STRUCTURE GEOTECHNICAL REPORT

Proposed Structure No. 003-0063

EXISTING STRUCTURE No. 003-0020

U.S. ROUTE 40 OVER WEST FORK SHOAL CREEK
FAS ROUTE 779 (IL 130)
SECTION 35-1-BR
BOND COUNTY
STATION 1574+34.50
D-98-068-10

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Bureau of Bridges and Structures
Illinois Department of Transportation

Prepared for:
Bridge Planning Unit and Bridge Design Section
Bureau of Bridges and Structures
Illinois Department of Transportation

May 13, 2016

Illinois Department of Transportation

Bureau of Bridges & Structures • 2300 S. Dirksen Parkway • Springfield, Illinois 62764

Table of Contents

TABLES

EXHIBITS

1.0 PROJECT DESCRIPTION AND SCOPE

1.1 Scope

The project consists of total replacement of the existing 3-span bridge that carries FAS 779 (U.S. Route 40) over West Fotk Shoal Creek with a single span bridge using Slide-In Bridge Construction (SIBC) as an innovative Accelerated Bridge Construction technique. The purpose of this SGR is to provide a geotechnical assessment of the planned replacement structure, based on subsurface conditions encountered at two borings.

1.2 Project Location

This project will be constructed on FAS 779 (U.S. Route 40) over West Fork Shoal Creek, located in the SE ¼ of Section 35, Township 5N, Range 4W of the 3rd P.M; 1.7 miles east of Pocahontas, in Bond County, Illinois. The general site area is shown on the attached Location Map, Exhibit A.

1.3 Existing Structure Information

The original structure number 003-0020 carries FAS 779 (U.S. Route 40) over West Fork Shoal Creek. The original structure was built in 1938 under FA Route 12, Section 35-1-B at Station 1574+34.46, skewed 20 degrees right forward. The original 1938 structure consists of a 3-span steel wide flange bridge. The existing bridge out-to-out deck width is 32'-4", the bridge roadway width is 26'-0", and the back to back of abutments length is 105'-9¼". The existing substructure consists of spill thru pile bent abutments with open pile bent piers, all using precast concrete piles.

1.4 Proposed Structure Information

The proposed replacement structure (S.N. 003-0063) will consist of a single span steel bridge with a total length of 108'-0" from back to back of abutments and width of 35'-2" out to out. Abutments will be supported by steel H-piles at each end, and the bridge deck, consisting of an 8" thick slab, will be supported by 45" web plate girders. The proposed structure will carry US 40 at 0 degree skew over West Fork Shoal Creek. The proposed grade of the roadway will have minimum variation when compared to the existing. The proposed bridge centerline station will be 1574+34.50. A Type, Size, and Location (TS&L) preliminary sketch, as provided by IDOT

Planning Unit, is included in Exhibit B. The new superstructure is to be built on temporary supports adjacent to the existing bridge with traffic maintained on existing bridge. Once construction is complete, the road is closed, the existing bridge structure is demolished or slid to a staging area for demolition, and the new bridge is slid into its final, permanent location. Once in place, the roadway approach tie-ins to the bridge are constructed.

2.0 FIELD EXPLORATION AND SUBSURFACE CONDITIONS

2.1 Subsurface Exploration and Testing

A truck mounted drill rig with hollow-stem augers was used to drill the borings. Samples were collected using a standard split spoon sampler, driven by a 140# automatic hammer, according to the methods outline in ASTM D1586,"Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils." Split spoon samples were obtained on 2½-foot intervals in the upper 30 feet and on 5-foot intervals thereafter. Unconfined compressive strengths of cohesive split-spoon samples were measured with Rimac testing apparatus. The sampling sequence for each boring is summarized on the Boring Logs in Exhibit C.

Two standard penetration test (SPT) borings, designated B-1 (W. Abut.) and B-2 (E. Abut.), were drilled on September 10, 2015. B-1 located at station 1573+50, offset 4.5 ft. right and B-2 located at station 1575+04, offset 3.5 ft. Right. Detailed boring locations are shown on the TS&L Plan, Exhibit B. The borings were drilled to depths of approximately 50 feet below existing ground surface extended into rock (auger refusal), one rock core was taken at B-2 (E. Abut.).

2.2 Subsurface Conditions

Generalized subsurface conditions, based on boring B-1 and B-2, mainly consist of a mixture of medium to medium stiff clay loam, sandy clay, and sand. These soils were followed by weathered shale. Rock Core was taken at boring B-2, from Elev. 429.4 to 416.7, which mainly consists of soft to highly weathered fine grained shale. RQD values were low and the unconfined compressive strength values were not documented. Grain size distribution analyses were performed on both borings.

The attached borings show that groundwater was encountered during drilling at elevations 447.7 ft. and 454.2 ft. at borings B-1 and B-2, respectively. Seasonal variations and other unknown considerations could cause fluctuations in the water level and the presence of water in the soils at the site. Detailed information concerning top of rock elevations are presented in Table 2.2.1.

Table 2.2.1 – Summary of Rock Elevations

Boring	Estimated Top of Rock Elevation (ft)
B-1 (W. Abut.)	435.7
B-2 (E. Abut.)	438.2

3.0 GEOTECHNICAL EVALUATIONS

3.1 Settlement

The existing and proposed profile grades are about the same and there will be little new embankment to cause settlement. No problems due to settlement are anticipated.

3.2 Slope Stability

There is no significant increase in the roadway profile grade for slopes which have been stable for over 75 years; therefore, no stability problems are expected for the new side embankment slopes considering a proposed inclination equal to the existing or having the standard inclination of 2 horizontal to 1 vertical (2H:1V).

3.3 Seismic Considerations

Seismic Data

According to the AASHTO LRFD Bridge Design Specifications (Seventh Edition), a site coefficient, which is a function of the soil profile types, is required for the calculation of minimum earthquake design forces. Based on the soils encountered and the depth to bedrock, the Seismic Performance Zone (SPZ) is 2 and the Soil Site Class is D. The global site class definition is based on the results of IDOT Bureau of Bridge and Structures Seismic Site Class Determination spreadsheet (Exhibit F). The AASHTO Specifications indicate that the site has a Design Spectral Acceleration at 1.0 second (S_{D1}) of 0.238g, and a Design Spectral Acceleration (S_{Ds}) at 0.2 second of 0.534g.

Liquefaction

Liquefaction analyses were performed (attached in exhibit G) and potentially liquefiable soils were not observed. Therefore, liquefaction is not a concern.

3.4 Scour

The design scour elevations should correspond to the bottom of the abutment cap as shown in Table 3.4.1.

Table 3.4.1 – Design Scour Elevation Table

Event/Limit State	Design Scour Elevations (ft.)		Item 113
	W. Abut.	E. Abut.	
Q100	471.54	471.66	8
Q200	471.54	471.66	
Design	471.54	471.66	
Check	471.54	471.66	

3.5 Mining Activity

According to the Illinois State Geological Survey (ISGS) “Coal Mines in Illinois Viewer,” the project site was not undermined.

4.0 FOUNDATION TYPE EVALUATION AND DESIGN RECOMMENDATIONS

4.1 Foundation Type Feasibility

Based on the preliminary TSL, the proposed structure (SN 003-0063), Station 1574+34.50 will be constructed of 45” web plate girder (composite full length) on semi-integral abutments with an estimated abutment length of 35 ft. Slide-In Bridge Construction (SIBC), an innovative Accelerated Bridge Construction technique, was chosen to be used for this project. Abutments will bear on two rows of vertical steel H-piles. Please note that metal shell (MS) piles are not feasible based on the proximity to rock and the risk of pile damage that may likely occur upon driving to an appreciable bearing.

4.2 Driven Pile Supported Foundations

The piles considered for this site are end bearing H-piles. Since shallow rock is encountered in both borings, located at the West and East Abutments, metal shell piles are not recommended, as discussed above. The Modified IDOT static method Excel spreadsheet was used to estimate the pile lengths as per AGMU Memo 10.2. It is recommended that the H-piles be driven into rock to their Maximum Nominal Required Bearing. Pile shoes are not required.

The preliminary axial factored loads of 1353 kips per each abutment were obtained from the structural planning engineer. No geotechnical losses due to down drag or liquefaction were included in the axial pile capacity calculations based on the results of the subsurface investigation, settlement, and liquefaction analyses described in Section 3.0.

Tables 4.2.1 and 4.2.2 summarize the estimated pile lengths for H-piles of various sizes for the West and East Abutments. The pile cutoff elevations used for the analyses were taken at Elevs. 473.5 and 473.7 for the West and East Abutments, respectively (based on 2 feet of embedment into the cap). The 2 feet of pile into the cap is to establish a fixed condition at the top of the pile in order to limit deflection and moment produced by the lateral loads applied by the sliding system. See section 5.0 for more information.

Test Piles:

One test pile is recommended at the East Abutment.

Tables 4.2.1 and 4.2.2 are to be used for the pile design at the West and East Abutments, respectively.

Table 4.2.1 – Pile Design for West Abutment (Boring B-1)

Pile Description	Maximum Nominal Required Bearing (kips)	Factored Resistance Available (kips)	Estimated Pile Length (ft)
HP 10 x42	335	184	46
HP 12x 53	418	229	46
HP 12 x 63	497	273	48
HP 14 x 73	578	318	47
HP 14 x 89	705	388	48
HP 14 x 102	810	446	50

Table 4.2.2 – Pile Design for East Abutment (Boring B-2)

Pile Description	Nominal Required Bearing (kips)	Factored Resistance Available (kips)	Estimated Pile Length (ft)
HP 10 x42	335	184	49
HP 12x 53	418	230	48
HP 12 x 63	497	273	49
HP 14 x 73	578	318	49
HP 14 x 89	705	388	51
HP 14 x 102	810	446	52

4.3 Lateral Pile Response

Based on discussions with the structural planning engineer, the Slide-In Bridge Construction (SIBC) will require lateral forces to move the new bridge into place; these lateral forces may vary depending of what type of bridge slide system will be used (at the time of this writing it is unknown if IDOT will determine the slide system to be specified in the plans or if it will be left up to the contractor; for the temporary works and slide system discussions please see Section 5.1). In turn, these lateral forces resulting from the Slide-In process will impart loads to the newly installed abutment piles. Lateral loads (see the following paragraph below) were provided by the planner, and these loads were used in the computer program AllPile7 in conjunction with the soil properties for borings B-1 and B-2 that are summarized in Table 4.3.1.

Preliminary lateral load analyses were performed on different sizes of H-piles, with results presented in Exhibit E. The deflection and moment values presented in Exhibit E were obtained by using the 20%, 15%, 10% and 5% of the preliminary total service axial load of 966 kips provided by the structural planning engineer. The piles were analyzed within a group and for fixed head condition, and with a transverse and longitudinal spacing of 78” and 30” between piles, respectively, assuming a total of 9 piles per abutment (provided by the planner). It should be noted that we analyzed the lateral pile response for fixed head condition **(2 feet into cap**) to show reasonable deflection and moment values. If the number of piles or distance between piles changes, these Lateral Pile Responses will need to be re-analyzed based on the final pile configuration. In the event that the pile configuration does change or the lateral load per pile applied to the abutment piles extends beyond the uppermost values shown in Exhibit E, the SGR author shall be contacted in order to perform any additional analyses necessary.

Table 4.3.1 – Profile and Soil Parameters used for Static Lateral Load Analysis

Soil Type	Elev. at Top of Layer (ft.)	Unit Weight (pcf)	Angle of Internal Friction (degrees)	Average Undrained Shear Strength, Su or Cohesion (ksf)	Static Soil Modulus, K (pci)	Soil Strain Parameter E50 (%)
Silty Clay Loam with Trace Sand	471.5	120.0	27.2	1.25	55.3	1.52
	469.0	120.0	26.7	0.49	41.5	1.81
Soft Silty Clay Loam	467.5	120.0	0	0.41	40.1	1.85
Medium Stiff Silty Clay	464.0	120.0	0	0.94	120.2	1.24
Medium Stiff Sandy Clay	460.0	120.0	0	1.14	188.0	1.07
Sandy Clay Loam	457.0	120.0	27.7	0.41	103.7	1.3
Very soft Loam	454.5	62.6	26.8	0.20	45.6	1.71
Fine to Medium Coarse Sand	448.0	62.6	33.0	-	45.0	-
Shale	438.0	90.1	17.0	2.00	120.0	0.33

5.0 CONSTRUCTION CONSIDERATIONS

5.1 Temporary Works and Slide System

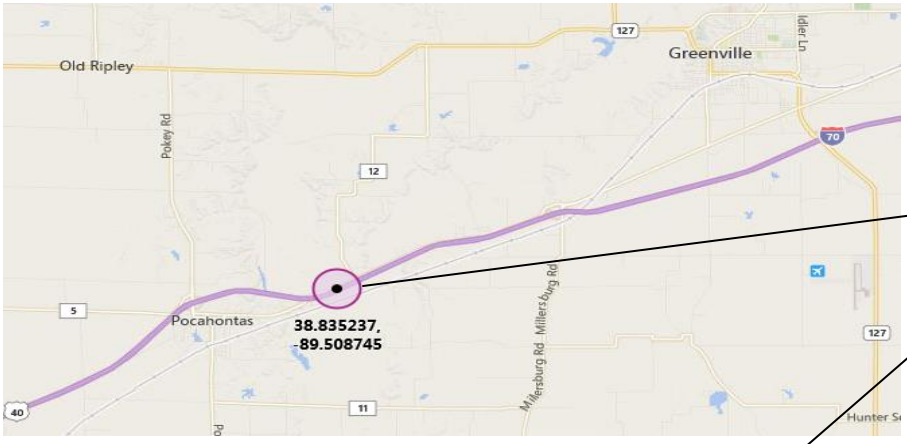
Based on discussion with our Bridge Design Unit, the contractor will be responsible for the design of the temporary works and slide system. The geotechnical aspects of this design should be reviewed by the Foundation and Geotechnical Unit at the request of Bridge Design.

5.2 Temporary Sheeting and Soil Retention

Based on the planner, traffic will be detoured. Therefore, temporary soil retention used for stage construction will not be required. Use of temporary construction slopes appear feasible.

EXHIBIT A – LOCATION MAP

EXHIBIT A – LOCATION MAP



Project Location

S.N. 024-2002 (Existing)

S.N. 024-2008 (Proposed)

EXHIBIT B – TYPE, SIZE, AND LOCATION (TS&L) PRELIMINARY SKETCH

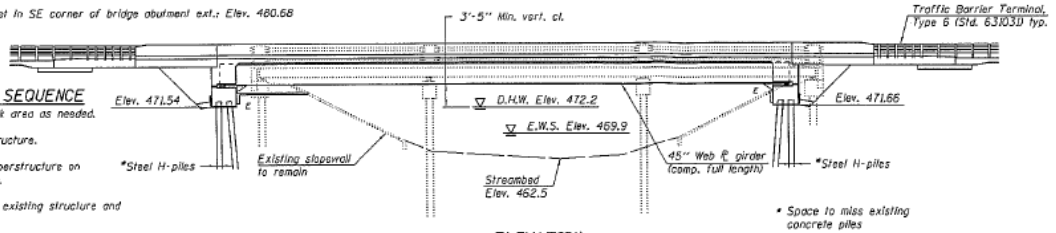
Existing Structure: S.N. 003-0020 built 1938 as F.A. 12, Section 35-1-B-1 at Sta. 1574+34.46 as a 3-span steel wide flange bridge, 105'-9¼" back-to-back spill thru abutments supported on concrete piles. Existing bridge to be removed and replaced. New bridge built temporarily next to existing bridge with traffic maintained on existing bridge. New bridge to be moved into final location using slide-in-bridge-construction (SIBC) techniques with traffic detoured. Accelerated Bridge Construction (ABC) contract to reduce traffic detour days.

Benchmark: Chiseled "□" set in SE corner of bridge abutment ext.; Elev. 480.68

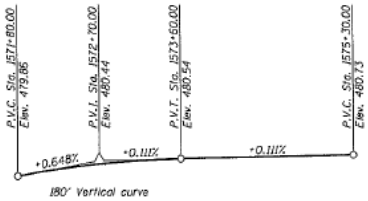
No salvage.

CONSTRUCTION SEQUENCE

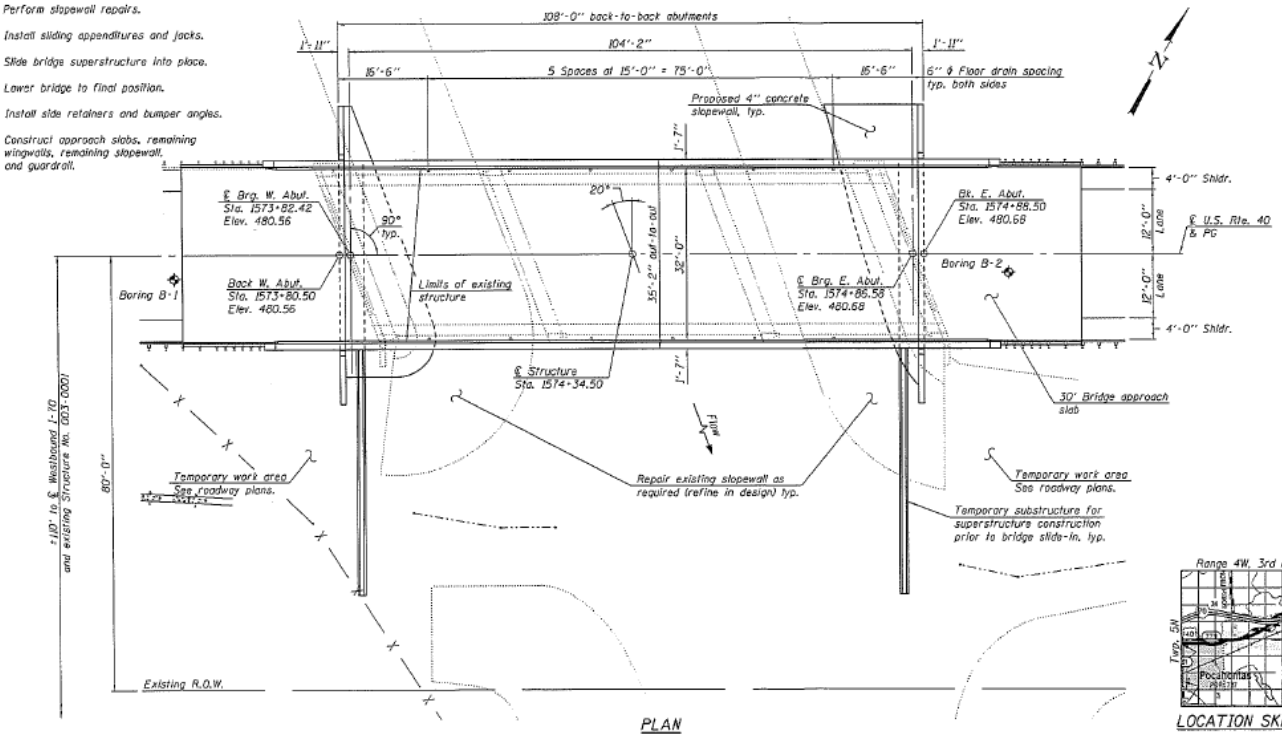
1. Prepare temporary work area as needed.
2. Erect temporary substructure.
3. Construct proposed superstructure on temporary substructure.
4. Detour traffic, remove existing structure and portion of slopewall.
5. Drive proposed abutment piles and construct abutment.
6. Perform slopewall repairs.
7. Install sliding appendiitures and jacks.
8. Slide bridge superstructure into place.
9. Lower bridge to final position.
10. Install side retainers and bumper angles.
11. Construct approach slabs, remaining wingwalls, remaining slopewall, and guardrail.



ELEVATION



PROFILE GRADE
(Along ℄ U.S. Rte. 40)



PLAN

DESIGN SPECIFICATIONS

2014 AASHTO LRFD Bridge Design Specifications, 7th Edition with 2015 Interims

DESIGN STRESSES

FIELD UNITS

f'c = 3,500 psi
f'c = 4,000 psi (Concrete Superstructure)
fy = 60,000 psi (Reinforcement)
fy = 50,000 psi (M270 Grade 50W)

HIGHWAY CLASSIFICATION

F.A.S. Rte. 779 - U.S. Rte. 40
Functional Class: Major Collector (Non-Urban)
ADT: 1,200 (2013); 1,550 (2038)
ADTT: 81 (2038)
DHV: 140
Design Speed: 55 m.p.h.
Posted Speed: 55 m.p.h.
Two-Way Traffic
Directional Distribution: 50:50

LOADING HL-93

Allow 50#/sq. ft. for future wearing surface.

SEISMIC DATA

Seismic Performance Zone (SPZ) = 2
Design Spectral Acceleration at 1.0 sec. (S_{D1}) = 0.238 g
Design Spectral Acceleration at 0.2 sec. (S_{DS}) = 0.534 g
Soil Site Class = D

LOCATION SKETCH

GENERAL PLAN & ELEVATION
U.S. ROUTE 40 OVER
WEST FORK SHOAL CREEK
F.A.S. RTE. 779 - SEC. 35-1-BR
BOND COUNTY
STATION 1574+34.50
STRUCTURE NO. 003-0063

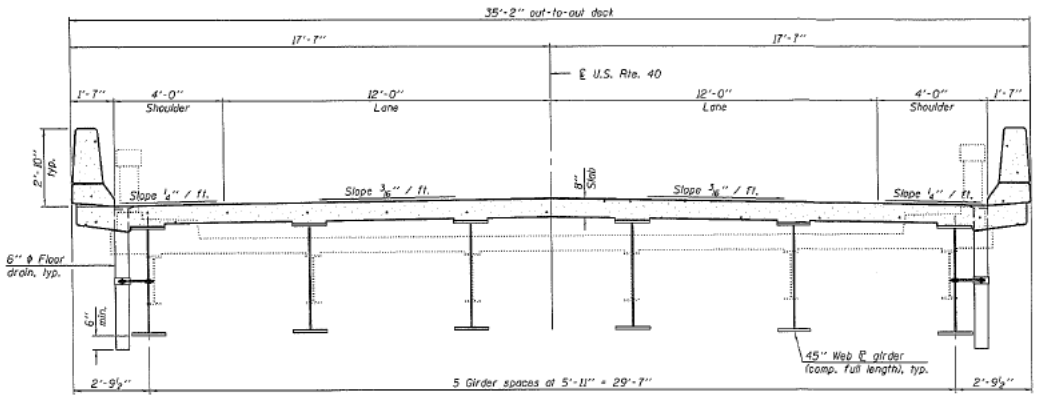
DESIGNED	RICHARD J. CHAPUT
CHECKED	DEREK G. VERHULST
DRAWN	MICHAEL B. MOSSMAN
CHECKED	R.J.C. / D.G.V.

FEBRUARY 29, 2016

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO. 1 OF 2 SHEETS

F.A.S. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
779	35-1-BR	BOND		
		CONTRACT NO. 76E04		
		ILLINOIS FED. AID PROJECT		



CROSS SECTION

WATERWAY INFORMATION

Drainage Area = 478 mi.²

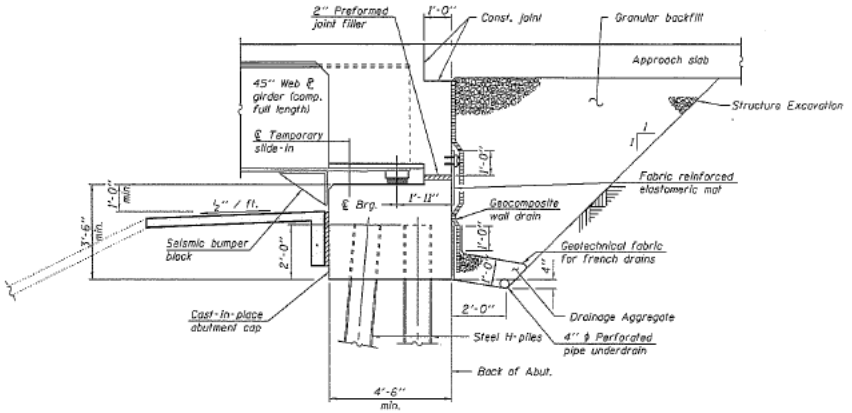
Existing overtopping Elev. 478.97 at Sta. 1570+09.18
Proposed overtopping

Flood Event		Discharge (cfs)		Opening (sq. ft.)		Natural H.W.E. (ft.)	Head (ft.)		Headwater Elev.	
		Exist.	Prop.	Exist.	Prop.		Exist.	Prop.	Exist.	Prop.
10	Main Channel	16164	15277	3032	3032	470.7	0.6	0.5	471.3	471.2
	003-0063	1836	2723	355	527					
	Total	18000	18000	3387	3559					
50	Main Channel	24548	22996	3655	3655	472.2	0.9	0.9	473.1	473.1
	003-0063	2852	4404	458	679					
	Total	27400	27400	4113	4334					
100	Main Channel	28206	26336	3915	3915	472.9	1.1	1.0	474.0	473.9
	003-0063	3294	5164	503	744					
	Total	31500	31500	4418	4659					
200	Main Channel	31956	29761	4165	4165	473.5	1.2	1.1	474.7	474.6
	003-0063	3744	5939	547	807					
	Total	35700	35700	4712	4972					
Overtopping	Main Channel	-	-	-	-	-	-	-	-	-
	003-0063	-	-	-	-					
	Total	-	-	-	-					
500	Main Channel	36742	35575	4470	4470	474.2	1.5	1.4	475.7	475.6
	003-0063	4458	5625	603	886					
	Total	41200	41200	5073	5356					

10 Year velocity through existing bridge = 4.59 ft./sec.
10 Year velocity through proposed bridge = 4.62 ft./sec.

DESIGN SCOUR ELEVATION TABLE

Event / Limit State	Design Scour Elevations (ft.)		
	W. Abut.	E. Abut.	Item 113
Q100	472.34	472.46	8
Q200	472.34	472.46	
Design	472.34	472.46	
Check	472.34	472.46	



SECTION THRU
SEMI-INTEGRAL ABUTMENT

DETAILS
U.S. ROUTE 40 OVER
WEST FORK SHOAL CREEK
F.A.S. RTE. 779 - SEC. 35-1-BR
BOND COUNTY
STATION 1574+34.50
STRUCTURE NO. 003-0063

DESIGNED	RICHARD J. CHAPUT
CHECKED	DEREK G. VERHULST
DRAWN	MICHAEL B. MOSSMAN
CHECKED	R.J.C. / D.G.V.

FEBRUARY 29, 2016

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SHEET NO. 2 OF 2 SHEETS

F.A.S. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
779	35-1-BR	BOND		
		CONTRACT NO. 76E04		
	ILLINOIS FED. AID PROJECT			

EXHIBIT C – BORING LOGS

Illinois Department of Transportation
Division of Highways
Illinois Department of Transportation

SOIL BORING LOG

Date 9/9/15

ROUTE FAS 779 DESCRIPTION US 40 over West Fork Shoal Creek LOGGED BY DI (TSi)

SECTION 35-1-BR LOCATION SEC. 35, TWP. 5N, RNG. 4W, 3 PM

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

STRUCT. NO. 003-0020 (E) / 003-0063 (P)
Station 1574+34.46

BORING NO. B-1 W Abut
Station 1573+50
Offset 4.50ft Right
Ground Surface Elev. 480.2 ft

Surface Water Elev. ____ ft
Stream Bed Elev. ____ ft

Groundwater Elev.:
First Encounter 447.7 ft ▼
Upon Completion ____ ft
After ____ Hrs. ____ ft

DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)	Description
				Asphaltic Concrete (4"), Portland Cement Concrete (8") 479.2
	5	1.02 S	20	Greenish Gray (Medium Moist, Medium Stiff) Clay LOAM with Trace Sand and Limestone Pieces A-6(7) See Class @ 5 ft
-5	14	1.31 B	15	Trace Sand and Gravel
	7	1.64 B	20	Stiff
-10	7	1.83 B	20	No Trace Materials
	4	1.14 B	22	Medium Stiff, Trace Sand 467.7
-15	4	0.94 B	23	Dark Brown (Medium Moist to Moist, Medium Stiff) Silty Clay LOAM with Trace Sand A-6(15) See Class @ 15 ft 464.7
	5	0.94 S	23	Greenish Gray (Moist, Medium Stiff) Silty CLAY A-6(13) See Class @ 17 ft 462.2
-20	8	2.45 B	22	Brown & Gray (Moist, Stiff) Silty Clay LOAM A-6(15)
				See Class @ 19.5 ft 459.7
	10	2.04 B	20	Brown & Gray (Medium Moist, Medium Stiff) Silty CLAY with Trace Sand and Gravel 457.7
-25	11	1.88 B	21	Brown & Gray (Medium Moist to Moist, Medium Stiff) Silty Clay LOAM with Trace Sand
	5	0.49 B	24	Moist, Soft 452.7
-30	6	1.55	22	Brown and Gray (Moist, Medium Stiff) Clay LOAM with Fine Sand Lenses 447.7 ▼
-35	2	0.20 B	24	Gray (Very Moist, Very Soft) Sandy CLAY 2" Sand Seam 444.7
				Brown (Wet) Well Graded SAND See Gradation @ 36 ft 441.2
-40	4	0.12 B	23	Gray (Very Moist, Very Soft) Sandy LOAM 440.2

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 9/9/15

ROUTE FAS 779 DESCRIPTION US 40 over West Fork Shoal Creek LOGGED BY DI (TSi)

SECTION 35-1-BR LOCATION SEC. 35, TWP. 5N, RNG. 4W, 3 PM

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

STRUCT. NO. 003-0020 (E) / 003-0063 (P)
Station 1574+34.46

BORING NO. B-1 W Abut
Station 1573+50
Offset 4.50ft Right
Ground Surface Elev. 480.2 ft

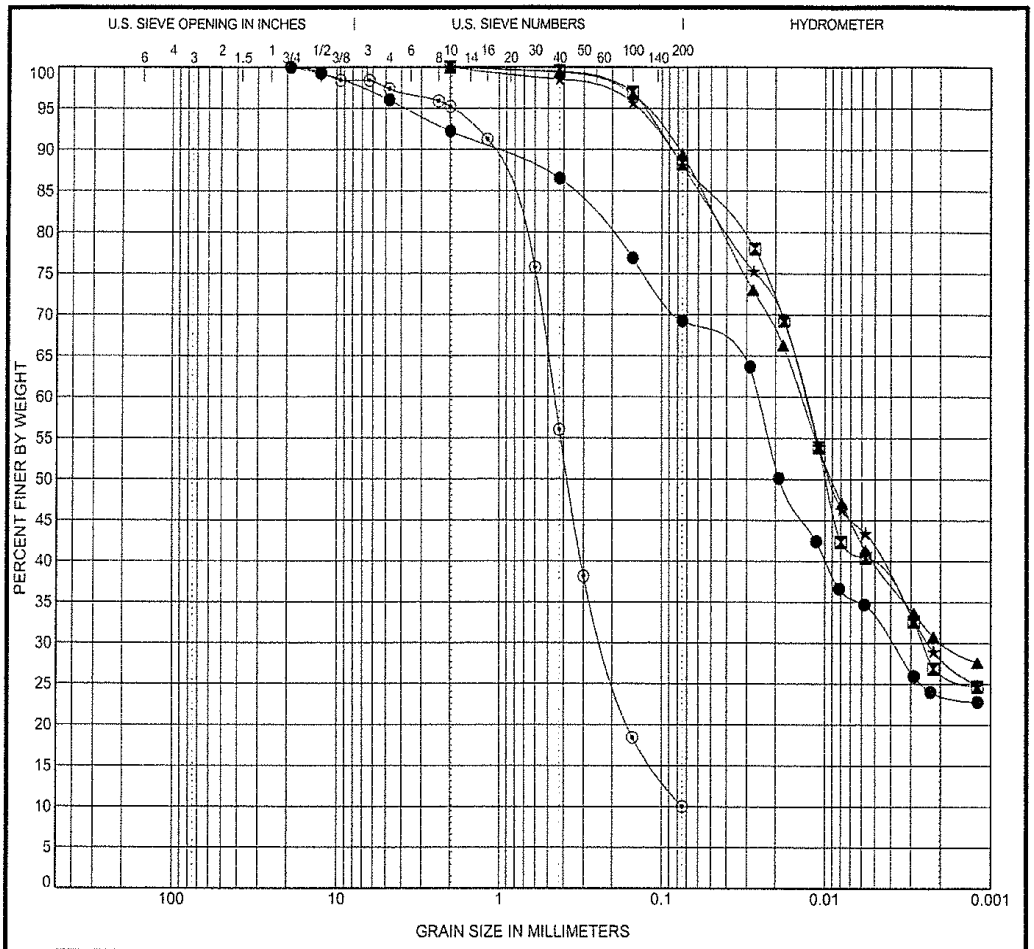
Surface Water Elev. ____ ft
Stream Bed Elev. ____ ft

Groundwater Elev.:
First Encounter 447.7 ft
Upon Completion ____ ft
After ____ Hrs. ____ ft

DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)	Description
	2			Brown & Gray (Wet, Very Soft) Sandy Clay LOAM with Gravel
435.7	24	1.61	13	
-45	50/4"	S		Gray (Dry, Very Stiff) SHALE with Trace Sand
431.9	50/5"	1.47 S	16	
				Auger Refusal - END OF BORING
-50				NOTE: Ponding water in augers at water table to reduce hydrostatic pressure
				NOTE: Top of Water is 13 feet below bridge deck
				NOTE: Bottom of Creek is 17 feet below bridge deck
-55				NOTE: For samples between 0 feet and 40 feet, blow count is "N-Value" for respective sample
-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)



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-1	5.00	A-6 (7) CLAY LOAM	29.3	16.0	13.3		
⊠	B-1	15.00	A-6 (15) SILTY CLAY LOAM	34.5	16.4	18.1		
▲	B-1	17.00	A-6 (13) SILTY CLAY	32.7	17.5	15.2		
★	B-1	19.50	A-6 (15) SILTY CLAY LOAM	35.6	18.4	17.2		
⊙	B-1	36.00	SAND				1.49	6.08

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-1	5.00	19	0.026	0.004		7.8	23.0	45.5	23.7
⊠	B-1	15.00	2	0.013	0.003		0.0	11.7	61.8	26.5
▲	B-1	17.00	2	0.014	0.002		0.0	10.6	59.2	30.2
★	B-1	19.50	2	0.013	0.002		0.0	11.9	59.8	28.3
⊙	B-1	36.00	19	0.456	0.225		4.8	85.2	10.0	

Illinois Department of Transportation
Division of Highways
Illinois Department of Transportation

IDH GRAIN SIZE DISTRIBUTION

Route: FAS 779
Section: 35-1-BR
County: Bond

GRAIN_SIZE_IDH_3-18-11 003-0020 GPJ IL_DOT GDT 9/28/15

Illinois Department of Transportation
Division of Highways
Illinois Department of Transportation

SOIL BORING LOG

Date 9/10/15

ROUTE FAS 779 DESCRIPTION US 40 over West Fork Shoal Creek LOGGED BY DI (TSi)

SECTION 35-1-BR LOCATION , SEC. 35, TWP. 5N, RNG. 4W, 3 PM

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

STRUCT. NO. 003-0020 (E) / 003-0063 (P)
Station 1574+34.46

BORING NO. B-2 E Abut
Station 1575+04
Offset 3.50ft Right
Ground Surface Elev. 480.2 ft

Surface Water Elev. ft
Stream Bed Elev. ft

Groundwater Elev.:
First Encounter 454.2 ft
Upon Completion ft
After Hrs. ft

DEPTH (ft)	Description	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
	Asphaltic Concrete (4"), Portland Cement Concrete (8")			
479.2				
	Brown (Medium Moist, Medium Stiff) Clay LOAM with Trace Gravel	8	1.23 B	15
477.2				
	Brown & Gray (Medium Moist, Medium Stiff) Sandy CLAY with Trace Gravel	6	1.06 B	17
-5				
474.7				
	Light Brown (Medium Moist, Medium Stiff to Stiff) Silty Clay LOAM with Trace Sand A-4(7) See Class @ 11.5 ft	9	1.92 B	18
		4	1.25 P	22
-10				
		3	0.49 B	23
467.2				
	Gray (Moist, Soft, Silty Clay LOAM	3	0.41 B	24
-15				
463.2		6	0.94 B	25
	Brown & Gray (Medium Moist, Medium Stiff) Silty CLAY with Trace Sand			
462.2				
	Brown & Gray (Moist, Medium Stiff) Silty Clay LOAM with Trace Sand	5	0.94 B	23
-20				

DEPTH (ft)	Description	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
459.7				
	Brown & Gray (Medium Moist, Medium Stiff) Sandy CLAY	7	1.14 B	21
457.2				
	Brown & Gray (Moist, Soft) Sandy Clay LOAM	5	0.41 B	20
-25				
454.7				
	Brown (Wet, Very Soft) LOAM A-4(1) See Class @ 26.5 ft	3	0.20 B	27
450.7		6	0.20 B	25
-30				
	Brown (Wet, Very Soft) LOAM A-4(0) See Class @ 30 ft			
447.7				
	Brown (Wet) Poorly Graded Fine to Medium Coarse SAND with Trace Gravel See Gradation @ 34 ft	10	NC	--
-35				
444.2				
	Gray (Wet, Very Soft) Loamy SAND with Trace Gravel			
-40		10	0.20 B	22

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)

Illinois Department of Transportation
Division of Highways
Illinois Department of Transportation

SOIL BORING LOG

Date 9/10/15

ROUTE FAS 779 DESCRIPTION US 40 over West Fork Shoal Creek LOGGED BY DI (TSi)

SECTION 35-1-BR LOCATION , SEC. 35, TWP. 5N, RNG. 4W, 3 PM

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

STRUCT. NO. 003-0020 (E) / 003-0063 (P)
Station 1574+34.46

BORING NO. B-2 E Abut
Station 1575+04
Offset 3.50ft Right
Ground Surface Elev. 480.2 ft

Surface Water Elev. ____ ft
Stream Bed Elev. ____ ft

Groundwater Elev.:
First Encounter 454.2 ft
Upon Completion ____ ft
After ____ Hrs. ____ ft

DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)	Description
				Gray (Wet, Very Soft) Loamy SAND with Trace Gravel *(continued)*
438.2				
				Gray (Dry, Hard) SHALE
	11			
	50/5"	2.25	14	
-45	--	S		
433.2				
				Gray (Dry, Hard) Shaley Silty Clay LOAM A-4(7) See Class @ 49 ft
	50/5"			
	--	2.67	13	
-50	--	B		
429.4				
				Borehole continued with rock coring.
-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)

Illinois Department of Transportation
Division of Highways
Illinois Department of Transportation

ROCK CORE LOG

Date 9/10/15

ROUTE FAS 779 DESCRIPTION US 40 over West Fork Shoal Creek LOGGED BY DI (TSi)

SECTION 35-1-BR LOCATION , SEC. 35, TWP. 5N, RNG. 4W, 3 PM

COUNTY Bond CORING METHOD NQ Conventional

STRUCT. NO. 003-0020 (E) / 003-0063 (P)
Station 1574+34.46

CORING BARREL TYPE & SIZE

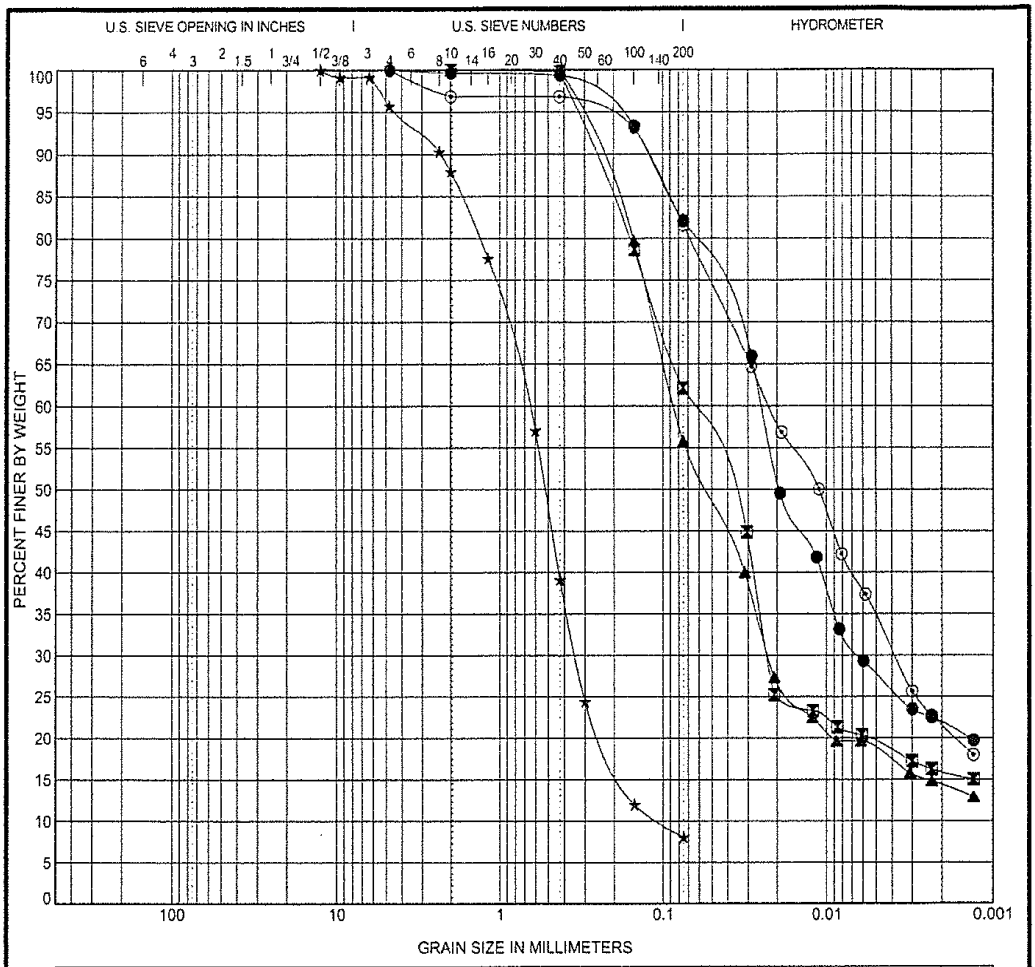
Core Diameter 1.8 in
Top of Rock Elev. 429.40 ft
Begin Core Elev. 429.40 ft

BORING NO. B-2 E Abut
Station 1575+04
Offset 3.50ft Right
Ground Surface Elev. 480.2 ft

	DEPTH (ft)	CORE (#)	RECOVERY (%)	R.Q.D. (%)	CORE TIME (min/ft)	STRENGTH (tsf)
429.40						
Dark Gray (Moderately Soft, Moderately Weathered) Very Fine Grained SHALE		1	100	14	2	
		1	100	14	2	
		1	100	14	1	
	-55	2	61	0	3	
		2	61	0	1	
422.70		2	61	0	2	
Dark Gray (Soft to Moderately Soft, Highly Weathered) Very Fine Grained Oily SHALE		3	23	0	2	
		3	23	0	2	
	-60	3	23	0	2	
418.70		3	23	0	2	
Dark Gray (Soft to Moderately Soft, Moderately to Highly Weathered) Very Fine Grained SHALE		4	100	21	2.5	
416.70		4	100	21	2.5	
END OF BORING AND ROCK CORE	-65					
NOTE: Ponding water in augers at water table to reduce hydrostatic pressure						
NOTE: For samples between 0 feet and 40 feet, blow count is "N-Value" for respective sample						
	-70					

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

BBS, form 138 (Rev. 8-99)



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	B-2	11.50	A-4 (7) SILTY CLAY LOAM	28.1	18.4	9.7		
⊠	B-2	26.50	A-4 (1) LOAM	24.0	17.8	6.2		
▲	B-2	30.00	A-4 (0) LOAM	22.5	17.0	5.5		
★	B-2	34.00	SAND				1.68	6.24
⊙	B-2	49.00	A-4 (7) SILTY CLAY LOAM	30.2	20.3	9.9		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-2	11.50	4.75	0.025	0.006		0.3	17.6	60.3	21.8
⊠	B-2	26.50	2	0.067	0.023		0.0	37.9	46.2	15.9
▲	B-2	30.00	2	0.085	0.023		0.0	44.2	41.4	14.4
★	B-2	34.00	12.5	0.661	0.343	0.106	12.1	79.9	8.0	
⊙	B-2	49.00	4.75	0.022	0.004		3.1	15.3	60.0	21.6

Illinois Department of Transportation
Division of Highways
Illinois Department of Transportation

IDH GRAIN SIZE DISTRIBUTION

Route: FAS 779
Section: 35-1-BR
County: Bond

GRAIN_SIZE_IDH_3-18-11 003-0020.GPJ IL_DOT.GDT 9/28/15

EXHIBIT D – PILE LENGTH/PILE TYPE

IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

I.D.O.T. BBS FOUNDATIONS AND GEOTECHNICAL UNIT — Modified 10/18/2011

SUBSTRUCTURE==========	west abut.	
REFERENCE BORING ==========	1	
LRFD or ASD or SEISMIC ==========	LRFD	
PILE CUTOFF ELEV. ==========	473.40	ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING =	472.40	ft
GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) ===	None	
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ==========	424.00	ft
TOP ELEV. OF LIQUEF. (so layers above apply DD) =======	434.00	ft
TOTAL FACTORED SUBSTRUCTURE LOAD ==========	1353	kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)=======	32.00	ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE =======	2	
Approx. Factored Loading Applied per pile at 8 ft. Cts ========	169.13	KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ========	63.42	KIPS

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

Maximum Nominal Req'd Bearing of Pile	Maximum Nominal Req.d Bearing of Bori	Maximum Factored Resistance Available in Boring	Maximum Pile Driveable Length in Boring
705 KIPS	705 KIPS	388 KIPS	49 FT.

Print Input Sheet | Print Pile Design Table | Clear Input Cells | Print Bearing Graph

PILE TYPE AND SIZE ========== Steel HP 14 X 89

Plugged Pile Perimeter==========	4.750	FT.	Unplugged Pile Perimeter==========	7.033 FT.
Plugged Pile End Bearing Area==========	1.409	SQFT.	Unplugged Pile End Bearing Area========	0.181 SQFT.

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.)
469.70	2.70	1.80	7		13.9		35.7	20.7		*23.4*	23	0	0	13	4
467.70	2.00	1.10	4		7.3	21.7	39.0	10.8	2.8	*33.7*	34	0	0	19	6
464.70	3.00	0.90	4		9.3	17.8	48.3	13.8	2.3	*47.5*	47	0	0	26	9
462.20	2.50	0.90	5		7.7	17.8	87.6	11.5	2.3	*63.0*	63	0	0	35	11
459.70	2.50	2.50	8		16.0	49.4	93.7	23.7	6.4	*85.4*	85	0	0	47	14
457.70	2.00	2.00	10		11.1	39.5	102.8	16.4	5.1	*101.5*	102	0	0	56	16
455.20	2.50	1.90	11		13.4	37.5	*88.6*	19.8	4.8	117.8	89	0	0	49	18
452.70	2.50	0.50	5		4.6	9.9	*114.9*	6.9	1.3	127.4	115	0	0	63	21
447.70	5.00	1.60	6		23.9	31.6	*111.1*	35.4	4.1	159.2	111	0	0	61	26
444.70	3.00	0.20	2		2.3	3.9	*113.5*	3.5	0.5	162.7	113	0	0	62	29
441.20	3.50	0.20	2		2.7	3.9	*114.2*	4.0	0.5	166.5	114	0	0	63	32
435.70	5.50	0.10	4		2.2	2.0	*146.0*	3.2	0.3	173.5	146	0	0	80	38
433.70	2.00	1.60	74		9.6	31.6	*153.6*	14.1	4.1	187.4	154	0	0	84	40
431.70	2.00	1.50	100		9.1	29.6	308.6	13.5	3.8	*213.7*	220	0	0	121	42
430.70	1.00			Shale	59.2	175.5	367.8	87.6	22.6	*307.3*	307	0	0	169	42.7
429.70	1.00			Shale	59.2	175.5	427.0	87.6	22.6	*394.9*	395	0	0	217	43.7
428.70	1.00			Shale	59.2	175.5	486.1	87.6	22.6	*482.6*	483	0	0	265	44.7
427.70	1.00			Shale	59.2	175.5	*545.3*	87.6	22.6	570.2	545	0	0	300	45.7
426.70	1.00			Shale	59.2	175.5	*604.5*	87.6	22.6	657.8	604	0	0	332	46.7
425.70	1.00			Shale	59.2	175.5	*663.7*	87.6	22.6	745.4	664	0	0	365	47.7
424.70	1.00			Shale	59.2	175.5	*722.8*	87.6	22.6	833.0	~~723~~	~~0~~	~~0~~	~~398~~	~~48.7~~
423.70	1.00			Shale	59.2	175.5	*782.0*	87.6	22.6	920.6	~~782~~	~~0~~	~~0~~	~~430~~	~~49.7~~
422.70	1.00			Shale	59.2	175.5	*841.2*	87.6	22.6	1008.3	~~841~~	~~0~~	~~0~~	~~463~~	~~50.7~~
421.70	1.00			Shale		175.5			22.6						

IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

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

Modified 10/18/2011

SUBSTRUCTURE==========	west abut.	
REFERENCE BORING ==========	1	
LRFD or ASD or SEISMIC ==========	LRFD	
PILE CUTOFF ELEV. ==========	473.40	ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING =	472.40	ft
GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) ===	None	
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ==========	424.00	ft
TOP ELEV. OF LIQUEF. (so layers above apply DD) =======	434.00	ft
TOTAL FACTORED SUBSTRUCTURE LOAD ==========	1353	kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)=======	32.00	ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE =======	2	
Approx. Factored Loading Applied per pile at 8 ft. Cts =======	169.13	KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts =======	63.42	KIPS

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

Maximum Nominal Req'd Bearing of Pile	Maximum Nominal Req.d Bearing of Bori	Maximum Factored Resistance Available in Boring	Maximum Pile Driveable Length in Boring
705 KIPS	705 KIPS	388 KIPS	49 FT.

Print Input Sheet | Print Pile Design Table | Clear Input Cells | Print Bearing Graph

PILE TYPE AND SIZE ========== Steel HP 14 X 89

Plugged Pile Perimeter==========	4.750	FT.	Unplugged Pile Perimeter========== 7.033 FT.
Plugged Pile End Bearing Area==========	1.409	SQFT.	Unplugged Pile End Bearing Area======= 0.181 SQFT.

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.)
469.70	2.70	1.80	7		13.9		35.7	20.7		*23.4*	23	0	0	13	4
467.70	2.00	1.10	4		7.3	21.7	39.0	10.8	2.8	*33.7*	34	0	0	19	6
464.70	3.00	0.90	4		9.3	17.8	48.3	13.8	2.3	*47.5*	47	0	0	26	9
462.20	2.50	0.90	5		7.7	17.8	87.6	11.5	2.3	*63.8*	63	0	0	35	11
459.70	2.50	2.50	8		16.0	49.4	93.7	23.7	6.4	*85.4*	85	0	0	47	14
457.70	2.00	2.00	10		11.1	39.5	102.8	16.4	5.1	*101.5*	102	0	0	56	16
455.20	2.50	1.90	11		13.4	37.5	*88.6*	19.8	4.8	117.8	89	0	0	49	18
452.70	2.50	0.50	5		4.6	9.9	*114.3*	6.9	1.3	127.4	115	0	0	63	21
447.70	5.00	1.60	6		23.9	31.6	*111.1*	35.4	4.1	159.2	111	0	0	61	26
444.70	3.00	0.20	2		2.3	3.9	*113.5*	3.5	0.5	162.7	113	0	0	62	29
441.20	3.50	0.20	2		2.7	3.9	*114.2*	4.0	0.5	166.5	114	0	0	63	32
435.70	5.50	0.10	4		2.2	2.0	*146.8*	3.2	0.3	173.5	146	0	0	80	38
433.70	2.00	1.60	74		9.6	31.6	*153.6*	14.1	4.1	187.4	154	0	0	84	40
431.70	2.00	1.50	100		9.1	29.6	308.6	13.5	3.8	*218.7*	220	0	0	121	42
430.70	1.00			Shale	59.2	175.5	367.8	87.6	22.6	*307.3*	307	0	0	169	42.7
429.70	1.00			Shale	59.2	175.5	427.0	87.6	22.6	*394.9*	395	0	0	217	43.7
428.70	1.00			Shale	59.2	175.5	486.1	87.6	22.6	*482.6*	483	0	0	265	44.7
427.70	1.00			Shale	59.2	175.5	*545.3*	87.6	22.6	570.2	545	0	0	300	45.7
426.70	1.00			Shale	59.2	175.5	*604.5*	87.6	22.6	657.8	604	0	0	332	46.7
425.70	1.00			Shale	59.2	175.5	*663.7*	87.6	22.6	745.4	664	0	0	365	47.7
424.70	1.00			Shale	59.2	175.5	*722.8*	87.6	22.6	833.0	~~723~~	~~0~~	~~0~~	~~398~~	~~48.7~~
423.70	1.00			Shale	59.2	175.5	*782.0*	87.6	22.6	920.6	~~782~~	~~0~~	~~0~~	~~430~~	~~49.7~~
422.70	1.00			Shale	59.2	175.5	*841.2*	87.6	22.6	1008.3	~~841~~	~~0~~	~~0~~	~~463~~	~~50.7~~
421.70	1.00			Shale		175.5			22.6						

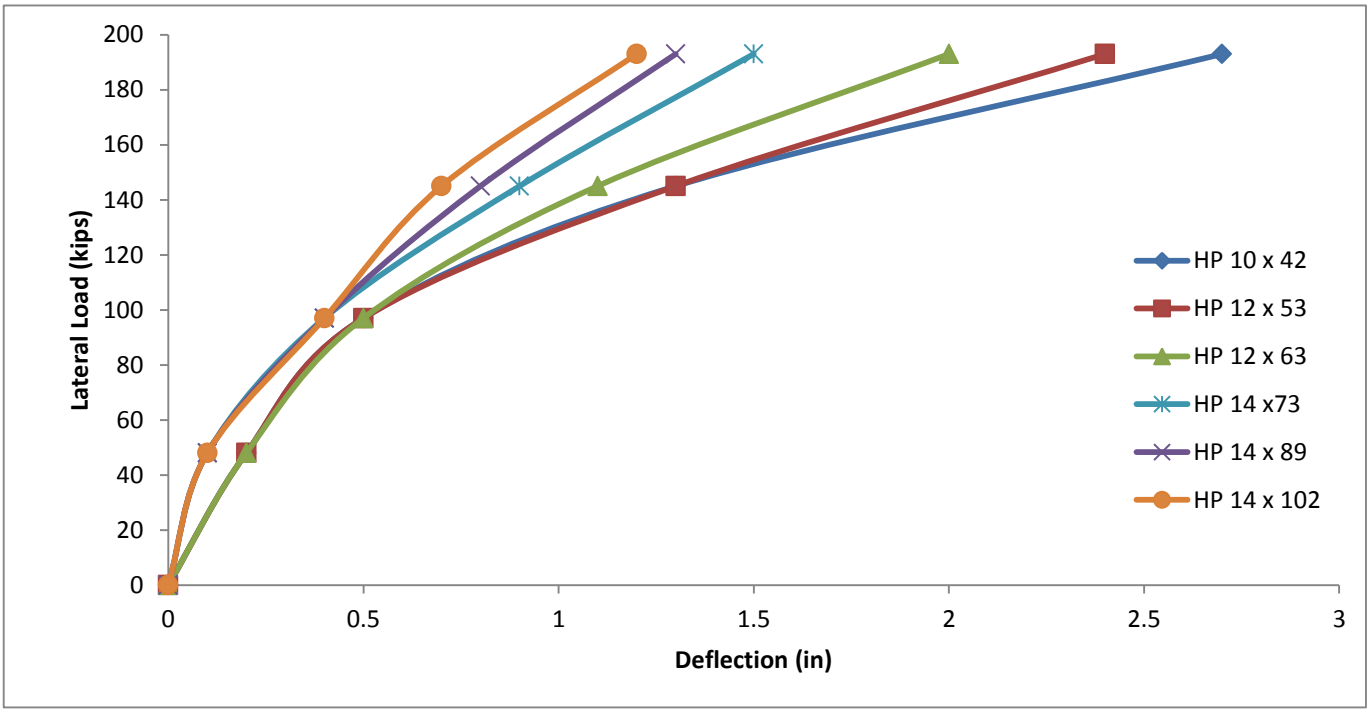
Exhibit E – Lateral Load Analysis

Lateral Load Analysis

PILE SIZE	LATERAL LOAD PER PILE (kips)	DEFLECTION PER PILE (Fixed Head Condition, two feet into cap) (inches)	MOMENT PER PILE (Fixed Head Condition, two feet into cap) (Kip-ft)
HP 10 x42	21	2.7	127.0
	16	1.3	80.0
	11	0.5	43.0
	5	0.2	18.7
HP 12 x 53	21	2.4	157.5
	16	1.3	105.0
	11	0.5	58.0
	5	0.2	24.5
HP 12 x 63	21	2.0	156.0
	16	1.1	104.0
	11	0.5	59.0
	5	0.2	25.0
HP 14 x 73	21	1.5	176.0
	16	0.9	123.0
	11	0.4	71.0
	5	0.1	30.1
HP 14 x 89	21	1.3	181.0
	16	0.8	126.0
	11	0.4	74.0
	5	0.1	31.5
HP 14 x 102	21	1.2	185.0
	16	0.7	128.0
	11	0.4	77.0
	5	0.1	33.0

*Lateral Loads were obtained assuming some percentages of the preliminary service axial load of 107 kips per pile: 20%(21k), 15%(16k), 10%(11k) and 5%(5k). The piles were analized within a group and for fixed head condition, and with a transverse and longitudinal spacing of 78" and 30" between piles, respectively, assuming a total of 9 piles per abutment (provided by the planner). It should be noted that we analized the lateral pile response for fixed head condition **(2 feet into cap**) to show reasonable deflection and moment values. If the number of piles or distance between piles change, these lateral Pile Response will need to be re-analyzed with the final configurations between piles.

FIXED HEAD CONDITIONS



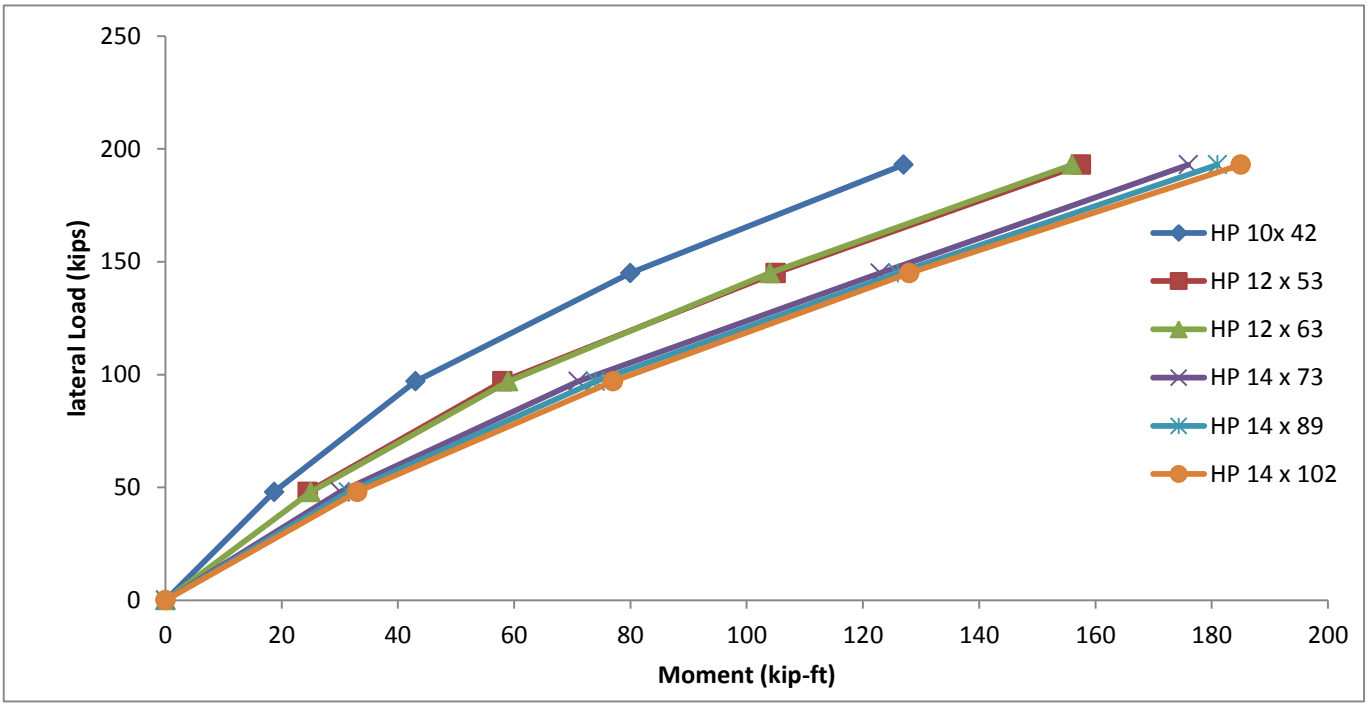


Exhibit F – Seismic Site Class Determination

Print Sheet 1 | Print Sheet 2 | Clear Input

SEISMIC SITE CLASS DETERMINATION

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

Modified on 12/10/10

PROJECT TITLE======

Substructure 1

Base of Substruct. Elev. (or ground surf for ber	472	ft.
Pile or Shaft Dia.	12	inches
Boring Number	B-1	
Top of Boring Elev.	480	ft.
Approximate Fixity Elev.	466	ft.

Individual Site Class Definition:

N (bar):	13	(Blows/ft.	Soil Site Class E <----Controls
N_{ch} (bar):	NA	(Blows/ft.	NA
s_u (bar):	0.7	(ksf)	Soil Site Class E

Seismic Soil Column Depth (ft)	Bot. Of Sample Elevation	Sample Thick. (ft.)	N	Qu (tsf)	Layer Description Boundary
	466.0	14.00	5	5.00	B
1.3	464.7	1.30	4	0.94	B
3.8	462.2	2.50	5	0.94	B
6.3	459.7	2.50	8	2.45	B
8.3	457.7	2.00	10	2.00	B
10.8	455.2	2.50	11	1.88	
13.3	452.7	2.50	5	0.49	B
18.3	447.7	5.00	6	1.55	B
21.3	444.7	3.00	2	0.20	B
23.3	442.7	2.00	2	0.20	
24.8	441.2	1.50	4	0.12	B
30.3	435.7	5.50	4	0.12	B
34.3	431.7	4.00	99	1.61	B
39.3	426.7	5.00	100	1.47	B
100.0	366.0	60.70	100	1.50	R

Substructure 2

Base of Substruct. Elev. (or ground surf for ber	472.5	ft.
Pile or Shaft Dia.	12	inches
Boring Number	B-2	
Top of Boring Elev.	480	ft.
Approximate Fixity Elev.	466.5	ft.

Individual Site Class Definition:

N (bar):	16	(Blows/ft.	Soil Site Class D <----Controls
N_{ch} (bar):	NA	(Blows/ft.	NA
s_u (bar):	0.85	(ksf)	Soil Site Class E

Seismic Soil Column Depth (ft)	Bot. Of Sample Elevation	Sample Thick. (ft.)	N	Qu (tsf)	Layer Description Boundary
	466.5	13.50			
3.3	463.2	3.30	3	0.41	B
4.3	462.2	1.00	6	0.94	B
6.8	459.7	2.50	5	0.94	B
9.3	457.2	2.50	7	1.14	B
11.8	454.7	2.50	5	0.41	B
15.8	450.7	4.00	3	0.20	B
18.8	447.7	3.00	6	0.20	B
22.3	444.2	3.50	10		B
28.3	438.2	6.00	10	0.20	B
33.3	433.2	5.00	71	2.25	B
37.3	429.2	4.00		2.67	B
100.0	366.5	62.70	71	2.50	R

Substructure 3

Base of Substruct. Elev. (or ground surf for bents)		ft.
Pile or Shaft Dia.		inches
Boring Number		
Top of Boring Elev.		ft.
Approximate Fixity Elev.		ft.

Individual Site Class Definition:

N (bar):		(Blows/ft.	NA
N_{ch} (bar):		(Blows/ft.	NA
s_u (bar):		(ksf)	NA

Seismic Soil Column Depth (ft)	Bot. Of Sample Elevation	Sample Thick. (ft.)	N	Qu (tsf)	Layer Description Boundary

Substructure 4

Base of Substruct. Elev. (or ground surf for bents)		ft.
Pile or Shaft Dia.		inches
Boring Number		
Top of Boring Elev.		ft.
Approximate Fixity Elev.		ft.

Individual Site Class Definition:

N (bar):		(Blows/ft.	NA
N_{ch} (bar):		(Blows/ft.	NA
s_u (bar):		(ksf)	NA

Seismic Soil Column Depth (ft)	Bot. Of Sample Elevation	Sample Thick. (ft.)	N	Qu (tsf)	Layer Description Boundary

Global Site Class Definition: Substructures 1 through 2

N (bar):	15	(Blows/ft.)	Soil Site Class D <----Controls
N_{ch} (bar):		(Blows/ft.)	NA, H < 0.1*H (Total)
s_u (bar):	0.77	(ksf)	Soil Site Class E

Exhibit G – Liquefaction Analysis

LIQUEFACTION ANALYSIS

I.D.O.T. Bureau of Bridges and Structures FOUNDATIONS AND GEOTECHNICAL UNIT — Modified 5/24/10

CLEAR INPUT CELLS | PRINT SHEET

REFERENCE BORING NUMBER	B-1 W. Abut.	
ELEVATION OF BORING GROUND SURFACE	480.20	FT.
DEPTH TO GROUNDWATER - DURING DRILLING	26.00	FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE	26.00	FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As)	0.144	(PGA (0.090) x Fpga (1.6) (Table 3.10.3.2-1)
EARTHQUAKE MOMENT MAGNITUDE	7.7	
FINISHED GRADE FILL OR CUT FROM BORING SURFACE	1.20	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) = **0.948**

AVG. SHEAR WAVE VELOCITY (top 40')
$V_{s,40'}$ = **414** FT./SEC.

PGA CALCULATOR

Earthquake Moment Magnitude =	7.7
Source-To-Site Distance, R (km) =	189.7
Ground Motion Prediction Equations =	NMSZ
PGA =	**0.090**

	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	
479.2	1	10	1	100				0.122	0.122	18.150	26.780	0.332	0.122	0.266	0.266	1.500	**0.473**	0.978	**0.092**	**N.L. (1)**	
476.7	3.5	5	1	72	13.3	29.3	20	0.122	0.427	7.879	14.454	0.155	0.122	0.571	0.571	1.405	**0.206**	0.950	**0.089**	**N.L. (1)**	
474.2	6	14	1.3	72	13.3	29.3	15	0.125	0.740	21.755	31.106	0.571	0.125	0.884	0.884	1.374	**0.745**	0.917	**0.086**	**N.L. (1)**	
469.2	11	7	1.6	72	13.3	29.3	20	0.127	1.375	9.306	16.167	0.172	0.127	1.519	1.519	1.094	**0.178**	0.843	**0.079**	**N.L. (1)**	
467.7	12.5	4	1.1	72	13.3	28.1	22	0.123	1.559	5.233	11.280	0.125	0.123	1.703	1.703	1.054	**0.124**	0.819	**0.077**	**N.L. (1)**	
464.7	15.5	4	0.9	88	18.1	34.5	23	0.120	1.919	5.027	11.032	0.122	0.120	2.063	2.063	1.007	**0.117**	0.771	**0.072**	**N.L. (1)**	
462.2	18	5	0.9	60	15.2	32.7	23	0.120	2.219	6.036	12.243	0.133	0.120	2.363	2.363	0.974	**0.123**	0.732	**0.068**	**N.L. (1)**	
459.7	20.5	8	2.5	88	17.2	35.6	22	0.133	2.552	9.187	16.024	0.171	0.133	2.696	2.696	0.937	**0.152**	0.694	**0.065**	**N.L. (1)**	
455.2	25	10	1.9	88	17.2	35.6	20	0.129	3.132	10.513	17.615	0.188	0.067	2.997	3.009	0.908	**0.161**	0.635	**0.060**	**N.L. (2)**	
452.7	27.5	5	0.5	62	17.2	35.6	24	0.051	3.260	5.176	11.211	0.124	0.051	3.125	3.293	0.911	**0.107**	0.607	**0.060**	**N.L. (2)**	
447.7	32.5	6	1.6	88	17.2	35.6	26	0.065	3.585	5.937	12.125	0.132	0.065	3.450	3.930	0.888	**0.111**	0.564	**0.060**	**N.L. (2)**	
444.7	35.5	2	0.2	56	5.5	17	24	0.042	3.711	1.947	7.337	0.090	0.042	3.576	4.243	0.894	**0.077**	0.545	**0.061**	**1.262**	**(C)**
441.2	39	5		10				0.055	3.903	4.744	5.716	0.077	0.055	3.768	4.654	0.889	**0.065**	0.528	**0.061**	**1.066**	**(C)**
439.2	41	4	0.12	20	6.2	23	23	0.037	3.977	3.761	7.675	0.093	0.037	3.842	4.853	0.879	**0.078**	0.521	**0.062**	**1.258**	**(C)**

* FACTOR OF SAFETY DESCRIPTIONS

N.L. (1) = NOT LIQUEFIABLE, ABOVE EQ GROUND WATER ELEVATION
N.L. (2) = NOT LIQUEFIABLE, PI $\geq$ 12 OR 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

CLEAR PRINT of Bridges and Structures FOUNDATIONS AND GEOTECHNICAL UNIT Modified 5/24/10

REFERENCE BORING NUMBER	B-2 E. Abut.	
ELEVATION OF BORING GROUND SURFACE	480.20	FT.
DEPTH TO GROUNDWATER - DURING DRILLING	26.00	FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE	26.00	FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As)	0.144	(PGA (0.090) x Fpga (1.6) (Table 3.10.3.2-1)
EARTHQUAKE MOMENT MAGNITUDE	7.7	
FINISHED GRADE FILL OR CUT FROM BORING SURFACE	1.20	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) = **0.948**

AVG. SHEAR WAVE VELOCITY (top 40')
$V^{*}_{s,40'}$ = **401** FT./SEC.

PGA CALCULATOR

Earthquake Moment Magnitude =	7.7
Source-To-Site Distance, R (km) =	189.7
Ground Motion Prediction Equations =	NMSZ
PGA =	**0.090**

	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. (K_s)	CORR. RESIST. $CRR_{7.5}$ CRR	SOIL MASS PART. FACTOR (r_d)	EQ INDUCED CSR	FACTOR OF SAFETY * CRR/CSR
479.2	1	10	1	100				0.122	0.122	18.150	26.780	0.332	0.122	0.266	0.266	1.500	**0.473**	0.976	**0.091**	N.L. (1)
477.2	3	6	1.2	30				0.124	0.370	9.639	15.833	0.169	0.124	0.514	0.514	1.462	**0.234**	0.951	**0.089**	N.L. (1)
474.7	5.5	6	1.1	42				0.123	0.678	8.719	15.463	0.165	0.123	0.822	0.822	1.286	**0.201**	0.917	**0.086**	N.L. (1)
472.2	8	9	1.9	82	9.7	28.1	18	0.129	1.000	12.383	19.859	0.214	0.129	1.144	1.144	1.198	**0.243**	0.880	**0.082**	N.L. (1)
469.7	10.5	4	1.3	82	9.7	28.1	22	0.125	1.313	5.342	11.410	0.126	0.125	1.457	1.457	1.094	**0.131**	0.839	**0.079**	N.L. (1)
467.2	13	3	0.5	82	9.7	28.1	23	0.114	1.598	3.922	9.706	0.111	0.114	1.742	1.742	1.046	**0.110**	0.798	**0.075**	N.L. (1)
463.2	17	3	0.4	82	9.7	28.1	24	0.111	2.042	3.728	9.474	0.109	0.111	2.186	2.186	0.993	**0.102**	0.732	**0.069**	N.L. (1)
459.7	20.5	6	0.9	82				0.120	2.462	7.014	13.417	0.145	0.120	2.606	2.606	0.949	**0.130**	0.679	**0.064**	N.L. (1)
457.2	23	7	1.1	40				0.123	2.769	7.805	14.366	0.154	0.123	2.913	2.913	0.921	**0.134**	0.645	**0.060**	N.L. (1)
454.2	26	5	0.4	62	6.2	24	20	0.111	3.102	5.300	11.360	0.125	0.173	3.432	3.507	0.891	**0.106**	0.609	**0.058**	N.L. (2)
450.7	29.5	3		62	6.2	24	26	0.051	3.281	3.108	8.729	0.102	0.051	3.611	3.904	0.888	**0.086**	0.575	**0.058**	**1.483** (C)
447.7	32.5	6		56	5.5	17	25	0.057	3.452	6.069	12.283	0.134	0.057	3.782	4.262	0.867	**0.110**	0.552	**0.058**	**1.897** (C)
444.2	36	10		8				0.061	3.665	9.815	10.238	0.115	0.061	3.995	4.694	0.863	**0.094**	0.531	**0.058**	**1.621** (C)
438.2	42	10		8				0.061	4.031	9.336	9.753	0.111	0.061	4.361	5.434	0.847	**0.089**	0.507	**0.059**	**1.508** (C)

* FACTOR OF SAFETY DESCRIPTIONS

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