STRUCTURE GEOTECHNICAL REPORT

SN 061-0093
Existing SN: 061-0065

US 50 over Brubaker Creek Tributary
FAP Route 327
Section 15BR
Marion County
D-98-017-06
Contract #76949
PTB #153/053

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IDOT, Region 5, District 8
Geotechnical Unit

Checked By: LC / RW

Date: August 27, 2010
Revised: December 2, 2010

Prepared For: F. Allen Smith, P.E., S.E.
TranSystems
Saint Louis, Missouri
(314) 997-2459

Attachments

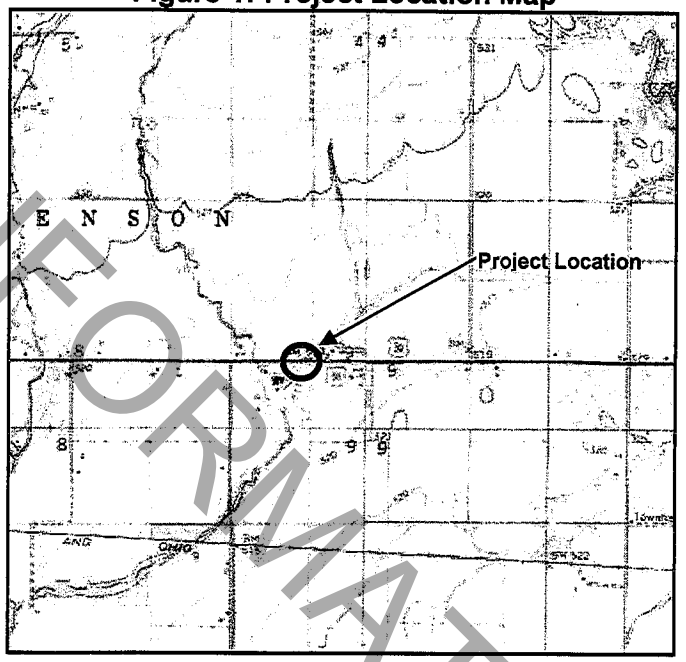
- Preliminary TS&L Plans
- Soil Profile
- Soil Boring Logs
- Liquefaction Analysis
- Settlement Analysis
- Slope Stability
- Pile Analysis
- Preliminary Abutment Loads

This report has been prepared based on a preliminary TS&L dated 8/16/10 and a preliminary plan and profile sheet dated 8/16/10. Contact the author if there are any questions regarding this report of if there are modifications to structure location, size, geometry, or vertical alignment.

Project Description

This project consists of the complete replacement of existing structure 061-0065 with proposed structure 061-0093. The structure is located at the intersection of FAP 327 (US 50) over Brubaker Creek Tributary at Station 1100+61 in Marion County. Specifically, the structure is located in the west half of Section 9, Township 2 North, Range 3 East, 3rd Principal Meridian. The location of the structure is 2.3 miles east of Salem. See Figure 1 for the Project Location Map.

Figure 1: Project Location Map



Existing and Proposed Structure Information

The existing structure consists of a single span concrete deck slab bridge on abutments with attached wingwalls supported by spread footings. The existing structure is 22'-0" back-to-back abutments and 40'-6" out-to-out deck. It was originally constructed in 1920 as SBI Route 12, Section 15-BY, and was reconstructed in 1951 by widening the deck and abutments. The existing structure has been programmed for total replacement due to the deteriorated condition of the deck and existing substructure.

The proposed structure will consist of a single span slab bridge on integral abutments. The planned length is 43'-0" back-to-back abutments and 47'-2" out-to-out deck. The proposed structure station is 1100+61. There is no skew.

Soils Investigation

Area Geology

The proposed structure lies in the Springfield Plain physiographic province of Illinois and the Tills Plains Section of the Central Lowlands Province of the United States. The location consists of surficial materials from the Glasford Formation (Radnor Till

and Sterling Till Members). Bedrock is generally limestone, sandstone, shale, and underclay of the Spoon Formation, formed during the Pennsylvanian period. There are four coal layers in the bedrock, the DeKoven Coal, the Davis Coal, and two unnamed layers.

Based on a review of the Marion County Soil Survey, the primary soil type at the proposed structure is the Hoyleton-Darmstadt Silt Loam. This soil is eroded and somewhat poorly drained, and consists of loess over mixed loess and drift.

Subsurface Profile

Two borings were conducted by District 8 in June 2010. Boring 1, E Abut is located at Station 1100+33 with a 14 foot Right offset. Boring 2, W Abut is located at Station 1100+91.5 with a 14 foot Left offset. These borings describe a soil profile of stiff clay loam, silty clay, and silty clay loam over hard sandy loam and silty loam. Sand was encountered from Elev 488.5 to Elev 483.0 at the West Abutment. Weathered shale was encountered at Elev 470.5 at the West Abutment and competent shale was encountered at Elev 466.5 at the East Abutment. Groundwater elevations were recorded at Elev 500.0 at the West Abutment and at Elev 513.5 at the East Abutment.

Geotechnical Evaluation

Liquefaction

Liquefaction analysis was conducted as per AGMU Memo 10.1. The analysis indicates that the potentially liquefiable layer at Elev. 470.0 at the West Abutment exhibits an adequate factor of safety against liquefaction. The remaining layers are considered to be non-liquefiable.

Mining Activity

According to the Illinois State Geological Survey's collection of County Coal Mine Maps and Directories, there has been no recorded mining activity in the effective area of the project.

Scour

According to the District 8 Hydraulic Report, the proposed structure is subject to 3 feet of contraction scour at the 100-year event level. The existing overtopping frequency occurs at the 135-year event level. The entire bridge opening is protected with RR-5 riprap, which extends from 10 feet upstream to 10 feet downstream of the existing structure.

The Design Scour Table provides the appropriate elevations at each of the substructure units. Note that the scour elevation at each of the abutments is at the bottom of the abutment pile casing. Assuming that the RR-5 riprap is an appropriate scour countermeasure, the piles do not need to be designed for scour.

Design Scour Elevation	*West Abutment*	*East Abutment*
	512.01 ft	512.01 ft

Seismic

The area is within the Seismic Performance Zone 2. The site's soil profile is most accurately described as Soil Site Class C. The Design Spectral Acceleration at 1 second is 0.19 g and 0.51 g at 0.2 seconds.

Settlement

Since only 0.7 feet of additional embankment is to be added to the existing bridge cones, any settlement that occurs is expected to be insignificant. Our calculations, utilizing split spoon boring data available at the site, estimate the settlement to be on the order of 0.12 to 0.16 inches. This amount of settlement is considered negligible and should have little to no impact on the structure.

Slope Stability

Based on information obtained for the boring and recommendation from the IDOT Geotechnical Manual, slope stability calculations have been performed using the computer program XSTABL. The use of 1:2 (V:H) end slopes results in acceptable Factors of Safety ranging from 10.918 for the static analysis to 8.306 for the seismic analysis.

Design Recommendations

Spread Footings

Spread footings are not appropriate for integral abutments, due to the necessity of an integral abutment foundation being able to deflect laterally with the expansion and contraction of the bridge.

Drilled Shafts

Drilled shaft foundations will not allow the deflection tolerances required for an integral abutment, and therefore, are not recommended for this location.

Piles

It appears that pile-supported substructures should be feasible at this location given the preliminary axial loads provided by TranSystems. With the soil conditions present, it appears that metal shell piles or end-bearing steel H-piles can be used both abutments.

Design Capacity Limitations

No geotechnical losses were taken into account in the design of the abutment piles because the end slopes have effective scour countermeasures. According to our analyses, liquefaction is not an issue at any of the substructure locations.

Pile Design Table – West Abutment

Est. Pile Length (ft)	12" MS 0.25" Wall *Max R_N 355 kips*		14" MS 0.25" Wall *Max R_N 416 kips*		14" MS 0.312" Wall *Max R_N 516 kips*		HP 10x42 *Max R_N 335 kips*		HP 12x53 *Max R_N 418 kips*		HP 12x63 *Max R_N 497 kips*	
	R_N (kips)	R_F (kips)	R_N (kips)	R_F (kips)	R_N (kips)	R_F (kips)	R_N (kips)	R_F (kips)	R_N (kips)	R_F (kips)	R_N (kips)	R_F (kips)
15	117	64	143	79	143	79	142	78	178	98	180	99
17	146	80	178	98	178	98	179	99	223	123	225	124
19	159	88	193	106	193	106	196	108	244	134	246	135
21	185	102	222	122	222	122	231	127	285	157	288	158
27					383	211	271	149	335	184	338	186

Pile Design Table – East Abutment

Est. Pile Length (ft)	12" MS 0.25" Wall Max R_N 355 kips		14" MS 0.25" Wall Max R_N 416 kips		14" MS 0.312" Wall Max R_N 516 kips		HP 10x42 Max R_N 335 kips		HP 12x53 Max R_N 418 kips		HP 12x63 Max R_N 497 kips	
	R_N (kips)	R_F (kips)	R_N (kips)	R_F (kips)	R_N (kips)	R_F (kips)	R_N (kips)	R_F (kips)	R_N (kips)	R_F (kips)	R_N (kips)	R_F (kips)
14	240	132	313	172	313	172	143	79	172	94	176	97
16	256	141	330	181	330	181	157	87	188	104	192	106
18	263	145	338	186	338	186	161	89	196	108	200	110
22							220	121	263	145	270	148
26							280	154	335	184	343	189
30							329	171	405	223	414	228

Lateral Loading

The factored lateral loading for each abutment is anticipated to be less than 3 kips per pile, therefore, no lateral loading analysis was conducted.

Test Piles

We recommend that one test pile be driven, due to relatively uniform rock elevations between the abutments. The test pile should be driven at the west abutment because of the presence of highly weathered rock and longer estimated pile lengths.

Metal Shoes

No conditions exist which would require metal shoes to be installed on any of the piles at this site.

Final Plans

The following is an example of the information that should be shown for each substructure unit on the Final Plans:

PILE DATA
Type and Size: Steel HP XX x XX
Nominal Required Bearing: XXX kips
Factored Resistance Available: XXX kips
Estimated Pile Length: XXX ft
Number of Production Piles: XXX
Number of Test Piles: XXX

Under the General Notes, the following note should be included:

"The Contractor shall drive test piles to 110% of the nominal required bearing specified in permanent locations at substructures specified or approved by the Engineer before ordering the remainder of the piles."

Construction Considerations

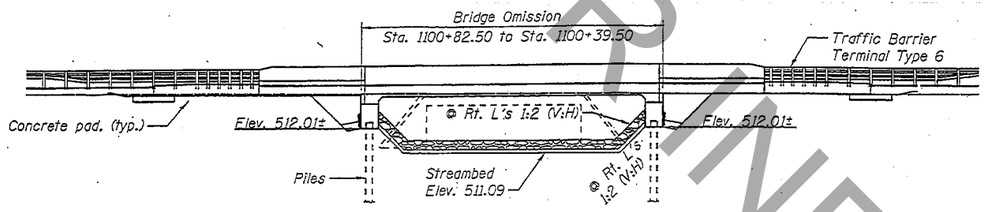
Because of stage construction requirements, temporary retention will be necessary at both abutments for Stage 1 and Stage 2 traffic. Based on our analyses, cantilevered sheet piling is feasible at both abutments between the proposed abutments and the existing abutments.

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

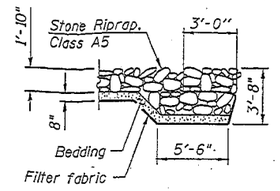
Bench Mark: B.M. 213 cut square on the Southeast Wingwall of Structure No. 061-0065 Sta. 1100+50.00 21' Lt. Elev. 517.35

Existing Structure: Sturcture No. 061-0093 was built in 1920 as a single span reinforced concrete deck slab structure with abutments founded on spread footings. It consists of a superstructure 22'-0" in length (back to back abutments) and provides a width of 40'-6" out to out. The structure was constructed with a 0 degree skew. The structure was reconstructed in 1951. The road shall be kept open to one lane traffic at all times utilizing stage construction.

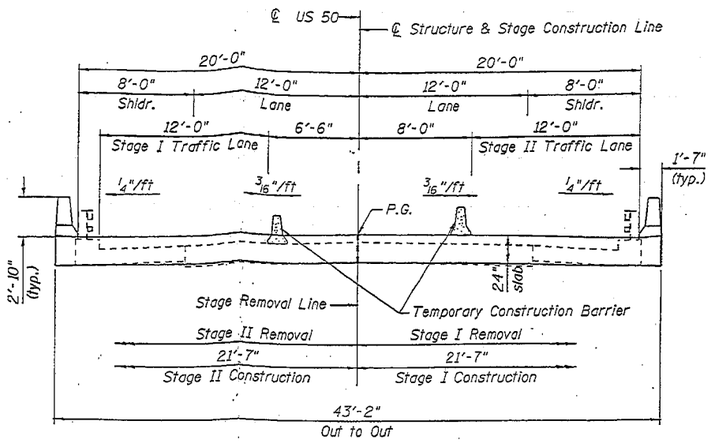
Salvage: No Salvage



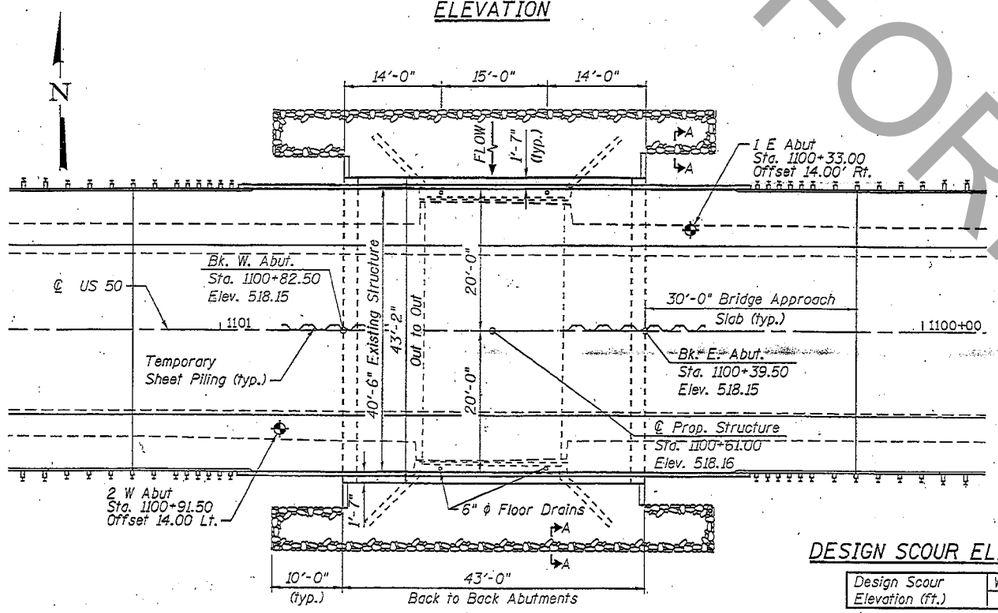
ELEVATION



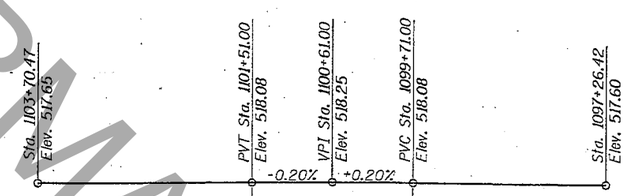
SECTION A-A



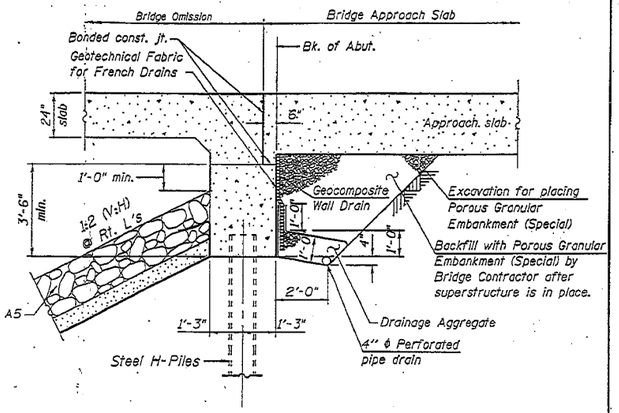
CROSS SECTION
(Looking West)



PLAN



PROFILE GRADE
Along ℄ Roadway



SECTION THRU ABUTMENT
(Horiz. dim. @ Rt. L's)

Notes:
Excavation behind existing abutment walls shall be performed to balance front and back soil pressure before removing the existing superstructure. The Contractor shall sawcut the upper portion of the existing abutment at the stage removal line before Stage I removal to ensure the remaining portion will not be prematurely damaged.

DESIGN SCOUR ELEVATION TABLE

Design Scour Elevation (ft.)	W. Abut.	E. Abut.
	512.01	512.01

WATERWAY INFORMATION

Drainage Area = 1.9 Sq Miles — Low Grade Elev. 517.31 @ Sta. 1110+56.00

Flood	Freq. Yr.	SN	Q C.F.S. Exist.	Q C.F.S. Prop.	Opening Sq. Ft. Exist.	Opening Sq. Ft. Prop.	Nat. H.W.E.	Head - Ft. Exist.	Head - Ft. Prop.	Headwater El. Exist.	Headwater El. Prop.
Design	50	061-0065	717	747	89	112	514.78	1.66	1.42	516.44	516.20
		10'x4' Culvert	262	232	30	30					
		Total	979	979	118	142					
Base	100	061-0065	846	877	91	118	514.92	2.07	1.61	516.99	516.53
		10'x4' Culvert	304	273	31	31					
		Total	1,150	1,150	123	149					
Existing Overtopping	135	061-0065	904		92		514.97	2.34		517.31	
		10'x4' Culvert	318		32						
		Total	1,222		124						
Proposed Overtopping	333	061-0065		1,118		127	515.17		2.14		517.31
		10'x4' Culvert		322		35					
		Total		1,440		162					
Scour	10	061-0065	466	477	79	94	514.31	0.51	0.41	514.82	514.72
		10'x4' Culvert	138	127	25	25					
		Total	604	604	104	120					

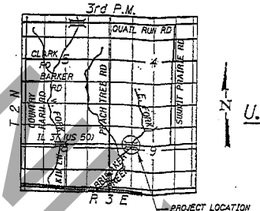
SEISMIC DATA
Seismic Performance Zone (SPZ) = 2
Design Spectral Acceleration at 1.0 sec. (S_{D1}) = 0.209 g
Design Spectral Acceleration at 0.2 sec. (S_{DS}) = 0.585 g
Soil Site Class = C

HIGHWAY CLASSIFICATION
F.A.P. Rte. 327 - US Rte. 50
Functional Class:
ADT: 4900 (2007); 6,200 (2031)
ADTT: 789 (2007); 999 (2031)
DHV: 620
Design Speed: 55 m.p.h.
Posted Speed: 55 m.p.h.
Two -Way Traffic
Directional Distribution: 50:50

DESIGN SPECIFICATIONS
2010 AASHTO LRFD Bridge Design Specifications

LOADING HL-93
Allow 50#/sq. ft. for future wearing surface.

DESIGN STRESSES
FIELD UNITS
f'c = 3,500 psi
fy = 60,000 psi (Reinforcement)
fy = 50,000 psi (M270 Grade 50)



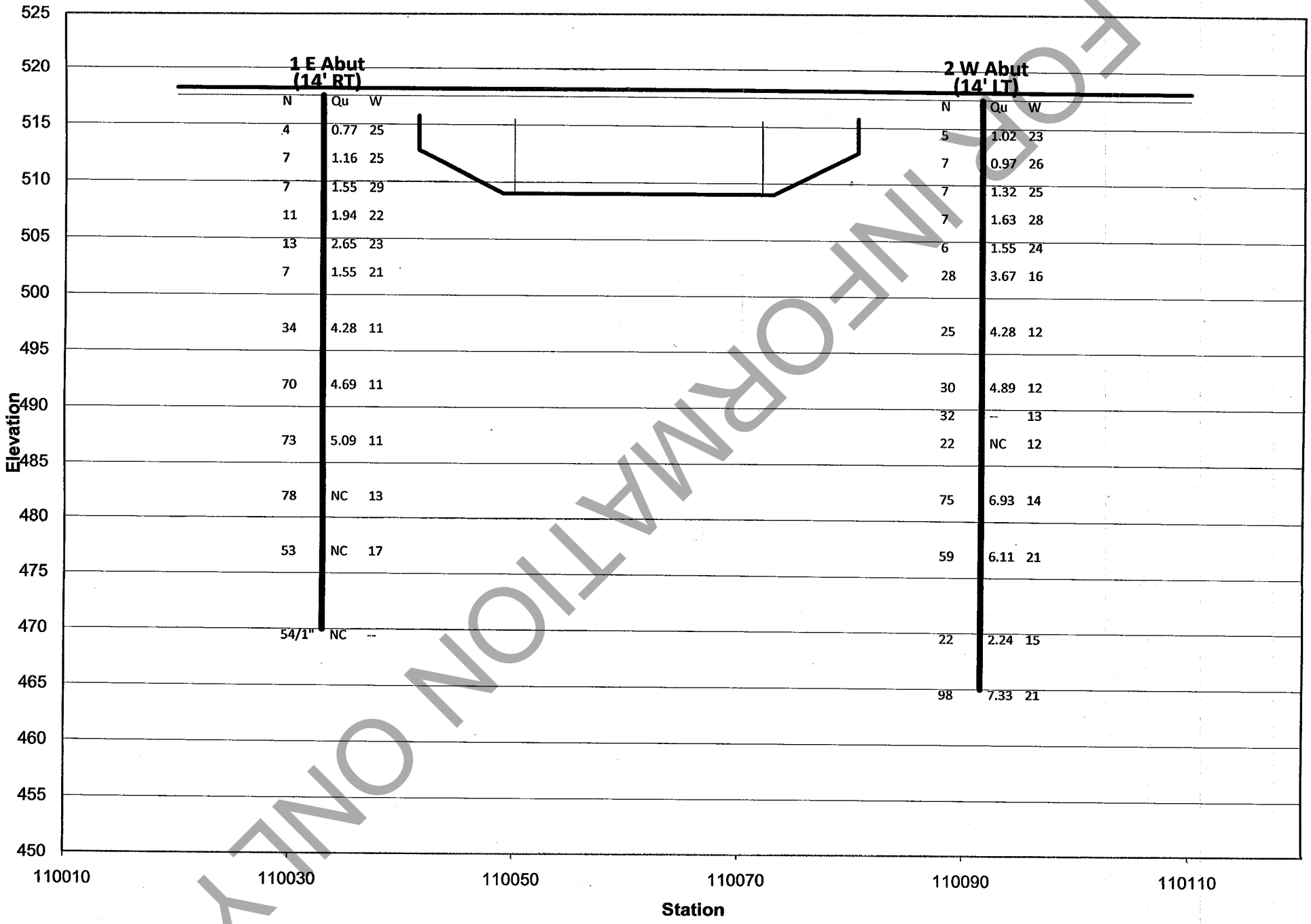
LOCATION SKETCH

GENERAL PLAN AND ELEVATION
U.S. Route 50 OVER BRUBAKER CREEK
F.A.P. 327 SEC. (15-BR)
MARION COUNTY
STATION 1100+61.00
STRUCTURE NO. 061-0093

DESIGNED -	
CHECKED -	
DRAWN -	
CHECKED -	

SHEET NO. 1	F.A.P RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
1 SHEETS	327	15-BR	MARION		
			CONTRACT NO. 76A23		
	ILLINOIS	FED. AID PROJECT			

US 50 over Brubaker Creek Tributary - 061-0065 (E) / 061-0093 (P)



12/3/2010

Log Plot (SLW 81810).xls

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Division of Highways
Illinois Department of Transportation

SOIL BORING LOG

Date 6/21/10

ROUTE FAP 327 DESCRIPTION US 50 over Brubaker Creek Tributary LOGGED BY VPG

SECTION 15BR LOCATION , SEC. 9, TWP. 2N, RNG. 3E, 3 PM

COUNTY Marion DRILLING METHOD Hollow Stem Auger HAMMER TYPE 140# Automatic

STRUCT. NO. 061-0065 (E) / 061-0093 (P)
Station

BORING NO. 1 E Abut
Station 1100+33
Offset 14.00ft Right
Ground Surface Elev. 517.5 ft

Surface Water Elev. ft
Stream Bed Elev. ft

Groundwater Elev.:
First Encounter 513.5 ft
Upon Completion ft
After Hrs. ft

DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
	Asphalt		
516.5			
	Brown Silty CLAY A-6(13)		
	1		
	2	0.77	25
	2	S/15	
-5	3		
	3	1.16	25
	4	S/5	
	3		
	3	1.55	29
509.0	4	S/5	
	Brown Clay LOAM A-7-6(14)		
-10	3		
	5	1.94	22
506.0	6	S/5	
	Gray Clay LOAM A-7-6(16)		
	4		
	6	2.65	23
	7	S/15	
-15	2		
	3	1.55	21
	4	S/5	
500.0			
	Gray Sandy LOAM A-2-4(0)		
-20	10		

DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
	Gray Sandy LOAM A-2-4(0) *(continued)*		
	14	4.28	11
	20	S/0	
-25	10		
	36	4.69	11
	34	S/0	
-30	25		
	30	5.09	11
	43	S/0	
484.0			
	Sandy LOAM		
-35	3		
	29		13
	49	NC	
	With Shale		
-40	7		

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

BBS, from 137 (Rev. 8-99)

Illinois Department of Transportation
Division of Highways
Illinois Department of Transportation

SOIL BORING LOG

Date 6/21/10

ROUTE FAP 327 DESCRIPTION US 50 over Brubaker Creek Tributary LOGGED BY VPG

SECTION 15BR LOCATION , SEC. 9, TWP. 2N, RNG. 3E, 3 PM

COUNTY Marion DRILLING METHOD Hollow Stem Auger HAMMER TYPE 140# Automatic

STRUCT. NO. 061-0065 (E) / 061-0093 (P)
Station

BORING NO. 1 E Abut
Station 1100+33
Offset 14.00ft Right
Ground Surface Elev. 517.5 ft

Surface Water Elev. ft
Stream Bed Elev. ft

Groundwater Elev.:
First Encounter 513.5 ft
Upon Completion ft
After Hrs. ft

DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)	
	24		17	Sandy LOAM *(continued)*
	29	NC		
-45				
	54/1"			
469.5	-		--	
		NC		Borehole continued with rock coring.
-50				
-55				
-60				

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

BBS, from 137 (Rev. 8-99)

Illinois Department of Transportation
Division of Highways
Illinois Department of Transportation

ROCK CORE LOG

Date 6/21/10

ROUTE FAP 327 DESCRIPTION US 50 over Brubaker Creek Tributary LOGGED BY VPG

SECTION 15BR LOCATION , SEC. 9, TWP. 2N, RNG. 3E, 3 PM

COUNTY Marion CORING METHOD

STRUCT. NO. 061-0065 (E) / 061-0093 (P)
Station

BORING NO. 1 E Abut
Station 1100+33
Offset 14.00ft Right
Ground Surface Elev. 517.5 ft

CORING BARREL TYPE & SIZE

Core Diameter 2 in
Top of Rock Elev. 469.50 ft
Begin Core Elev. 469.50 ft

	DEPTH (ft)	CORE (#)	RECOVERY (%)	R.Q.D. (%)	CORE TIME (min/ft)	STRENGTH (tsf)
Weathered SHALE	469.50				19.82	
	-50				19.41	
	466.50				15.46	
Gray SHALE	465.25				32.64	
Core Barrel Clogged - End of Boring	-55					
	-60					
	-65					

Color pictures of the cores Yes
Cores will be stored for examination until Indefinite
The "Strength" column represents the uniaxial compressive strength of the core sample (ASTM D-2938)

Illinois Department of Transportation
Division of Highways
Illinois Department of Transportation

SOIL BORING LOG

Date 6/23/10

ROUTE FAP 327 DESCRIPTION US 50 over Brubaker Creek Tributary LOGGED BY VPG

SECTION 15BR LOCATION , SEC. 9, TWP. 2N, RNG. 2E, 3 PM

COUNTY Marion DRILLING METHOD Hollow Stem Auger HAMMER TYPE 140# Automatic

STRUCT. NO. 061-0065 (E) / 061-0093 (P)
Station

BORING NO. 2 W Abut
Station 1100+91.5
Offset 14.00ft Left
Ground Surface Elev. 517.5 ft

Surface Water Elev. ft
Stream Bed Elev. ft

Groundwater Elev.:
First Encounter 500.0 ft
Upon Completion ft
After Hrs. ft

DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)	Material
	3			Brown and Gray Silty CLAY
	2	1.02	23	
	3	S/0		
-5	2			
	3	0.97	26	
	4	S/5		
	2			
	3	1.32	25	
509.0	4	S/5		
	2			Gray CLAY A-7-6(16)
-10	3	1.63	28	
	4	S/20		
	3			Brown
	3	1.55	24	
	3	S/5		
-15	6			
	10	3.67	16	
501.5	18	S/0		
				Gray Sandy LOAM A-4(2)
-20	8			

DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)	Material
	10	4.28	12	Gray Sandy LOAM A-4(2) *(continued)*
	15	S/0		
-25	8			
	12	4.89	12	
	18	S/0		
	5			
	15		13	
488.5	17	--		
-30	5			Medium to Fine SAND
	5		12	
	17	NC		
483.0	10			
-35	26	6.93	14	Gray Silty LOAM A-4(8)
	49	S/0		
-40	12			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

BBS, from 137 (Rev. 8-99)

Illinois Department of Transportation
Division of Highways
Illinois Department of Transportation

SOIL BORING LOG

Date 6/23/10

ROUTE FAP 327 DESCRIPTION US 50 over Brubaker Creek Tributary LOGGED BY VPG

SECTION 15BR LOCATION , SEC. 9, TWP. 2N, RNG. 2E, 3 PM

COUNTY Marion DRILLING METHOD Hollow Stem Auger HAMMER TYPE 140# Automatic

STRUCT. NO. 061-0065 (E) / 061-0093 (P)
Station

BORING NO. 2 W Abut
Station 1100+91.5
Offset 14.00ft Left
Ground Surface Elev. 517.5 ft

Surface Water Elev. ft
Stream Bed Elev. ft

Groundwater Elev.:
First Encounter 500.0 ft
Upon Completion ft
After Hrs. ft

DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)	Material
	22	6.11	21	Gray Silty LOAM A-4(8) *(continued)*
	37	S/0		
-45				
470.5				
	3			Gray Weathered SHALE
	7	2.24	15	
	15	S/0		
-50				
	8			
	24	7.33	21	
464.0	74	S/0		
				END OF BORING
-55				
-60				

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

BBS, from 137 (Rev. 8-99)

LIQUEFACTION ANALYSIS

I.D.O.T. Bureau of Bridges and Structures FOUNDATIONS AND GEOTECHNICAL UNIT

Modified 3/11/10

REFERENCE BORING NUMBER ========== 1 E Abut
ELEVATION OF BORING GROUND SURFACE ========== 517.50 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ========== 4.00 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ========== 4.65 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.203
EARTHQUAKE MOMENT MAGNITUDE ========== 4.8
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ========== 0.65 FT. (Fill Height)
HAMMER EFFICIENCY ========== 73 %
BOREHOLE DIAMETER ========== 2.5 to 4.5 IN.
SAMPLING METHOD ========== Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = **2.701**

AVG. SHEAR WAVE VELOCITY (top 40')
$V_{s,40'}$ = **791** FT./SEC.

PGA CALCULATOR
Earthquake Moment Magnitude = 4.8
Source-To-Site Distance, R (km) = 12.4
Ground Motion Prediction Equations = CEUS
PGA = **0.169**

	BORING DATA							CONDITIONS DURING DRILLING					CONDITIONS DURING EARTHQUAKE							
ELEV. OF SAMPLE (FT.)	BORING SAMPLE DEPTH (FT.)	SPT N VALUE (BLOWS)	UNCONF. COMPR. STR., Q_u (TSF.)	% FINES < #200 (%)	PLAST. INDEX PI	LIQUID LIMIT LL	MOIST. CONTENT w_c (%)	EFFECTIVE UNIT WT. (KCF.)	EFFECTIVE VERT. STRESS (KSF.)	CORR. SPT N VALUE $(N_1)_{60}$	EQUIV. CLN. SAND SPT N VALUE $(N_1)_{60cs}$	CRR RESIST. MAG 7.5 $CRR_{7.5}$	EFFECTIVE UNIT WT. (KCF.)	EFFECTIVE VERT. STRESS (KSF.)	TOTAL VERT. STRESS (KSF.)	OVER-BURDEN CORR. FACT. (Ks)	CORR. RESIST. $CRR_{7.5}$ CRR	SOIL MASS PART. FACTOR (r_d)	EQ INDUCED CSR	FACTOR OF SAFETY * CRR/CSR
515	2.5	4	0.77	84.3	22	38	25	0.119	0.298	6.590	12.908	0.140	0.119	0.375	0.375	1.500	0.566	0.999	0.132	N.L. (1)
512.5	5	7	1.16	84.3	22	38	25	0.061	0.450	11.035	18.242	0.195	0.061	0.528	0.590	1.482	0.779	0.997	0.147	N.L. (2)
510	7.5	7	1.55	84.3	22	38	29	0.064	0.610	10.491	17.589	0.187	0.064	0.688	0.906	1.369	0.692	0.995	0.173	N.L. (2)
507.5	10	11	1.94	60	31	47	22	0.067	0.778	17.681	26.218	0.318	0.067	0.855	1.230	1.353	1.163	0.993	0.188	N.L. (2)
505	12.5	13	2.65	71.6	29	43	23	0.071	0.955	21.272	30.526	0.509	0.071	1.033	1.563	1.295	1.782	0.990	0.197	N.L. (2)
502.5	15	7	1.55	71.6	29	43	21	0.064	1.115	10.665	17.798	0.190	0.064	1.193	1.879	1.175	0.602	0.986	0.205	N.L. (2)
497.5	20	34	4.28	30.4			11	0.077	1.500	57.965	71.833	0.501	0.077	1.578	2.576	1.125	1.522	0.975	0.210	N.L. (3)
492.5	25	70	4.69	30.4			11	0.078	1.890	111.332	133.611	0.975	0.078	1.968	3.278	1.030	2.712	0.958	0.210	N.L. (3)
487.5	30	73	5.08	30.4			11	0.079	2.285	107.894	129.632	0.945	0.079	2.363	3.985	0.958	2.444	0.932	0.207	N.L. (3)
482.5	35	78		34.2			13	0.080	2.685	107.292	132.619	0.967	0.080	2.763	4.697	0.899	2.350	0.897	0.201	N.L. (3)
477.5	40	53		34.2			17	0.076	3.065	68.392	86.328	0.615	0.076	3.143	5.389	0.854	1.420	0.853	0.193	N.L. (3)
470	47.5	648		34.2				0.103	3.838	740.965	886.693	6.562	0.103	3.916	6.630	0.782	13.868	0.780	0.174	N.L. (3)

* FACTOR OF SAFETY DESCRIPTIONS

N.L. (1) = NOT LIQUEFIABLE, ABOVE EQ GROUND WATER ELEVATION
N.L. (2) = NOT LIQUEFIABLE, PI $\geq$ 12 & w_c/LL $\leq$ 0.85
N.L. (3) = NOT LIQUEFIABLE, $(N_1)_{60} > 25$
(C) = CONTRACTIVE SOIL TYPES
(D) = DILATIVE SOIL TYPES

LIQUEFACTION ANALYSIS

I.D.O.T. Bureau of Bridges and Structures FOUNDATIONS AND GEOTECHNICAL UNIT

Modified 3/11/10

REFERENCE BORING NUMBER ========== 2 W Abut
ELEVATION OF BORING GROUND SURFACE ========== 517.50 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ========== 17.50 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ========== 18.15 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.203
EARTHQUAKE MOMENT MAGNITUDE ========== 4.8
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ========== 0.65 FT. (Fill Height)
HAMMER EFFICIENCY========== 73 %
BOREHOLE DIAMETER========== 2.5 to 4.5 IN.
SAMPLING METHOD========== Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = **2.701**

AVG. SHEAR WAVE VELOCITY (top 40')
$V_{s,40'}$ = **729** FT./SEC.

PGA CALCULATOR
Earthquake Moment Magnitude = 4.8
Source-To-Site Distance, R (km) = 12.4
Ground Motion Prediction Equations = CEUS
PGA = **0.169**

BORING DATA								CONDITIONS DURING DRILLING					CONDITIONS DURING EARTHQUAKE							
ELEV. OF SAMPLE (FT.)	BORING SAMPLE DEPTH (FT.)	SPT N VALUE (BLOWS)	UNCONF. COMPR. STR., Q_u (TSF.)	% FINES < #200 (%)	PLAST. INDEX PI	LIQUID LIMIT LL	MOIST. CONTENT w_c (%)	EFFECTIVE UNIT WT. (KCF.)	VERT. STRESS (KSF.)	CORR. SPT N VALUE $(N_1)_{60}$	EQUIV. CLN. SAND SPT N VALUE $(N_1)_{60cs}$	CRR RESIST. MAG 7.5 $CRR_{7.5}$	EFFECTIVE UNIT WT. (KCF.)	VERT. STRESS (KSF.)	TOTAL VERT. STRESS (KSF.)	OVER-BURDEN CORR. FACT. (Ks)	CORR. RESIST. $CRR_{7.5}$ CRR	SOIL MASS PART. FACTOR (r_d)	EQ INDUCED CSR	FACTOR OF SAFETY * CRR/CSR
515	2.5	5	1.02	90			23	0.122	0.305	8.216	14.859	0.159	0.122	0.383	0.383	1.500	**0.643**	0.997	**0.131**	N.L. (1)
512.5	5	7	0.97	90			26	0.121	0.608	10.432	17.519	0.186	0.121	0.685	0.685	1.369	**0.690**	0.995	**0.131**	N.L. (1)
510	7.5	7	1.32	90			25	0.125	0.920	9.522	16.426	0.175	0.125	0.998	0.998	1.227	**0.579**	0.991	**0.131**	N.L. (1)
507.5	10	7	1.63	74.3	28	44	28	0.127	1.238	9.417	16.300	0.173	0.127	1.316	1.316	1.138	**0.533**	0.987	**0.130**	N.L. (1)
505	12.5	6	1.55	74.3	28	44	24	0.127	1.555	7.857	14.429	0.154	0.127	1.633	1.633	1.070	**0.446**	0.981	**0.129**	N.L. (1)
502.5	15	28	3.67	74.3	28	44	16	0.137	1.898	41.343	54.611	0.351	0.137	1.976	1.976	1.029	**0.976**	0.974	**0.128**	N.L. (1)
497.5	20	25	4.28	43	10	24	12	0.077	2.283	34.106	45.928	0.252	0.077	2.361	2.517	0.958	**0.651**	0.954	**0.134**	N.L. (3)
492.5	25	30	4.89	43	10	24	12	0.079	2.678	39.519	52.423	0.329	0.079	2.756	3.224	0.900	**0.801**	0.925	**0.143**	N.L. (3)
490	27.5	32		43	10	24	13	0.071	2.855	41.321	54.586	0.351	0.071	2.933	3.557	0.878	**0.832**	0.906	**0.145**	N.L. (3)
487.5	30	22		3.4			12	0.068	3.025	25.685	25.685	0.306	0.068	3.103	3.883	0.882	**0.729**	0.884	**0.146**	N.L. (3)
482.5	35	75	6.93	73.2	7	20	14	0.084	3.445	90.074	113.088	0.820	0.084	3.523	4.615	0.816	**1.808**	0.834	**0.144**	N.L. (3)
477.5	40	59	6.11	73.2	7	20	21	0.082	3.855	66.735	85.083	0.606	0.082	3.933	5.337	0.781	**1.278**	0.777	**0.139**	N.L. (3)
470	47.5	22	2.24	90			15	0.069	4.373	20.503	29.603	0.442	0.069	4.451	6.323	0.769	**0.919**	0.696	**0.130**	**7.069** (D)
465	52.5	98	7.33	90			21	0.084	4.793	97.878	122.453	0.891	0.084	4.871	7.055	0.717	**1.725**	0.653	**0.125**	N.L. (3)

* FACTOR OF SAFETY DESCRIPTIONS

N.L. (1) = NOT LIQUEFIABLE, ABOVE EQ GROUND WATER ELEVATION
N.L. (2) = NOT LIQUEFIABLE, PI ≥ 12 & w_c/LL ≤ 0.85
N.L. (3) = NOT LIQUEFIABLE, $(N_1)_{60}$ > 25
(C) = CONTRACTIVE SOIL TYPES
(D) = DILATIVE SOIL TYPES

SETTLEMENT ANALYSIS

I.D.O.T. BBS FOUNDATIONS AND GEOTECHNICAL UNIT — Modified on 1/31/05

METRIC OR ENGLISH ========== 1 (1=ENGLISH, 2=METRIC)
TYPE OF SURCHARGE ========== 1 (1=bridge cone, 2=continuous embankment, 3=rectangular)
DEPTH TO WATER TABLE (below surf. of exist. embank. or exist. rectang. surch.) == 4 FT.

NEW EMBANKMENT:
- NEW EMBANKMENT FILL UNIT WEIGHT ========== 120 PCF.
- NEW EMBANKMENT FILL HEIGHT ========== 0.7 FT.
- PROPOSED WIDTH AT TOP ========== 47.167 FT.
- PROPOSED WIDTH AT BOTTOM ========== 51.3 FT. WHICH WOULD BE A 3.0:1 SIDE SLOPE
- PROPOSED LENGTH OF EMBANK. OR SURCHARGE (RECTANGULAR ONLY) 0 FT.

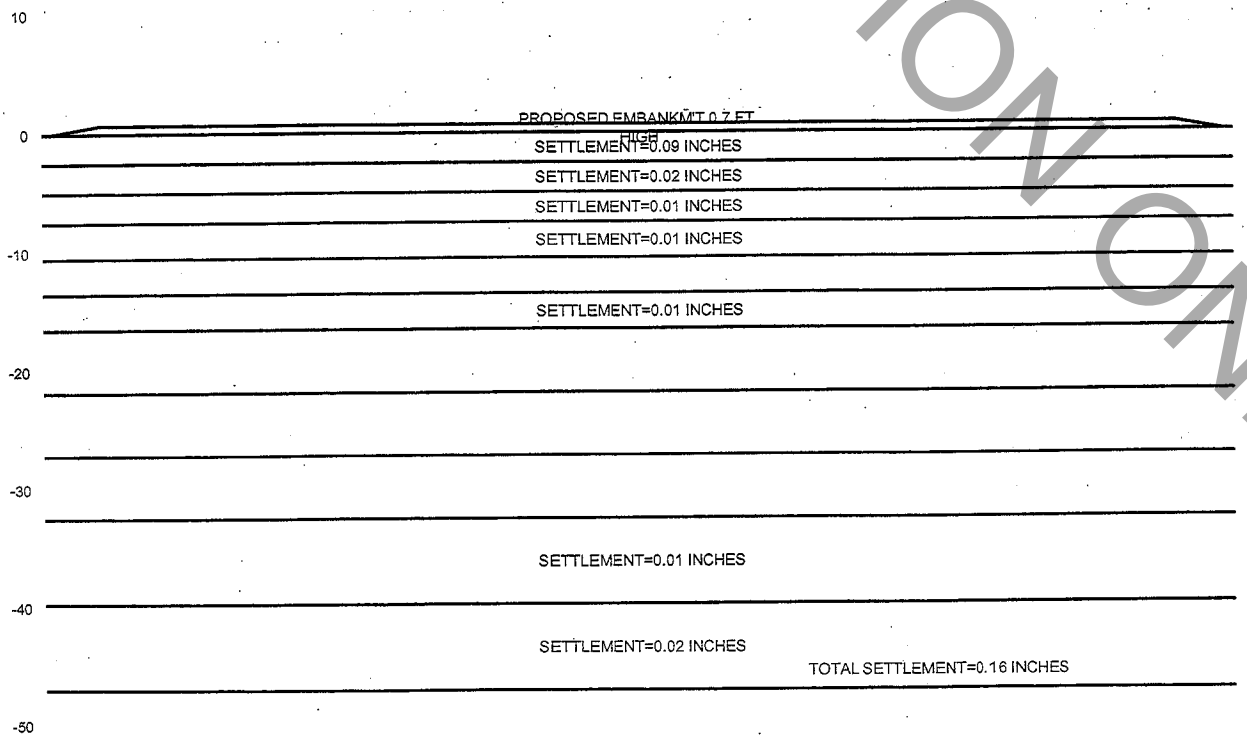
EXISTING EMBANKMENT (IF ANY):
- EXIST. EMBANKMENT UNIT WEIGHT ========== PCF.
- EXIST. EMBANKMENT HEIGHT ========== FT.
- WIDTH AT TOP ========== FT.
- WIDTH AT BASE ========== FT. WHICH WOULD BE A 0.0:1 SIDE SLOPE
- EXISTING LENGTH OF EMBANK. OR SURCHARGE (RECTANGULAR ONLY) == FT.

LAYER THICK (FT.)	*TOTAL UNIT WT. (PCF.)*	*UNCONFINED COMP. STR. (TSF.)*	*MOIST. CONTENT (%)*	*OVERBURDEN PRESSURE (KSF.)*	*PRESSURE INCREASE (KSF.)*	*INITIAL VOID RATIO*	*COMPRESSION INDEX, Cc*	*LAYER SETTLEMENT (IN.)*
2.5	120	0.77	25	0.150	0.067	0.675	0.030	**0.09**
2.5	120	1.16	25	0.450	0.052	0.675	0.025	**0.02**
2.5	120	1.55	29	0.610	0.048	0.783	0.025	**0.01**
3.0	120	1.94	22	0.768	0.045	0.594	0.011	**0.01**
3.0	120	2.65	23	0.941	0.043	0.621	0.000	**0.00**
3.0	120	1.55	21	1.114	0.042	0.567	0.014	**0.01**
5.3	120	4.28	11	1.354	0.039	0.297	0.000	**0.00**
5.3	120	4.69	11	1.661	0.036	0.297	0.000	**0.00**
5.3	120	5.09	11	1.968	0.033	0.297	0.000	**0.00**
7.3	120	0.00	13	2.330	0.029	0.351	0.027	**0.01**
7.3	120	0.00	17	2.747	0.026	0.459	0.063	**0.02**

ASSUMPTIONS:
SOIL IS NORMALLY CONSOLIDATED
SOIL IS SATURATED
Eo=2.7*(MOIST CONT.%)/100
Cc=0.009*(LL-10)
LL=MOIST CONT.%
SOIL HAS A LOW SENSITIVITY

TOTAL SETTLEMENT UNDER CENTER OF EARTH EMBANKMENT = *0.16 IN*

EMBANKMENT AND SOIL PROFILE



SETTLEMENT ANALYSIS

I.D.O.T. BBS FOUNDATIONS AND GEOTECHNICAL UNIT — Modified on 1/31/05

METRIC OR ENGLISH	1	(1=ENGLISH, 2=METRIC)
TYPE OF SURCHARGE	1	(1=bridge cone, 2=continuous embankment, 3=rectangular)
DEPTH TO WATER TABLE (below surf. of exist. embank. or exist. rectang. surch.)	17.5	FT.

NEW EMBANKMENT:

NEW EMBANKMENT FILL UNIT WEIGHT	120	PCF.	
NEW EMBANKMENT FILL HEIGHT	0.7	FT.	
PROPOSED WIDTH AT TOP	47.167	FT.	
PROPOSED WIDTH AT BOTTOM	51.3	FT.	WHICH WOULD BE A 3.0:1 SIDE SLOPE
PROPOSED LENGTH OF EMBANK. OR SURCHARGE (RECTANGULAR ONLY)	0	FT.	

EXISTING EMBANKMENT (IF ANY):

EXIST. EMBANKMENT UNIT WEIGHT		PCF.	
EXIST. EMBANKMENT HEIGHT		FT.	
WIDTH AT TOP		FT.	
WIDTH AT BASE		FT.	WHICH WOULD BE A 0.0:1 SIDE SLOPE
EXISTING LENGTH OF EMBANK. OR SURCHARGE (RECTANGULAR ONLY)		FT.	

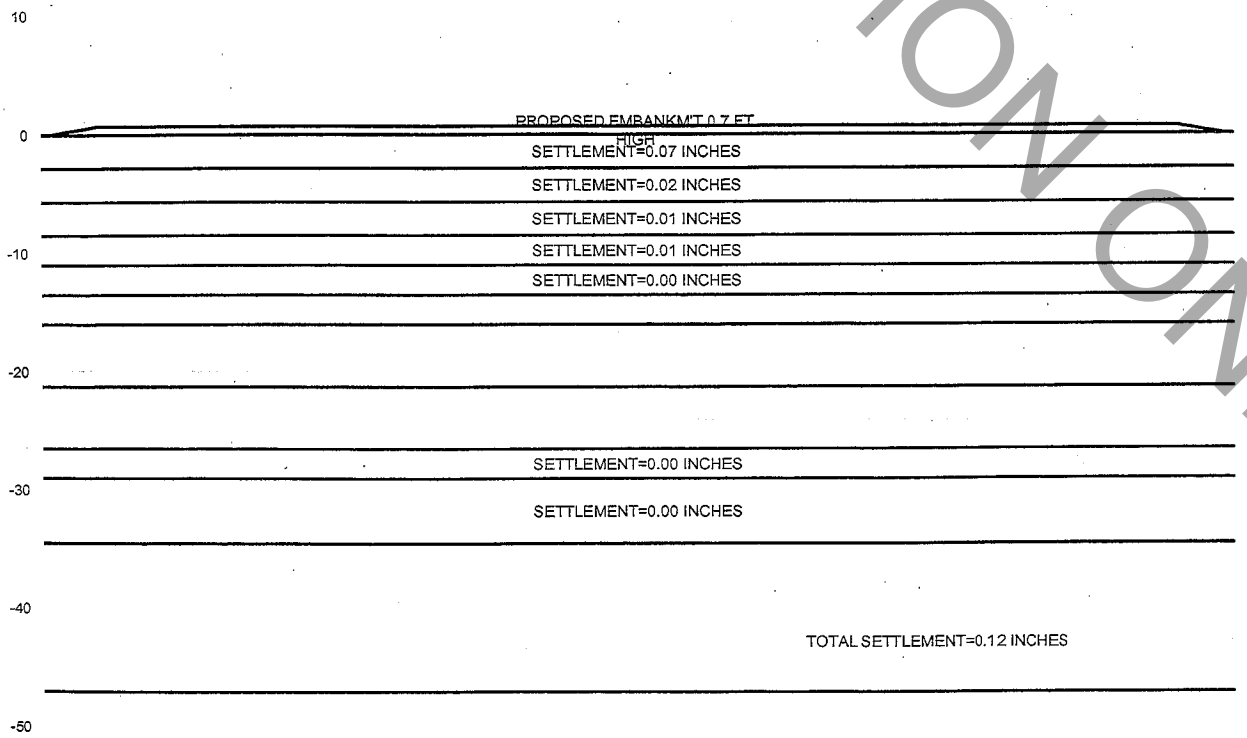
LAYER THICK (FT.)	*TOTAL UNIT WT. (PCF.)*	*UNCONFINED COMP. STR. (TSF.)*	*MOIST. CONTENT (%)*	*OVERBURDEN PRESSURE (KSF.)*	*PRESSURE INCREASE (KSF.)*	*INITIAL VOID RATIO*	*COMPRESSION INDEX, Cc*	*LAYER SETTLEMENT (IN.)*
2.8	120	1.02	23	0.170	0.065	0.621	0.023	**0.07**
2.8	120	0.97	26	0.509	0.051	0.702	0.029	**0.02**
2.8	120	1.32	25	0.849	0.047	0.675	0.023	**0.01**
2.5	120	1.63	28	1.169	0.045	0.756	0.022	**0.01**
2.5	120	1.55	24	1.469	0.043	0.648	0.018	**0.00**
2.5	120	3.67	16	1.769	0.042	0.432	0.000	**0.00**
5.3	120	4.28	12	2.164	0.039	0.324	0.000	**0.00**
5.3	120	4.89	12	2.467	0.036	0.324	0.000	**0.00**
2.5	120	0.00	13	2.690	0.034	0.351	0.027	**0.00**
5.5	120	0.00	12	2.920	0.032	0.324	0.018	**0.00**
12.5	120	6.52	17.5	3.439	0.027	0.473	0.000	**0.00**

ASSUMPTIONS:

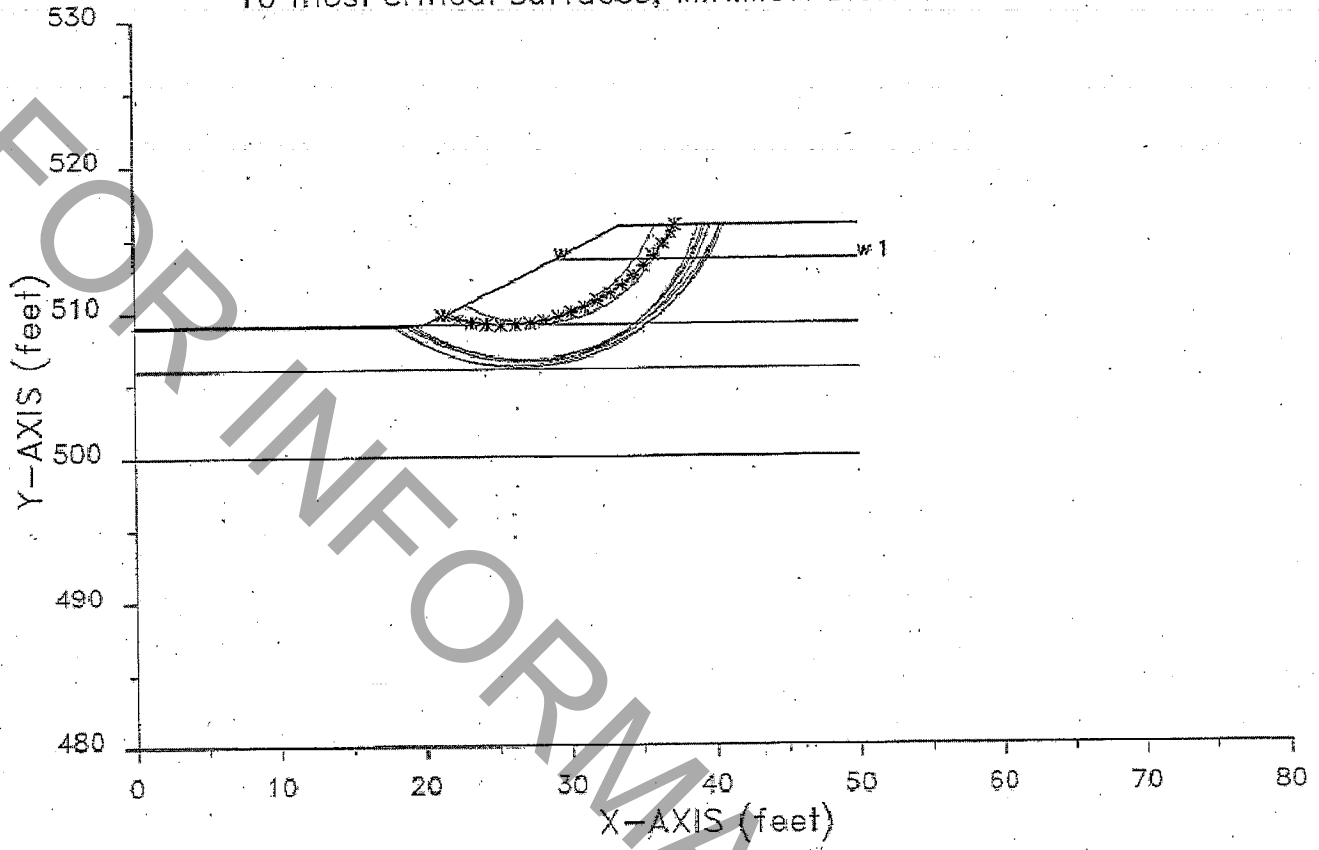
SOIL IS NORMALLY CONSOLIDATED
SOIL IS SATURATED
Eo=2.7*(MOIST CONT.%)/100
Cc=0.009*(LL-10)
LL=MOIST CONT.%
SOIL HAS A LOW SENSITIVITY

TOTAL SETTLEMENT UNDER CENTER OF EARTH EMBANKMENT = *0.12 IN*

EMBANKMENT AND SOIL PROFILE

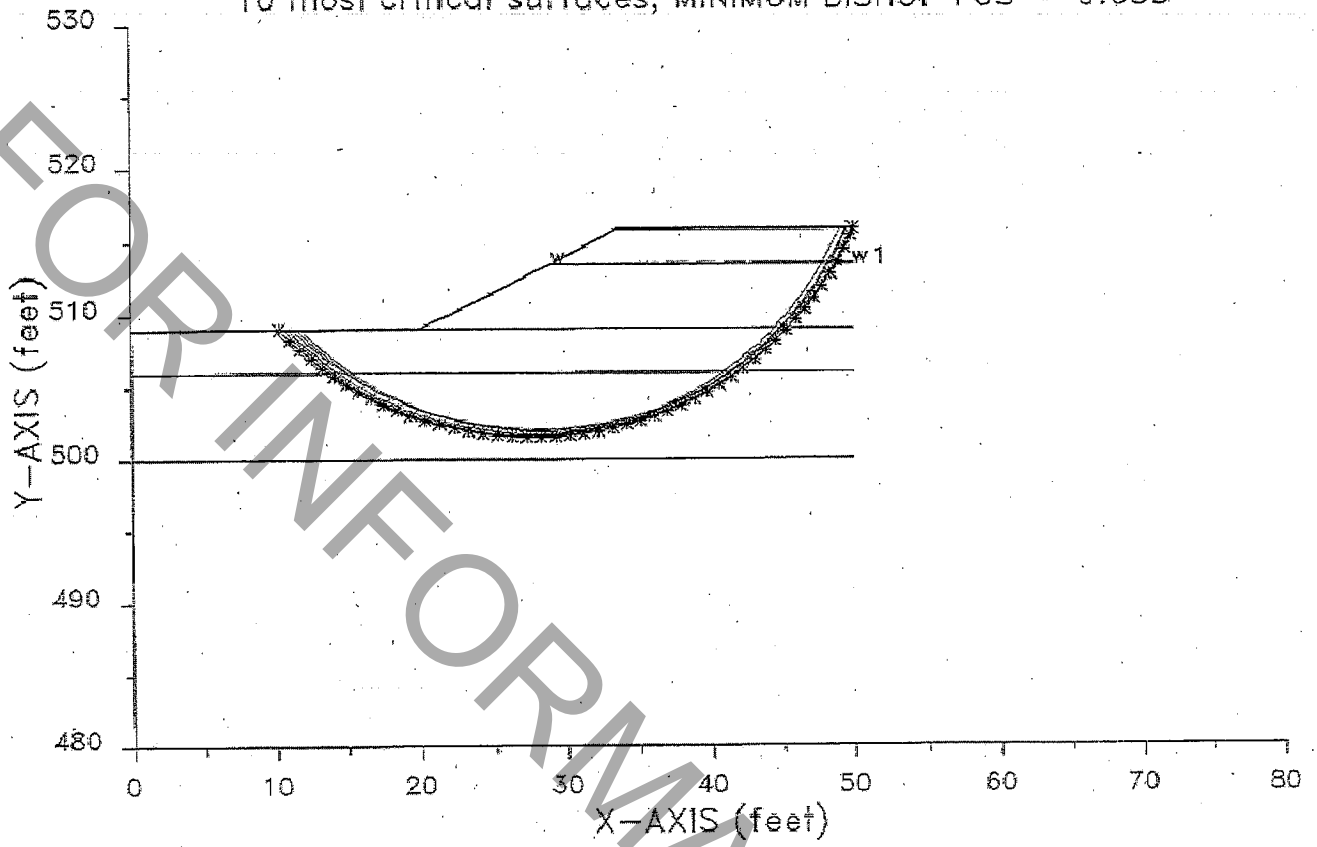


FAP 327, 061-0093, E Abut End
10 most critical surfaces, MINIMUM BISHOP FOS = 12.515



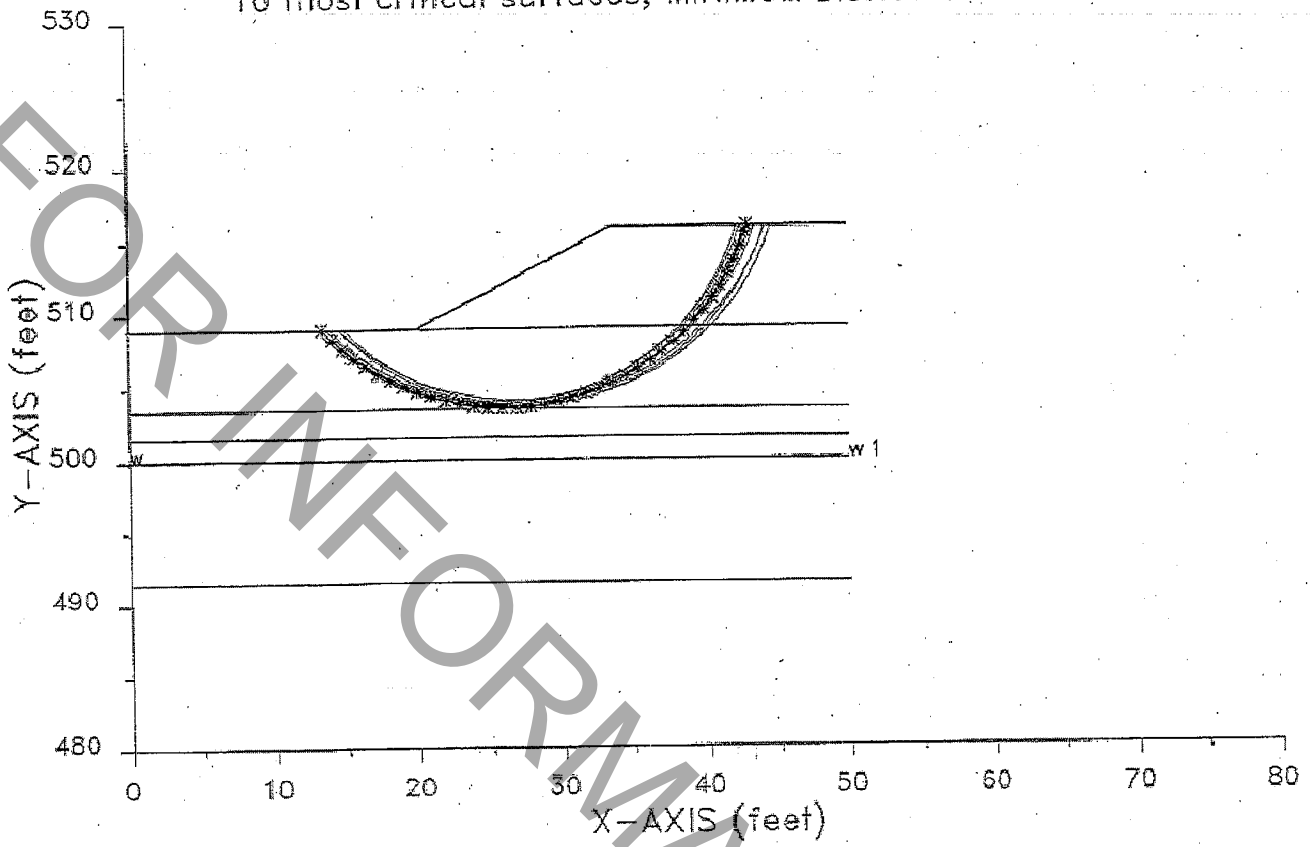

```
PROFIL                                        FILE: EABUT     8-23-**   11:16    ft
FAP 327, 061-0093, E Abut End
      8       4
       .0       509.0       20.0       509.0    2
     20.0       509.0       29.0       513.5    2
     29.0       513.5       33.5       515.8    1
     33.5       515.8       50.0       515.8    1
     29.0       513.5       50.0       513.5    2
       .0       509.0       50.0       509.0    3
       .0       506.0       50.0       506.0    4
       .0       500.0       50.0       500.0    5
SOIL
  5
  120.0    125.0     770.0      .00      .000       .0    0
  120.0    125.0    1355.0      .00      .000       .0    1
  120.0    125.0    1940.0      .00      .000       .0    1
  120.0    125.0    2100.0      .00      .000       .0    1
  120.0    125.0    4686.6      .00      .000       .0    1
WATER
  1       62.40
      2
         29.0        513.5
         50.0        513.5
CIRCL2
    50       25
     10.0        25.0        34.0        50.0
       .0          .0          .0          .0
```

FAP 327, 061-0093, E Abut End EQ
10 most critical surfaces, MINIMUM BISHOP FOS = 9.655




```
PROFIL                                        FILE: EABUTE     8-23-**   11:25     ft
FAP 327, 061-0093, E Abut End EQ
     8       4
      .0      509.0       20.0      509.0   2
    20.0      509.0       29.0      513.5   2
    29.0      513.5       33.5      515.8   1
    33.5      515.8       50.0      515.8   1
    29.0      513.5       50.0      513.5   2
      .0      509.0       50.0      509.0   3
      .0      506.0       50.0      506.0   4
      .0      500.0       50.0      500.0   5
SOIL
  5
  120.0    125.0     770.0       .00      .000        .0    0
  120.0    125.0    1355.0       .00      .000        .0    1
  120.0    125.0    1940.0       .00      .000        .0    1
  120.0    125.0    2100.0       .00      .000        .0    1
  120.0    125.0    4686.6       .00      .000        .0    1
WATER
  1       62.40
    2
       29.0        513.5
       50.0        513.5
EQUAKE
   .090      .000
CIRCL2
    50       25
     10.0        25.0        34.0        50.0
      .0          .0          .0          .0
```

FAP 327, 061-0093, W Abut End
10 most critical surfaces, MINIMUM BISHOP FOS = 10.918

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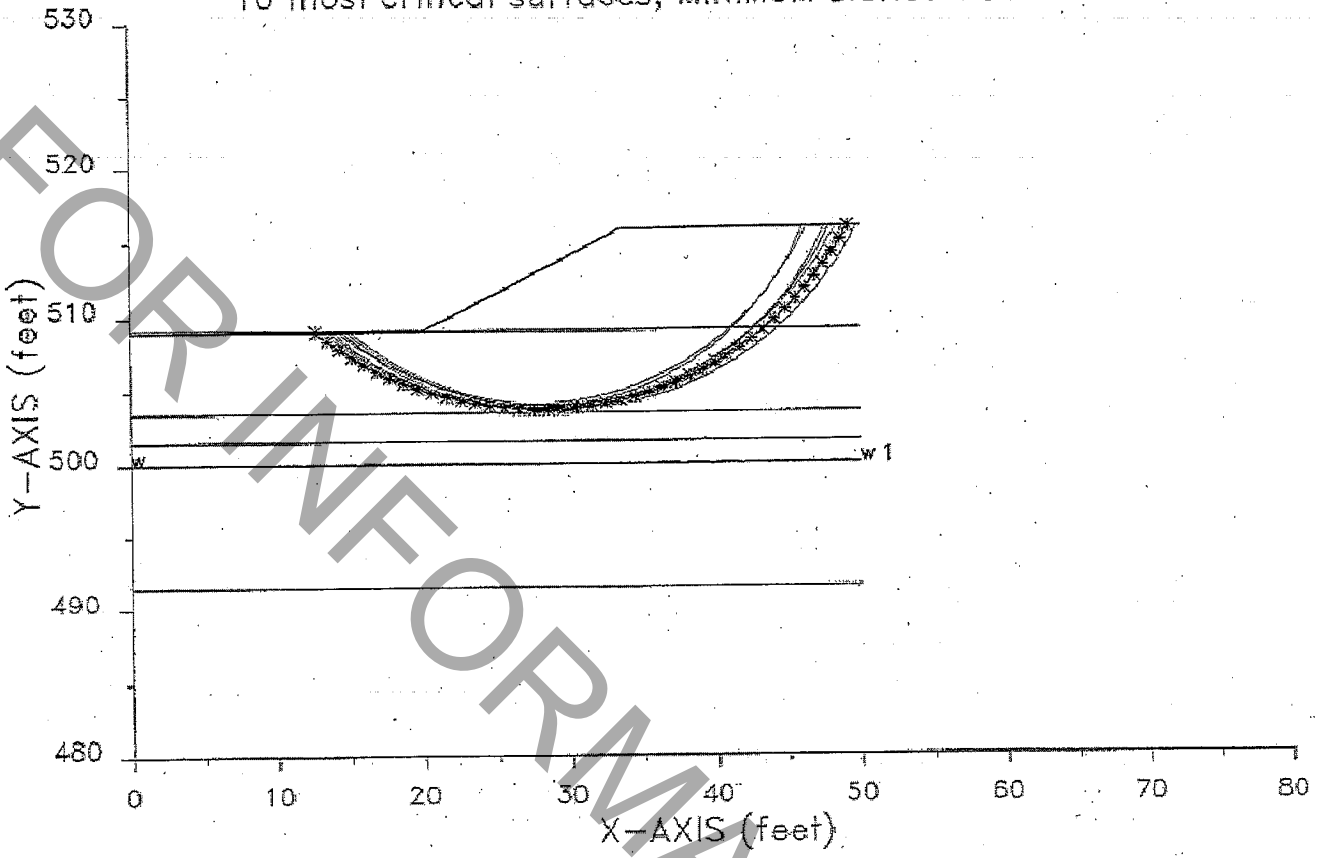
PROFIL                                        FILE: WABUT      8-23-**    11:21      ft
FAP 327, 061-0093, W Abut End
     8        3
      .0       509.0       20.0       509.0    1
    20.0       509.0       33.5       515.8    1
    33.5       515.8       50.0       515.8    1
      .0       509.0       50.0       509.0    2
      .0       503.5       50.0       503.5    3
      .0       501.5       50.0       501.5    4
      .0       500.0       50.0       500.0    5
      .0       491.5       50.0       491.5    6
SOIL
  6
  120.0     125.0     1103.3       .00       .000          .0     0
  120.0     125.0     1590.0       .00       .000          .0     0
  120.0     125.0     3670.0       .00       .000          .0     0
  120.0     125.0     4280.0       .00       .000          .0     0
  120.0     125.0     4585.0       .00       .000          .0     1
  120.0     125.0         .0     33.50       .000          .0     1
WATER
  1        62.40
     2
       .0        500.0
     50.0        500.0
CIRCL2
    50       25
     10.0        25.0        34.0        50.0
       .0         .0          .0          .0
```

FAP 327, 061-0093, W Abut End EQ
10 most critical surfaces, MINIMUM BISHOP FOS = 8.306




```
PROFIL                                          FILE: WABUTE    8-23-**  11:24    ft
FAP 327, 061-0093, W Abut End EQ
     $       $
      .0     509.0      20.0     509.0   1
    20.0     509.0      33.5     515.8   1
    33.5     515.8      50.0     515.8   1
      .0     509.0      50.0     509.0   2
      .0     503.5      50.0     503.5   3
      .0     501.5      50.0     501.5   4
      .0     500.0      50.0     500.0   5
      .0     491.5      50.0     491.5   6
SOIL
  6
  120.0    125.0    1103.3      .00     .000      .0   0
  120.0    125.0    1590.0      .00     .000      .0   0
  120.0    125.0    3670.0      .00     .000      .0   0
  120.0    125.0    4280.0      .00     .000      .0   0
  120.0    125.0    4585.0      .00     .000      .0   1
  120.0    125.0        .0    33.50     .000      .0   1
WATER
  1       62.40
    2
        .0       500.0
      50.0       500.0
EQUAKE
   .090     .000
CIRCL2
    50      25
     10.0       25.0       34.0       50.0
       .0        .0         .0         .0
```

MODIFIED IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

I.D.O.T. BBS FOUNDATIONS AND GEOTECHNICAL UNIT

Modified 5/3/2010

SUBSTRUCTURE========== East Abut
REFERENCE BORING ========== 1
GROUND SURFACE ELEV. AT BORING ========== 517.50 FT.
PILE CUTOFF ELEV. ========== 513.77 FT.
GROUND SURFACE ELEV. AGAINST PILE DURING DRIV 512.77 FT.
GROUND WATER ELEVATION========== 513.50 FT.
HAMMER EFFICIENCY========== 73 %
LRFD or ASD or SEISMIC ========== LRFD

TOTAL FACTORED SUBSTRUCTURE LOAD ========== 988 KIPS
TOTAL WIDTH OF SUBSTRUCTURE ========== 47.17 FT.
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE == 1
Approx. Factored Loading Applied per pile at 8 ft. Cts ===== 167.53 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ===== 62.82 KIPS

PILE TYPE AND SIZE ========== Steel HP 12 X 53
Plugged Pile Perimeter========== 3.967 FT. Unplugged Pile Perimeter========== 5.800 FT.
Plugged Pile End Bearing Area====== 0.983 SQFT. Unplugged Pile End Bearing Area==== 0.108 SQFT.

GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) : None
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ========== N/A FT.
TOP ELEV. OF LIQUEF. (so layers above apply DD) ===== N/A FT.

MAX. REQUIRED BEARING & RESISTANCE for Selected Pile, Soil Profile, & Losses

Maximum Nominal Req'd Bearing of Pile	Maximum Nominal Req.d Bearing of Boring	Maximum Factored Resistance Available in Boring	Maximum Pile Driveable Length in Boring
418 KIPS	405 KIPS	223 KIPS	30 FT.

BOT. OF LAYER ELEV. (FT.)	LAYER THICK. (FT.)	UNCONF. COMPR. STRENGTH (TSF.)	S.P.T. N VALUE (BLOWS)	GRANULAR OR ROCK LAYER DESCRIPTION	NOMINAL PLUGGED SIDE RESIST. (KIPS)	NOMINAL PLUGGED END BRG. RESIST. (KIPS)	NOMINAL PLUGGED TOTAL RESIST. (KIPS)	NOMINAL UNPLUG'D SIDE RESIST. (KIPS)	NOMINAL UNPLUG'D END BRG. RESIST. (KIPS)	NOMINAL UNPLUG'D TOTAL RESIST. (KIPS)	NOMINAL REQ'D BEARING (KIPS)	FACTORED GEOTECH. LOSS FROM SCOUR or DD (KIPS)	FACTORED GEOTECH. LOSS LOAD FROM DD (KIPS)	FACTORED RESISTANCE AVAILABLE (KIPS)	ESTIMATED PILE LENGTH (FT.)
511.00	1.77	1.16	7		11.2		25.5	16.4		***18.0***	18	0	0	10	3
509.00	2.00	1.55	7		15.6	14.3	44.7	22.9	1.6	***41.2***	41	0	0	23	5
507.50	1.50	1.94	11		13.6	17.9	***58.3***	19.9	2.0	61.2	58	0	0	32	6
506.00	1.50	1.94	11		13.6	17.9	***78.5***	19.9	2.0	81.8	78	0	0	43	8
504.50	1.50	2.65	13		16.7	24.4	***95.2***	24.4	2.7	106.2	95	0	0	52	9
503.00	1.50	2.65	13		16.7	24.4	***101.8***	24.4	2.7	129.5	102	0	0	56	11
501.50	1.50	1.55	7		11.7	14.3	***113.5***	17.1	1.6	146.7	114	0	0	62	12
500.00	1.50	1.55	7		11.7	14.3	195.7	17.1	1.6	***171.5***	172	0	0	94	14
498.67	1.33		34	Hard Till	5.9	84.7	199.7	8.7	9.3	***180.0***	180	0	0	99	15
497.34	1.33		34	Hard Till	5.7	82.8	203.6	8.4	9.1	***188.2***	188	0	0	104	16
496.01	1.33		34	Hard Till	5.6	81.0	207.3	8.1	8.9	***196.1***	196	0	0	108	18
494.67	1.34		34	Hard Till	5.4	79.2	293.8	7.9	8.7	***212.9***	213	0	0	117	19
493.34	1.33		70	Hard Till	17.5	160.1	309.4	25.6	17.5	***238.3***	238	0	0	131	20
492.01	1.33		70	Hard Till	17.2	158.3	322.9	25.1	17.3	***263.0***	263	0	0	145	22
490.68	1.33		70	Hard Till	16.4	154.6	337.5	24.0	16.9	***286.8***	287	0	0	158	23
489.34	1.34		70	Hard Till	16.2	152.8	357.4	23.7	16.7	***310.9***	311	0	0	171	24
488.01	1.33		73	Hard Till	16.8	156.5	372.3	24.6	17.1	***335.2***	335	0	0	184	26
486.68	1.33		73	Hard Till	16.4	154.6	385.1	24.0	16.9	***358.9***	359	0	0	197	27
485.35	1.33		73	Hard Till	15.7	150.9	398.9	23.0	16.5	***381.6***	382	0	0	210	28
484.00	1.35		73	Hard Till	15.6	149.1	421.9	22.8	16.3	***405.2***	405	0	0	223	30
482.19	1.81		78	Hard Till	22.9	156.5	441.1	33.5	17.1	***438.3***	~~438~~	~~0~~	~~0~~	~~241~~	~~32~~
480.38	1.81		78	Hard Till	21.9	152.8	***461.2***	32.0	16.7	470.1	~~461~~	~~0~~	~~0~~	~~254~~	~~33~~
478.56	1.81		78	Hard Till	21.4	150.9	***478.9***	31.3	16.5	501.0	~~479~~	~~0~~	~~0~~	~~263~~	~~35~~
476.75	1.81		78	Hard Till	20.5	147.3	***451.5***	29.9	16.1	525.7	~~452~~	~~0~~	~~0~~	~~248~~	~~37~~
474.94	1.81		53	Hard Till	10.4	99.4	***460.0***	15.1	10.9	540.6	~~460~~	~~0~~	~~0~~	~~253~~	~~39~~
473.13	1.81		53	Hard Till	10.0	97.6	***468.2***	14.7	10.7	555.1	~~468~~	~~0~~	~~0~~	~~258~~	~~41~~
471.31	1.81		53	Hard Till	9.7	95.7	***476.1***	14.3	10.5	569.2	~~476~~	~~0~~	~~0~~	~~262~~	~~42~~
469.50	1.81		53	Hard Till	9.5	93.9	***514.4***	13.8	10.3	586.2	~~514~~	~~0~~	~~0~~	~~283~~	~~44~~
468.50	1.00			Shale	49.5	122.7	***563.9***	72.4	13.4	658.6	~~564~~	~~0~~	~~0~~	~~310~~	~~45.3~~
467.50	1.00			Shale	49.5	122.7	***613.4***	72.4	13.4	730.9	~~613~~	~~0~~	~~0~~	~~337~~	~~46.3~~
466.50	1.00			Shale	49.5	122.7	***540.2***	72.4	13.4	789.9	~~540~~	~~0~~	~~0~~	~~297~~	~~47.3~~
465.00	1.50					0.0			0.0						

MODIFIED IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

I.D.O.T. BBS FOUNDATIONS AND GEOTECHNICAL UNIT

Modified 5/3/2010

SUBSTRUCTURE========== West Abut
REFERENCE BORING ========== 2
GROUND SURFACE ELEV. AT BORING ========== 517.50 FT.
PILE CUTOFF ELEV. ========== 513.77 FT.
GROUND SURFACE ELEV. AGAINST PILE DURING DRIV 512.77 FT.
GROUND WATER ELEVATION========== 500.00 FT.
HAMMER EFFICIENCY========== 73 %
LRFD or ASD or SEISMIC ========== LRFD

TOTAL FACTORED SUBSTRUCTURE LOAD ========== 988 KIPS
TOTAL WIDTH OF SUBSTRUCTURE ========== 47.17 FT.
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE == 1
Approx. Factored Loading Applied per pile at 8 ft. Cts ===== 167.53 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ===== 62.82 KIPS

PILE TYPE AND SIZE ========== Steel HP 12 X 53
Plugged Pile Perimeter========== 3.967 FT. Unplugged Pile Perimeter========== 5.800 FT.
Plugged Pile End Bearing Area====== 0.983 SQFT. Unplugged Pile End Bearing Area==== 0.108 SQFT.

GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) : None
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ========== N/A FT.
TOP ELEV. OF LIQUEF. (so layers above apply DD) ===== N/A FT.

MAX. REQUIRED BEARING & RESISTANCE for Selected Pile, Soil Profile, & Losses

Maximum Nominal Req'd Bearing of Pile	Maximum Nominal Req.d Bearing of Boring	Maximum Factored Resistance Available in Boring	Maximum Pile Driveable Length in Boring
418 KIPS	343 KIPS	189 KIPS	29 FT.

BOT. OF LAYER ELEV. (FT.)	LAYER THICK. (FT.)	UNCONF. COMPR. STRENGTH (TSF.)	S.P.T. N VALUE (BLOWS)	GRANULAR OR ROCK LAYER DESCRIPTION	NOMINAL PLUGGED SIDE RESIST. (KIPS)	NOMINAL PLUGGED END BRG. RESIST. (KIPS)	NOMINAL PLUGGED TOTAL RESIST. (KIPS)	NOMINAL UNPLUG'D SIDE RESIST. (KIPS)	NOMINAL UNPLUG'D END BRG. RESIST. (KIPS)	NOMINAL UNPLUG'D TOTAL RESIST. (KIPS)	NOMINAL REQ'D BEARING (KIPS)	FACTORED GEOTECH. LOSS FROM SCOUR or DD (KIPS)	FACTORED GEOTECH. LOSS LOAD FROM DD (KIPS)	FACTORED RESISTANCE AVAILABLE (KIPS)	ESTIMATED PILE LENGTH (FT.)
510.89	1.89	0.97	7		10.4		22.5	15.2		***16.5***	17	0	0	9	3
509.00	1.89	1.32	7		13.2	12.1	38.6	19.3	1.3	***36.1***	36	0	0	20	5
507.75	1.25	1.63	7		10.1	15.0	***48.7***	14.8	1.6	50.9	49	0	0	27	6
506.50	1.25	1.63	7		10.1	15.0	***58.1***	14.8	1.6	65.6	58	0	0	32	7
505.25	1.25	1.55	6		9.8	14.3	***67.8***	14.3	1.6	79.9	68	0	0	37	9
504.00	1.25	1.55	6		9.8	14.3	97.1	14.3	1.6	***96.3***	96	0	0	53	10
502.75	1.25	3.67	28		17.6	33.8	***114.7***	25.8	3.7	122.1	115	0	0	63	11
501.50	1.25	3.67	28		17.6	33.8	***138.0***	25.8	3.7	148.5	138	0	0	76	12
500.25	1.25	4.28	25		19.9	39.4	***157.9***	29.0	4.3	177.5	158	0	0	87	14
499.00	1.25	4.28	25		19.9	39.4	***177.7***	29.0	4.3	206.5	178	0	0	98	15
497.75	1.25	4.28	25		19.9	39.4	***197.6***	29.0	4.3	235.6	198	0	0	109	16
496.50	1.25	4.28	25		19.9	39.4	***223.0***	29.0	4.3	265.2	223	0	0	123	17
495.25	1.25	4.89	30		20.7	45.0	***243.7***	30.2	4.9	295.4	244	0	0	134	19
494.00	1.25	4.89	30		20.7	45.0	***264.3***	30.2	4.9	325.6	264	0	0	145	20
492.75	1.25	4.89	30		20.7	45.0	***285.0***	30.2	4.9	355.8	285	0	0	157	21
491.50	1.25	4.89	30		20.7	45.0	***323.2***	30.2	4.9	387.9	323	0	0	178	22
490.00	1.50		32	Very Fine Silty Sand	6.5	62.6	***327.8***	9.4	6.8	397.2	328	0	0	180	24
488.50	1.50		32	Very Fine Silty Sand	6.2	60.7	***354.3***	9.1	6.6	408.5	354	0	0	195	25
487.13	1.38		32	Medium Sand	7.2	81.0	***334.5***	10.5	8.9	416.1	335	0	0	184	27
485.75	1.38		22	Medium Sand	4.4	54.0	***338.9***	6.4	5.9	422.5	339	0	0	186	28
484.38	1.38		22	Medium Sand	4.4	54.0	***343.3***	6.4	5.9	428.9	343	0	0	189	29
483.00	1.38		22	Medium Sand	4.4	54.0	***428.0***	6.4	5.9	444.1	~~428~~	~~0~~	~~0~~	~~235~~	~~31~~
481.44	1.56		75	Hard Till	14.9	134.4	***441.1***	21.9	14.7	465.7	~~441~~	~~0~~	~~0~~	~~243~~	~~32~~
479.88	1.56		75	Hard Till	14.6	132.5	***453.9***	21.3	14.5	486.9	~~454~~	~~0~~	~~0~~	~~250~~	~~34~~
478.31	1.56		75	Hard Till	14.2	130.7	***466.3***	20.8	14.3	507.5	~~466~~	~~0~~	~~0~~	~~256~~	~~35~~
476.75	1.56		75	Hard Till	13.9	128.9	***452.5***	20.3	14.1	524.7	~~453~~	~~0~~	~~0~~	~~249~~	~~37~~
475.19	1.56		59	Hard Till	9.2	101.2	***459.9***	13.4	11.1	538.0	~~460~~	~~0~~	~~0~~	~~253~~	~~39~~
473.63	1.56		59	Hard Till	8.9	99.4	***467.0***	13.1	10.9	550.8	~~467~~	~~0~~	~~0~~	~~257~~	~~40~~
472.06	1.56		59	Hard Till	8.7	97.6	***475.6***	12.7	10.7	563.5	~~476~~	~~0~~	~~0~~	~~262~~	~~42~~
470.50	1.56		59	Hard Till	8.7	97.6	***509.4***	12.7	10.7	578.9	~~509~~	~~0~~	~~0~~	~~280~~	~~43~~
469.50	1.00			Shale	49.5	122.7	***559.0***	72.4	13.4	651.3	~~559~~	~~0~~	~~0~~	~~307~~	~~44.3~~
468.50	1.00			Shale	49.5	122.7	***608.5***	72.4	13.4	723.7	~~608~~	~~0~~	~~0~~	~~335~~	~~45.3~~
467.50	1.00			Shale		122.7			13.4						

Brubaker Creek TSL Design Forces

Wind Load to Superstructure

Transverse	7 kips per abutment

Wind Load to Substructure from Superstructure

Transverse	6 kips per abutment
Longitudinal	2 kips per abutment

Wind Load Applied Directly to the Substructure

Longitudinal	19 kips per abutment
Transverse	1 kips per abutment

Wind Load from Vehicles

Transverse	3 kips per abutment
Longitudinal	1 kips per abutment

Braking Force

18 kips per abutment

Stream Pressure

Longitudinal	3 kips per abutment
Transverse	0 kips per abutment

Seismic Forces

215 kips per abutment

Factored Vertical Loads - (Per Abutment Includes dead loads, live load reaction +impact only, no lateral loads)

	Gamma	DC kips	Gamma	DW kips	Factor	LL+IM kips	Total (kips)
Strength 1	1.25	491	1.5	46.2	1.75	172.4	984.75
Strength 2	1.25	491	1.5	46.2	1.35	172.4	915.79
Strength 3	1.25	491	1.5	46.2	-	-	683.05
Strength 4	1.25	491	1.5	46.2	-	-	683.05
Strength 5	1.25	491	1.5	46.2	1.35	172.4	915.79
Service 1	1	491	1	46.2	1	172.4	709.6

Up to 5 ft of contraction scour
0 feet of pier scour (no piers)
7 feet of pressure flow scour