

ARKANSAS DEPARTMENT OF TRANSPORTATION



**SUBSURFACE INVESTIGATION**

STATE JOB NO. 110717

FEDERAL AID PROJECT NO. ACNHPP-0068(47)

N.E. ST. FRANCIS CO. STRS. & APPRS. (S)

STATE HIGHWAY 50, 75, & 357 SECTION 1, 0, & 1

IN ST. FRANCIS COUNTY

The information contained herein was obtained by the Department for design and estimating purposes only. It is being furnished with the express understanding that said information does not constitute a part of the Proposal or Contract and represents only the best knowledge of the Department as to the location, character and depth of the materials encountered. The information is only included and made available so that bidders may have access to subsurface information obtained by the Department and is not intended to be a substitute for personal investigation, interpretation and judgment of the bidder. The bidder should be cognizant of the possibility that conditions affecting the cost and/or quantities of work to be performed may differ from those indicated herein.



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

October 12, 2020

**TO:** Mr. Trinity Smith, Engineer of Roadway Design

**SUBJECT:** Job No. 110717  
N. E. St. Francis Co Strs. & Apprs. (S)  
Routes 50, 75, 357 Sections 1, 0, 1  
St. Francis County

Based on soil information from projects in the surrounding area, an estimated R-Value of less than five is appropriate for pavement design.

Listed below is the additional information requested for use in developing the plans:

Asphalt Concrete Hot Mix

<u>Type</u>	<u>Asphalt Cement %</u>	<u>Mineral Aggregate %</u>
Surface Course	5.2	94.8
Binder Course	4.3	95.7
Base Course	3.9	96.1

  
Jonathan A. Annable  
Materials Engineer

JAA:pt:bjj  
Attachment

cc: State Constr. Eng. – Master File Copy  
District 1 Engineer  
System Information and Research Div.  
G. C. File



ARKANSAS DEPARTMENT OF TRANSPORTATION

[ARDOT.gov](http://ARDOT.gov) | [IDriveArkansas.com](http://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 22, 2023

**TO:** Mr. Rick Ellis, Bridge Engineer

**SUBJECT:** Job No. 110717  
N.E. St. Francis Co. Strs. & Apprs. (S)  
St. Francis County  
Route 50, Section 1

As per the request from Bridge Division by interoffice memo dated July 6, 2021, a surface investigation was conducted by Materials Division for the subject project. This project consisted of performing two borings for the proposed bridge over Blackfish Bayou. Lab test on recovered soil samples and geotechnical analyses were conducted by ARDOT staff and are included in this report. Recommendations were made based on the results of the analyses and are also included in this report.

If there are any questions concerning the recommendations made, please contact the Materials Division.

A handwritten signature in blue ink that reads 'Paul Tinsley'.

Paul Tinsley  
Materials Engineer

# Geotechnical Report

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**Job No. 110717**

**N.E. St. Francis Co. Strs. & Apprs. (S)**

**Hwy. 50 over Blackfish Bayou**



**Prepared For:**

Bridge Division

*ARDOT*

**Prepared By:**

Geotechnical Section

*Materials Division*





## **INTRODUCTION**

Submitted herein are the results of the subsurface investigation and geotechnical recommendations for the proposed bridge planned on Highway 50 in St. Francis County.

This project consists of constructing two (2) structures: a box culvert to replace the existing bridge on Highway 75 (Site 1) over an agriculture irrigation ditch, and one bridge to replace the existing bridge on Highway 50 (Site 2) over Blackfish Bayou. The proposed bridge crossing Blackfish Bayou consists of a 209 feet long integral composite prestressed concrete girder unit (Type IV) with an out-to-out width of 32.5 feet.

Based on the correspondence with Bridge Division, foundation loads are expected to be supported on 18 inch and 24 inch diameter concrete filled steel shell piles at the end bents and intermediate bents, respectively. 2-Horizontal to 1-vertical (2H:1V) end slopes and 3H:1V side slopes are planned for the bridge embankment. Maximum embankment height varies from 15 feet to 17 feet. Dumped riprap will be utilized to protect both abutment slopes.

## **FIELD INVESTIGATION**

A subsurface investigation was requested on July 6, 2021 by Bridge Division to develop recommendations for bridge foundations and to verify the suitability of bridge embankment configuration. Four (4) borings were requested at Blackfish Bayou and two (2) borings were performed at offset locations, due to access limitations and utility conflicts. Proposed intermediate bent borings were inaccessible due to steep slopes and high water in the river channel.

The approximate locations of the borings at Blackfish Bayou are presented in the Plan of Borings included in Attachment A. All borings were advanced with an Acker Renegade rotary drill rig using a combination of hollow-stem auger and rotary wash methods. The respective boring logs, showing the subsurface conditions encountered in the borings and the results of field and laboratory tests, are also included in Attachment A, immediately following the Plan of Borings. A Legend is attached after the boring logs to interpret / explain the symbols, terms, and conventions used on the logs. Standard Penetration Tests (SPT) were conducted in accordance with ASTM D1586 for field-testing and soil sampling. The correction factor for the hammer is indicated on the boring logs. Liners were not used inside the standard split-barrel samplers.

The number of blows required to drive the standard split-barrel sampler for each 6-inch increment of the total 18-inch drive were measured and recorded on the boring logs. SPT N-values are defined as the total number of blows required to advance the split barrel sampler the final 12 inches of the total 18-inch drive depth. The SPT N-values indicated on the logs are raw (uncorrected) blow counts measured in field.

Undisturbed samples of cohesive soils were obtained for laboratory determination of engineering properties using thin-wall tube samplers (Shelby tubes) hydraulically inserted into the subsurface soils.

## **LAB INVESTIGATION**

All samples were brought to the Materials laboratory for further evaluation and testing. These samples were tested to evaluate index and engineering properties and to verify soil type and classification. Lab tests were performed on representative soil samples to determine moisture



content, Atterberg limits, and gradation. Tested soils were classified by experienced professionals in accordance with both USCS and AASHTO soil classification systems. Strength of cohesive soils was evaluated by unconsolidated-undrained (UU) triaxial compression tests on undisturbed Shelby tube samples.

These test results are plotted or indicated on the logs using appropriate denotation (symbols in accordance with scale, number, text, etc.). Table 1 lists the laboratory test, their corresponding ASTM and AASHTO test methods, and the respective denotation are shown on the logs.

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
Atterberg Limits	D4318	T 89 and T 90
UU Triaxial Compression	D2850	T 296
One-Dimensional Consolidation Properties of Soils	D2435	T 216

The particle size through which 50% of particles by weight passing,  $D_{50}$ , is summarized below in Table 2. Detailed particle size distribution curves used for  $D_{50}$  determination are included in Attachment B.

Table 2: Summary of  $D_{50}$  for Scour Analysis

Bridge	Station	Sample Type	Location	$D_{50}$ , mm
Blackfish Bayou	211+55, 65' RT	Bulk	Creek Bank	<0.075

**SITE CONDITIONS**

The existing bridge (No. M3331) is a 189.8 feet long, 27.8 feet wide, 10 span structure that spans Blackfish Bayou. The bridge spans consist of 19 feet precast concrete channel beams supported by timber piles. Timber piles from a previous structure were observed in the channel upstream of the existing bridge. The bridge has concrete end walls and both end slopes under the bridge have been plated with riprap. There are steel guardrails leading up to the existing bridge and steel guardrails supported by concrete posts spanning the bridge. At the project location, Blackfish Bayou flows north to south and is located in a deep narrow channel that meanders through agricultural fields. Overhead power lines parallel the north side of Route 50 over Blackfish Bayou. No other utilities were observed at this location. Site photos are included in Attachment C.

**SITE GEOLOGY AND GENERAL SUBSURFACE CONDITIONS**

The existing bridge at Blackfish Bayou is located east of Forrest City in the mapped outcrops of Quaternary alluvium. This includes alluvial deposits in major stream channels and in mappable meanders of major streams (map symbol Qcm) and alluvial deposits from local streams and overbank flow from major streams (map symbol Qso). These deposits overlie Late Wisconsin



Stage Valley Train deposits, which can be described as gently sloping plains underlain by coarse-grained glacial outwash confined by valley walls. Alluvial deposits have been further delineated in a more detailed map as point bar deposits of Mississippi River meander belts (map symbol Hpm 2). According to this map, the bridge also lies within the boundaries of an abandoned channel. Abandoned channels typically consist of low-density clayey soils. Low-density clay was encountered in both borings from approximately 15 to 70 feet below ground level. Valley Train deposits were encountered in both borings at around 65 to 70 feet below ground level.

A generalized Subsurface Profile is included in Attachment D to aid in visualizing subsurface conditions and stratigraphy. In light of natural variations in stratigraphy and subsurface conditions, deviation from these illustrated on the profile must be anticipated.

**SEISMIC CONDITIONS**

Seismic Site Class and Seismic Performance Zone – In light of the average subsurface conditions as revealed by the borings, a **Seismic Site Class E (Soft Soil Profile)** was calculated for the project site. Utilizing the Seismic Site Class E and the approximate GPS coordinates of the project site, the following code-based design peak ground acceleration coefficient ( $A_S$ ), design short-period spectral acceleration coefficient ( $S_{DS}$ ), as well as design long-period spectral acceleration coefficient ( $S_{D1}$ ), are determined. These seismic coefficients are summarized in Table 3. Design Response Spectrum is presented in Attachment E. For the design long-period spectral acceleration coefficient ( $S_{D1}$ ) of 0.665, a **Seismic Performance Zone 4** is considered applicable.

Table 3: Design Ground Motion Acceleration Response Coefficients

Coefficient	Code-Based Value (g)
	Blackfish Bayou
$A_S$ (Site PGA)	0.39
$S_{DS}$ (0.2 sec)	0.914
$S_{D1}$ (1 sec)	0.665

Site-specific ground motion response analysis was not performed for this bridge site. However, at least 10 site-specific seismic studies have been performed adjacent (within 25-mile radius) to and around the project site. Based on these studies performed near and around the project site, a design value of **0.26 for  $A_S$** , which is 67% of the code-based value of 0.39, is considered appropriate for seismic analysis and design of this bridge that has an assigned Seismic Operational Classification of “Other” and a projected ADTT (Average Daily Truck Traffic) of 36 in the year of 2043.

Liquefaction Potential – Liquefaction potential of the subsurface soils were evaluated based on the results of the borings and utilizing the current Microsoft Excel® spreadsheet developed by the University of Arkansas for ARDOT. Three (3) procedures are incorporated into this spreadsheet, i.e., Youd et al. (2001) procedure, Idriss and Boulanger (2012) procedure, and Cetin et al. (2018) procedure. The results of liquefaction analyses performed utilizing the Idriss and Boulanger (2012) procedure are presented in this report.



An earthquake Moment Magnitude ( $M_w$ ) of 7.5 and the design peak ground acceleration coefficient ( $A_s$ ) of 0.26 were modelled in the analysis. Utilizing the data from Boring 1 and Boring 2 at Blackfish Bayou, the results were plotted for Bents 1 and 4 and are presented in Attachment F as a plot of calculated factor of safety against liquefaction versus depth below existing ground surface at the boring location.

Although the spreadsheet was developed with the capability to calculate factor of safety against liquefaction to any depth, research suggest that there has only been one case in which liquefaction has occurred at a depth greater than 50 feet. Liquefaction below 50-foot depth is generally considered unlikely. Consequently, it is recommended liquefiable zones below 50-foot-depth be neglected from design consideration.

At Bent 1, a factor of safety of less than one is calculated between depths of 15 and 70 feet. At Bent 4, a factor of safety of less than one is calculated between a depth of 65 and 70 feet.

### **PLAN APPROACH EMBANKMENTS**

Configuration – As noted, 2H:1V end slopes and 3H:1V side slopes are planned for the embankments at Blackfish Bayou. Maximum embankment height varies from approximately 15 feet to 17 feet.

Settlement Analysis – A settlement analysis was performed utilizing data from undisturbed samples at Boring 1. It was determined that due to thick clay stratum and loading from the placement of fill at the planned west abutment, excessive consolidation settlement of **10 to 15 inches** was calculated. With similar cohesive stratum and similar abutment configuration, approximately equal consolidation settlement at the east abutment should be anticipated.

Slope Stability – Stability analyses have been performed on the approximately 15 feet tall, 2H:1V and approximately 17 feet tall, 2H:1V end slopes for the west and east abutment, respectively, to evaluate the design abutment configuration. Slope stability analyses were performed utilizing a commercial computer program Slide2 (Version 2021) developed by RocScience. Spencer analysis method was utilized to analyze each abutment at Blackfish Bayou. Three (3) general loading conditions were analyzed with respect to slope stability: Short Term / End of Construction Condition, Long Term Condition, and Seismic / Pseudo-Static Condition. A horizontal acceleration coefficient ( $k_h$ ) of 0.13 ( $0.5A_s$ ) was utilized for analysis of the Seismic / Pseudo-Static Condition.



A surcharge of 250 psf is included to model the live load in Long Term Condition. The results of the analyses mentioned above are listed in Table 4.

Table 4. Results of Slope Stability Analyses Utilizing Plan Configuration

Loading Condition	Factor of Safety		Recommended Minimum Factor of Safety
	West Embankment	East Embankment	
Short Term / End of Construction	0.97	1.19	1.3
Long Term	1.57	1.55	1.4
Seismic	0.55	0.70	1.05

**Conclusion** – The analyses listed above were performed based on plan configuration without consideration of ground improvements. Based on these analyses, plan configuration of the west and east abutments without ground improvements yields an excessive settlement of **10 to 15 inches** and unstable abutment end slopes.

**GROUND IMPROVEMENTS**

**Proposed Improvements** – Ground improvements are necessary in order to mitigate liquefaction, limit settlement and to provide stable abutment slopes. Several alternatives were considered but due to the ability to mitigate liquefaction in conjunction with reducing settlement and providing slope reinforcement, timber piles are recommended for this project. Analysis was performed utilizing a trial and error approach with different timber pile configurations. Recommended timber pile configuration is shown in Attachment G. A Special Provision including information regarding Timber Piling is included in Attachment H.

**Settlement Analysis** – Settlement analysis with the addition of Timber Piles was performed by determining the settlement within the reinforced zone and the settlement below the reinforced zone. Due to the densification effects and reduced compressibility of the cohesive layers beneath the planned abutments, the settlement was calculated to be less than **2 inches** at the west and east abutment.

**Slope Stability** – Spencer analysis method was utilized to analyze each abutment supported on reinforced subgrade. The results of the analyses are shown in Attachment I and listed in Table 5.



Table 5. Results of Slope Stability Analyses Utilizing Timber Piles

Loading Condition	Factor of Safety		Recommended Minimum Factor of Safety
	West Embankment	East Embankment	
Short Term / End of Construction	1.73	1.67	1.3
Long Term	1.57	1.57	1.4
Seismic	0.89	0.92	1.05

Newmark Analysis – As shown in Table 5, the east and west abutment with the subgrade reinforcement under the Seismic Loading Condition have a factor of safety below the recommended minimum value. Due to the inadequate factor of safety, the abutment end slope was analyzed utilizing Simplified Newmark Method analysis.

Conclusion – As stated in “Proposed Improvements”, Timber piles are recommended for this project and were utilized for settlement and slope stability analyses. The anticipated settlement at the west and east abutments was determined to be reduced from **10 - 15 inches** to less than **2 inches**. Slope stability for the abutment end slopes were acceptable under the Short Term and Long Term loading conditions. However, due to the factor of safety under the Seismic Loading Condition being less than the recommended minimum value, Newmark Method analysis was analyzed. Calculations included in Attachment J, show a displacement of **11.6 inches** and **10.3 inches** for the west and east abutment end slope, respectively.

**DEEP FOUNDATIONS**

It is anticipated that 18-inch diameter, Concrete-Filled Steel Shell piles will be utilized to support the foundation loads at the end bents with a required nominal axial compression capacity of 175 tons. For the intermediate bents, 24-inch diameter, Concrete-Filled Steel Shell piles will be utilized to support the foundation loads with a required nominal axial compression capacity of 325 tons.

Nominal axial capacities (compression and uplift) vs. pile tip penetration / elevation curves for single 18-inch diameter and single 24-inch diameter Concrete-Filled Shell Piles are provided in Attachment K. These nominal axial capacities have been calculated using static analysis method. For single isolated foundations, a resistance factor ( $\phi_{stat}$ ) of 0.45 is recommended for calculating factored compression resistance and a resistance factor ( $\phi_{up}$ ) of 0.35 is recommended for determining factored uplift resistance.

Based on the axial pile capacity curves, it is determined the following shallowest pile tip elevation will be required to obtain the nominal compression capacity of 175 tons for the 18-inch diameter piles at the end bents.

Table 6. Summary of Recommended Shallowest Pile Tip Elevation – Abutment Piles

Structure	Bent No.	Boring No.	Recommended Shallowest Pile Tip Elevation (ft.)
Hwy. 50 over Blackfish Bayou	1	1	115
	4	2	120

For the 24-inch diameter piles at the intermediate bents, the following shallowest piles tip elevation will be required to achieve the nominal compression capacity of 325 tons.

Table 7. Summary of Recommended Shallowest Pile Tip Elevation – Intermediate Piles

Structure	Bent No.	Boring No.	Recommended Shallowest Pile Tip Elevation (ft.)
Hwy. 50 over Blackfish Bayou	2	1	105
	3	2	105

Piling should commence only after the required consolidation settlement is determined to be complete. If piles are to be driven before the required consolidation is complete, the axial pile capacities provided in Attachment K should be re-evaluated. In addition, these capacities are determined for piles driven to the required penetration / elevation. If jetting or other methods are used to assist in advancing the piles, re-evaluation of these pile capacities will be warranted.

The nominal capacities are based on single, isolated foundations. Group effect on pile resistance should be evaluated in accordance with AASHTO LRFD Sections 10.7.3.9 and 10.7.3.10 for compression resistance and uplift resistance respectively. For evaluation of pile group settlement, Sections 10.7.2.3 applies. Materials Division is available to assist in evaluating group effect upon request when detailed pile group configuration is provided.

It is recommended a minimum of one (1) dynamic load test be performed at an abutment bent (e.g., Bent 4) and at an intermediate bent (e.g., Bent 2) to verify the calculated nominal axial pile compression capacity. Dynamic testing should be conducted in accordance with ASTM D4945 as specified in AASHTO LRFD Section 10.7.3.8.3. Materials Division recommends a minimum of 2 percent of the production piles be subject to dynamic testing. Piles from each bent should be tested. Dynamic testing should be performed on the test piles at the end of initial drive as well as after a restrike. Due to the high plasticity of the clay, Materials Division recommends a restrike test be performed at least seven (7) days after the initial drive. Test piles subjected to dynamic testing are



suitable for use as production piles to support foundation loads. It is understood drivability analysis and lateral load analysis will be performed by Bridge Division.

Geotechnical Input Parameters for Lateral Load Analysis Using LPile – Lateral Load analysis will be performed by the Structural Engineer using commercial computer program LPile. Table 8 through Table 11 contain the geotechnical input parameters recommended for use in LPile lateral load analysis.

Table 8. Recommended Geotechnical Parameters for LPile Analysis – Bent 1

Elevation (ft.)	p-y Curve Model	Effective Unit Weight ( $\gamma'$ ) (pcf)	Undrained Shear Strength ( $c_u$ ) (psf)	Strain Factor ( $\epsilon_{50}$ )	Friction Angle ( $\phi$ ) (Deg.)	Soil Modulus (k) (pci)
Above Existing Grade (fill)	Soft Clay (Matlock)	125	750	0.01	NA	NA
Existing Grade to 181	Soft Clay (Matlock)	112	750	0.01	NA	NA
181 to 166	Soft Clay (Matlock)	50	400	0.02	NA	NA
166 to 126	Soft Clay (Matlock)	48	300	0.02	NA	NA
126 to 116	Sand (Reese)	65	NA	NA	30	20.3
116 to 111	Sand (Reese)	73	NA	NA	34	66.6
111 to 94	Sand (Reese)	78	NA	NA	38	119.2

Table 9. Recommended Geotechnical Parameters for LPile Analysis – Bent 2

Elevation (ft.)	p-y Curve Model	Effective Unit Weight ( $\gamma'$ ) (pcf)	Undrained Shear Strength ( $c_u$ ) (psf)	Strain Factor ( $\epsilon_{50}$ )	Friction Angle ( $\phi$ ) (Deg.)	Soil Modulus (k) (pci)
181 to 166	Soft Clay (Matlock)	50	400	0.02	NA	NA
166 to 126	Soft Clay (Matlock)	48	300	0.02	NA	NA
126 to 116	Sand (Reese)	65	NA	NA	30	20.3
116 to 111	Sand (Reese)	73	NA	NA	34	66.6
111 to 94	Sand (Reese)	78	NA	NA	38	119.2

Table 10. Recommended Geotechnical Parameters for LPile Analysis – Bent 3

Elevation (ft.)	p-y Curve Model	Effective Unit Weight ( $\gamma'$ ) (pcf)	Undrained Shear Strength ( $c_u$ ) (psf)	Strain Factor ( $\epsilon_{50}$ )	Friction Angle ( $\phi$ ) (Deg.)	Soil Modulus (k) (pci)
169 to 128	Soft Clay (Matlock)	47	450	0.02	NA	NA
128 to 123	Sand (Reese)	63	NA	NA	31	36.4
123 to 118	Soft Clay (Matlock)	47	600	0.01	NA	NA
118 to 83	Sand (Reese)	68	NA	NA	34	66.6
83 to 71	Sand (Reese)	73	NA	NA	36	92.6

Table 11. Recommended Geotechnical Parameters for LPile Analysis – Bent 4

Elevation (ft.)	p-y Curve Model	Effective Unit Weight ( $\gamma'$ ) (pcf)	Undrained Shear Strength ( $c_u$ ) (psf)	Strain Factor ( $\epsilon_{50}$ )	Friction Angle ( $\phi$ ) (Deg.)	Soil Modulus (k) (pci)
Above Existing Grade (fill)	Soft Clay (Matlock)	120	750	0.01	NA	NA
Existing Grade to 185	Stiff Clay Above Water	125	1500	0.007	NA	NA
185 to 180	Stiff Clay Below Water	42	1100	0.007	NA	200
180 to 135	Soft Clay (Matlock)	47	450	0.02	NA	NA
135 to 130	Sand (Reese)	63	NA	NA	31	36.4
130 to 125	Soft Clay (Matlock)	47	600	0.01	NA	NA
125 to 90	Sand (Reese)	68	NA	NA	34	66.6
90 to 78	Sand (Reese)	73	NA	NA	36	92.6

If there are any questions concerning these recommendations, please contact the Materials Division.

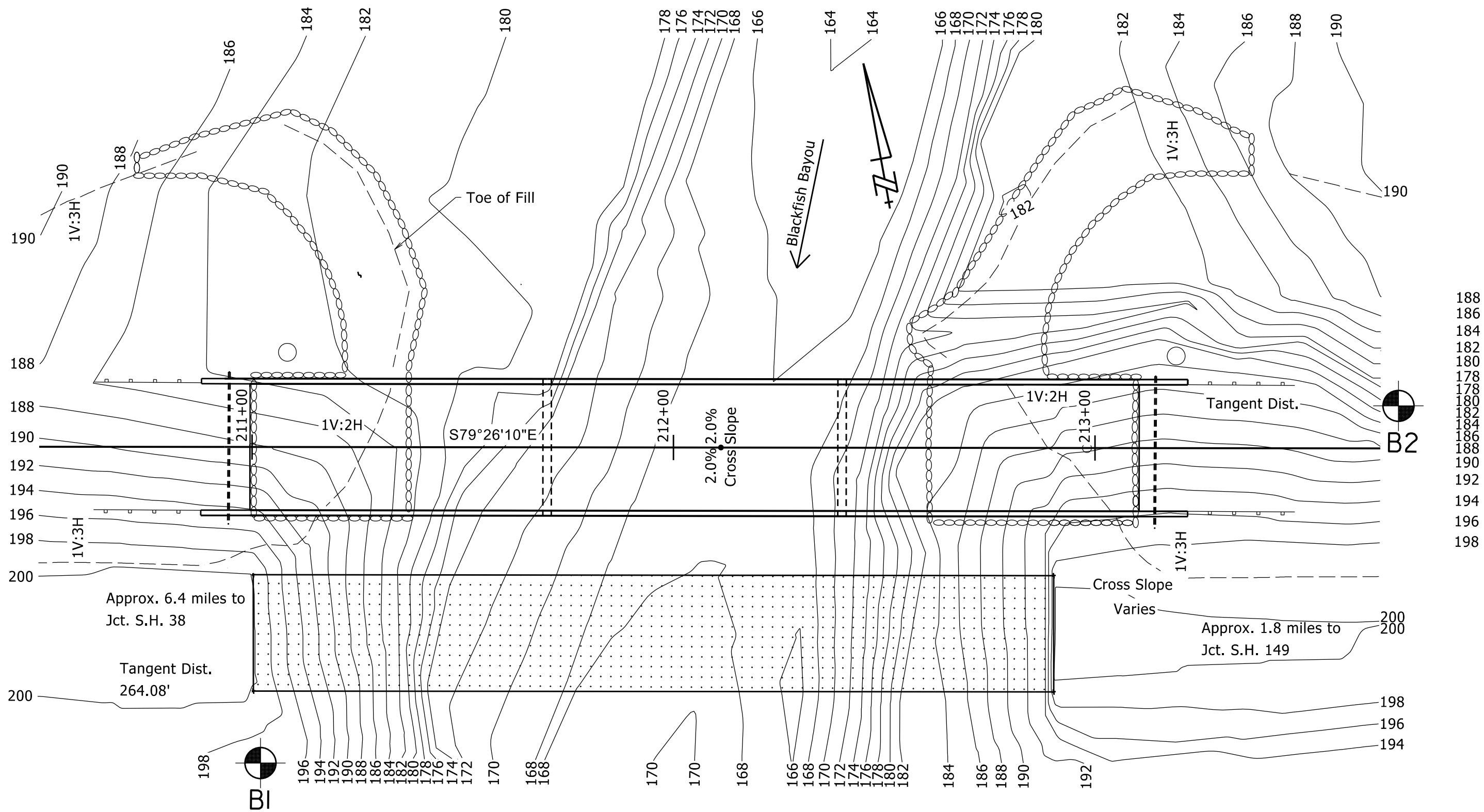


Paul Tinsley  
Materials Engineer

RPT:yz:pt:pwc  
cc: State Construction Engineer  
District 1 Engineer

## Attachment A

FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
6	AR			
JOB NO.		110717		
PLAN OF BORINGS				



PLAN OF BORINGS	
N.E. ST. FRANCIS CO. STRS. & APPRS. (S) ROUTE 50, SECTION 1 ST. FRANCIS COUNTY FED. AID PROJECT NHPP-0068(47)	
JOB NO. 110717	SHEET 1/1
NOT TO SCALE	

**ARKANSAS DEPARTMENT OF TRANSPORTATION  
MATERIALS DIVISION - GEOTECHNICAL SEC.**

BORING NO. 1 Site 2, Blackfish Bayou  
PAGE 1 OF 3

JOB NO. 110717 St. Francis County  
JOB NAME: N.E. St. Frances Co. Strs. & Apprs. (S)

DATE: June 13-14, 2022

STATION: 211+02  
LOCATION: 75' Right of Construction Centerline  
LOGGED BY: Don McCollum

TYPE OF DRILLING:  
Hollow Stem Auger - Rotary Wash  
EQUIPMENT: Acker 1

HAMMER CORRECTION FACTOR: 1.54

COMPLETION DEPTH: 101.5

DEPTH FT.	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	SOIL GROUP	MOISTURE CONTENT (%) PL ————— LL	PERCENT PASSING NO. 200 SIEVE	NO. OF BLOWS PER 6-IN.	% T C R	% R Q D
			SURFACE ELEVATION: 196.0						
			Moist, Brown Sandy Silt with Gravel	ML	● ———	55			
			Moist, Brown Lean Clay with Sand	CL		66	2 — 3-3		
			Moist, Medium Stiff, Brown Clay with Sand			76			
5			Moist, Brown Lean Clay	CL	—●—	86			
			Moist, Medium Stiff, Brown Lean Clay	CL	———	95	0 — 2-3		
10				-					
			Moist, Medium Stiff, Brown Lean Clay	CL	———	99	1 — 2-3		
15				-					
			Wet, Soft, Gray Lean Clay with Sand	CL	———	82	0 — 1-1		
20				-					
			Wet, Soft, Gray Lean Clay	CL	———	96	0 — 0-2		
25				-					
			Wet, Soft, Gray Lean Clay with Sand	CL	———	72	1 — 1-1		
30				-					
			Wet, Very Soft, Gray Lean Clay	CL	———	99	0 — 0-0		
35				-					

REMARKS:

**ARKANSAS DEPARTMENT OF TRANSPORTATION  
MATERIALS DIVISION - GEOTECHNICAL SEC.**

BORING NO. 1 Site 2, Blackfish Bayou  
PAGE 2 OF 3

JOB NO. 110717 St. Francis County  
JOB NAME: N.E. St. Frances Co. Strs. & Apprs. (S)

DATE: June 13-14, 2022  
TYPE OF DRILLING:  
Hollow Stem Auger - Rotary Wash  
EQUIPMENT: Acker 1

STATION: 211+02  
LOCATION: 75' Right of Construction Centerline  
LOGGED BY: Don McCollum

HAMMER CORRECTION FACTOR: 1.54

COMPLETION DEPTH: 101.5

DEPTH FT.	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	SOIL GROUP	MOISTURE CONTENT (%)		PERCENT PASSING NO. 200 SIEVE	NO. OF BLOWS PER 6-IN.	% TCR	% RQD
					PL	LL				
			SURFACE ELEVATION: 196.0							
		X	Moist, Very Soft, Gray Fat Clay	CH	15	55	96	0		
				-				0-0		
40		X		CH	20	60	100	0		
				-				0-0		
45		X		CH	20	60	99	0		
				-				0-0		
50		X	CH	20	60	100	0			
			-				0-0			
55		X	Moist, Very Soft, Gray Lean Clay	CL	20	60	100	0		
				-				0-0		
60		X		CL	30	50	100	0		
				-				0-0		
65		X		CL	30	50	100	0		
				-				0-0		
70		X								

REMARKS:

**ARKANSAS DEPARTMENT OF TRANSPORTATION  
MATERIALS DIVISION - GEOTECHNICAL SEC.**

BORING NO. 1 Site 2, Blackfish Bayou  
PAGE 3 OF 3

JOB NO. 110717 St. Francis County  
JOB NAME: N.E. St. Frances Co. Strs. & Apprs. (S)

DATE: June 13-14, 2022  
TYPE OF DRILLING:  
Hollow Stem Auger - Rotary Wash  
EQUIPMENT: Acker 1

STATION: 211+02  
LOCATION: 75' Right of Construction Centerline  
LOGGED BY: Don McCollum

HAMMER CORRECTION FACTOR: 1.54

COMPLETION DEPTH: 101.5

DEPTH FT.	SYMBOL	SAMPLE	DESCRIPTION OF MATERIAL	SOIL GROUP	MOISTURE CONTENT (%)											PERCENT PASSING NO. 200 SIEVE	NO. OF BLOWS PER 6-IN.	% TCR	% RQD
					PL	10	20	30	40	50	60	70	LL						
			SURFACE ELEVATION: 196.0																
		X	Moist, Loose, Gray Poorly Graded Silty Sand	SM												29	$\frac{2}{4-6}$		
75		X	Moist, Medium Dense, Gray Poorly Graded Silty Sand	SM												37	$\frac{4}{6-8}$		
80		X	Moist, Medium Dense, Gray Poorly Graded Sand with Trace Gravel	SP												3	$\frac{7}{11-14}$		
85		X	Moist, Medium Dense, Gray Poorly Graded Sand with Silt and Some Gravel	SP-SM												5	$\frac{8}{10-17}$		
90		X	Moist, Dense, Gray Poorly Graded Sand with Silt and Some Gravel	SP-SM												6	$\frac{7}{16-18}$		
95		X	Moist, Very Dense, Poorly Graded Sand with Silt and Some Gravel	SP-SM												7	$\frac{10}{24-31}$		
100		X	Moist, Medium Dense, Gray Poorly Graded Sand with Silt and Trace Gravel	SP-SM												5	$\frac{4}{12-13}$		
			Boring Terminated																
105																			

REMARKS:

**ARKANSAS DEPARTMENT OF TRANSPORTATION  
MATERIALS DIVISION - GEOTECHNICAL SEC.**

BORING NO. 2 Site 2, Blackfish Bayou  
PAGE 1 OF 4

JOB NO. 110717 St. Francis County  
JOB NAME: N.E. St. Frances Co. Strs. & Apprs. (S)

DATE: June 21, 2022  
TYPE OF DRILLING:  
Hollow Stem Auger - Rotary Wash  
EQUIPMENT: Acker 1

STATION: 213+72  
LOCATION: 10' Left of Construction Centerline  
LOGGED BY: Don McCollum

HAMMER CORRECTION FACTOR: 1.54

COMPLETION DEPTH: 121.5

DEPTH FT.	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	SOIL GROUP	MOISTURE CONTENT (%)										PERCENT PASSING NO. 200 SIEVE	NO. OF BLOWS PER 6-IN.	% T C R	% R Q D
					PL	10	20	30	40	50	60	70	LL					
			SURFACE ELEVATION: 199.5															
5		X	Moist, Stiff, Brown Sandy Clay														3	3-6
10			Moist, Brown Lean Clay with Sand	CL									78				4	4-6
15		X	Moist, Stiff, Brown Sandy Clay														3	3-3
20		X	Moist, Medium Stiff, Brown Clay with Sand														0	0-1
25		X	Moist, Very Soft, Brown Clay with Sand														0	0-0
30		X	Wet, Very Soft, Brown Clay														0	0-3
35		X	Wet, Soft, Gray Clay														0	0-3

REMARKS:

**ARKANSAS DEPARTMENT OF TRANSPORTATION  
MATERIALS DIVISION - GEOTECHNICAL SEC.**

BORING NO. 2 Site 2, Blackfish Bayou  
PAGE 2 OF 4

JOB NO. 110717 St. Francis County  
JOB NAME: N.E. St. Frances Co. Strs. & Apprs. (S)

DATE: June 21, 2022  
TYPE OF DRILLING:  
Hollow Stem Auger - Rotary Wash  
EQUIPMENT: Acker 1

STATION: 213+72  
LOCATION: 10' Left of Construction Centerline  
LOGGED BY: Don McCollum

HAMMER CORRECTION FACTOR: 1.54

COMPLETION DEPTH: 121.5

DEPTH FT.	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	SOIL GROUP	MOISTURE CONTENT (%)										PERCENT PASSING NO. 200 SIEVE	NO. OF BLOWS PER 6-IN.	% T C R	% R Q D
					PL	10	20	30	40	50	60	70	LL					
			SURFACE ELEVATION: 199.5															
40			Wet, Soft, Gray Clay with Some Sand												0	0-3		
45															0	1-3		
50			Wet, Very Soft, Gray Clay												0	0-0		
55															0	0-0		
60			Moist, Soft, Gray Clay with Organic Matter (Wood)												0	0-2		
65			Wet, Soft, Gray Clay												0	1-3		
70			Moist, Loose, Gray Silty Sand	-											3	3-4		

REMARKS:

**ARKANSAS DEPARTMENT OF TRANSPORTATION  
MATERIALS DIVISION - GEOTECHNICAL SEC.**

BORING NO. 2 Site 2, Blackfish Bayou  
PAGE 3 OF 4

JOB NO. 110717 St. Francis County  
JOB NAME: N.E. St. Frances Co. Strs. & Apprs. (S)

DATE: June 21, 2022  
TYPE OF DRILLING:  
Hollow Stem Auger - Rotary Wash  
EQUIPMENT: Acker 1

STATION: 213+72  
LOCATION: 10' Left of Construction Centerline  
LOGGED BY: Don McCollum

HAMMER CORRECTION FACTOR: 1.54

COMPLETION DEPTH: 121.5

DEPTH FT.	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	SOIL GROUP	MOISTURE CONTENT (%)										PERCENT PASSING NO. 200 SIEVE	NO. OF BLOWS PER 6-IN.	% TCR	% RQD
					PL	20	30	40	50	60	70	LL						
			SURFACE ELEVATION: 199.5															
		X	Moist, Soft, Gray Clay with Trace Gravel													0 1-3		
75		X	Sand and Gravel													7 7-10		
80		X	Moist, Medium Dense, Gray Sand with Trace Gravel													11 18-20		
85		X	Moist, Dense, Gray Sand													8 9-10		
90		X														7 11-15		
95		X	Moist, Medium Dense, Gray Sand with Some Gravel													7 8-12		
100		X														9 13-17		
105		X																

REMARKS:

**ARKANSAS DEPARTMENT OF TRANSPORTATION  
MATERIALS DIVISION - GEOTECHNICAL SEC.**

BORING NO. 2 Site 2, Blackfish Bayou  
PAGE 4 OF 4

JOB NO. 110717 St. Francis County  
JOB NAME: N.E. St. Frances Co. Strs. & Apprs. (S)

DATE: June 21, 2022  
TYPE OF DRILLING:  
Hollow Stem Auger - Rotary Wash  
EQUIPMENT: Acker 1

STATION: 213+72  
LOCATION: 10' Left of Construction Centerline  
LOGGED BY: Don McCollum

HAMMER CORRECTION FACTOR: 1.54

COMPLETION DEPTH: 121.5

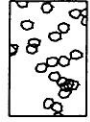
DEPTH FT.	SYMBOL	SAMPLE	DESCRIPTION OF MATERIAL	SOIL GROUP	MOISTURE CONTENT (%)											PERCENT PASSING NO. 200 SIEVE	NO. OF BLOWS PER 6-IN.	% T C R	% R Q D
					PL	10	20	30	40	50	60	70	LL						
			SURFACE ELEVATION: 199.5																
110		X	Moist, Dense, Gray Sand														11 20-21		
115		X	Moist, Medium Dense, Gray Sand with Gravel														14 13-9		
120		X	Moist, Medium Dense, Gray Gravel with Sand														10 10-13		
125			Boring Terminated																
130																			
135																			
140																			

REMARKS:

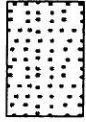
# LEGEND

## SOIL TYPES

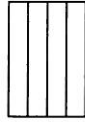
(SHOWN IN SYMBOL COLUMN)  
(PREDOMINANT TYPE SHOWN HEAVY)



GRAVEL



SAND



SILT



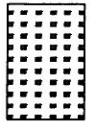
CLAY



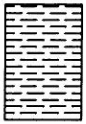
ORGANIC  
MATTER

## ROCK TYPES

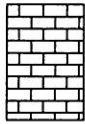
(SHOWN IN SYMBOL COLUMN)



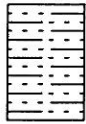
SANDSTONE



SHALE  
or  
SILTSTONE



LIMESTONE  
or  
DOLOMITE



ALTERNATING  
LAYERS of  
SHALE and  
SANDSTONE



OTHER

## SAMPLER TYPES

(SHOWN IN SAMPLE COLUMN)

### SHELBY TUBE



UNDISTURBED  
SAMPLE  
RECOVERY

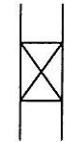


DISTURBED  
SAMPLE  
RECOVERY

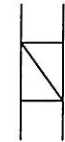


NO  
RECOVERY

### SPLIT SPOON

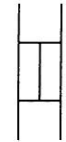


SAMPLE  
RECOVERY



NO  
RECOVERY

### ROCK CORING



% 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	

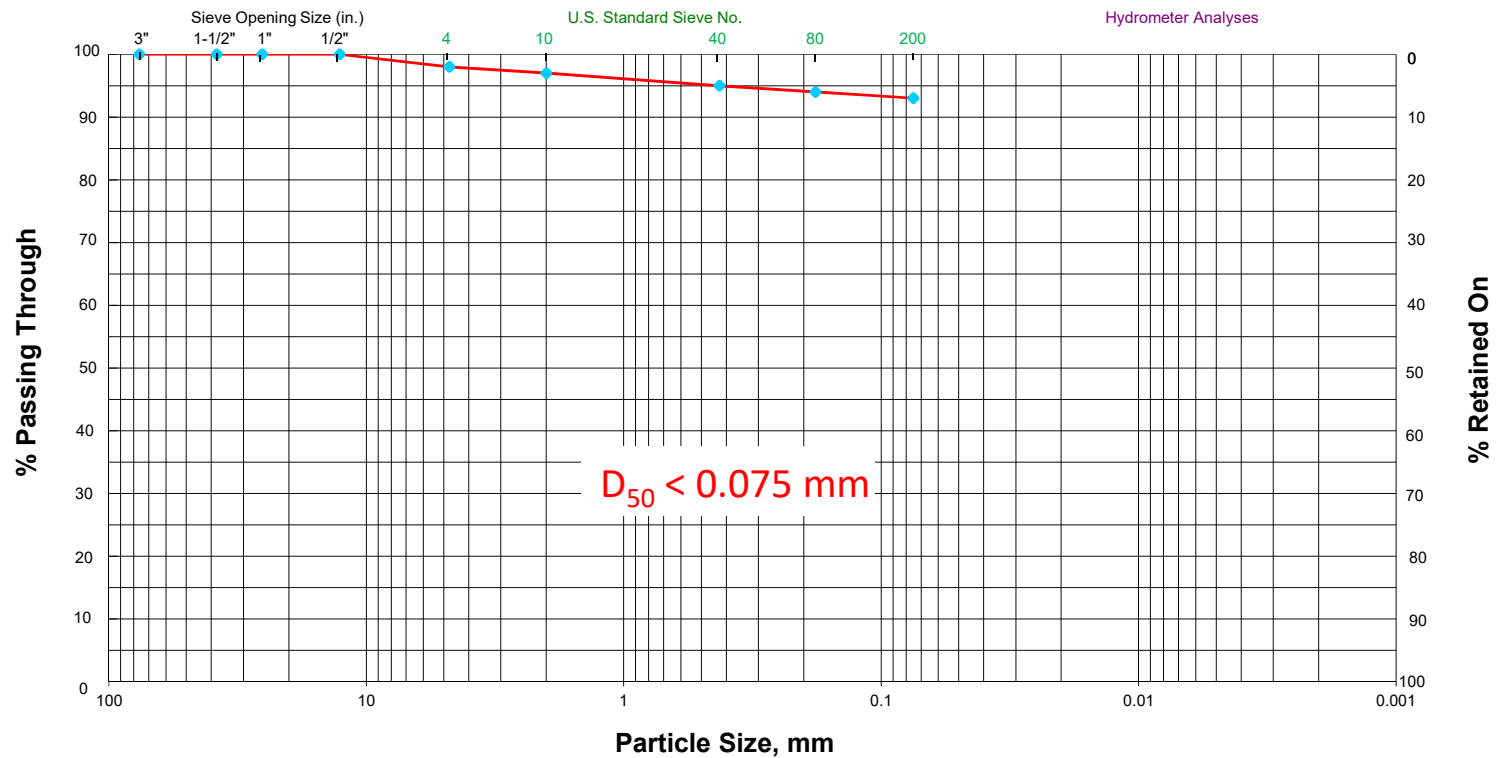
1. Ground water elevations indicated on boring logs represent ground water elevations at date or time shown on boring log. Absence of water surface implies that no ground water data is available but does not necessarily mean that ground water will not be encountered at locations or within the vertical 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:  $\frac{6}{8-9} \Rightarrow 8+9 = 17 \text{ blows/ft}$ . 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



**110717 Particle Size Distribution Curve**  
Station 211+55 / 65' Rt of CL - Blackfish Bayou



## Attachment C

**SITE PICTURES**

**Job No.: 110717**

**Job Name: N.E. St. Francis Co. Strs. & Apprs. (S)**



**Site 3, Ditch 20 (June 2022)  
Looking south from the north**

**SITE PICTURES**

**Job No.: 110717**

**Job Name: N.E. St. Francis Co. Strs. & Apprs. (S)**



**Site 3, Ditch 20 (June 2022)  
Looking north from the south**

**SITE PICTURES**

**Job No.: 110717**

**Job Name: N.E. St. Francis Co. Strs. & Apprs. (S)**



**Site 2, Blackfish Bayou (March 2022)  
Looking down river to the south**

**SITE PICTURES**

**Job No.: 110717**

**Job Name: N.E. St. Francis Co. Strs. & Apprs. (S)**



**Site 2, Blackfish Bayou (March 2022)  
Looking up river to the north**

**SITE PICTURES**

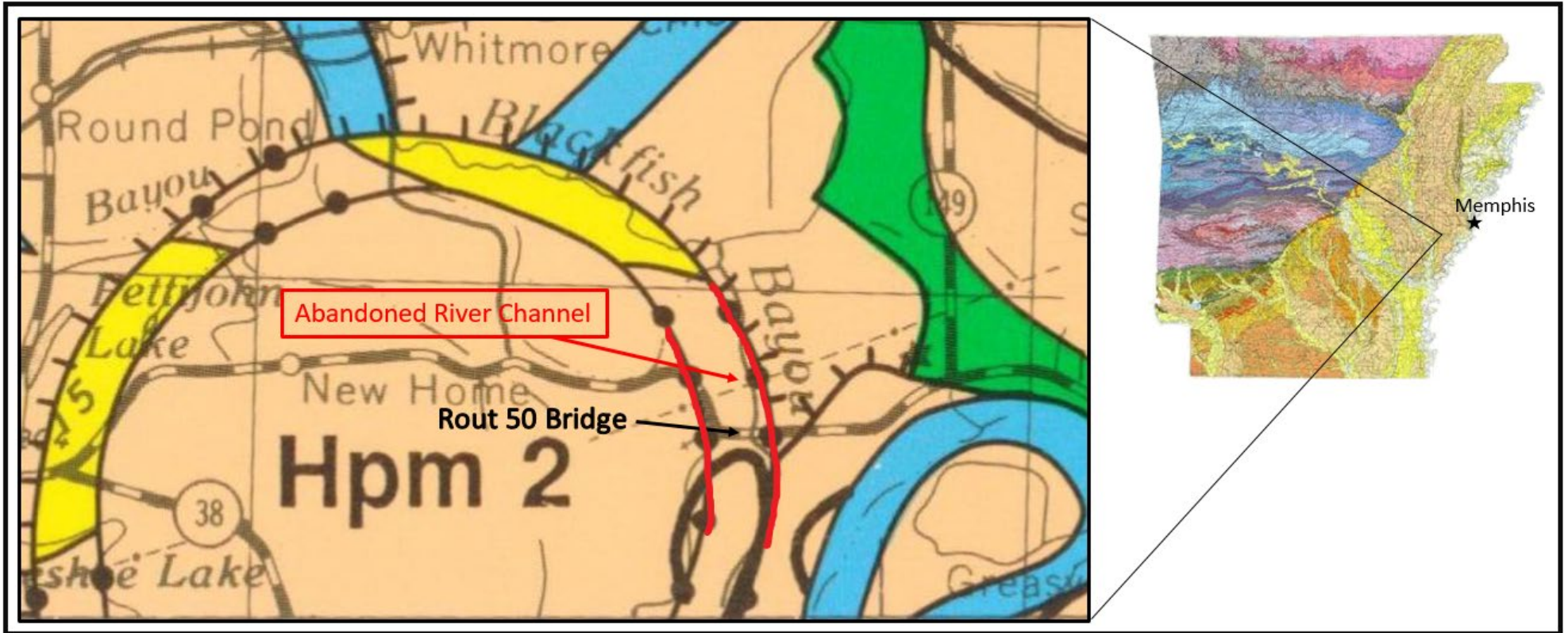
**Job No.: 110717**

**Job Name: N.E. St. Francis Co. Strs. & Apprs. (S)**

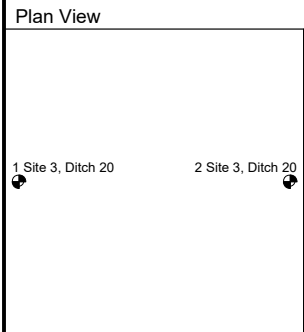
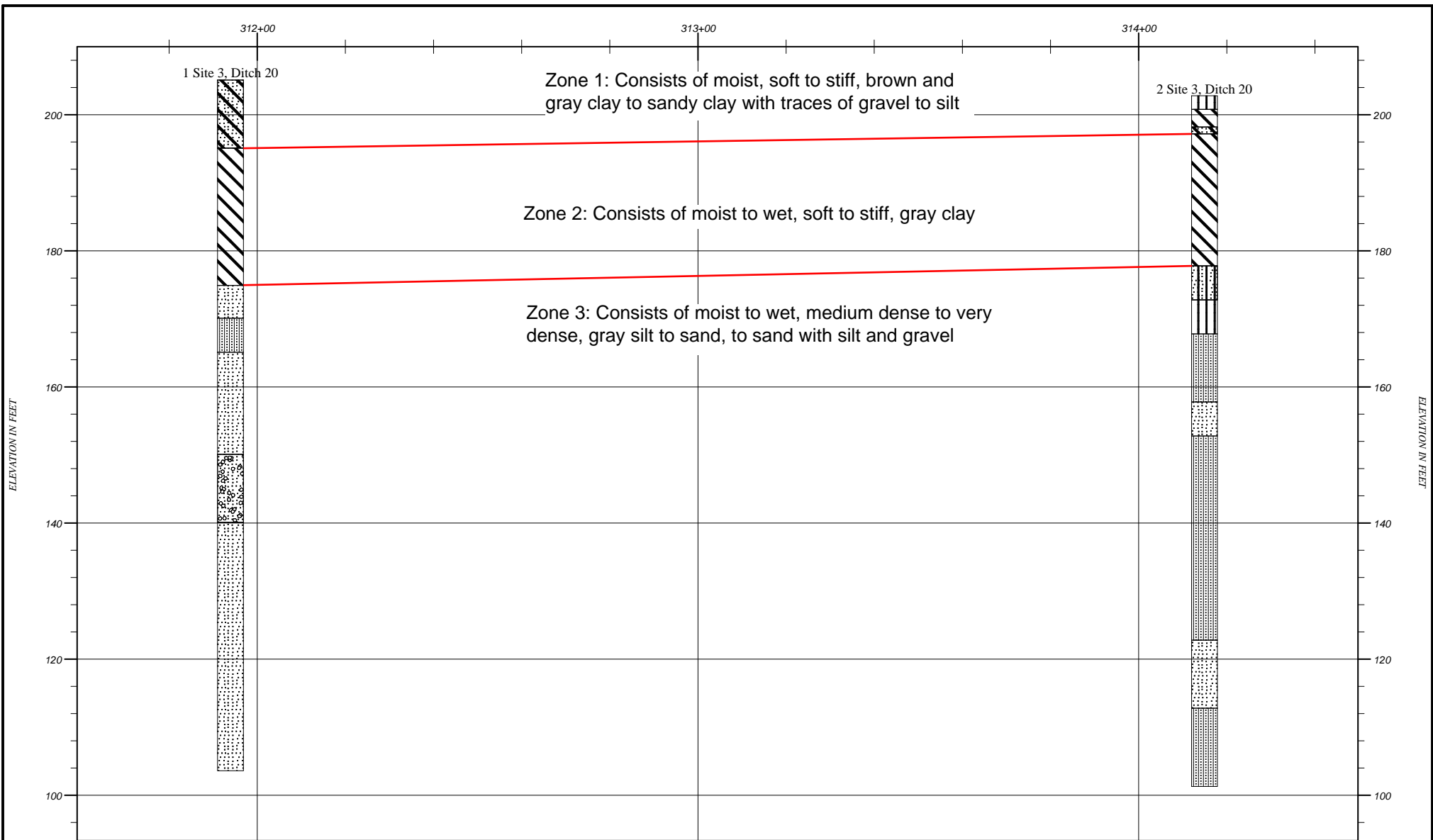


**Site 2, Blackfish Bayou (March 2022)  
Piled up debris on upstream (north side) of the bridge**

## Attachment D



Route 50 intersecting the mapped location of an abandoned channel at Blackfish Bayou bridge.



- Strata symbols**
- sandy clay
  - clay
  - sand
  - silty sand
  - sand and gravel
  - silt/cemented silt
  - sandy silt

<b>ARDOT</b>		
<b>GENERALIZED SAUBSURFACE PROFILE</b>		
HORIZONTAL SCALE: NTS	DRAWN BY/APPROVED BY	DATE DRAWN
VERTICAL SCALE: NTS		7/19/2022
<b>N.E. St. Frances Co. Strs. &amp; Apprs. (S)</b>		
<b>PROJECT NO. 110717</b>		Site 3, Ditch 20
<b>St. Francis County</b>		

## Attachment E

Title: 110717 - Blackfish Bayou

Latitude: 35.021888

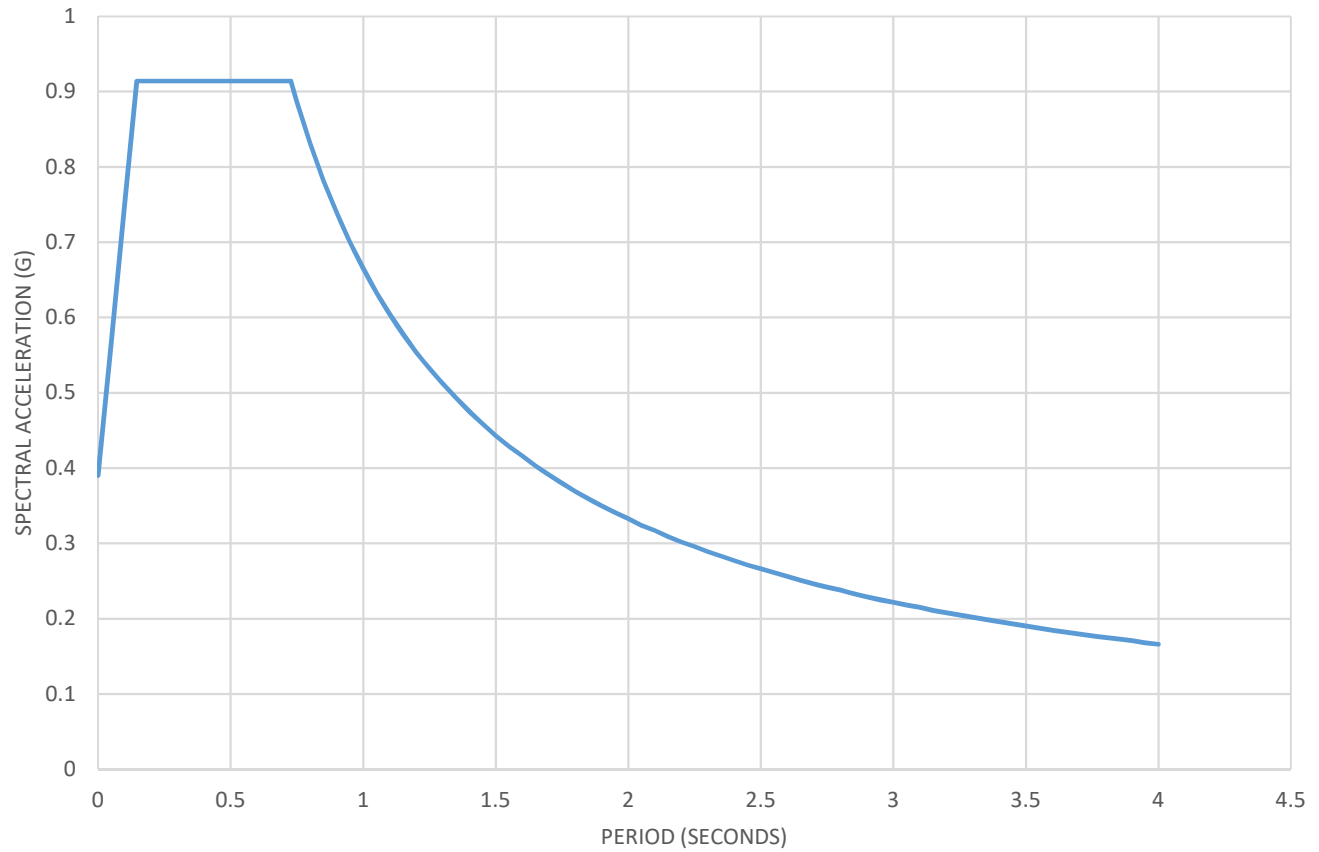
Longitude: -90.520133

Site Class: E

Get USGS Data

PGA:	0.433
F <sub>PGA</sub> :	0.9
A <sub>S</sub> :	0.39
S <sub>S</sub> :	0.81
F <sub>A</sub> :	1.128
S <sub>DS</sub> :	0.914
S <sub>1</sub> :	0.211
F <sub>V</sub> :	3.158
S <sub>D1</sub> :	0.665
S <sub>DC</sub> :	D
T <sub>S</sub> :	0.728
T <sub>0</sub> :	0.146

### 110717 - BLACKFISH BAYOU DESIGN RESPONSE SPECTRUM

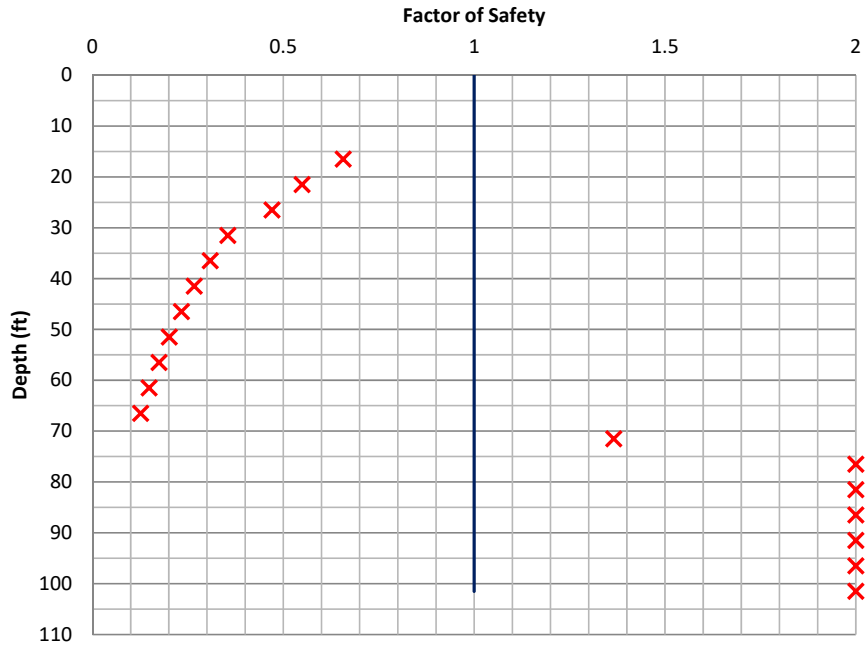


## Attachment F

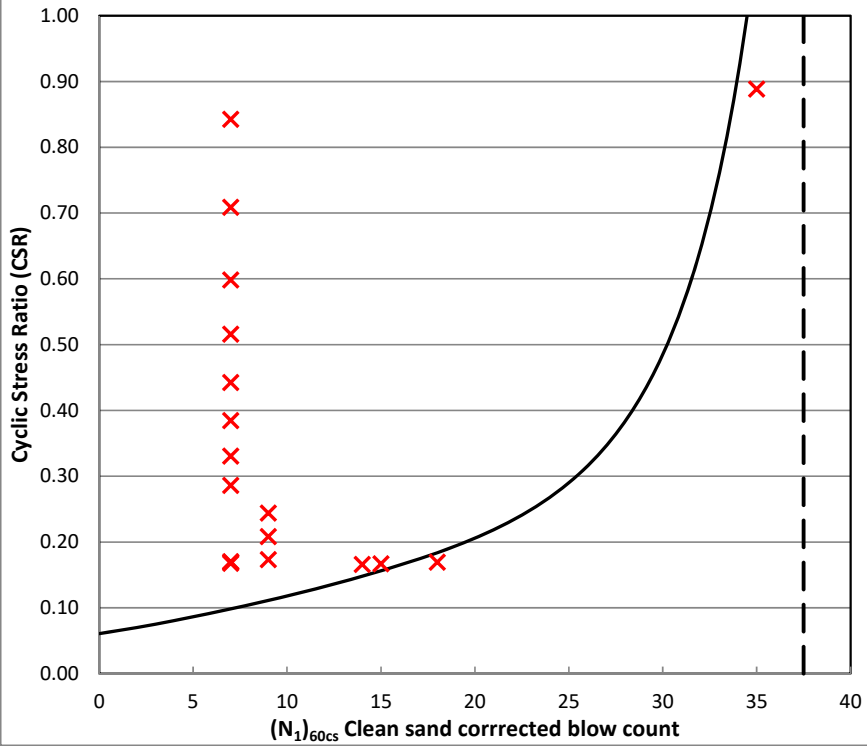
Bent 1: 211+02, CL of Const.

### Boring Elevation

#### Factor of Safety Idriss and Boulanger (2012)



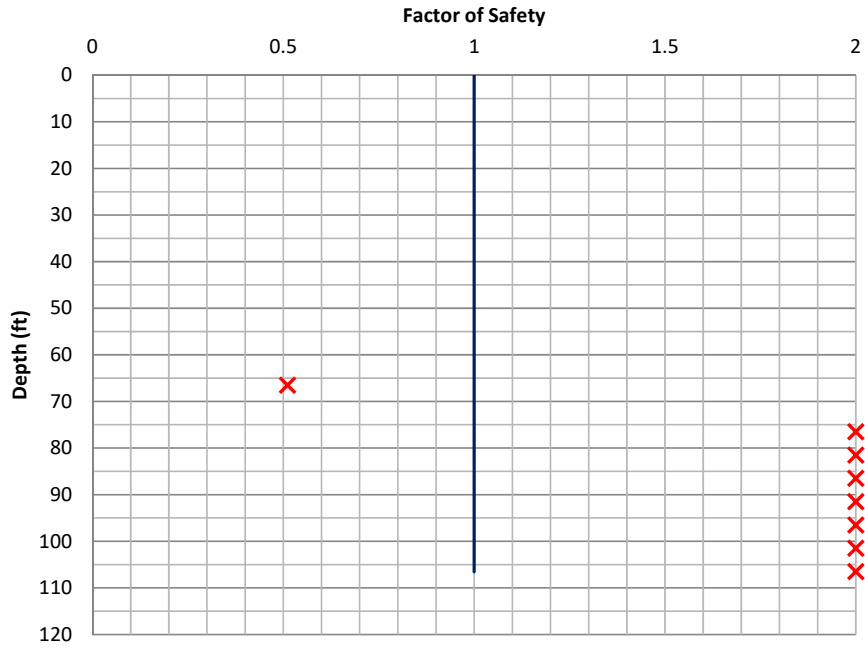
#### Clean Sand CRR Curve



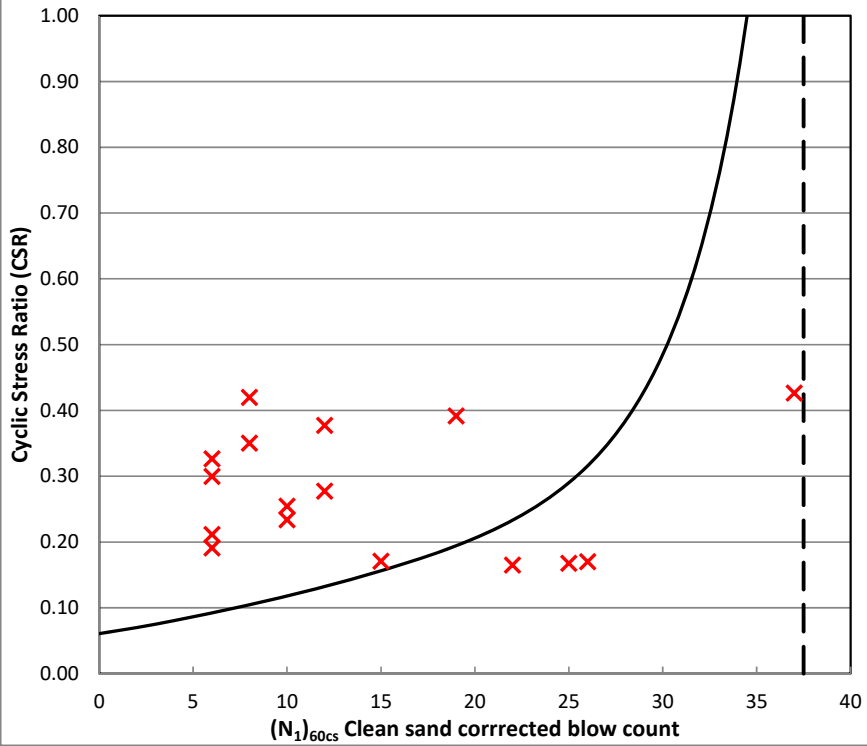
Bent 4: 213+72, CL of Const.

### Boring Elevation

#### Factor of Safety Idriss and Boulanger (2012)

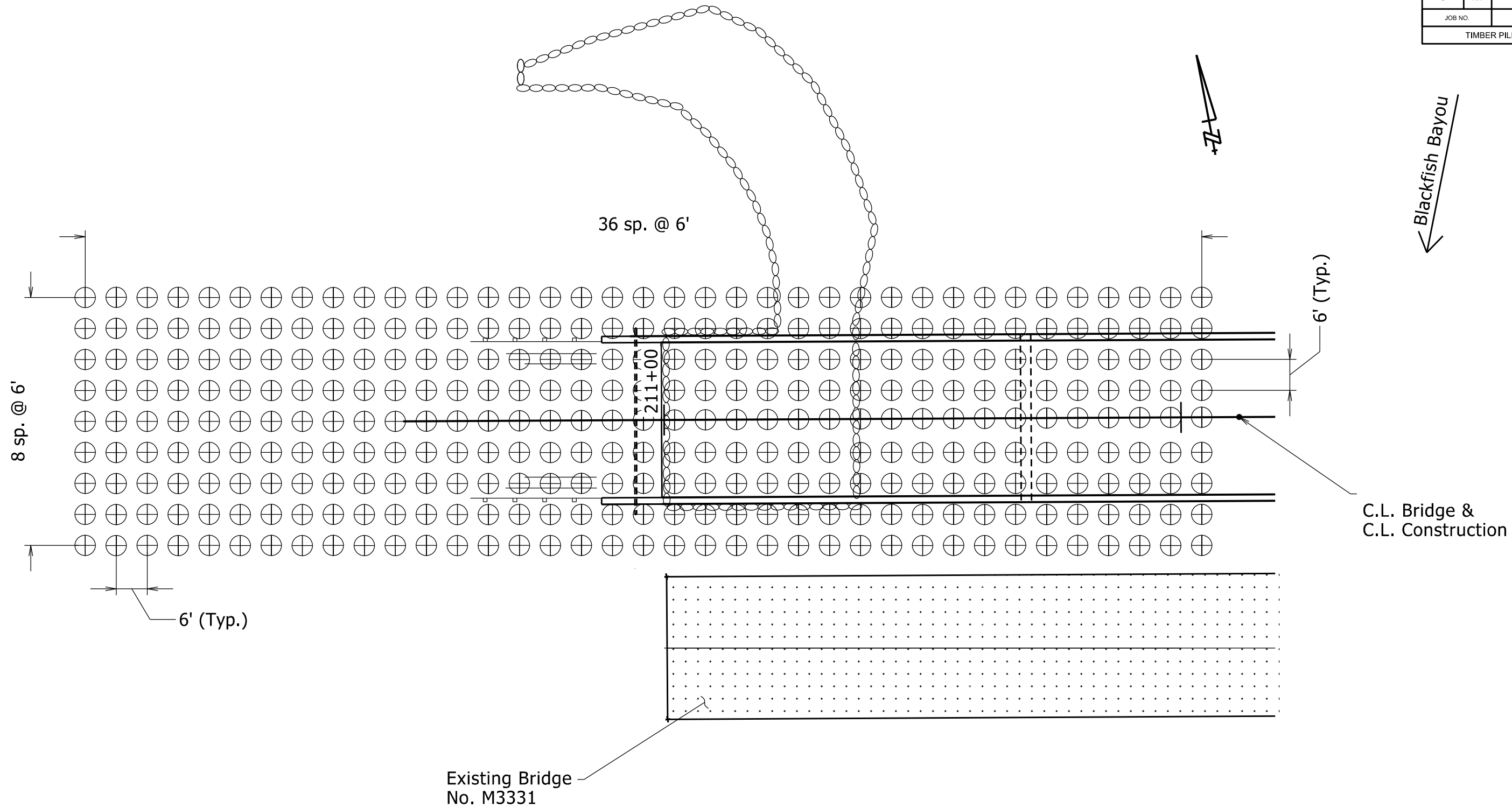


#### Clean Sand CRR Curve



## Attachment G

FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
6	AR			
JOB NO.		110717		
TIMBER PILE LAYOUT - PLAN VIEW				

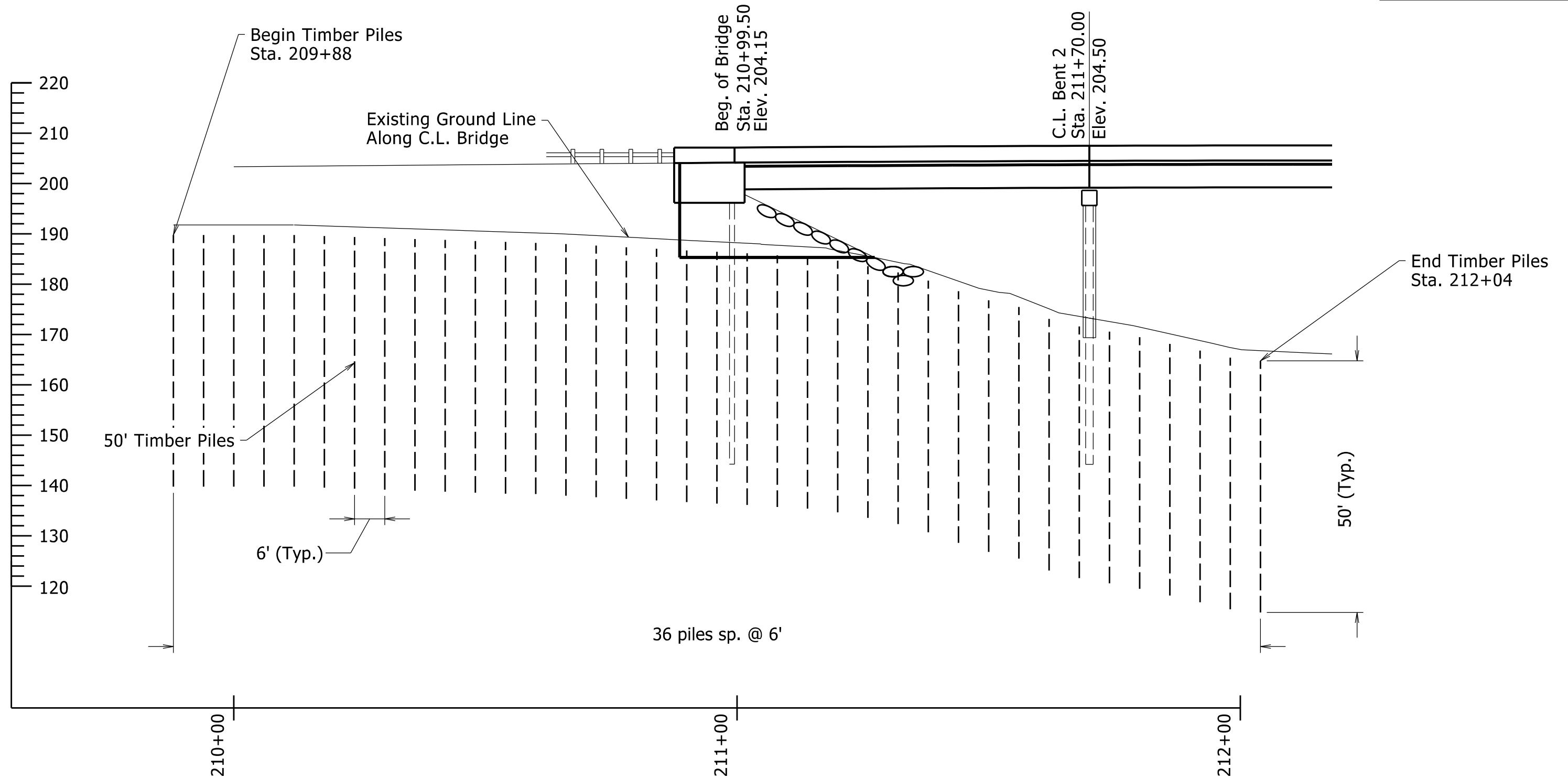


**NOTES:**

1. Timber piles and timber pile installation shall conform to SP "Timber Piling for Soil Densification and Reinforcement".
2. Timber piles should be offset in field to avoid conflict with foundation piles.

TIMBER PILE LAYOUT - PLAN VIEW	
N.E. ST. FRANCIS CO. STRS. & APPRS. (S) ROUTE 50, SECTION 1 ST. FRANCIS COUNTY WEST EMBANKMENT - BLACKFISH BAYOU	
JOB NO. 110717	SHEET 1/1
NOT TO SCALE	

FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
6	AR			
JOB NO.		110717		
TIMBER PILE LAYOUT - PROFILE VIEW				

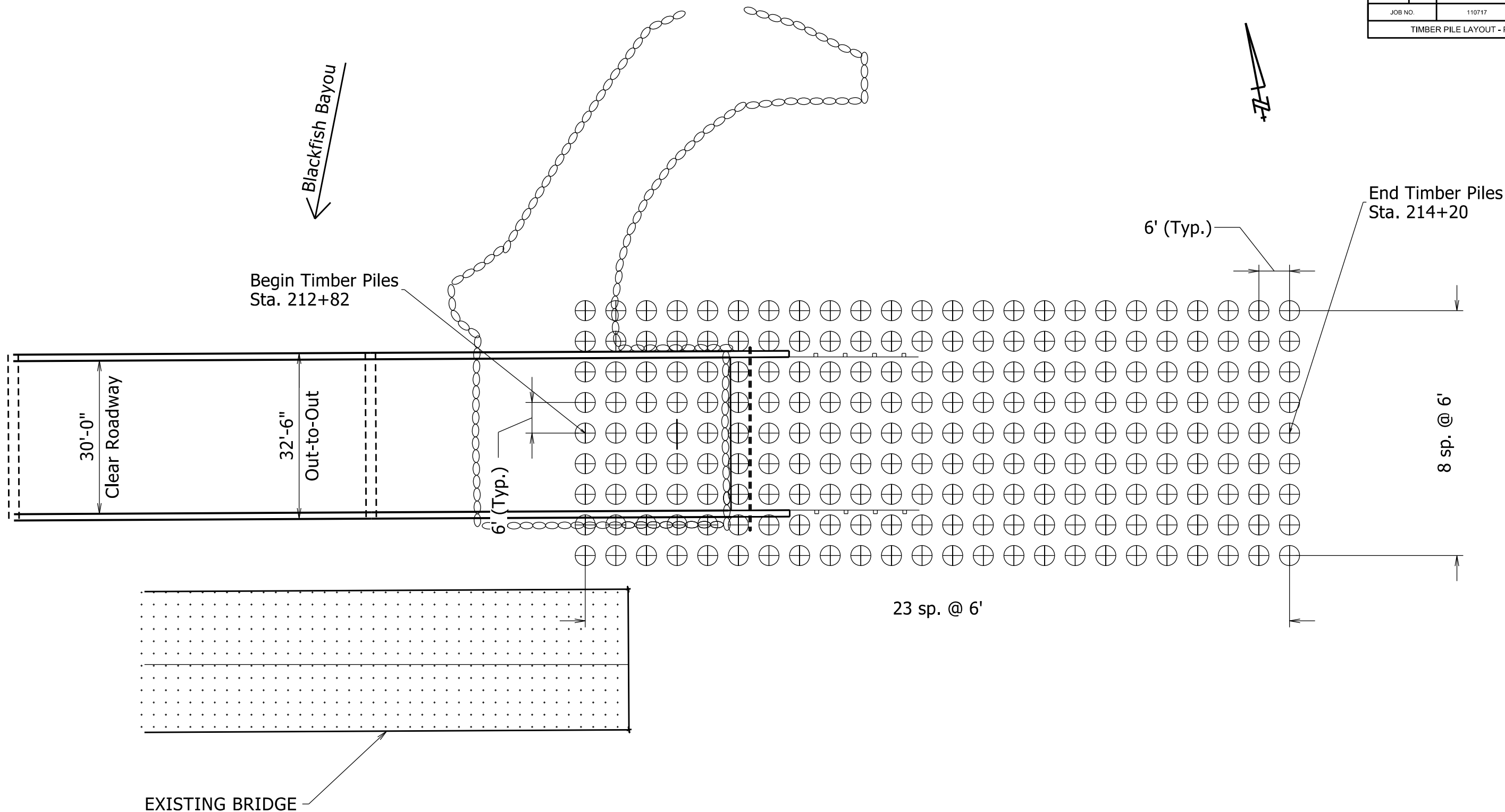


**NOTES:**

1. Timber piles and timber pile installation shall conform to SP "Timber Piling for Soil Densification and Reinforcement".
2. Timber piles should be offset in field to avoid conflict with foundation piles.

TIMBER PILE LAYOUT - PROFILE VIEW	
N.E. ST. FRANCIS CO. STRS. & APPRS. (S) ROUTE 50, SECTION 1 ST. FRANCIS COUNTY WEST EMBANKMENT - BLACKFISH BAYOU	
JOB NO. 110717	SHEET 1/1
NOT TO SCALE	

FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
6	AR			
JOB NO.		110717		
TIMBER PILE LAYOUT - PLAN VIEW				

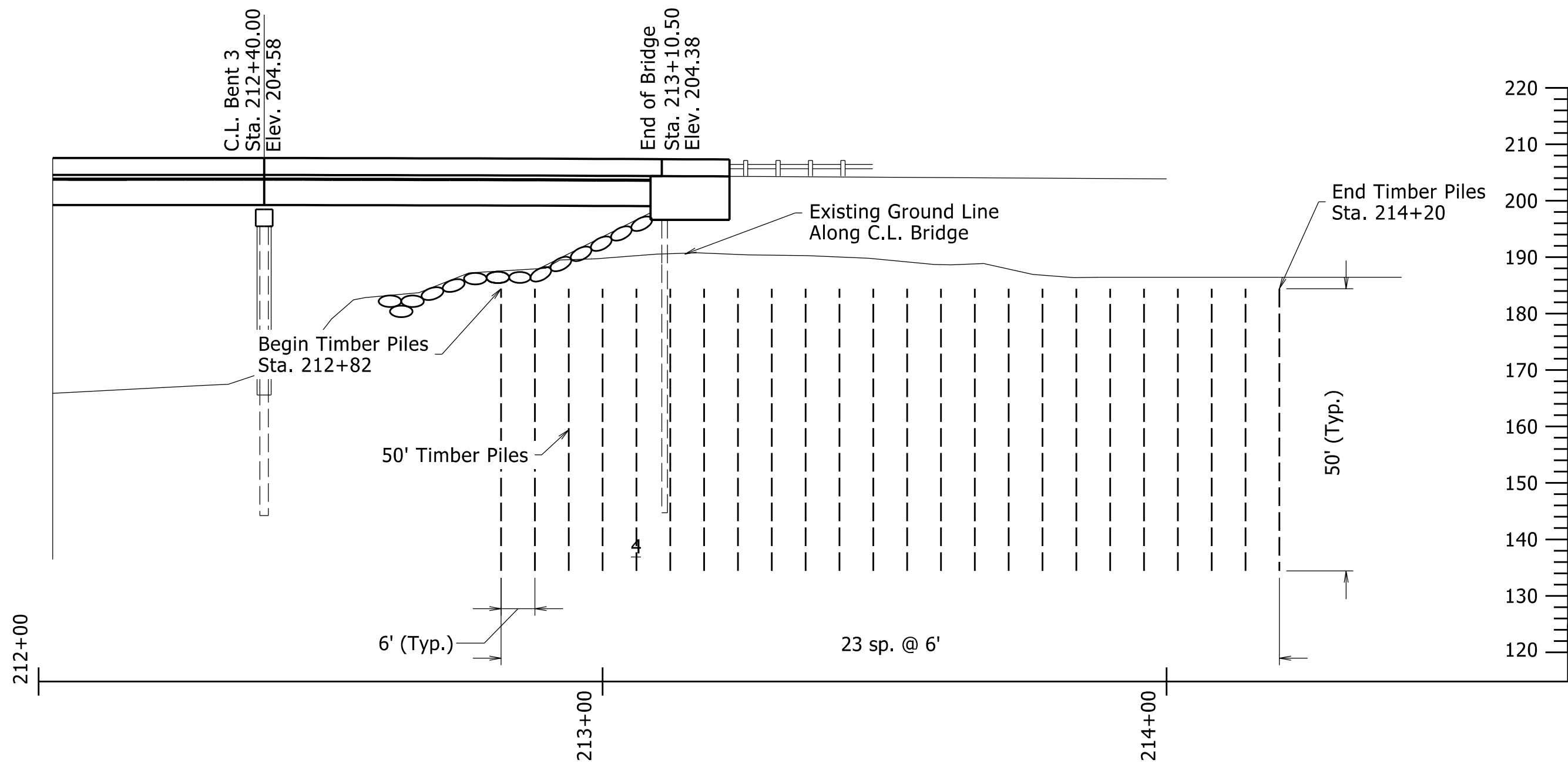


**NOTES:**

1. Timber piles and timber pile installation shall conform to SP "Timber Piling for Soil Densification and Reinforcement".
2. Timber piles should be offset in field to avoid conflict with foundation piles.

TIMBER PILE LAYOUT - PLAN VIEW	
N.E. ST. FRANCIS CO. STRS. & APPRS. (S) ROUTE 50, SECTION 1 ST. FRANCIS COUNTY EAST EMBANKMENT - BLACKFISH BAYOU	
JOB NO. 110717	SHEET 1/1
NOT TO SCALE	

FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
6	AR			
JOB NO.		110717		
TIMBER PILE LAYOUT - PROFILE VIEW				



**NOTES:**

1. Timber piles and timber pile installation shall conform to SP "Timber Piling for Soil Densification and Reinforcement".
2. Timber piles should be offset in field to avoid conflict with foundation piles.

TIMBER PILE LAYOUT - PROFILE VIEW	
N.E. ST. FRANCIS CO. STRS. & APPRS. (S) ROUTE 50, SECTION 1 ST. FRANCIS COUNTY EAST EMBANKMENT - BLACKFISH BAYOU	
JOB NO. 110717	SHEET 1/1
NOT TO SCALE	

## Attachment H

## ARKANSAS DEPARTMENT OF TRANSPORTATION

### SPECIAL PROVISION

JOB NO. **XXXXXX**

#### TIMBER PILING FOR SOIL DENSIFICATION AND REINFORCEMENT

**Description.** This Special Provision (SP) covers Timber Piles driven through or under roadway embankments or bridge approach embankments, around intermediate bents, or at locations shown on the plans for the purpose of soil densification and/or reinforcement. This item shall consist of furnishing and driving treated piling according to this SP and conforming to the lines, grades, and spacing shown on the plans.

**Materials.** Materials for timber piling shall conform to the following requirements.

1. Piling shall be treated timber of Southern Yellow Pine or Douglas Fir.
2. Piles shall be of sound wood, free from decay or insect damage and shall have a minimum amount of red heart. Sound knots shall be no larger than 4" or 1/3 of the diameter of the pile at the point where they occur, whichever is the smaller. The size of a knot shall be its diameter measured at right angles to the length of the pile. Piles may have unsound knots not exceeding 1/2 the permitted size of a sound knot, provided that the unsoundness extends to not more than 1 1/2" depth, and that the adjacent areas of the trunk are not affected. Cluster knots consisting of two or more knots grouped together, the fibers of the wood being deflected around the entire unit, are prohibited. The sum of the sizes of all knots in any foot of length of the pile shall not exceed six times the size of the largest permitted single knot.
  - a. Holes of 1/2" or less in average diameter will be permitted, provided the sum of the average diameters of all holes in any square foot of pile surface does not exceed 1 1/2".
  - b. Twist of spiral grain in any 20' of length shall not exceed 1/2 of the circumference at the midpoint of the length measured.
  - c. Splits shall be no longer than the butt diameter. The length of any shake in the outer half of the radius of the butt of the pile, when measured along the curve of the annual ring, shall not exceed 1/3 of the circumference of the butt of the pile. The butts and tips shall be sawed square. The tips may be tapered to a point not less than 4" in diameter.
  - d. All piles shall be peeled by removing all rough bark and at least 80% of the inner bark. No strip of the inner bark remaining on the pile shall be over 3/4" wide and there shall be at least 1" of clean wood surface between any two such strips. At least 80% of the surface of any circumference shall be clean wood.
  - e. Timber to be used for piling shall be cut above the ground swell and shall taper from butt to tip. A line from the center of the tip to the center of the butt shall not fall outside of the center of the pile at any point more than 1% of the length of the pile. In short bends, the distance from the center of the pile to a line stretched from the center of the pile above the bend to the center of the pile below the bend

**ARKANSAS DEPARTMENT OF TRANSPORTATION**

**SPECIAL PROVISION**

**JOB NO. xxxxxx**

**TIMBER PILING FOR SOIL DENSIFICATION AND REINFORCEMENT**

shall not exceed 4% of the length of the bend or a maximum of 2½". Knots shall be trimmed flush with the body of the pile.

3. Piles shall have a minimum diameter at the tip, measured under the bark, as follows:

<u>Length of Pile</u>	<u>Tip Diameter</u>
Less than 40'	8"
40' to 60'	6"

4. The minimum diameter of piles at sections 3' from the butt, measured under the bark, shall be as follows:

<u>Length of Pile</u>	<u>Diameter of Pile</u>
20' to 30'	12"
30' to 40'	12"
Over 40'	13"

The diameter of the pile at the butt shall not exceed 20". The diameter of a pile in cases where the tree is not exactly round shall be determined either by measuring the circumference and dividing the number of inches by 3.14 or by taking the average of the maximum and minimum diameters at the location specified.

**Storage and Protection of Materials.** Timber piles shall be stacked on supports at least 12" above the ground surface to avoid absorption of ground moisture. Piles shall be closely-stacked to prevent warping or sagging. The ground underneath and in the vicinity of material stacks shall be kept reasonably clear of vegetation.

**Preservation Treatment of Timber Piles.** Preservation treatment of timber piles shall be accomplished according to the requirements of Subsection 817.04 of the Standard Specifications.

**Driving.** Prior to beginning pile-driving operations the Contractor, shall field verify the location of all underground utilities and obtain approval from the Engineer to begin. The Contractor shall be responsible for all damages and/or claims arising out of the installation of Timber Piling for Soil Densification and/or Reinforcement. Driving equipment that damages the piling shall not be used. Hammers shall be capable of driving to the plan tip elevations or to refusal without damage to the pile. Driving shall be considered complete once the pile has reached the tip elevation shown on the plans or refusal in rock or intermediate geotechnical materials (IGM) is encountered, whichever is shallower.

1. **Hammers:** All piling shall be driven with an air, steam, or diesel hammer. Gravity hammers will be permitted only when shown on the plans or as elsewhere allowed by the specifications. Hammers shall develop a total energy of not less than 12,500 ft.-lbs.
  - a. The plant and equipment furnished for air or steam hammers shall have sufficient capacity to maintain, under working conditions, the pressure at the hammer

## ARKANSAS DEPARTMENT OF TRANSPORTATION

### SPECIAL PROVISION

JOB NO. **XXXXXX**

#### TIMBER PILING FOR SOIL DENSIFICATION AND REINFORCEMENT

specified by the manufacturer. Accurate pressure gauges shall be placed at the boiler or tank and at the hammer so that the drop in pressure between the gauges can be determined.

- b. When a single acting diesel hammer is used, it shall be equipped with a stroke indicator or the Contractor must furnish a method approved by the Engineer for determining the actual stroke. When a double acting diesel hammer is used, it shall be equipped with a bounce chamber pressure gauge in good working order mounted near ground level so as to be conveniently read by the Engineer when monitoring energy output of the hammer. The Contractor shall provide charts that equate the chamber pressure to equivalent energy.
2. **Hammer Cushions:** All impact pile driving equipment except gravity hammers shall be equipped with a hammer cushion of suitable thickness to prevent damage to the hammer or pile and to ensure uniform driving behavior. Hammer cushions shall be made of durable, manufactured materials, complying with the hammer manufacturer's guidelines except that all wood, wire rope, and asbestos hammer cushions are specifically prohibited. A striker plate as recommended by the hammer manufacturer shall be placed on the hammer cushion to ensure uniform compression of the cushion material. The hammer cushion shall be inspected in the presence of the Engineer before beginning pile driving at each structure or after each 100 hours of pile driving, whichever is more frequent. When the thickness of a hammer cushion is reduced by more than 25% of its original thickness, the Contractor shall replace it before driving is permitted to continue.
3. **Pile Drive Head:** A pile driven with an impact hammer requires an adequate drive head to distribute the hammer blow to the pile head. The drive head shall be axially aligned with the hammer and the pile. The drive head shall be guided by the leads and shall not be free swinging. The drive head shall fit around the pile head in a manner that will prevent transfer of torsional forces during driving while maintaining proper alignment of hammer and pile. The pile heads shall be cut squarely and a drive head, as recommended by the hammer manufacturer, shall be provided to hold the axis of the pile in line with the axis of the hammer.
4. **Driving Equipment Information:** The Contractor shall submit to the Engineer, for information and record purposes, pile driving equipment information at least 30 days before driving piles. The information shall be submitted on a Pile and Driving Equipment Data Form, which will be supplied by the Engineer. Any change in the driving system will require the Contractor to submit a new Pile and Driving Equipment Data Form.
5. **Additional Equipment:** In case the required penetration is not obtained with a hammer complying with the above minimum requirements, the Contractor shall provide a different hammer and/or sufficient additional equipment at no cost to the Department.

## ARKANSAS DEPARTMENT OF TRANSPORTATION

### SPECIAL PROVISION

JOB NO. **XXXXXX**

#### TIMBER PILING FOR SOIL DENSIFICATION AND REINFORCEMENT

Additional equipment not otherwise provided for herein shall be approved by the Engineer prior to its use. Pile tips shall be used where it may be required to reach the minimum tip elevation and shall be at no additional cost to the Department.

6. **Leads:** Pile driver leads shall be constructed in such a manner as to provide freedom for vertical movement of the hammer and shall be held in position in such a manner as to ensure adequate support to the pile during driving. The axis of the leads and hammer shall coincide with the axis of the pile as nearly as practicable.
7. **Accuracy of Driving:** Pile shall be driven with a variation of not more than  $\frac{1}{4}$ " per foot from the vertical. Piles spacing shall not differ from those shown on the plans by 1 foot. Piling shall be driven under the observation of the Engineer or his representative so that data may be obtained for determining the penetration.

**Order List for Piles.** The Contractor shall furnish piles according to an itemized list, which will be furnished by the Engineer, showing the number and length of piles. In determining lengths of piles for ordering and for quantities to be included in the Contract, the lengths given in the order list shall be based on the lengths that are assumed to be driven to minimum penetration and cut off at the elevation shown on the plans. The Contractor may, at no cost to the Department, increase the lengths given to provide for fresh heading and for such additional length as may be necessary to suit the Contractor's method of operation.

**Defective Piles.** The Contractor shall not subject piles to excessive abuse that will produce cracking, crushing, splitting, or deformation of the pile. Manipulation of piles to force them into proper position, considered by the Engineer to be excessive, will not be permitted. Any pile damaged because of internal defects or improper driving, or any pile driven out of its proper location or driven below the elevation fixed by the plans or the Engineer, shall be corrected at no cost to the Department by one of the following methods, as approved by the Engineer:

1. The pile may be withdrawn and replaced by a new, and if necessary, longer pile.
2. A second pile may be driven adjacent to the defective or low pile.
3. The pile may be spliced or built up as otherwise provided herein.

Piles pushed up by the driving of adjacent piles or by any other cause shall be re-driven to grade. Any crushed or damaged portion of piling may be cut off and built up or the pile completely replaced, as approved by the Engineer. Cutoff, buildup, and/or replacement of damaged piles shall be at no cost to the Department.

**Cutting Off Timber Piles.** Cut-offs shall be a minimum of 2 feet below roadway surface and embankment side slope faces. In addition, cut-off length shall be sufficient to permit the complete removal of any material damaged by driving.

**ARKANSAS DEPARTMENT OF TRANSPORTATION**

**SPECIAL PROVISION**

**JOB NO. xxxxxx**

**TIMBER PILING FOR SOIL DENSIFICATION AND REINFORCEMENT**

**Method of Measurement.** Timber Piling will be measured by the actual number of linear feet of accepted pile remaining in the finished work after all cut-offs or build-ups have been made, based upon lengths shown on the plans or established by the Engineer.

In case piles are driven to refusal in resistant rock or IGM that is present shallower than the plan tip elevations shown on plans, timber piles will be measured and paid by the plan lengths shown on plans, including any cut-off length.

No allowance for cut-off will be made on piling for any length in excess of the lengths shown on the plans or established by the Engineer. For piles furnished according to the lengths shown on the plans or established by the Engineer that are found to be too short and are spliced according to details shown in the plans, an allowance of 4 linear feet of piling will be made for each timber pile splice in addition to the actual length of accepted pile in place.

No allowance will be made for cut-off or build-up of any portion of a pile that has been damaged, for splices made for the convenience of the Contractor, for extra length ordered for the Contractor's convenience, or for cutback necessary for splicing. Cut-off material shall become the property and responsibility of the Contractor.

**Basis of Payment.** Work completed and accepted and measured as provided above will be paid for at the contract unit price bid per linear foot for Timber Piling, which price shall be full compensation for furnishing, transporting, handling and storing material, driving, drilling, and excavation, for cut-off, splicing, and build-up in accordance with the requirements of these Specifications, and for all labor, equipment, tools, and incidentals necessary to complete the work.

Payment will be made under:

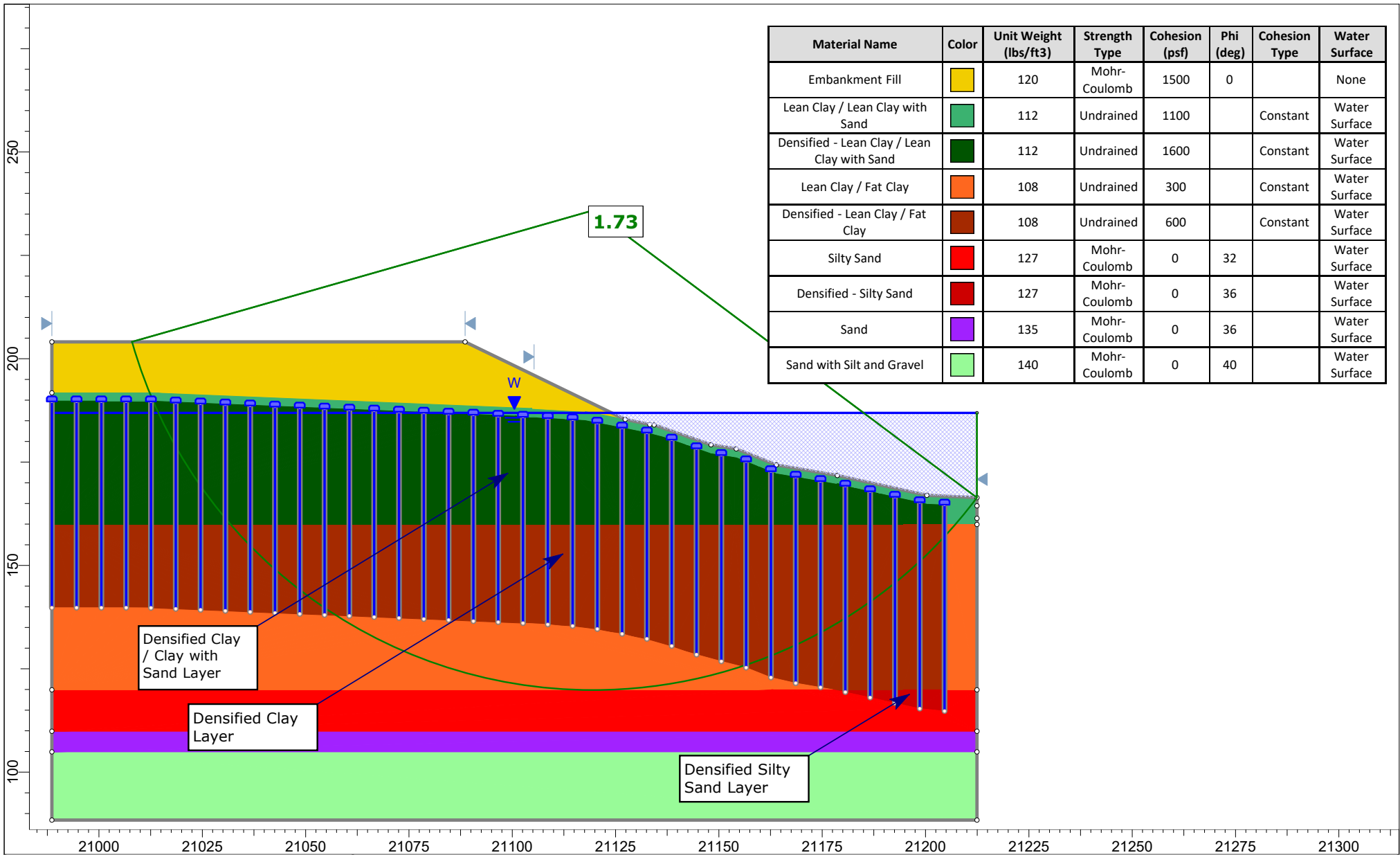
**Pay Item**

Timber Piling

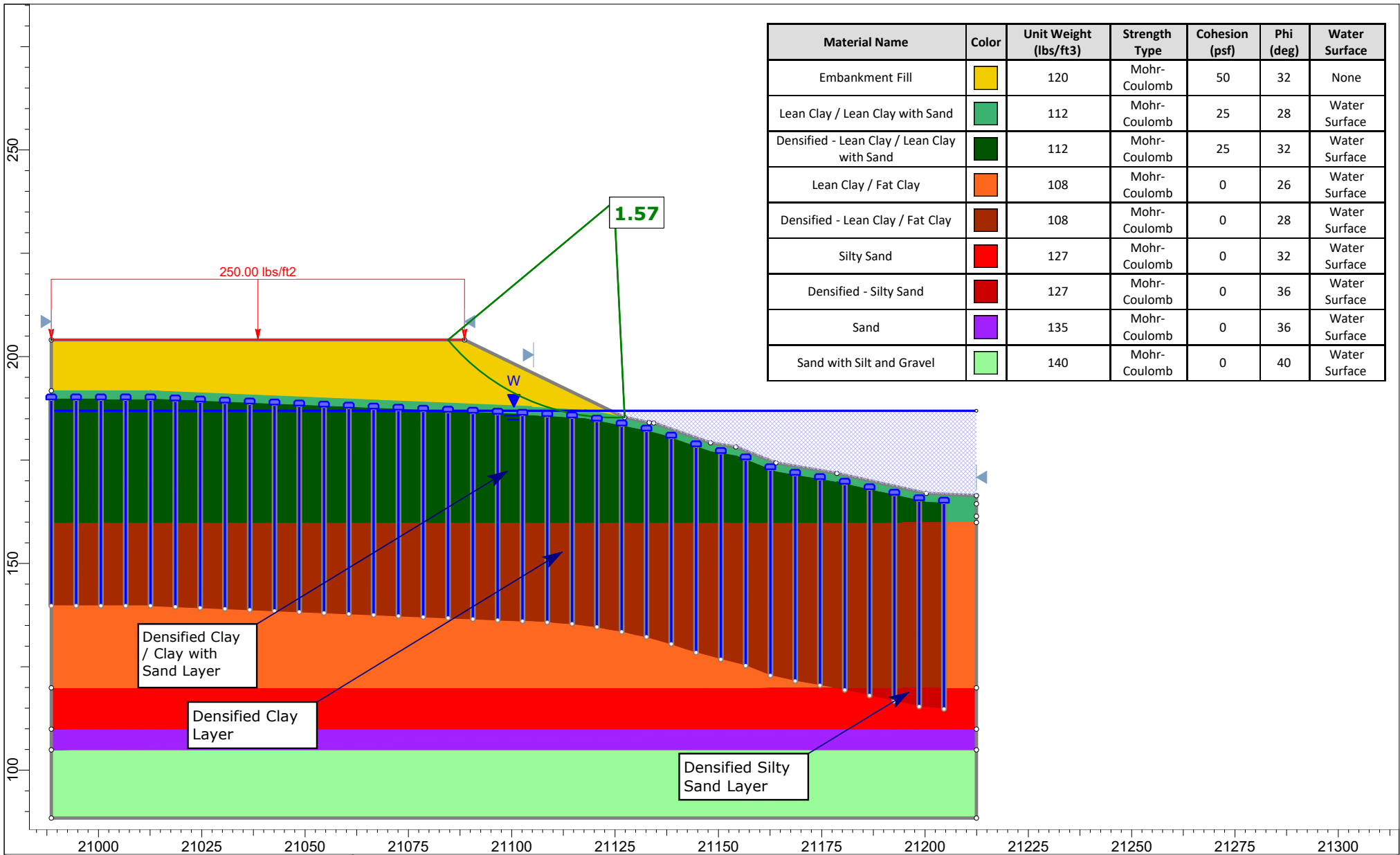
**Pay Unit**

Linear Foot

# Attachment I

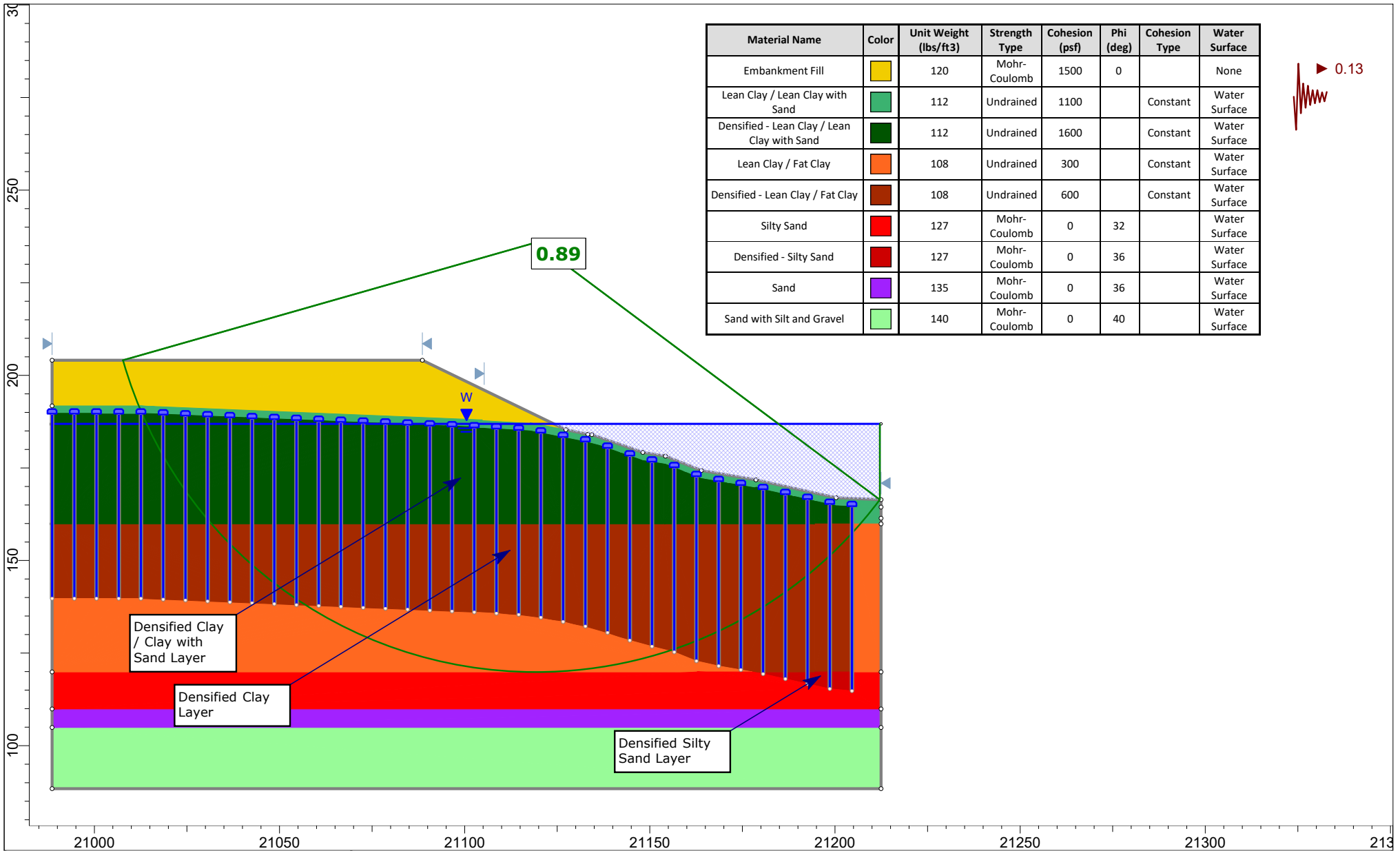


	Project		110717 - N.E. St. Francis Co. Strs. & Apprs. (S)	
	Site	West Embankment	Analysis Type	Short Term / End of Construction
	Analyzed By	PT	Configuration	Hwy. 50 over Blackfish Bayou
	Date	5/4/2023		

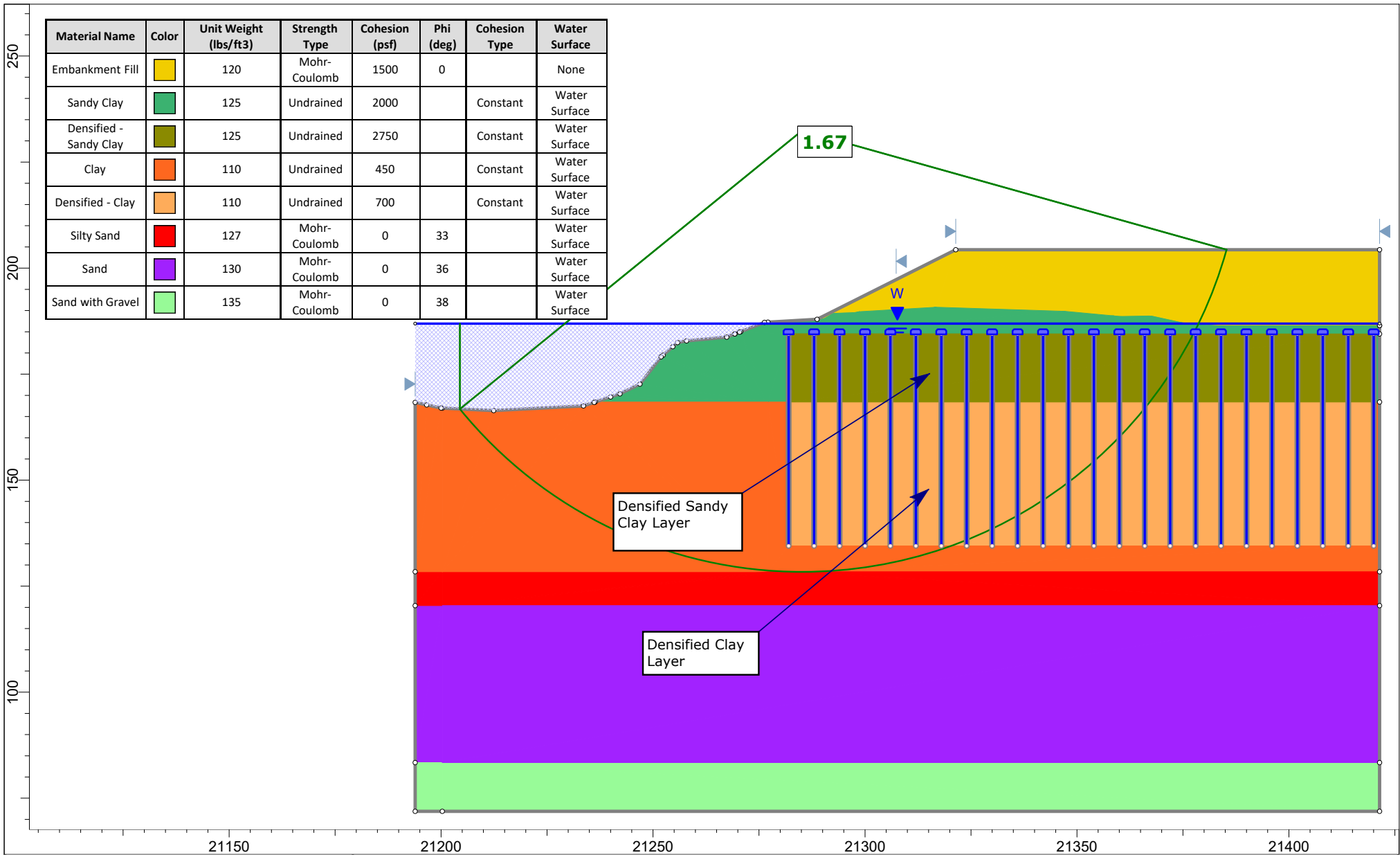


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Embankment Fill	Yellow	120	Mohr-Coulomb	50	32	None
Lean Clay / Lean Clay with Sand	Green	112	Mohr-Coulomb	25	28	Water Surface
Densified - Lean Clay / Lean Clay with Sand	Dark Green	112	Mohr-Coulomb	25	32	Water Surface
Lean Clay / Fat Clay	Orange	108	Mohr-Coulomb	0	26	Water Surface
Densified - Lean Clay / Fat Clay	Brown	108	Mohr-Coulomb	0	28	Water Surface
Silty Sand	Red	127	Mohr-Coulomb	0	32	Water Surface
Densified - Silty Sand	Dark Red	127	Mohr-Coulomb	0	36	Water Surface
Sand	Purple	135	Mohr-Coulomb	0	36	Water Surface
Sand with Silt and Gravel	Light Green	140	Mohr-Coulomb	0	40	Water Surface

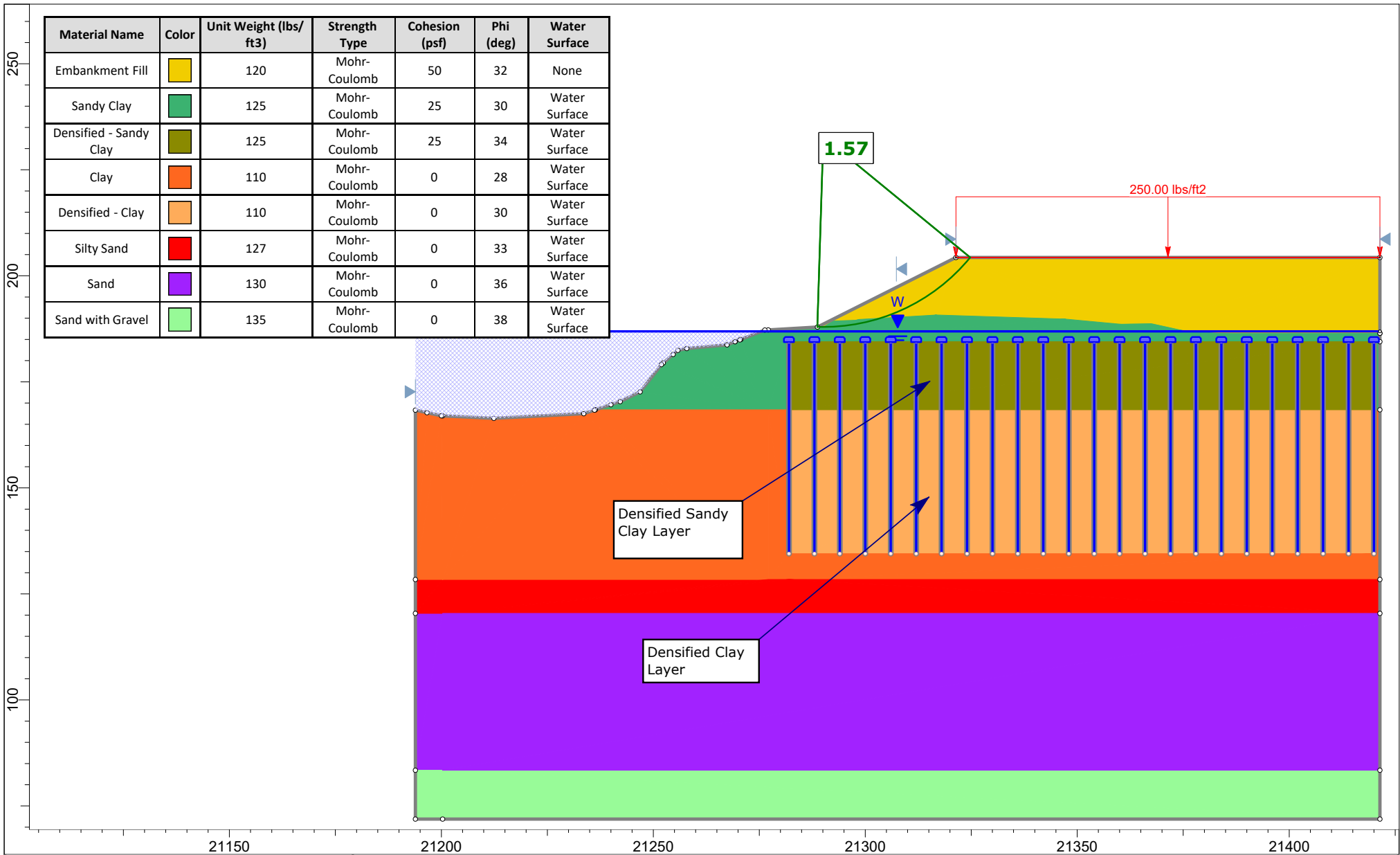
	Project		110717 - N.E. St. Francis Co. Strs. & Apprs. (S)	
	Site	West Embankment	Analysis Type	Long Term
	Analyzed By	PT	Configuration	Hwy. 50 over Blackfish Bayou
	Date	5/3/2023		











	Project		110717 - N.E. St. Francis Co. Strs. & Apprs. (S)	
	Site	West Embankment	Analysis Type	Seismic
	Analyzed By	PT	Configuration	Hwy. 50 over Blackfish Bayou
	Date	5/8/2023		

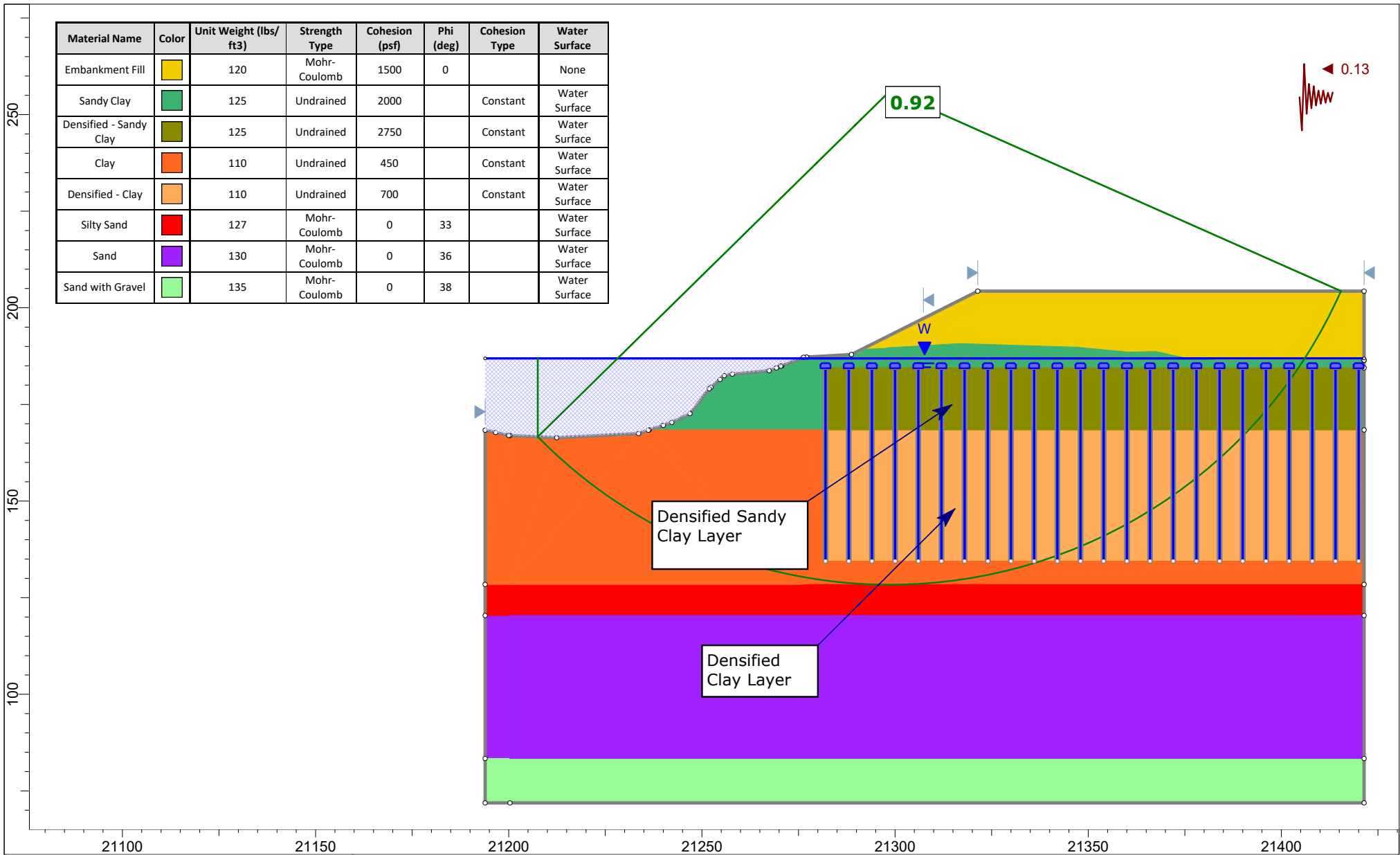



	Project			110717 - N.E. St. Francis Co. Strs. & Apprs. (S)			
	Site		East Embankment		Analysis Type		Short Term / End of Construction
	Analyzed By		PT		Configuration		Hwy. 50 over Blackfish Bayou
	Date		5/3/2023				



	Project		110717 - N.E. St. Francis Co. Strs. & Apprs. (S)	
	Site	East Embankment	Analysis Type	Long Term
	Analyzed By	PT	Configuration	Hwy. 50 over Blackfish Bayou
	Date	5/3/2023		

Material Name	Color	Unit Weight (lbs/ft <sup>3</sup> )	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface
Embankment Fill		120	Mohr-Coulomb	1500	0		None
Sandy Clay		125	Undrained	2000		Constant	Water Surface
Densified - Sandy Clay		125	Undrained	2750		Constant	Water Surface
Clay		110	Undrained	450		Constant	Water Surface
Densified - Clay		110	Undrained	700		Constant	Water Surface
Silty Sand		127	Mohr-Coulomb	0	33		Water Surface
Sand		130	Mohr-Coulomb	0	36		Water Surface
Sand with Gravel		135	Mohr-Coulomb	0	38		Water Surface



	Project		110717 - N.E. St. Francis Co. Strs. & Apprs. (S)	
	Site	East Embankment	Analysis Type	Seismic
	Analyzed By	PT	Configuration	Hwy. 50 over Blackfish Bayou
	Date	5/8/2023		

## Attachment J

## SIMPLIFIED NEWMARK BLOCK ANALYSIS - NCHRP 611 110717 - WEST EMBANKMENT

### 1. Seismic Coefficients

*Seismic coefficients from USGS Seismic Hazard Web using GPS = 35.021888, -90.520133 and Seismic Site Class E*

$$PGA := 0.433$$

$$F_{PGA} := 0.9$$

$$A_S := F_{PGA} \cdot PGA \cdot 0.67 = 0.261$$

$$S_S := 0.81$$

$$F_A := 1.128$$

$$S_{DS} := F_A \cdot S_S = 0.914$$

$$S_1 := 0.211$$

$$F_V := 3.158$$

$$S_{D1} := F_V \cdot S_1 = 0.666$$

$$k_{max} := A_S$$

*Peak ground acceleration coefficient at the ground surface (Eq. 7-1)*

$$PGV := 55 \cdot S_{D1} \cdot \frac{in}{s} = 36.6 \frac{in}{s}$$

*Peak Ground Velocity for M = 7.5 (Eq. 5-11)*

$$\beta := \frac{S_{D1}}{k_{max}} = 2.552$$

*Part of Eq. 7-2 to calculate reduction factor for peak ground acceleration*

### 2. Embankment Parameters

$$H := 15 \text{ ft}$$

*Embankment or wall height*

$$\alpha := 1 + 0.01 \cdot \frac{H}{ft} \cdot (0.5 \cdot \beta - 1) = 1.041$$

*Reduction factor accounting for fill height for Seismic Site Classes C, D, and E foundations (Eq. 7-2)*

$$k_{av} := \alpha \cdot k_{max} = 0.272$$

*Peak ground acceleration adjusted by fill height (Eq. 7-1)*

$$k_y := 0.103$$

*Yield acceleration of the failure mass, i.e., horizontal acceleration that results in a factor of safety of 1.0 in a pseudo-static limit equilibrium stability analysis, backcalculated by using stability analysis software*

$$k_{max} := k_{av} = 0.272$$

### 3. Newmark Block Displacement

$$A := -1.51 - 0.74 \cdot \log\left(\frac{k_y}{k_{max}}\right) + 3.27 \cdot \log\left(1 - \frac{k_y}{k_{max}}\right)$$

$$B := -0.80 \cdot \log(k_{max}) + 1.59 \cdot \log\left(\frac{PGV}{\frac{in}{s}}\right)$$

$$d := 10^{(A+B)} \cdot in = 11.6 \text{ in}$$

*Estimated permanent displacement (Eq. 5-8)*

## SIMPLIFIED NEWMARK BLOCK ANALYSIS - NCHRP 611 110717 - EAST EMBANKMENT

### 1. Seismic Coefficients

*Seismic coefficients from USGS Seismic Hazard Web using GPS = 35.021888, -90.520133 and Seismic Site Class E*

$$PGA := 0.433$$

$$F_{PGA} := 0.9$$

$$A_S := F_{PGA} \cdot PGA \cdot 0.67 = 0.261$$

$$S_S := 0.81$$

$$F_A := 1.128$$

$$S_{DS} := F_A \cdot S_S = 0.914$$

$$S_1 := 0.211$$

$$F_V := 3.158$$

$$S_{D1} := F_V \cdot S_1 = 0.666$$

$$k_{max} := A_S$$

*Peak ground acceleration coefficient at the ground surface (Eq. 7-1)*

$$PGV := 55 \cdot S_{D1} \cdot \frac{in}{s} = 36.6 \frac{in}{s}$$

*Peak Ground Velocity for M = 7.5 (Eq. 5-11)*

$$\beta := \frac{S_{D1}}{k_{max}} = 2.552$$

*Part of Eq. 7-2 to calculate reduction factor for peak ground acceleration*

### 2. Embankment Parameters

$$H := 17 \text{ ft}$$

*Embankment or wall height*

$$\alpha := 1 + 0.01 \cdot \frac{H}{ft} \cdot (0.5 \cdot \beta - 1) = 1.047$$

*Reduction factor accounting for fill height for Seismic Site Classes C, D, and E foundations (Eq. 7-2)*

$$k_{av} := \alpha \cdot k_{max} = 0.273$$

*Peak ground acceleration adjusted by fill height (Eq. 7-1)*

$$k_y := 0.108$$

*Yield acceleration of the failure mass, i.e., horizontal acceleration that results in a factor of safety of 1.0 in a pseudo-static limit equilibrium stability analysis, backcalculated by using stability analysis software*

$$k_{max} := k_{av} = 0.273$$

### 3. Newmark Block Displacement

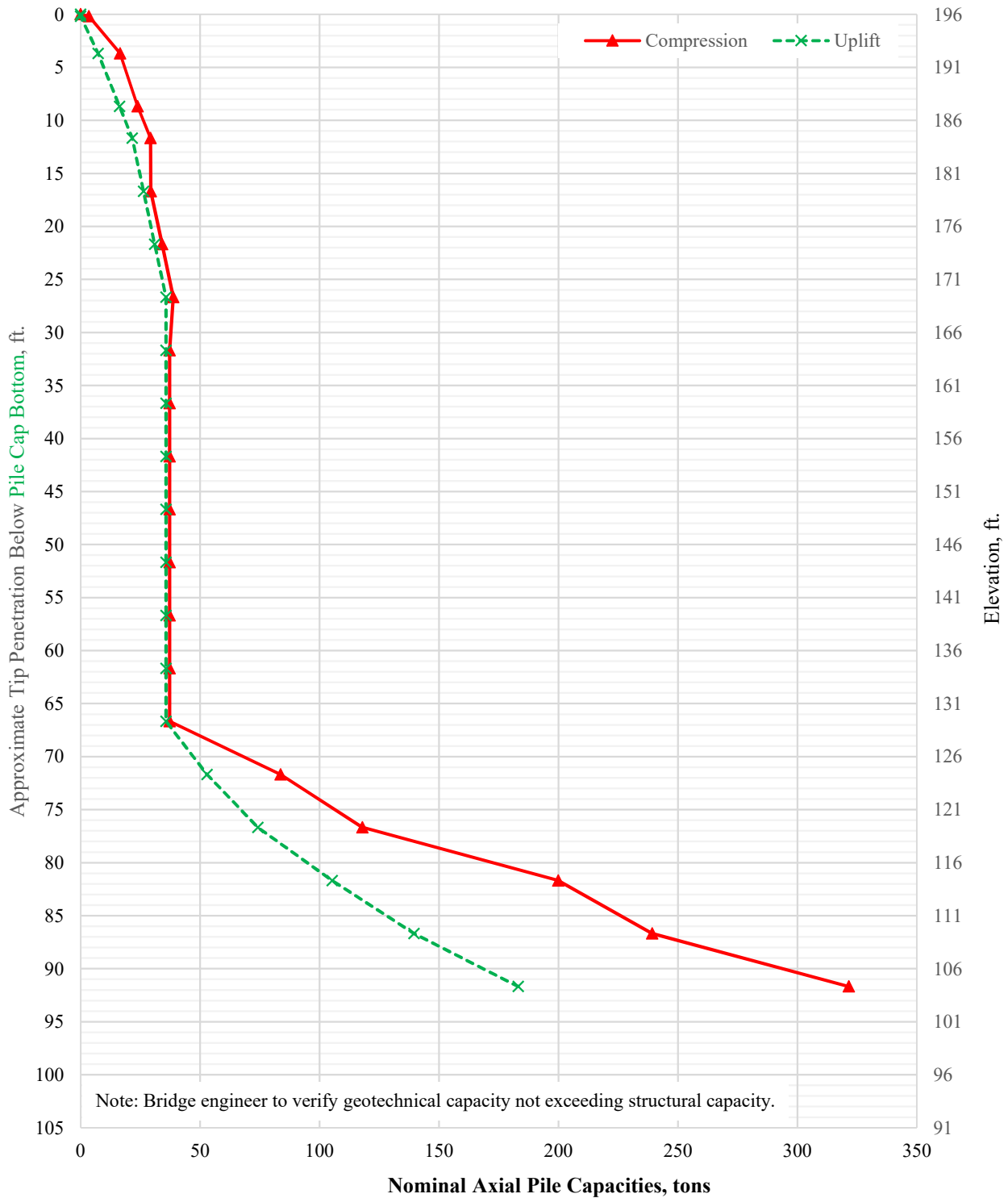
$$A := -1.51 - 0.74 \cdot \log\left(\frac{k_y}{k_{max}}\right) + 3.27 \cdot \log\left(1 - \frac{k_y}{k_{max}}\right)$$

$$B := -0.80 \cdot \log(k_{max}) + 1.59 \cdot \log\left(\frac{PGV}{\frac{in}{s}}\right)$$

$$d := 10^{(A+B)} \cdot in = 10.3 \text{ in}$$

*Estimated permanent displacement (Eq. 5-8)*

## Attachment K

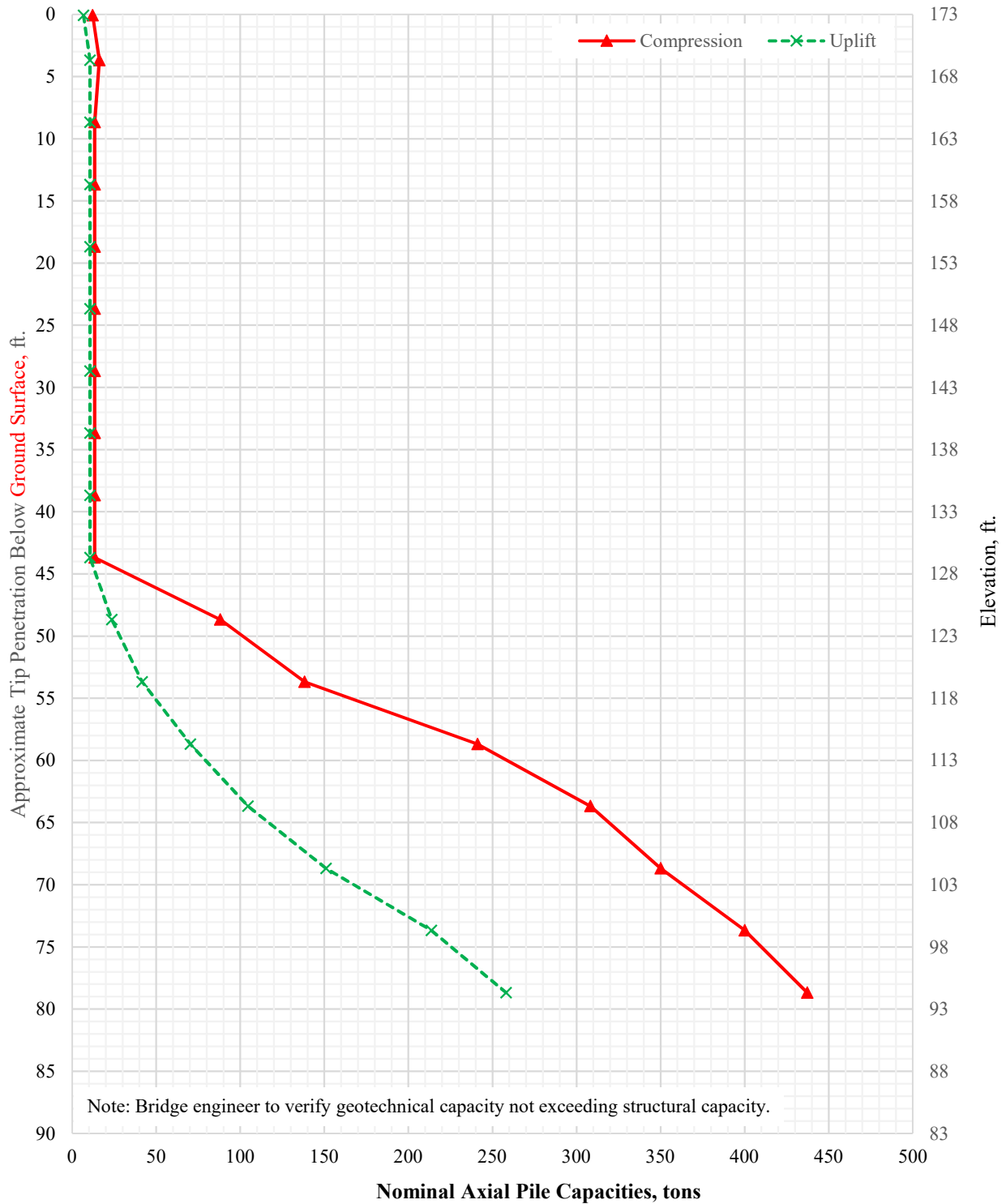


Note: Bridge engineer to verify geotechnical capacity not exceeding structural capacity.

**SINGLE 18"-DIAMETER CONCRETE-FILLED STEEL SHELL PILE**

Bent 1 - Sta. 210+99  
 Site No. 2 - Highway 50 over Blackfish Bayou  
 Project No.: 110717  
 Location: St. Francis County

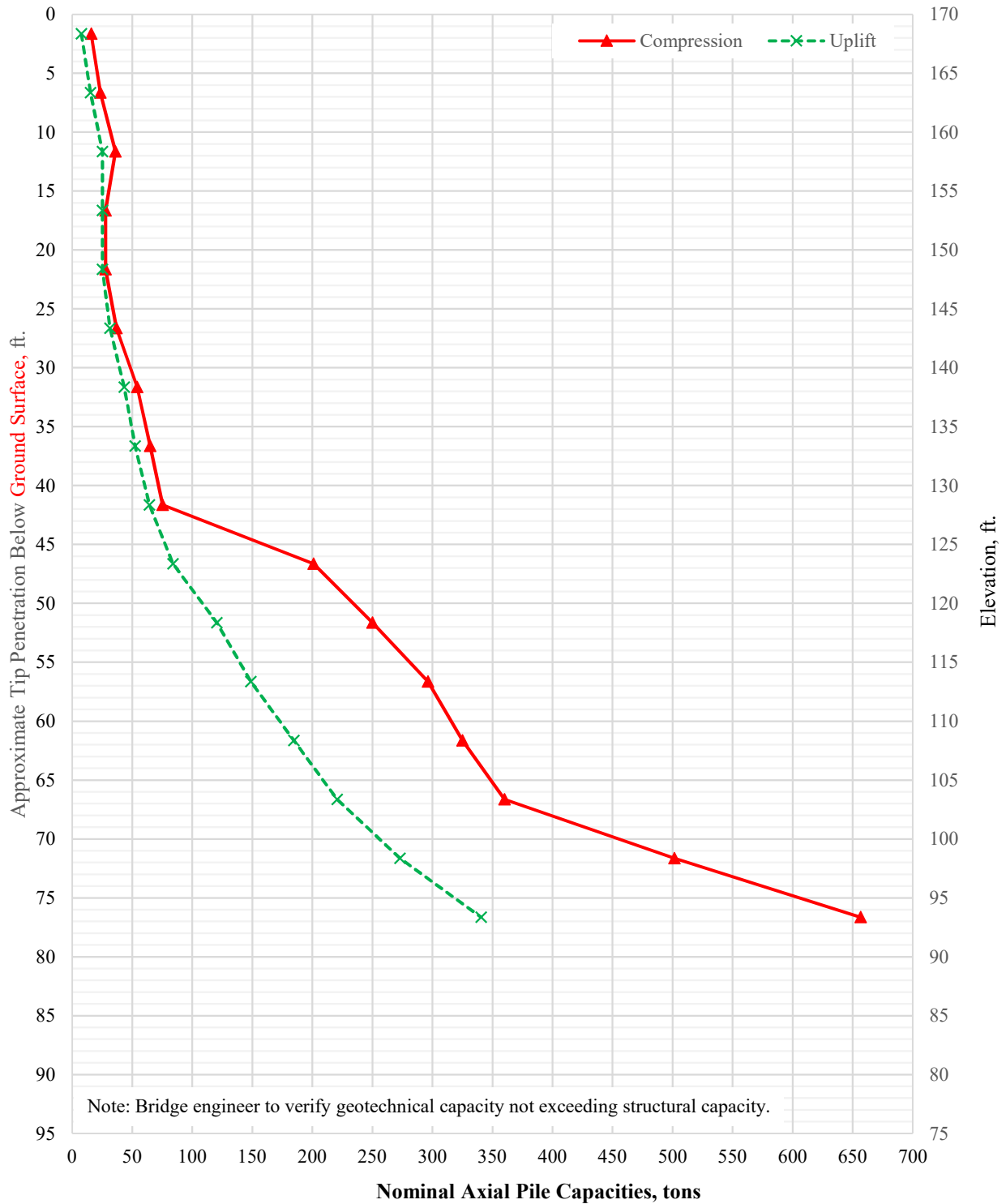




**SINGLE 24"-DIAMETER CONCRETE-FILLED STEEL SHELL PILE**

Bent 2 - Sta. 211+70  
 Site No. 2 - Highway 50 over Blackfish Bayou  
 Project No.: 110717  
 Location: St. Francis County

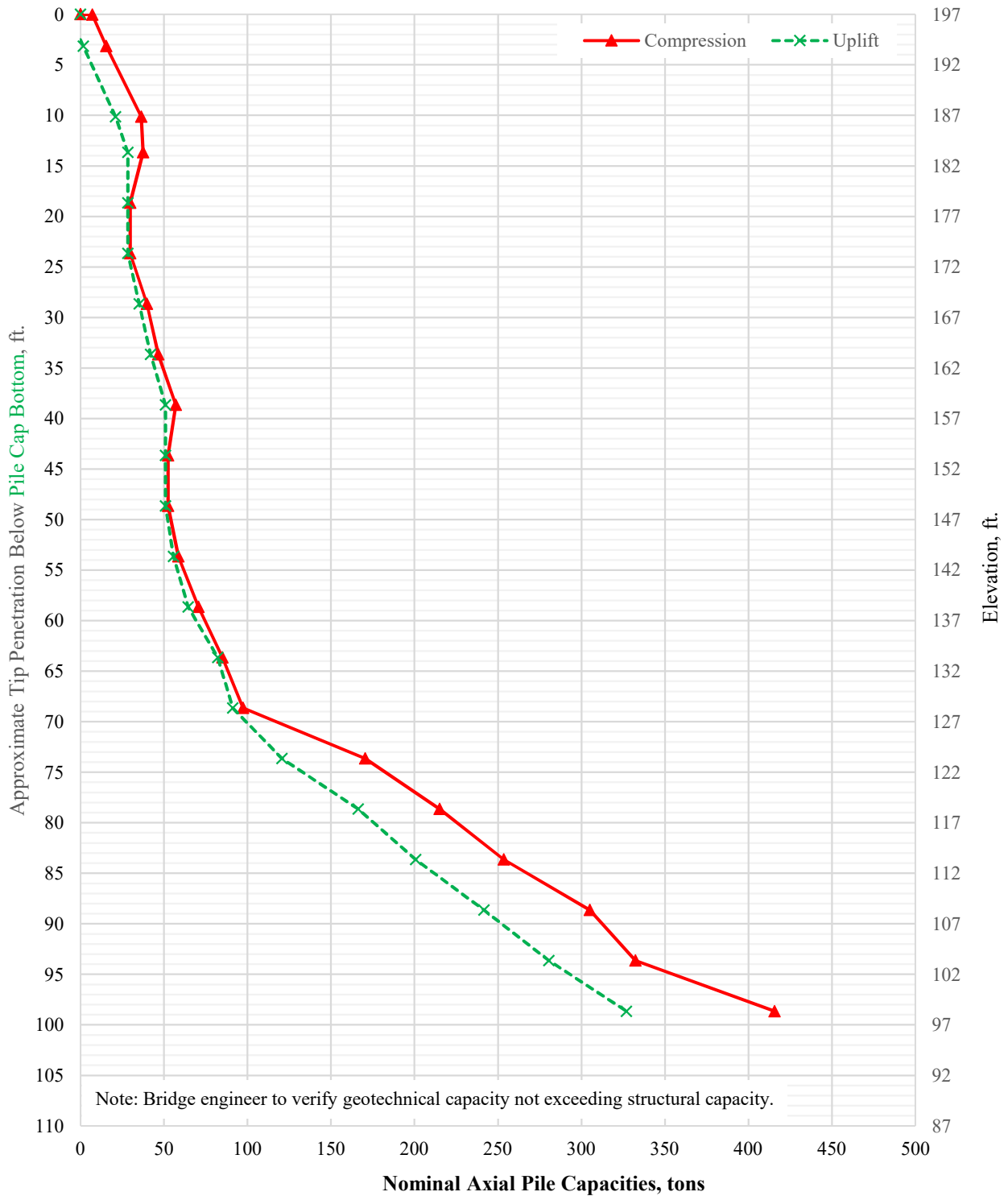




**SINGLE 24"-DIAMETER CONCRETE-FILLED STEEL SHELL PILE**

Bent 3 - Sta. 212+40  
 Site No. 2 - Highway 50 over Blackfish Bayou  
 Project No.: 110717  
 Location: St. Francis County





Note: Bridge engineer to verify geotechnical capacity not exceeding structural capacity.

**SINGLE 18"-DIAMETER CONCRETE-FILLED STEEL SHELL PILE**

Bent 4 - Sta. 213+11  
 Site No. 2 - Highway 50 over Blackfish Bayou  
 Project No.: 110717  
 Location: St. Francis County

