed to determine moisture content and gradation of soil samples. Rock core compressive strength was determined using uniaxial compressive test on intact rock cores. The rock core compressive strength is presented in Attachment B. The laboratory test and their corresponding test methods are listed in Table 1.

Table 1: Summary of Laboratory Tests and Methods

Laboratory Test	ASTM	AASHTO
Moisture Content	D2216	T 265
Grain Size Analysis by Sieving	D6913	T 88
Unconfined Compression of Rock Cores	D7012, Method C	

Site Conditions

This project consists of replacing the two existing bridges on Crawford Co. Rd. 45 and Franklin Co. Rd. 67 with a single bridge. Bridge 1 (existing bridge over Mulberry River) is a single lane, 4-span, southwest to northeast oriented steel truss bridge. The superstructure consists of corrugated steel bridge pans with an asphalt overlay. The decking is supported by three intermediate bents consisting of metal caissons filled with concrete resting on spread footings and cast-in-place concrete end walls and wing walls. The southwest bridge end rests on shale that is dipping to the north. There are steel guardrails both leading up to and crossing the bridge. The existing bridge crosses the Mulberry River where the river, flowing from the north, takes a sharp 90 degrees towards the east.

Bridge 2 (existing bridge over Mulberry Relief Creek) is a southwest to northeast oriented, single lane, 2-span bridge. Mulberry Relief Creek joins the Mulberry River south of the existing bridge. The superstructure of the bridge consists of cast-in-place concrete decking supported by steel beams. The steel beams are supported by one intermediate bent on a spread footing and cast-in-place concrete end walls and wing walls. There are steel guardrails spanning the bridge. There are remnants of a previous bridge in the channel beneath the existing structure.

Both existing bridges are located in a wooded area surrounded by agricultural fields. Shale dipping to the north is exposed in a pit on the right side of the southwest end of Bridge 1. Mulberry Relief Creek is a 1200-foot branch of the Mulberry River that most likely only has significant flow during heavy rainfall. Sediment observed on both channel banks consists of sand, gravel, cobbles, and boulders.

Scour Observations

Scour under the southwest end of existing Bridge 1 (Mulberry River) was observed in the field. This is likely due to the sharp 90 degree turn in the river under the bridge in combination with the fact that the shale at this location is dipping towards the river. It appears concrete has been poured on the embankment under the bridge in a past attempt to resolve this scour. Pictures showing the scour and attempted remediation are included in Attachment C. Because the alignment of the new bridge end is similar to the alignment of the existing bridge end, continued scour of the bank should be anticipated.

Site Geology

The project alignment is located in the Atoka Formation of Pennsylvanian age (Pa). The Atoka Formation is a sequence of marine, mostly tan to gray silty sandstones and grayish-black shales. Some rare calcareous beds and siliceous shales are known. The unit locally contains discontinuous streaks of coal and coaly shale. Atoka shale was observed in outcrops on the southwest end of Bridge 1, slightly dipping towards the north. The project alignment lies within close proximity to the Mulberry Fault Zone and there is a mapped fault located several hundred feet north of the project alignment.

Several observations made in the field and in the rock cores show possible evidence of faulting within the project alignment. This includes the fact that the river takes several sharp 90 degree turns north of the existing bridges and also directly under Bridge 1. Slickensided vertical fractures were observed in the rock cores, which are often associated with faulting. The depth to rock observed in the core and in outcrops on the southwest end of the project alignment was shallower than the rock encountered at the northeast end of the alignment. Shale encountered in Boring 1 at the southwest end of the alignment was approximately 0.5 feet below ground level. Shale encountered at the northeast end of the alignment, in borings 2 through 4, was between 24 and 30 feet below ground level.

Subsurface Conditions

Subsurface soil conditions observed above rock level represent a fining upwards sequence from boulder size sediments on top of the shale to sand to clayey sand near the surface. This is typical of bar type deposits found on the opposite banks from sharp bends in rivers. No obvious correlation between rock competence and depth was observed in the rock cores. To aid in visualizing the subsurface conditions, a Generalized Subsurface Profile is included in Attachment D.

Based on the results of Boring 1, the subsurface stratigraphy for Station 102+12 may be generalized as follows:

Stratum Ia: This surficial stratum extends to approximately 0.5-ft depth. The stratum consists of moist, very hard, brown sandy clay.

Stratum III: This basal stratum is below the Stratum I sandy clay and extends in excess of the 19-ft exploration depth. Stratum III consists of slightly weathered to unweathered / fresh, medium hard, gray shale.

Based on the results of Borings 2 through 4, the subsurface stratigraphy for Station 105+54 to Station 108+47 may be generalized as follows:

Stratum Ib: This surface stratum extends to approximately 0- to 7-ft depth. This stratum consists of moist, very loose to very dense, brown sand, sand with clay, to clayey sand.

Stratum II: Stratum II is below Stratum I soils and extends to approximately 24- to 30-ft depth. This stratum is comprised of moist, medium dense to very dense, brown sand with gravel to gravel with sand. The granular stratum contains variable amount of cobbles and boulders, particularly near the bottom of this stratum.

Stratum III: The basal stratum extends in excess of the 39- to 59-ft exploration depth of the borings. This stratum consists of slightly weathered to unweathered / fresh, medium hard, frequently to occasionally fractured shale.

Seismic Conditions

In light of the average subsurface conditions as revealed by the borings, a Seismic Site Class C (very Dense Soil and Soft Rock profile) is calculated for the project site. Utilizing the Seismic Site Class C and the approximate GPS coordinates of the project site, the following peak ground acceleration coefficient, short-period spectral acceleration coefficient, as well as long-period spectral acceleration coefficient, are determined. These seismic coefficients are summarized in Table 2 below. A Design Response Spectrum is presented in Attachment E.

Table 2: Summary of Ground Motion Acceleration Response Coefficients

Acceleration Coefficient	Value (g)
A_s (Site PGA)	0.069
S_{DS} (0.2 sec)	0.165
S_{D1} (1 Sec)	0.094

For the long-period spectral acceleration coefficient (S_{D1}) of 0.094, a Seismic Performance Zone 1 is considered applicable to the site.

Foundation Recommendations

Steel H-Piling – Bents 1 and 5. It is anticipated steel h-piling will be utilized to support the foundation loads at the end bents (Bents 1 and 5). Pile size to be used is not known at this time of writing. Steel h-piles should be driven to practical refusal and should penetrate through embankment fill, the overburden soils and the highly weathered to weathered shale, to bear in the competent slightly weathered to weathered shale.

Practical refusal is defined as a maximum penetration of 1.0 inch for 20 blows by a pile hammer. For the purpose of estimating pile length, a pile penetration of 1 ft into the competent rock is assumed. This estimated penetration is based on the results of the borings and our experience with similar foundation rock. The results of the borings indicate moderate to severe driving conditions are expected to be experienced. Consequently, rock points are recommended for all the h-piles driven to refusal.

A minimum pile penetration of 10 ft, measured below natural ground surface, is recommended. Greater pile length / penetration may be warranted by lateral resistance demand. Due to the depth of competent rock as revealed by the borings, preboring to achieve the minimum 10 ft of penetration will be required at Bent 1. In addition, preboring is also anticipated to be required for penetrating through the strata with gravel, cobbles, and / or boulders. Based on the results of the borings and the assumption of 1 ft penetration into the competent rock, the estimated pile tip elevation is summarized below in Table 3.

Table 3: Summary of Estimated Pile Tip Elevation

Bent No.	Boring Location	Estimated Tip Elevation
1	Sta. 102+12, 8 ft Rt. of CL	407 (10 ft below ground)
5	Sta. 108+47, 9 ft Lt. of CL	382

The estimated pile tip elevation summarized in the table above is based on our evaluation of the rock cores retrieved from the borings. Actual subsurface conditions can vary from those encountered in the borings. As-constructed pile tip elevation can vary and must be field verified.

Nominal axial resistance of steel h piles driven to refusal in competent rock is governed by the structural capacity of the piles. Therefore the nominal resistance should be determined by the Structural Engineer utilizing applicable AASHTO LRFD design procedures. We are available to provide geotechnical inputs for structural evaluation of the nominal axial pile resistance. In light of the expected moderate to severe driving conditions, a resistance factor (φ_c) of 0.50 is recommended for calculating factored structural bearing resistance of h-piles. For steel piling driven to refusal in competent rock, long-term, post-construction settlement is expected to be negligible.

Drilled Shafts – Bents 1, 2, 3 and 4. Borings drilled at Bents 3 and 4 indicate competent rock was encountered at 24 to 30 ft below ground surface. Drilled shafts are suitable to be utilized to support the foundation loads of Bents 3 and 4. For uniformity in foundation design, compatibility of bridge movement, as well as reduced influence by scour, drilled shaft foundations are also planned at Bent 2 in the river channel. We also understand drilled shaft in lieu of steel h-piles may be considered at Bent 1 if competent rock is reasonably near the cap bottom elevation. Drilled shaft recommendations for these bents are provided below.

Drilled shafts should be founded a minimum of two (2) shaft diameters into the competent medium hard slightly weathered to fresh shale.

A maximum nominal bearing capacity (q_p) of 110 ksf is recommended for drilled shafts founded as recommended above. A resistance factor (φ_{stat}) of 0.50 is considered suitable for drilled shaft tip resistance. Due to several unpredictable factors, such as: the roughness of the shaft side wall after drilling and the rate of deterioration of the shale mass once exposed to the atmosphere, it is recommended that shaft side resistance be neglected. Applying the resistance factor to the nominal tip resistance results in a maximum factored tip resistance (q_R) of 55 ksf.

Based on the results of the borings, elevation of the competent medium hard slightly weathered shale to shale that is suitable for rock socket is summarized in Table 4 for Bents 1, 3, and 4.

Table 4: Summary of Estimated Competent Rockline Elevation

Bent No.	Boring Location	Estimated Competent Rockline Elevation
1	Sta. 102+12, 8 ft Rt. of CL	417
3	Sta. 105+54, 4 ft Lt. of CL	375
4	Sta. 106+91, 8 ft Rt. of CL	383

Actual competent rockline elevation at the drilled shaft locations can vary from those summarized in the above table and must be field verified. Depending on specific rock quality, deepening or shortening of shaft length can be warranted. Settlement of properly constructed drilled shafts founded into the competent rock should be negligible.

The boring originally planned at Bent 2 was not accessible due to high water and was not performed. Exact surface elevation and subsurface conditions are not known. Consequently, we recommend one test boring be drilled prior to the drilled shaft excavation. Test borings are also recommended in other bents (Bents 1, 3 and 4) utilizing drilled shaft foundations due to the potential presence of soft zones / pockets of highly weathered to weathered shale. Test borings should be 1-1/2 inches or larger and should extend to a minimum depth of 1.5 times of the shaft diameter below planned tip elevation.

D_{50} for Scour Analysis

The particle size through which 50% of particles by weight passing, D_{50}, is summarized below in Table 5. Detailed particle size distribution curves used for D_{50} determination are included in Attachment F.

Table 5: Summary of D_{50} for Scour Analysis

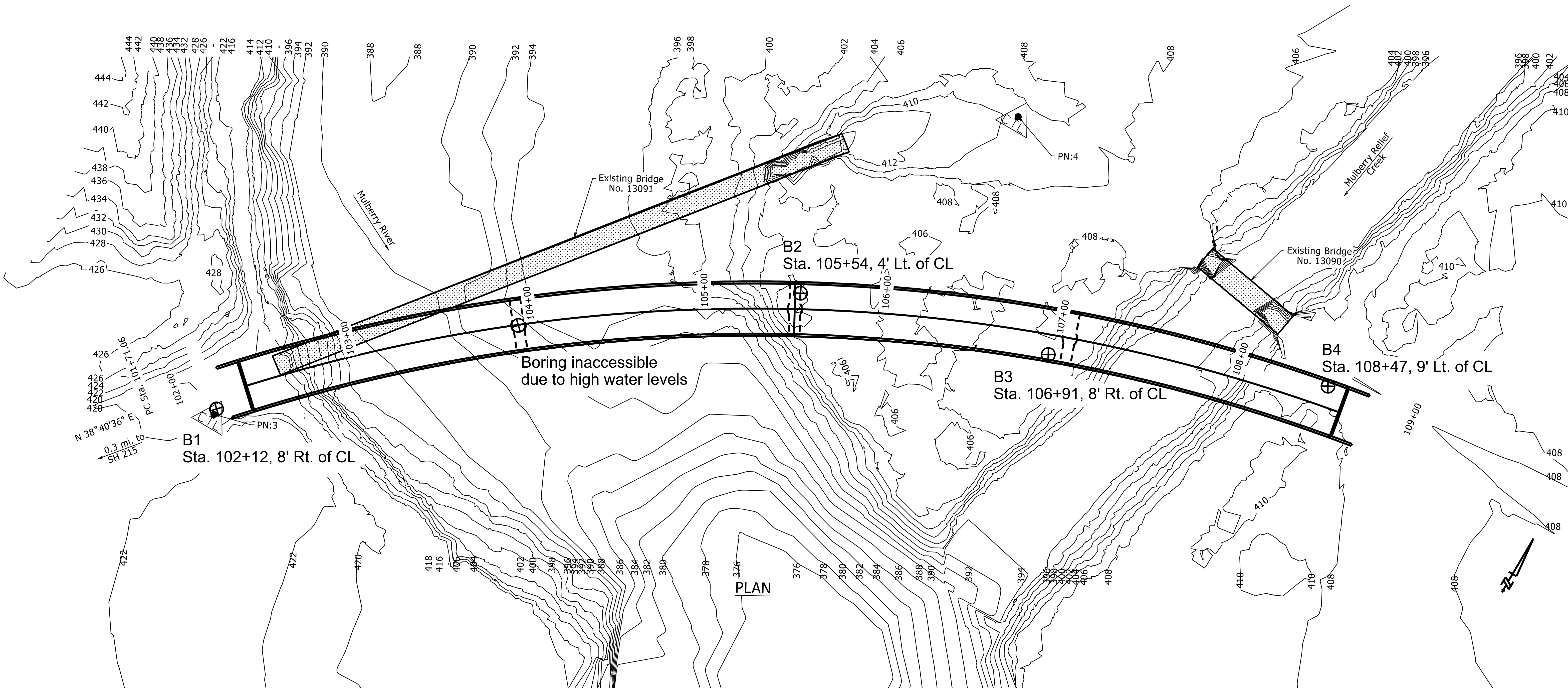
Creek Name	Station	Sample Type	Location	Depth (FT)	Soil Description	D_{50}, mm
Mulberry River	104+70	Creek Bank	156' Lt. CL	NA	Medium to coarse sand w/ gravel	0.91
Mulberry Relief Creek	107+60	Creek Bank	150' Lt. CL	NA	Poorly graded fine sand	0.22

Jonathan A. Annable
Materials Engineer

JAA:yz:pjt:pwc
cc: State Construction Engineer - Master File Copy
District 4 Engineer
G.C. File

Attachment A

FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
4	AR			
JOB NO.		BR7615		
PLAN OF BORINGS				



PLAN

PLAN OF BORINGS

MULBERRY RIVER STR. & APPRS. (S)
CO. RDS. 45 & 67
CRAWFORD & FANKLIN COUNTIES
FED. AID PROJECT

JOB NO. BR7615	SHEET 1/1

ARKANSAS HWY. & TRANS. DEPARTMENT
MATERIALS DIVISION - GEOTECHNICAL SEC.

BORING NO. 1
PAGE 1 OF 1

JOB NO. BR7615 Crawford & Franklin Counties
JOB NAME: Mulberry River STR. & APPRS. (S)
CO. RDS. 45 & 67
STATION: 102+12
LOCATION: 8' Right of Construction Centerline
LOGGED BY: Coty Campbell

DATE: March 2, 2021
TYPE OF DRILLING: Hollow Stem Auger - Diamond Core
EQUIPMENT: Acker 2094
HAMMER CORRECTION FACTOR: N/A

COMPLETION DEPTH: 19

DEPTH FT.	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL SURFACE ELEVATION: 417.1	SOIL GROUP	PLASTIC LIMIT	% MOIST.	LIQUID LIMIT	DRY WEIGHT LBS PER CU.FT.	NO. OF BLOWS PER 6-IN.	% TCR	% RQD
			Moist, Brown Sandy Clay								
			SHALE - Slightly Weathered, Medium Hard, Gray						5 15-50		
									10 (0")	100	98
10			SHALE - Unweathered, Medium Hard, Gray							100	100
										94	90
20			Boring Terminated								
30											
40											
50											
60											
70											

REMARKS:

ARKANSAS HWY. & TRANS. DEPARTMENT
MATERIALS DIVISION - GEOTECHNICAL SEC.

BORING NO. 2
PAGE 1 OF 1

JOB NO. BR7615 Crawford & Franklin Counties
JOB NAME: Mulberry River STR. & APPRS. (S)
CO. RDS. 45 & 67
STATION: 105+54
LOCATION: 4' Left of Construction Centerline
LOGGED BY: Coty Campbell

DATE: February 23, 2021
TYPE OF DRILLING: Hollow Stem Auger - Diamond Core
EQUIPMENT: Acker 2094
HAMMER CORRECTION FACTOR: N/A

COMPLETION DEPTH: 59

SURFACE ELEVATION: 405.3

DEPTH FT.	DESCRIPTION OF MATERIAL	SOIL GROUP	PLASTIC LIMIT	% MOIST.	LIQUID LIMIT	DRY WEIGHT LBS PER CU.FT.	NO. OF BLOWS PER 6-IN.	% TCR	% RQD
	Moist, Very Loose, Brown Clayey Sand			29			0 / 0-1		
	Moist, Loose, Brown Sand with Clay			11			3 / 3-4		
	Moist, Medium Dense, Brown Sand with Some Gravel			8			5 / 8-20		
10	Moist, Very Dense, Brown Gravel with Sand			7			63 / 21-35		
	Wet, Dense, Brown Gravel with Sand			16			9 / 13-25		
20							10 / 15-20		
	Wet, Very Dense, Brown Sand with Gravel						12 / 55-44		
30	SHALE - Slightly Weathered, Medium Hard, Gray						64 (6")	98	80
	SHALE - Unweathered, Medium Hard, Slightly Dipping, Gray								
	SHALE - Unweathered, Medium Hard, Frequent Fractures, Slightly Dipping, Gray							100	48
40	SHALE - Unweathered, Medium Hard, Gray							100	86
	SHALE - Unweathered, Medium Hard, Occasional Fractures, Gray							100	84
50	SHALE - Unweathered, Medium Hard, Gray							100	100
	SHALE - Unweathered, Medium Hard with Soft Layers, Frequent Fractures, Gray							100	66
60	Boring Terminated								
70									

REMARKS: Rock competence does not increase with depth.

ARKANSAS HWY. & TRANS. DEPARTMENT
MATERIALS DIVISION - GEOTECHNICAL SEC.

BORING NO. 3
PAGE 1 OF 1

JOB NO. BR7615 Crawford & Franklin Counties
JOB NAME: Mulberry River STR. & APPRS. (S)
CO. RDS. 45 & 67
STATION: 106+91
LOCATION: 8' Right of Construction Centerline
LOGGED BY: Brandon McKinney

DATE: February 8 and 9, 2021
TYPE OF DRILLING: Hollow Stem Auger - Diamond Core
EQUIPMENT: Acker 2094
HAMMER CORRECTION FACTOR: N/A

COMPLETION DEPTH: 53.5

SURFACE ELEVATION: 406.8

DESCRIPTION OF MATERIAL	SOIL GROUP	PLASTIC LIMIT	% MOIST.	LIQUID LIMIT	DRY WEIGHT LBS PER CU.FT.	NO. OF BLOWS PER 6-IN.	% TCR	% RQD
Moist, Very Loose, Brown Sand with Clay			26 21 19			0 0-2 0 0-0		
Moist, Loose, Brown Sand with Clay			14			0		
Moist, Very Loose, Brown Sand with Clay			14			1-1		
Moist, Loose, Brown Sand			12			2		
Moist, Dense, Brown Sand with Gravel*			6			3-2 1 2-2 4		
Sandstone Gravel, Cobbles, and Boulders						4-4 5 18-19 15 (0")	38 4	3 0
SHALE - Slightly Weathered, Medium Hard, Occasional Fractures, Gray							88	22
SHALE - Unweathered, Medium Hard with Occasional Soft Layers, Frequent Fractures, Gray							100	64
SHALE - Unweathered, Medium Hard, Gray							100 100	94 94
SHALE - Unweathered, Medium Hard, Occasional Fractures, Gray							98	91
SHALE - Unweathered, Medium Hard, Frequent Fractures, Dark Gray							100	23
Boring Terminated								

DEPTH FT.: 10, 20, 30, 40, 50, 60, 70

REMARKS: *A water stratum was encountered at approximately 12.7 feet below ground level. Rock competence does not increase with depth.

ARKANSAS HWY. & TRANS. DEPARTMENT MATERIALS DIVISION - GEOTECHNICAL SEC.	BORING NO. 4 PAGE 1 OF 1
JOB NO.: BR7615 Crawford & Franklin Counties JOB NAME: Mulberry River STR. & APPRS. (S) CO. RDS. 45 & 67 STATION: 108+47 LOCATION: 9' Left of Construction Centerline LOGGED BY: Austin Dillman and Paul Campbell	DATE: February 2, 2021 TYPE OF DRILLING: Hollow Stem Auger - Diamond Core EQUIPMENT: Acker 2094 HAMMER CORRECTION FACTOR: N/A

COMPLETION DEPTH: 39.3

DEPTH FT.	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL SURFACE ELEVATION: 407.4	SOIL GROUP	PLASTIC LIMIT	% MOIST.	LIQUID LIMIT	DRY WEIGHT LBS PER CU.FT.	NO. OF BLOWS PER 6-IN.	% TCR	% RQD
			Moist, Medium Dense, Brown Sand with Gravel			3%			5 / 7-9		
10						4%			9 / 12-8		
			Moist, Dense, Brown Sand with Gravel			9%			8 / 18-15		
20			Wet, Very Dense, Brown Sand with Gravel, Cobbles, and Boulders			12%			21 (1")		
			SHALE - Unweathered, Medium Hard, Gray						20 / 25 (1")		
			SHALE - Unweathered, Medium Hard, Occasional Fractures, Gray							100	74
30			LIMESTONE - Unweathered, Moderately Hard, Gray							94	78
			SHALE - Unweathered, Medium Hard, Occasional Fractures, Gray							100	86
40			Boring Terminated								
50											
60											
70											

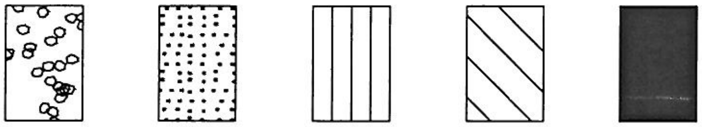
REMARKS: 19 hour water level reading was approximately 12.1 feet below ground level (BGL).

LEGEND

SOIL TYPES

(SHOWN IN SYMBOL COLUMN)

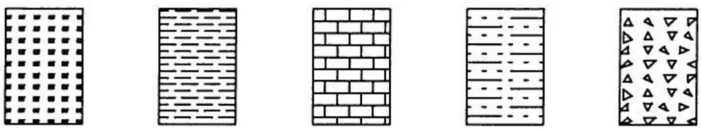
(PREDOMINANT TYPE SHOWN HEAVY)



GRAVEL SAND SILT CLAY ORGANIC MATTER

ROCK TYPES

(SHOWN IN SYMBOL COLUMN)



SANDSTONE SHALE or SILTSTONE LIMESTONE or DOLOMITE ALTERNATING LAYERS of SHALE and SANDSTONE OTHER

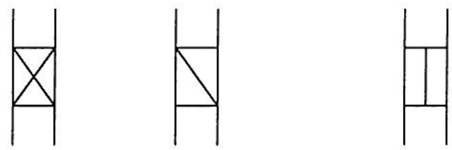
SAMPLER TYPES

(SHOWN IN SAMPLE COLUMN)

SHELBY TUBE

UNDISTURBED SAMPLE RECOVERY DISTURBED SAMPLE RECOVERY NO RECOVERY

SPLIT SPOON ROCK CORING



SAMPLE RECOVERY NO RECOVERY % RECOVERY INDICATED ON LOGS

TERMS DESCRIBING CONSISTENCY OR CONDITION

GRANULAR SOIL		CLAY		CLAY-SHALE		SHALE	
'N' Value	Density	'N' Value	Consistency	'N' Value	Consistency	'N' Value	Consistency
0-4	Very Loose	0-1	Very Soft	0-1	Very Soft		
5-10	Loose	2-4	Soft	2-4	Soft	31-60	Soft
11-30	Medium Dense	5-8	Medium Stiff	5-8	Medium Stiff	Over 60	
31-50	Dense	9-15	Stiff	9-15	Stiff	More than 2'	
Over 50	Very Dense	16-30	Very Stiff	16-30	Very Stiff	Penetration	
		31-60	Hard	31-60	Hard	in 60 Blows:	Medium Hard
		Over 60	Very Hard	Over 60	Very Hard	Less than 2'	
						Penetration	
						in 60 Blows:	Hard

1. Ground water elevations indicated on boring logs represent ground water elevations at date or time shown on boring log. Absence of water surface implies that no ground water data is available but does not necessarily mean that ground water will not be encountered at locations or within the vertical reaches of these borings.
2. Borings represent subsurface conditions at their respective locations for their respective depths. Variations in conditions between or adjacent to boring locations may be encountered.
3. Terms used for describing soils according to their texture or grain size distribution are in accordance with the Unified Soil Classification System.

Standard Penetration Test – Driving a 2.0" O.D., 1-3/8" I.D. sampler a distance of 1.0 foot into undisturbed soil with a 140 pound hammer free falling a distance of 30 inches. It is customary to drive the spoon 6.0 inches to seat into undisturbed soil, then perform the test. The number of hammer blows for seating the spoon and performing the test are recorded for each 6 inches of penetration on the drill log. The field "N" Value (N_f) can be obtained by adding the bottom two numbers for example: $\frac{6}{8-9} \Rightarrow 8+9=17\,blows/ft$. The "N" Value corrected to 60% efficiency (N_{60}) can be obtained by multiplying N_f by the hammer correction factor published on the boring log.

Attachment B

Rock Core Unconfined Compression Test Summary

Project Number: BR7615
Project Name: Mulberry River Str. & Apprs. (S)
Date Tested: 3/18/2020

Station	Location	Sample No.	Depth (ft.)	Diameter (in)	Height (in)	Total Load (lbs.)	Correction Factor	Stress (psi)	Remarks
106+91	8' RT CL	1	25.7	1.76	2.51	5,470		2249.53	
106+91	8' RT CL	2	33.0	1.76	4.43	2,370		974.66	
106+91	8' RT CL	3	33.5	1.76	3.55	9,850		4050.80	
106+91	8' RT CL	4	39.5	1.76	5.00	26,380		10848.75	
106+91	8' RT CL	5	48.7	1.76	3.88	260		106.92	
105+54	4' LT CL	6	35.0	1.76	2.72	7,640		3141.94	
105+54	4' LT CL	7	49.7	1.76	2.85	3,220		1324.22	
105+54	4' LT CL	8	56.8	1.76	0.00				Broke
105+54	4' LT CL	9	46.1	1.76	0.00	6,620		2722.47	
108+47	9' LT CL	10	28.6	1.76	3.55				Broke
102+12	8' RT CL	11	4.5	1.76	0.00				Broke

* Please note any broken samples, fractures or other characteristics of sample in Remarks.

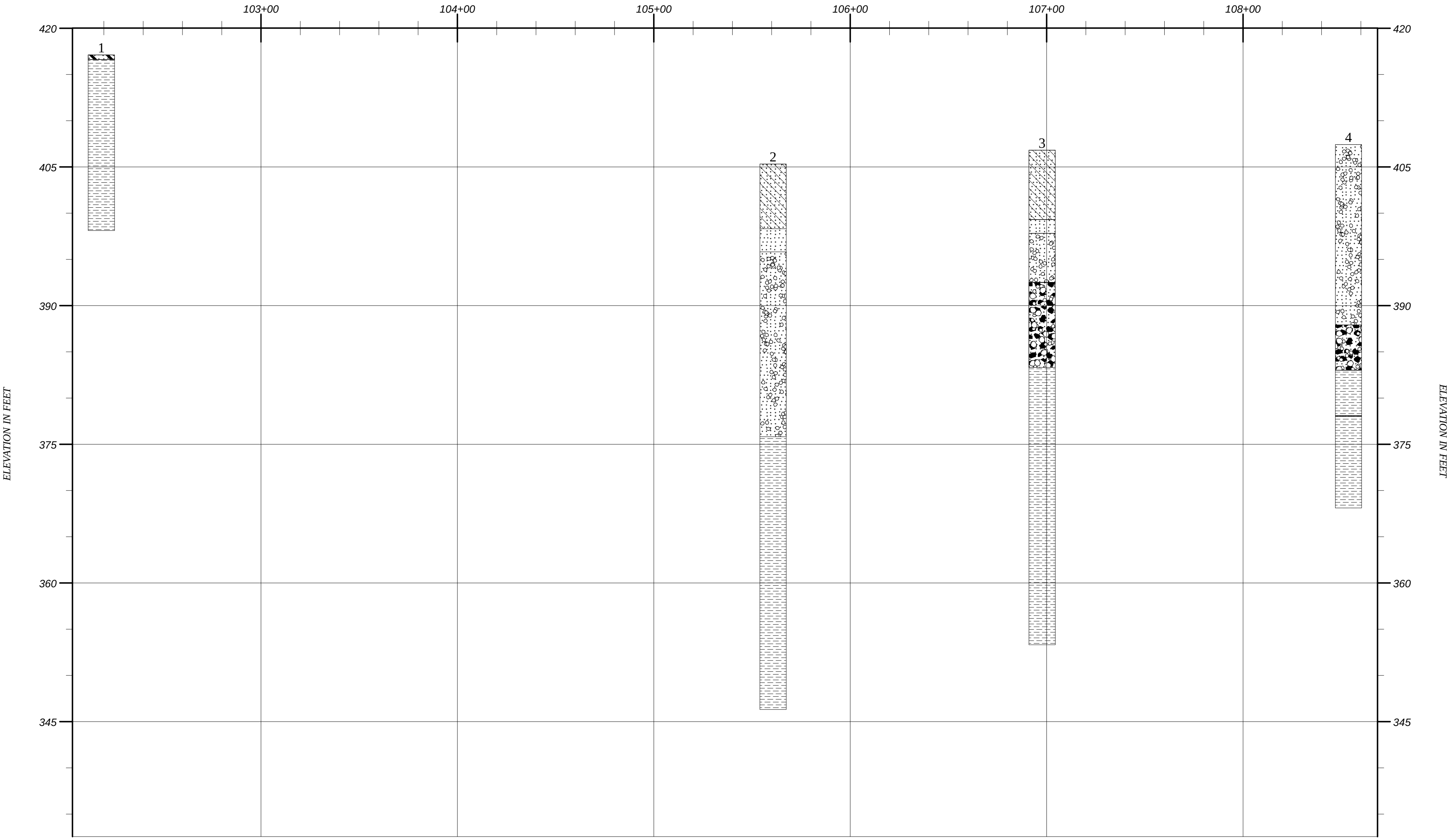
Attachment C


Figure 1. Concrete poured on the end slope of the southwest end of Bridge 1 (Mulberry River).

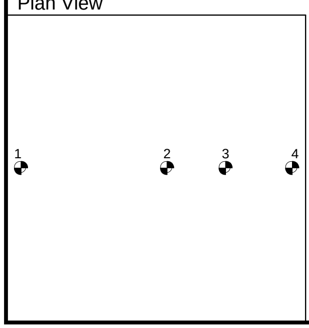
Figure 2. Concrete poured on the end slope of the southwest end of Bridge 1 (Mulberry River).

Figure 3. Scour of the river bank observed on the left side of the southwest end of Bridge 1 (Mulberry River).

Attachment D



Plan View



Strata symbols

- sandy clay
- shale/siltstone
- clayey sand
- sand
- sand and gravel
- sand, gravel, cobbles and boulders
- limestone/dolomite

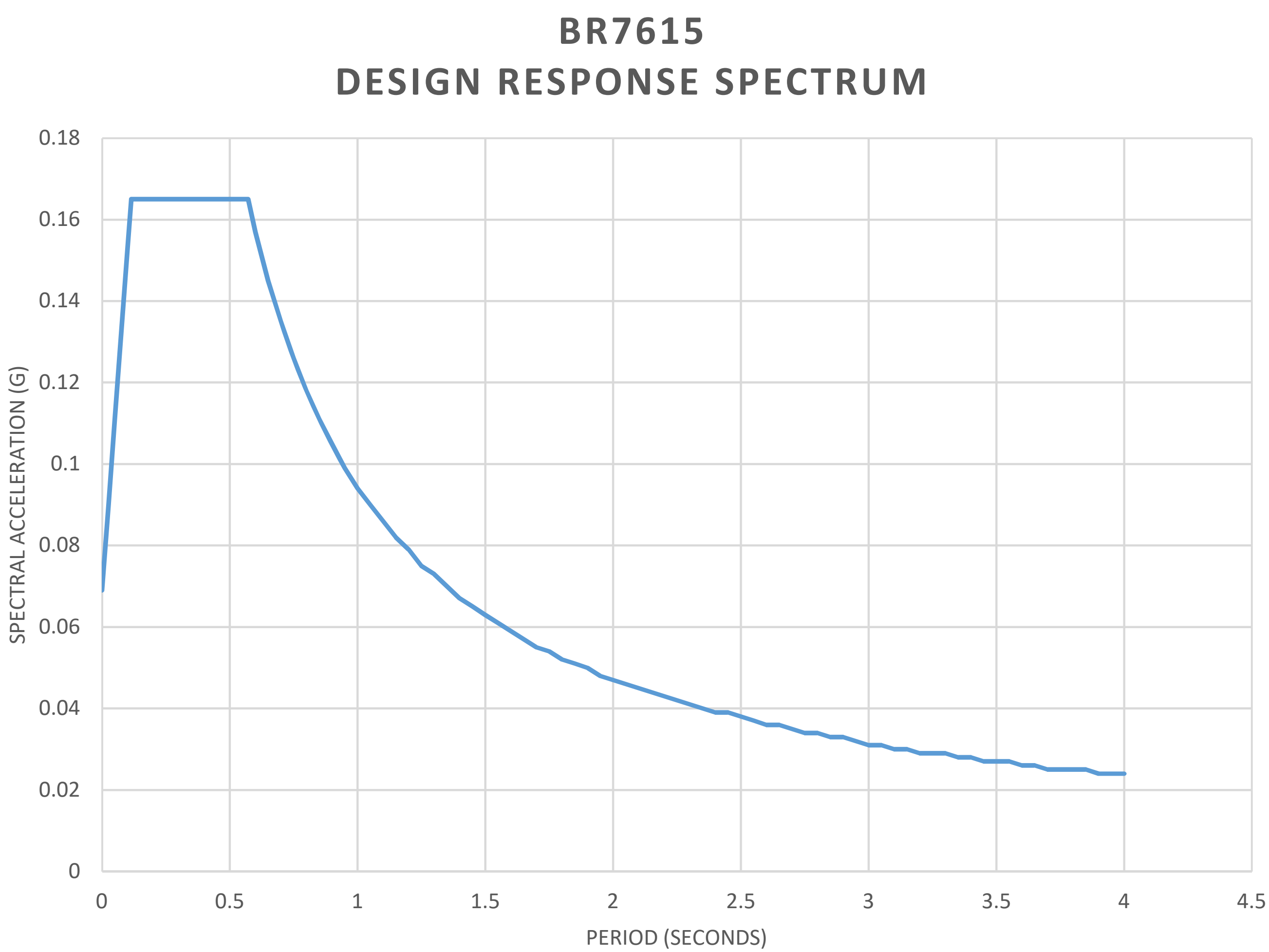
GENERALIZED SUBSURFACE PROFILE		
HORIZONTAL SCALE: 1"=(proportional)' VERTICAL SCALE: 1"=15'	DRAWN BY/APPROVED BY	DATE DRAWN 3/23/2021
Mulberry River STR. & APPRS. (S)		
PROJECT NO. BR7615 Crawford & Franklin Counties		FIGURE NUMBER

Attachment E

Title:	BR7615
Latitude:	35.530392
Longitude:	-94.04055
Site Class	C

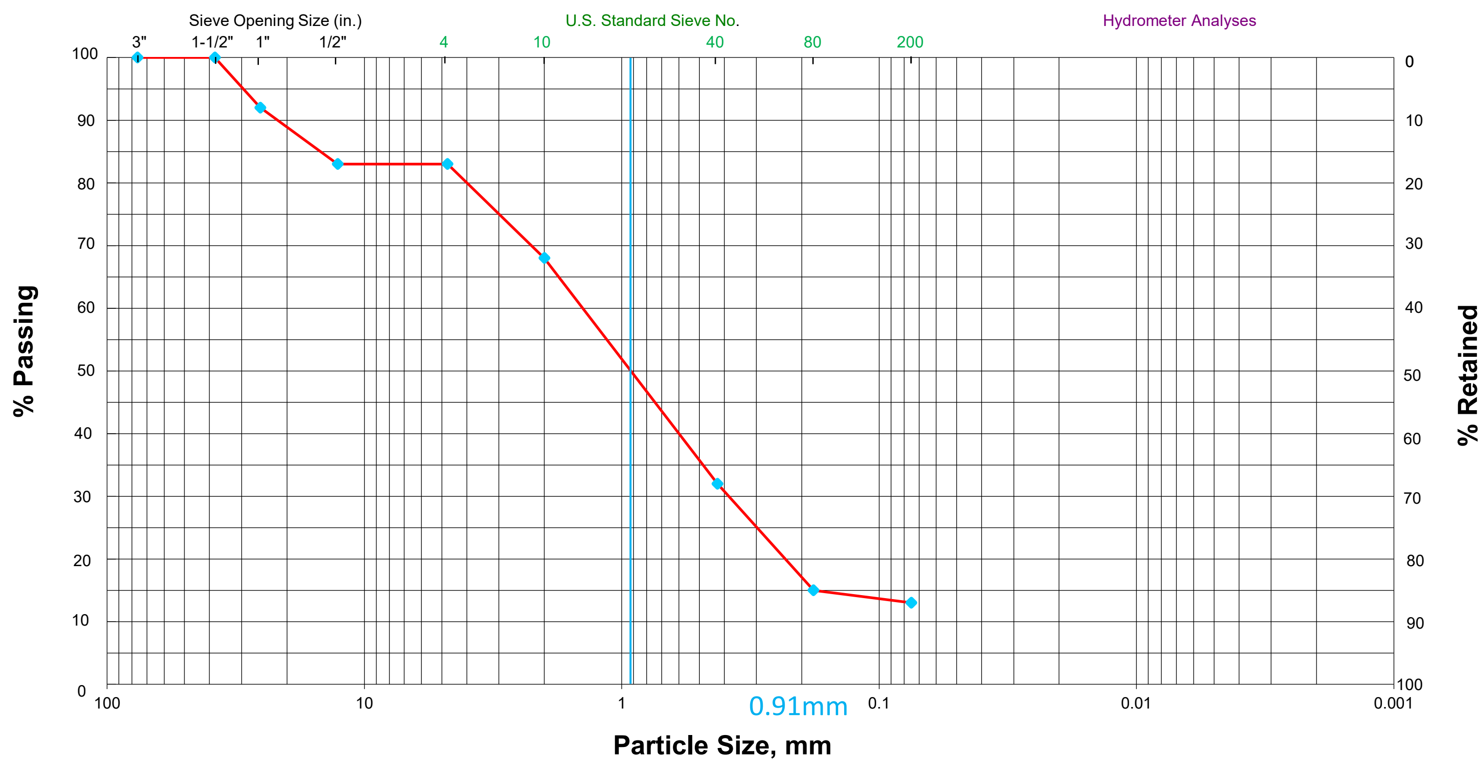
Get USGS Data

PGA:	0.058
F_{PGA}:	1.2
A_S:	0.069
S_S:	0.138
F_A:	1.2
S_{DS}:	0.165
S_1:	0.055
F_V:	1.7
S_{D1}:	0.094
S_{Dc}:	A
T_S:	0.572
T_0:	0.114



Attachment F

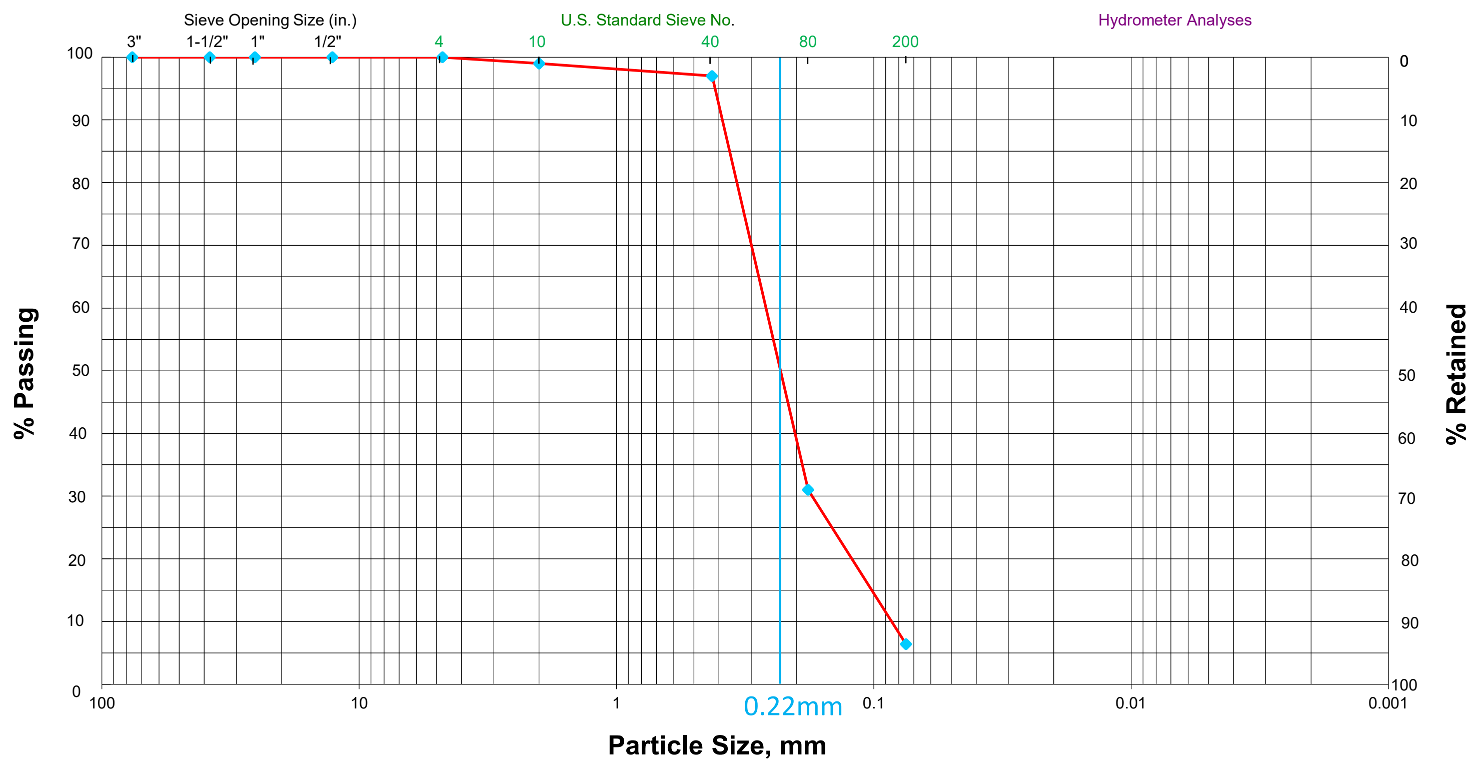
Station 104+70, 156' LT CL
D50 = 0.91mm



Particle Size Distribution Curve

ARDOT

Station 107+60, 150' LT CL
D50 = 0.22mm



Particle Size Distribution Curve

ARDOT

ARKANSAS DEPARTMENT OF TRANSPORTATION
ARDOT.gov | IDriveArkansas.com | Lorie H. Tudor, P.E., Director
MATERIALS DIVISION
11301 West Baseline Road | P.O. Box 2261 | Little Rock, AR 72203-2261 | Phone: 501.569.2185 | Fax: 501.569.2368

May 11, 2021

TO: Mr. Rick Ellis, Bridge Engineer

SUBJECT: Job No. BR7615
Mulberry River Str. & Apprs. (S)
Crawford & Franklin Counties
County Road 67

Submitted herein are abutment slope recommendations for construction of the replacement bridge over Mulberry River and Mulberry Relief Creek on County Road 67 in Crawford and Franklin Counties. This report is supplemental to the foundation report dated March 24, 2021.

Based on plans provided by Bridge Division, the west abutment fill will be placed on top of the existing embankment and will have a 2H:1V end slope and 3H:1V side slopes. The east abutment slope will be placed in a new location on top of the existing gravel county road 67 and will have a similar slope geometry with a 2H:1V end slope and 3H:1V side slopes.

ARDOT Geotechnical section personnel performed stability analyses for deep-seated, global failure of bridge abutment slopes using the Rocscience computer program Slide 2018. Three different stability conditions were analyzed for the west and east abutment slopes: end of construction (short term), long term, and pseudo-static (seismic). The 2H:1V bridge end slopes were modeled and analyzed for both abutments, since these are the steepest and most critical. A pseudo-static seismic acceleration of 0.035g, corresponding to one-half of the peak ground acceleration (per NCHRP 611 and FHWA Publication HI-99-012) was utilized for the seismic design. The analysis conditions, recommended minimum factors of safety, and calculated minimum factors of safety are listed below in Tables 1 and 2 for the west and east abutment slopes, respectively. The modeled abutment slopes showing the minimum factor of safety, critical slip surface, and design soil properties for the west and east abutment slopes are included in Attachment A and B, respectively.

Table 1: West Abutment Stability Analysis Summary

Analysis Condition	Recommended Minimum Factor of Safety	Calculated Minimum Factor of Safety
End of Construction (Short Term)	1.3	4.80
Long Term	1.4	1.62
Pseudo-Static (Seismic)	1.1	1.42

Table 2: East Abutment Stability Analysis Summary

Analysis Condition	Design Minimum Factor of Safety	Calculated Minimum Factor of Safety
End of Construction (Short Term)	1.3	2.33
Long Term	1.4	1.73
Pseudo-Static (Seismic)	1.1	1.58

Based on the results of the stability analyses and their respective calculated factors of safety, the current slope geometry is acceptable for all conditions.

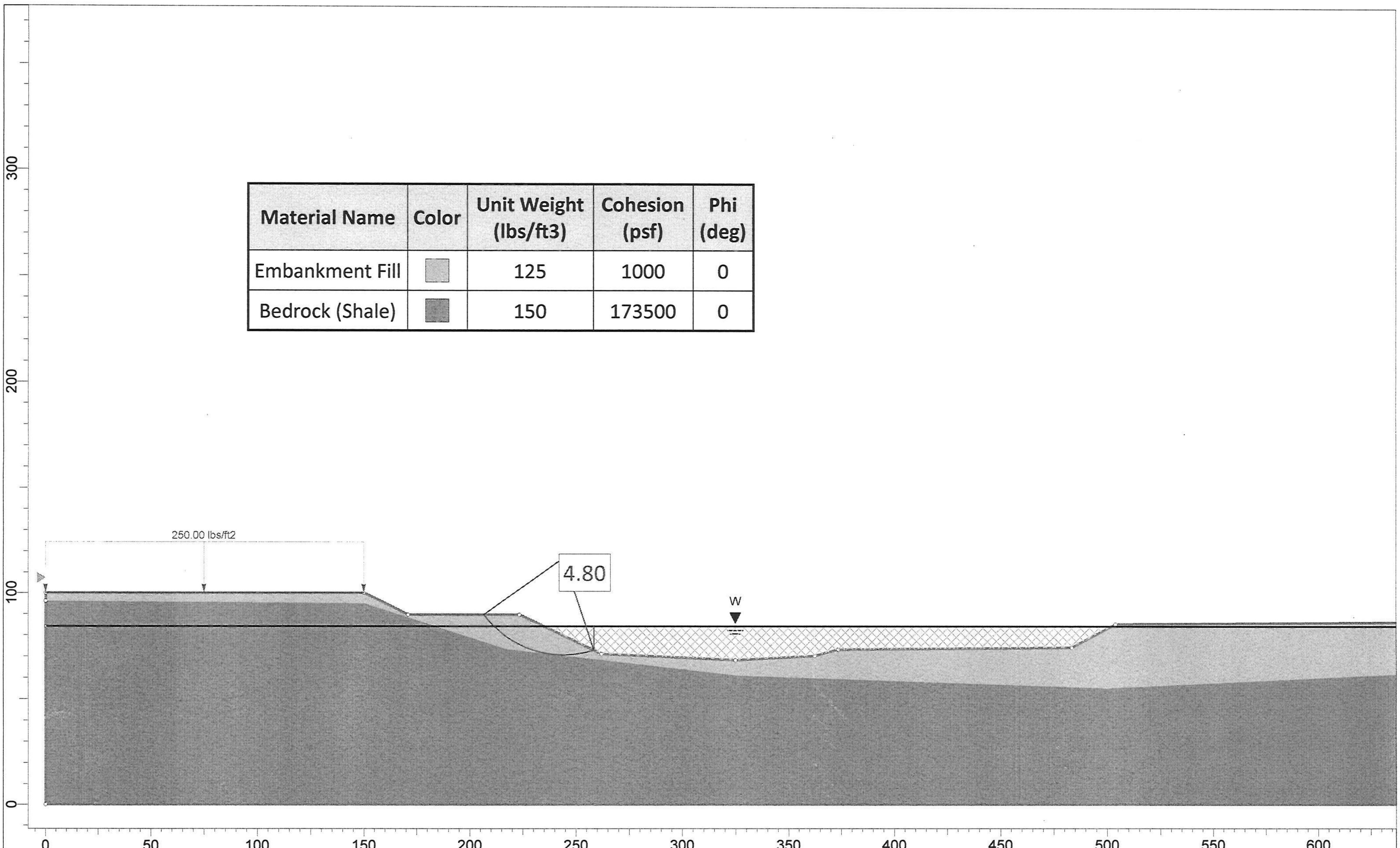
If you have any question concerning these recommendations, please contact the Geotechnical Section.

Jonathan A. Annable
Materials Engineer

JAA:yz:mlg
cc: State Construction Engineer - Master File Copy
District 4 Engineer
G.C. File

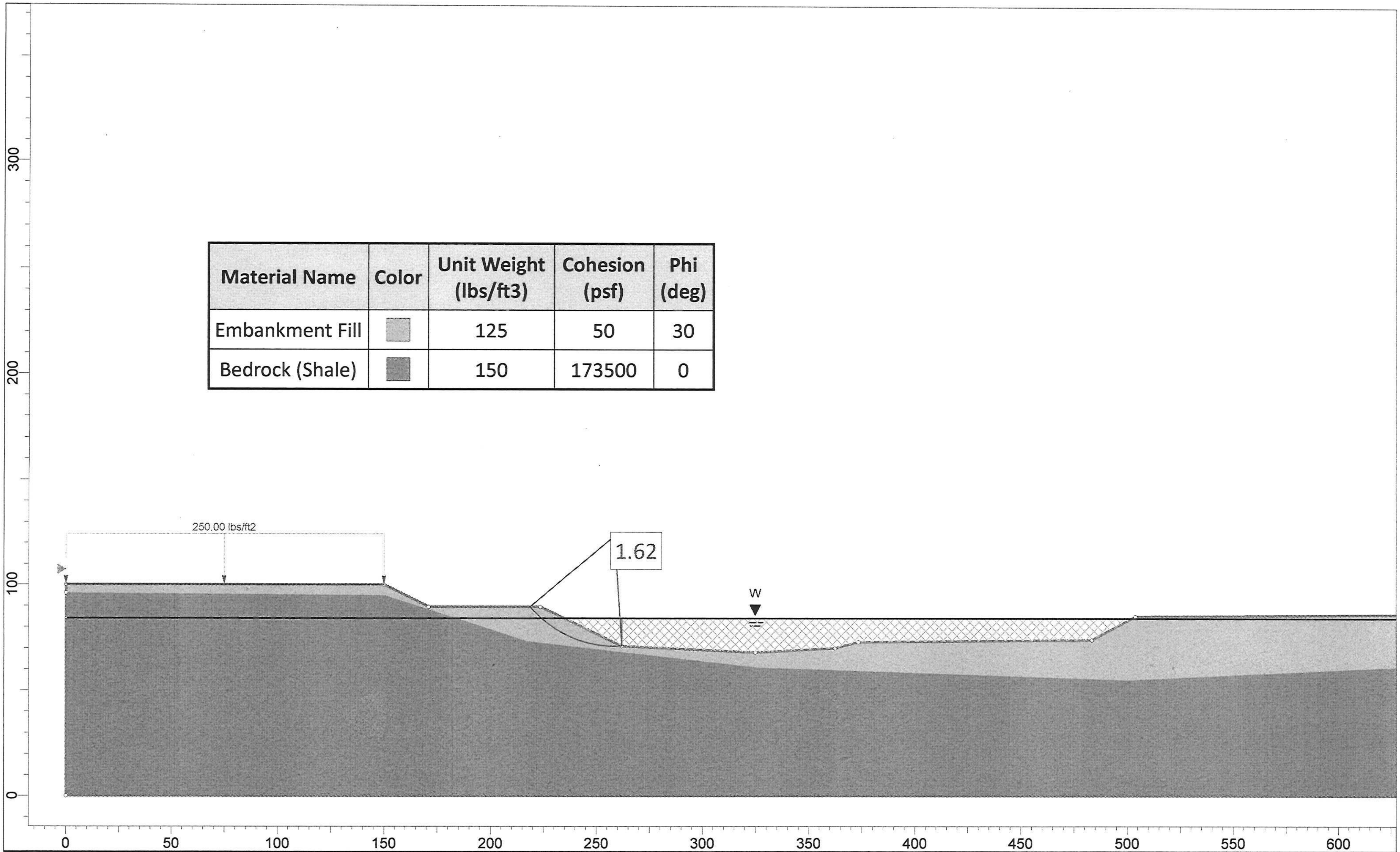
Attachment A

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Embankment Fill		125	1000	0
Bedrock (Shale)		150	173500	0

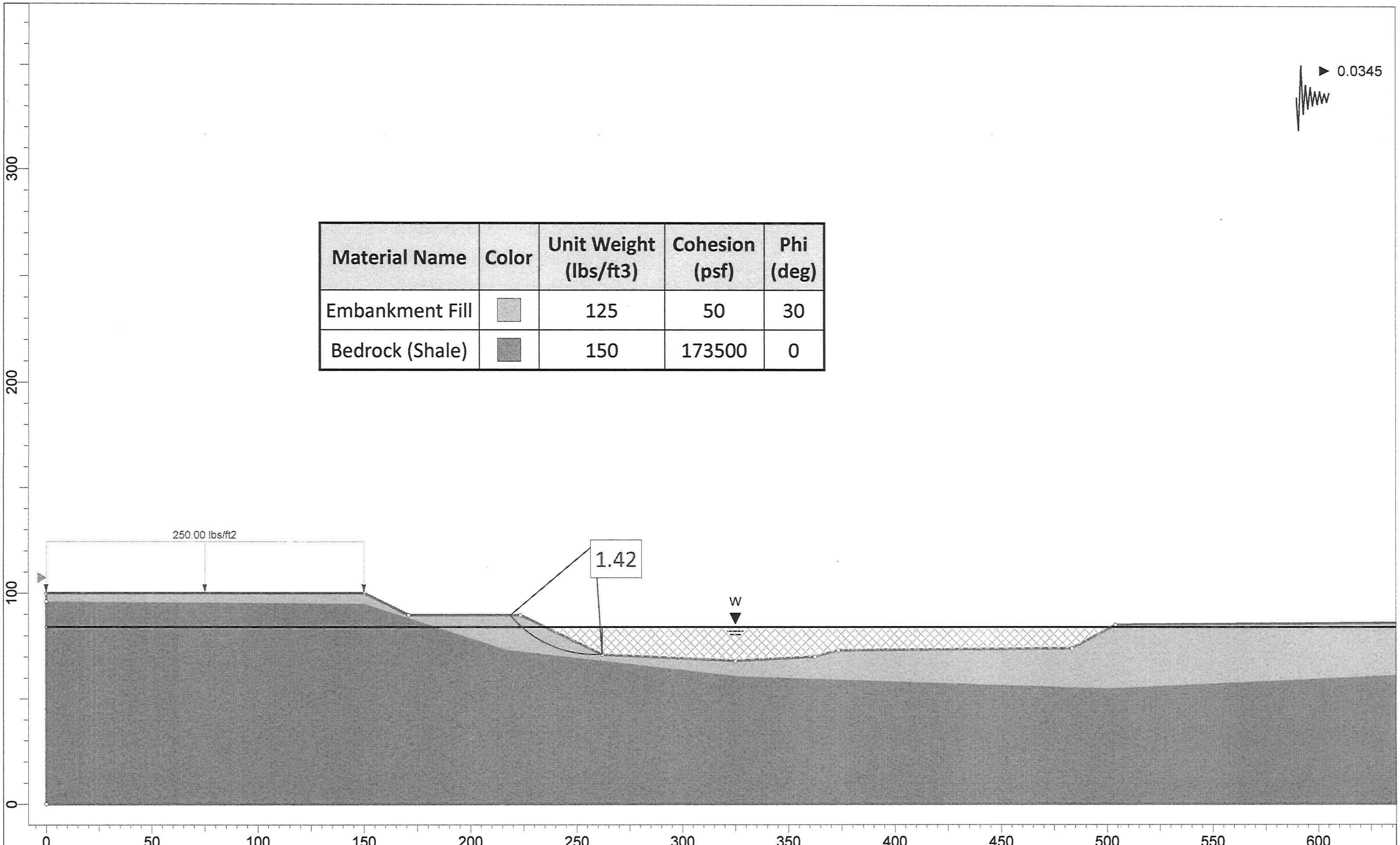


rocscience	Project: BR7615 - Mulberry River Str. & Apprs. (S)
	Analysis Description: West Embankment - End of Construction
	Drawn By: MLG / Scale: 1:751 / Company: ARDOT
SLIDEINTERPRET 8.031	Date: 4/8/2021, 4:05:40 PM / File Name: BR7615 West Embankment - End of Const..slmd

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Embankment Fill		125	50	30
Bedrock (Shale)		150	173500	0



rocscience	Project	BR7615 - Mulberry River Str. & Arrps. (S)	
	Analysis Description	West Embankment - Long Term	
	Drawn By	MLG	Scale 1:751	Company ARDOT
SLIDEINTERPRET 8.031	Date	4/8/2021, 4:05:40 PM	File Name BR7615 West Embankment - Long Term.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Embankment Fill		125	50	30
Bedrock (Shale)		150	173500	0

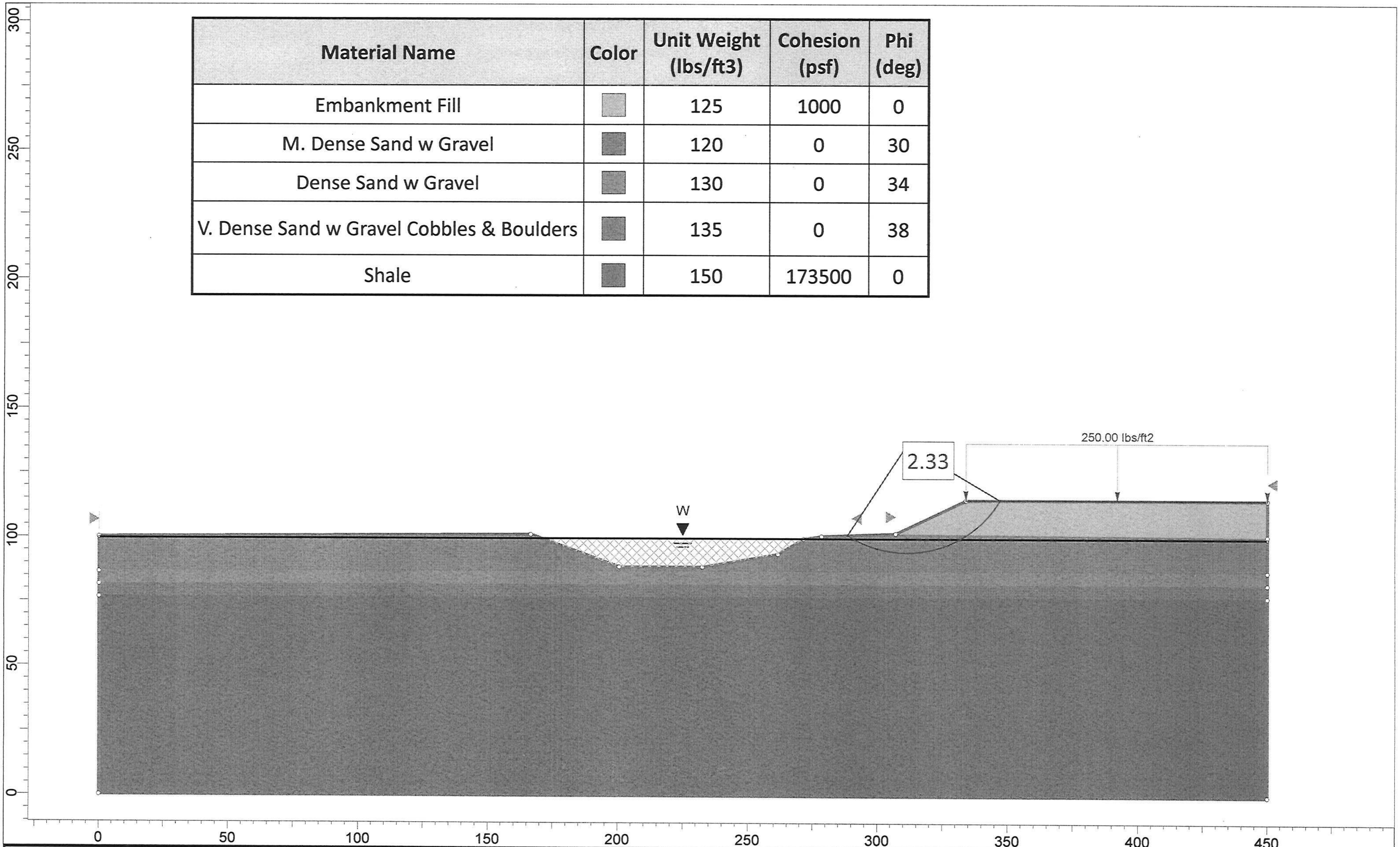
rocscience

SLIDEINTERPRET 8.031

Project	BR7615 - Mulberry River Str. & Arrps. (S)
Analysis Description	West Embankment - Seismic
Drawn By	MLG
Scale	1:751
Company	ARDOT
Date	4/8/2021, 4:05:40 PM
File Name	BR7615 West Embankment - Seismic.slmd

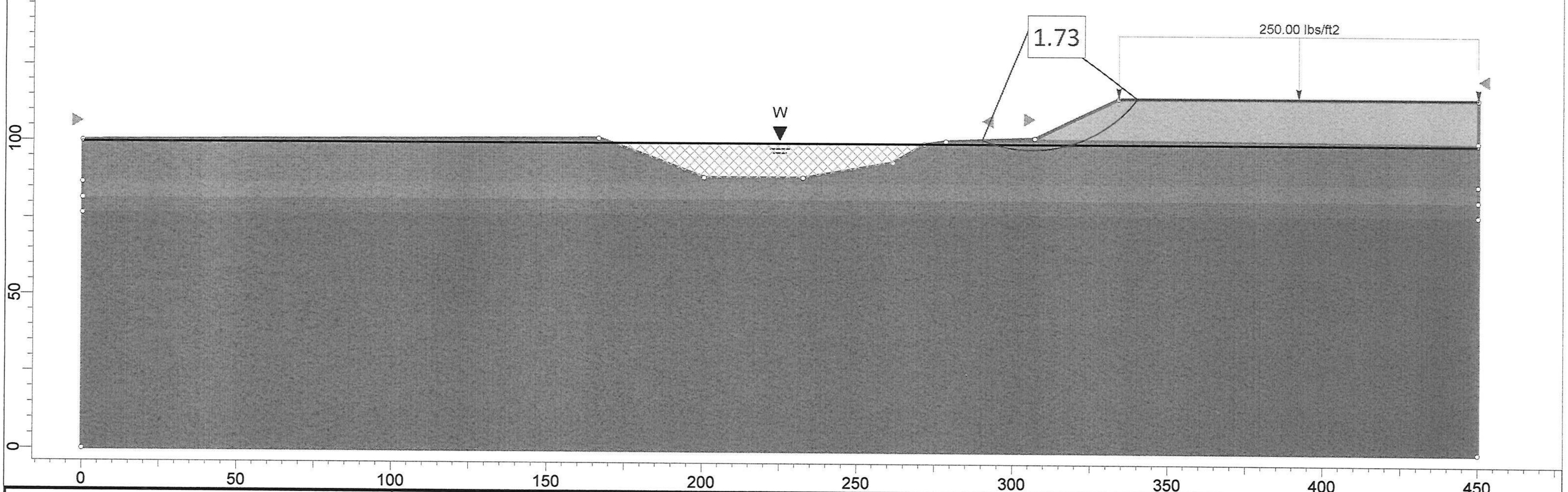
Attachment B

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Embankment Fill		125	1000	0
M. Dense Sand w Gravel		120	0	30
Dense Sand w Gravel		130	0	34
V. Dense Sand w Gravel Cobbles & Boulders		135	0	38
Shale		150	173500	0



rocscience	Project: BR7615 - Mulberry River Str. & Apprs. (S)		
	Analysis Description: East Embankment - End of Construction		
	Drawn By: MLG	Scale: 1:613	Company: ARDOT
SLIDEINTERPRET 8.031	Date: 4/20/2021, 8:49:24 AM		File Name: BR7615 East Embankment - End of Const..slmd

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Embankment Fill		125	50	30
M. Dense Sand w Gravel		120	0	30
Dense Sand w Gravel		130	0	34
V. Dense Sand w Gravel Cobbles & Boulders		135	0	38
Shale		150	5000	0

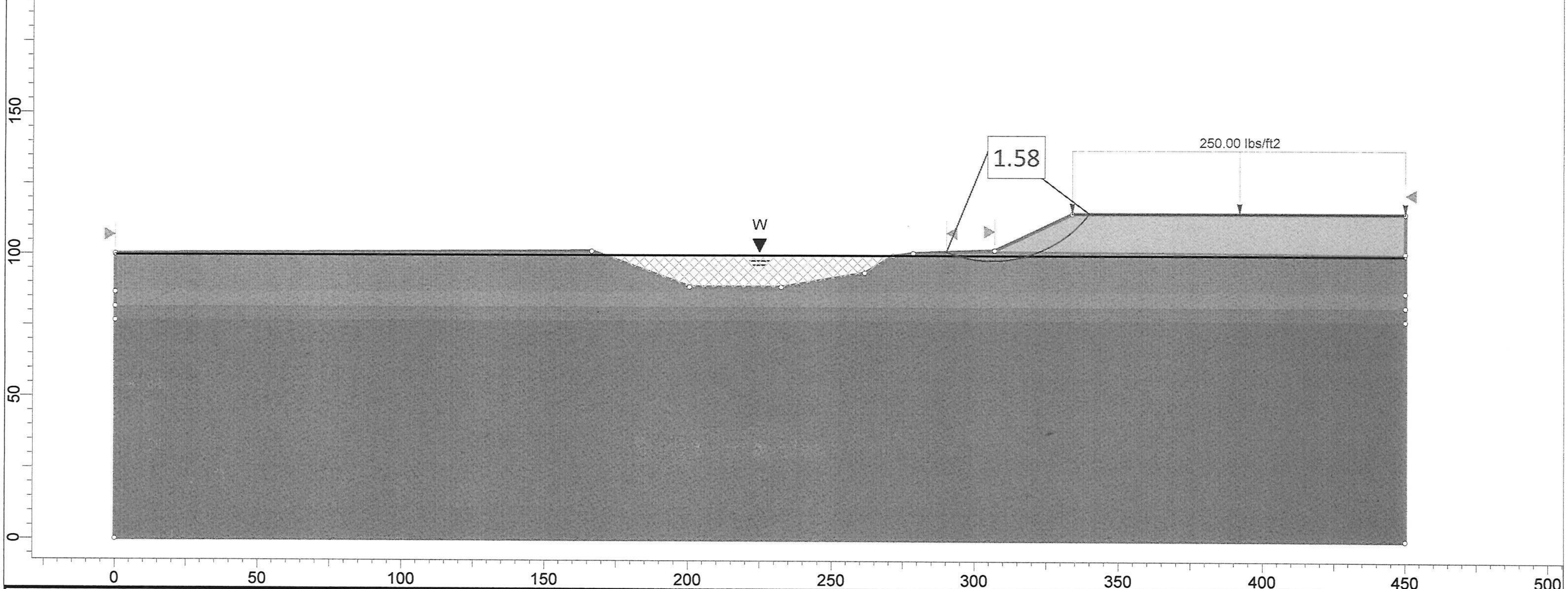


rocscience

Project	BR7615 - Mulberry River Str. & Apprs. (S)		
Analysis Description	East Embankment - Long Term		
Drawn By	MLG	Scale 1:574	Company ARDOT
Date	4/20/2021, 8:49:24 AM	File Name	BR7615 East Embankment - Long Term.slmd

SLIDEINTERPRET 8.031

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Embankment Fill		125	50	30
M. Dense Sand w Gravel		120	0	30
Dense Sand w Gravel		130	0	34
V. Dense Sand w Gravel Cobbles & Boulders		135	0	38
Shale		150	5000	0



rocscience

Project	BR7615 - Mulberry River Str. & Apprs. (S)		
Analysis Description	East Embankment - Seismic		
Drawn By	MLG	Scale 1:622	Company ARDOT
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SLIDEINTERPRET 8.031