REVISED STRUCTURE GEOTECHNICAL REPORT

BRIDGE REPLACEMENT
IL Route 37 over Atchison Creek

FAS Route 2869 (IL 37)
Section 2-B-2
Jefferson County, Illinois
Job No. D-99-003-010
Contract No. 78149
PTB 148/33 Work Order #4
Existing Structure No. 041-0036
Proposed Structure No. 041-0110

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June 2010

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1.0 PROJECT DESCRIPTION AND PROPOSED STRUCTURE INFORMATION

1.1 Introduction

The geotechnical study summarized in this report was performed for the proposed bridge on Illinois Route 37 over Atchison Creek in Jefferson County, Illinois. The purpose of this report is to present design and construction recommendations for the proposed structure.

1.2 Project Description

The project entails complete replacement of the existing bridge (S.N. 041-0036) located at Illinois Route 37 over Atchison Creek in Jefferson County, Illinois. The project is located about one-half mile south of Bonnie, Illinois and 3.5 miles north of Ina, Illinois. The general location of the bridge is shown on a USGS topographic Location Map, Exhibit A. The site lies within the limits of the Third Principal Meridian, (T. 4S, R. 3E, Section 8) in the Mt. Vernon Hill Country Physiographic region.

1.3 Proposed Bridge Information

The proposed structure (S.N. 041-0110) will consist of a two span structure built on a 90 degree skew. Its proposed centerline station will be at Station 429+65.00 with an overall length of 142 ft as measured from back to back abutments and a total deck width of 39 ft-2 in. The proposed substructure will consist of integral abutments and pile bent pier. See attached Type, Size and Location Plan (TS&L) as provided by HLR in Exhibit B. The project will be completed using staged construction to maintain one lane of traffic at all times.

2.0 EXISTING BRIDGE INFORMATION

The original structure (SN 041-0036) was constructed in 1921. In 1952 the bridge was reconstructed by widening the existing substructure and placing a 3-span continuous RC T-beam, superstructure. The existing structure is 129 ft -10 in. from back to back abutments and has a total deck width of 33 ft - 8 in.

The Bridge Condition Report, dated June 17, 2009, recommends complete replacement of the existing structure. The recent field inspection noted that the superstructure was in fair condition. The substructure was noted to be in satisfactory condition with some tight cracks and a few small delaminations at the abutments. It was also noted that the channel was silted in considerably in the north and center sections. There were no slope protection measures noted during the inspection and no significant scour was evident at the bridge.

3.0 SITE INVESTIGATION, SUBSURFACE EXPLORATION AND GENERALIZED SUBSURFACE CONDITIONS

The site investigation plan was determined and conducted by the Illinois Department of Transportation (IDOT). A site visit by a representative of Kaskaskia Engineering Group, LLC (KEG) to observe all or part of the borings, or to make site observations was not included in the scope of services. Therefore, no on-site observations have been made relative to existing conditions of the structure, stream, or roadway, or of subsurface sample conditions by KEG personnel.

Two standard penetration test (SPT) borings, designated 1-S and 2-S, were drilled near the proposed north and south abutments on February 24 and 25, 2009. Boring 1-S was located near the north abutment at Sta. 428+65, 6 ft left of the centerline. Boring 2-S was located near the south abutment at Sta. 430+37, 7 ft right of the centerline. All borings were extended to bedrock. Detailed information regarding the nature and thickness of the soils and rock encountered and the results of the field sampling and laboratory testing are shown on the Boring Logs, Exhibit C and the Soil Profile, Exhibit D. The boring locations are shown on the TS&L, Exhibit B.

The profile at Boring 1-S began at El. 415 with a 9.5 ft layer of silt loam and silty clay loam with an average unconfined compressive strength of 1200 psf. A soft 7.5 ft layer of silt and silty clay followed with weight of hammer blow counts and an average unconfined compressive strength of 200 psf. A stronger layer of silty clay, unconfined compressive strength of 1100 psf was encountered at El. 398 and continued for 4.5 ft to El. 390.5 where the boring commenced with a layer of clay with n-values of 1 bpf and an unconfined compressive strength of 500 psf. A layer of sandy clay followed with unconfined compressive strength of 1200 psf. A 3.5 ft. layer of clay loam was encountered just above the shale bedrock from El 388.0 to El 385.5 with unconfined compressive strength of 5,000 psf. Clay shale was encountered from El. 382 to El 370.0 where the boring was terminated.

The profile at Boring 2-S began at El. 414.9 with a layer of silty clay loam with an average unconfined compressive strength of 1100 followed by a 5 ft. layer of silty clay loam with an unconfined compressive strength of 800 psf. A 7.5 ft layer of silty clay with n-values ranging from weight of hammer to 1 followed. At El. 395.4 a layer of silty loam with an unconfined compressive strength of 600 psf was encountered thru El. 392.9. A 2.5 ft. layer of silt with unconfined compressive strength of 1100 psf followed. At El. 390.4 a layer of low plastic clay with unconfined compressive strength of 600 psf was encountered. At El. 382.9 the clay terminated into a sandy clay layer followed by shale at El. 377.9. The boring was terminated at El. 369.9 in clay shale.

Table 3.1 shows the top of rock elevations for Borings 1-S and 2-S.

Table 3.1 - Bedrock Elevation

Boring	Bedrock Elevation
1-S	382.0
2-S	377.9

Groundwater elevations, encountered during drilling, ranged from approximate El. 383 to El. 402. At Boring 1-S groundwater was encountered at El. 402.5 when drilling and at El. 401.1, at completion. At Boring 2-S groundwater was encountered at El. 382.9 when drilling and at El. 399.7 at completion.

It should be noted that the groundwater level is subject to seasonal and climatic variations and other factors and may be present at different depths in the future. In addition, without extended periods of observation, measurement of the true groundwater levels may not be possible.

4.0 GEOTECHNICAL EVALUATIONS

4.1 Settlement

Due to the nature of the soils encountered in the borings, their weight of hammer blow counts, the level of water held in the creek, and the high moisture contents exhibited in the boring data, settlement calculations were necessary at this location. Although the existing soils have been consolidated and settled over time, the increased weight of the fill, particularly at the north abutment will contribute to additional settlement of the existing soils.

According to the settlement calculations performed, approximately 5 in. of settlement could occur at the north abutment after the proposed 5' of fill is placed on the backslope (assuming the fill will be a granular material). The majority of the settlement is anticipated to occur in the first 5 feet directly under the fill from El. 405 to El. 400. Therefore, the effects of downdrag due to settlement were considered to occur through El. 400 at the north abutment. Downdrag due to settlement will not occur at the south abutment where existing ground will be cut to obtain the 2:1 slope.

4.2 Slope Stability

The proposed construction does not result in significant changes in roadway embankment sideslopes, but does result in new 2:1 backslopes at the abutments. No problems with the sideslopes are reflected in the documentation of existing conditions. Currently, the abutments are closed concrete abutments. When these abutments are replaced by open abutments supported by deep pile foundations, the existing vertical concrete wall face will be replaced with 2:1 (H:V) backslopes.

Slope stability was checked for the proposed backslopes using STABL for Windows 3.0, the soil properties at the site, and the geometrics of the embankments. Three conditions were modeled: end-of-construction, long-term stability, and a design seismic event. A critical factor of safety (FOS) was determined for each condition. According to current standard of practice, the target FOS is 1.5 for end-of-construction and long-term slope stability and 1.0 for a design seismic event.

In order to model the end of construction condition, full cohesion was used with no friction angle assumed. Nominal values for cohesion were used to model the long term and seismic conditions to analyze the theoretical condition where pore water pressure has dissipated. Friction angles ranged from 19 to 26 degrees.

The Bishop Circular Method, which generates circular shaped failure surfaces, was used to calculate the critical failure surfaces and FOS for the proposed conditions. The FOS obtained in the analysis are shown in Table 4.1. STABL program output from this analysis can be found in Exhibit E.

Table 4.1 – Slope Stability Critical FOS

	Calculated Critical FOS		
	End of Construction	Long Term	Seismic
South Abutment Backslope (critical slope)	3.4	1.5	1.0

4.3 Seismic Considerations

The determination of the Seismic Site Class was based on the method described by IDOT AGMU Memo 09.1 - Seismic Site Class Definition, and the IDOT-provided spreadsheet titled Seismic Site Class Determination. Using these resources, the controlling global site class for this project is Site Class D.

Additional seismic parameters were determined for use in design of the structure, and evaluation of liquefaction potential. The USGS published information and mapping (http://earthquake.usgs.gov/), including software directly applicable to the AASHTO Guide Specifications for LRFD Seismic Bridge Design, was used to determine the parameters for the project site location. The values, based on a 1000 Year Return Period with a Probability of Exceedance (PE) of 7% in 75 years, and the Site Class previously determined, are summarized below.

Table 4.2 – Summary of Seismic Parameters

Parameter	Value
Soil Site Class	D
Spectral Acceleration Coefficient at Period of 0.2 Sec, Ss	0.524g(Site Class B)
Spectral Acceleration Coefficient at Period of 1.0 Sec, S1	0.136g(Site Class B)
Site Factor, Zero Period, Fpga	1.26(Site Class D)
Site Factor, Short Period, Fa	1.38(Site Class D)
Site Factor, Long Period, Fv	2.26(Site Class D)
Spectral Response Acceleration, 0.2 Sec, S_{DS}	0.726g(Site Class D)
Spectral Response Acceleration, 1.0 Sec, S_{D1}	0.308g(Site Class D)
Seismic Performance Zone	2

As indicated in the table above, the Seismic Performance Zone is 2, based on S_{D1} and Table 3.15.2-1 in the IDOT Bridge Manual, as well as the Soil Site Class D and Figure 2.3.10-3 in the IDOT Bridge Manual.

4.4 Scour

Channel scour is expected to be negligible at this location with no evidence of channel degradation shown on the surveyed stream profile. The proposed structure will increase the waterway opening almost 30 percent for the 100 year event compared to the existing condition. Local pier scour is estimated to be 5.2 ft.

Scour countermeasures proposed include protecting the abutment slopes with stone riprap and driving pier piles to accommodate the predicted scour. As shown on the TS&L, included in Exhibit B, the integral abutments proposed for the bridge are positioned behind a 2:1 (H:V) embankment and lined with Class A4 stone riprap. This is considered an armored embankment and is considered to be an adequate level of scour protection according to the Bridge Manual.

Table 4.3 shows the Design Scour Elevations. No reduction in the scour elevations was applied. The near surface soil profile anticipated clay material, which would not be considered more scour prone than the default properties assumed in the hydraulic analysis.

Table 4.3 - Design Scour Elevations

	N. Abut	Pier	S. Abut
Design Scour Elevation (ft)	408.6	394.9	408.6

4.5 Mining Activity

According to the Illinois State Geological Survey (ISGS) website, coal mining has occurred in Jefferson County. According to the Coal Mines, Jefferson County dated May 2009, which was obtained from the Illinois State Geological Survey (ISGS) website (http://www.isgs.illinois.edu/maps-data-pub/coal-maps.shtml), the project site was not undermined.

The listed disclaimer indicates locations of some features on the mine map may be offset by 500 or more ft due to errors in the original source maps, the compilation process, digitizing, or a combination of these factors. The location of this bridge is approximately 3 miles away from the closest mining area shown on the map.

4.6 Lateral Pile/Pier Response

Generally, the geotechnical engineer provides soil parameters to the structural engineer so that an LPile program or other approved program can be used for the lateral or displacement analysis of the foundations. Therefore, Table 4.4 has been included showing the soil parameters needed to perform a displacement or lateral pile analysis, if deemed necessary by the Structural engineer.

Table 4.4 – Soil Parameters for Lateral Pile Load Analysis

	Elev. at Bottom of Layer	γ (pcf)	Φ (degrees)	K (pci)	N	% fines < #200	c (psf)	ε50
Boring 1-S North Abut	405.5	110	26	200	7	80	1200	0.010
	398.0	95	28	30	0	80	200	0.020
	390.5	105	26	200	7	85	1200	0.007
	388.0	100	23	100	1	85	500	0.020
	385.5	115	23	200	8	65	1200	0.007
	382.0	105	19	800	25	10	5000	0.004
	370.0	125	12	800	100	10	5000	0.004
Boring 2-S South Abut	407.9	110	26	200	5	65	1100	0.007
	402.9	110	26	100	3	65	800	0.010
	392.9	95	26	30	1.5	65	425	0.020
	390.4	105	26	200	7	65	1100	0.007
	382.9	105	19	100	1	80	600	0.010
	380.4	115	23	100	7	25	700	0.010
	377.9	110	32	100	0	10	500	0.010
	376.4	125	12	400	64	5	3000	0.005
	369.9	125	12	400	100	5	3500	0.004

4.7 Liquefaction

A liquefaction analysis was performed using the liquefaction worksheet provided by IDOT BBS Central Geotechnical Unit. The Peak Horizontal Ground Surface Acceleration value in the spreadsheet was set equivalent to the PGA (0.153 for NMSZ and 0.195 for CEUS), as determined based on deaggregation information from the USGS website and the liquefaction worksheet provided by the BBS. The PGA was calculated for both GMPE models. The Design Earthquake Mean Magnitudes (7.7 for NMSZ and 4.8 for CEUS) were determined using the USGS data and deaggregation methods provided at http://earthquake.usgs.gov/. The soil profiles for Borings 1-S and 2-S were analyzed.

The results for the soil profile encountered in Boring 2-S indicated a potentially liquefiable layer at approximate El. 379, using the NMSZ GMPE combination. The layer is loose, wet, fine sand to sandy loam with low blow counts. The layer is confined above by cohesive soils and below by clay shale, not susceptible to liquefaction. No other layers showed a potential for liquefaction in either boring.

Since the potentially liquefiable layer is overlain by competent non-liquefiable layers, vertical ground settlement should be expected to occur following liquefaction. This condition results in an added negative skin friction downdrag load. The liquefaction and downdrag losses are not to be assumed at the strength limit state group loading. At the time of writing this SGR, the information for the Extreme Event I loading (the loading that would occur during a seismic event) was not available from the structural engineer. Therefore, liquefaction was not considered as a reduction for the pile design capacity or other foundation considerations included herein. Once the Extreme Event I loadings are computed, additional analysis will be required to ensure that the piles considered will still be feasible with the added liquefaction loadings. In addition, due to the contractive nature of the soils, additional analysis may be necessary to investigate the effects of static shear stress on the liquefaction resistance of the soils. Liquefaction analysis results can be found in Exhibit F.

5.0 FOUNDATION EVALUATIONS AND DESIGN RECOMMENDATIONS

5.1 General Feasibility

The TS&L indicates use of integral abutments. For a 142 ft structure with integral abutments, H-piles and 14 in. Metal Shell piles are permitted for foundation support. These pile types were analyzed using the Modified IDOT Static Method of Estimating Pile Length provided by IDOT BBS Foundations and Geotechnical Unit. Based on the boring logs as provided by IDOT, the depth to a hard bedrock material, and the results of the pile design analysis, H-pile foundations driven to refusal on the shale bedrock are recommended for this structure. H-piles will develop significant end bearing resistance when driven to the clay shale material to the depths indicated in the pile design analysis.

The pile design analysis revealed that metal shell pile would not develop significant frictional or end bearing resistance before reaching the shale bedrock material; therefore, this pile type is not recommended, but is included in Table 5.1 – LRFD Pile Design Table as an option should the structural engineer deem it appropriate. If a metal shell pile is recommended by the structural engineer during the design phase, a pile shoe will be required to reduce potential damage to the pile end.

All readily available pile types acceptable for integral abutment foundations are included in Table 5.1 – LRFD Pile Design. Other pile types and sizes analyzed and obtained through the Modified IDOT Static Method of Estimating Pile Length worksheet are included in Modified IDOT Pile Length Calculations and Output, Exhibit G, along with the documentation of the input used for analysis.

5.2 Pile Supported Foundations

The foundations supporting the proposed bridge must provide sufficient support to resist dead and live loads, including seismic loadings. Based on the encountered subsurface conditions, the Modified IDOT Static Method of Estimating Pile Length provided by

IDOT BBS Foundations and Geotechnical Unit, and the information available to date, we recommend using H-pile driven to the shale bedrock material. The Modified IDOT Static Method uses the LRFD Pile Design Guide Procedure to estimate the pile lengths. Table 5.1 shows the calculated pile lengths and corresponding pile tip elevations, based on the pile top elevations as provided by HLR, at the pier and abutment locations for multiple piles.

The factored design loads provided by HLR are 984 kips at the abutments and 1760 kips at the piers. HLR requested, in addition to the typically required pile design data that is included in Table 5.1, KEG provide pile types and lengths for 80%, 90%, 100%, 115%, and 130% of the factored loads. This additional information can be found in Exhibit H – Estimated Pile Types and Lengths for Modified Factored Load Conditions.

The Estimated Pile Lengths for the pile types being considered are shown in the LRFD Pile Design Table 5.1. The Nominal Required Bearing (R_N) represents the resistance the pile will experience during driving as well as to assist the Contractor in selecting a proper hammer size. The Factored Resistance Available (R_F) documents the net long term axial factored pile capacity available at the top of pile to support factored structure loadings.

At the abutments the pile cutoff elevation was estimated at El. 410.6 based on the TS&L provided by HLR. At the piers, the pile cutoff elevation was estimated at El. 411. These pile cutoff elevations were used to determine the estimated pile lengths as shown in Table 5.1. Minimum pile groups were determined by dividing the total factored loads for each substructure unit, provided by HLR, by the R_F for each type of pile considered. The Minimum Pile Groups represent the minimum number of pile needed to support the factored structural loads provided by the structural engineer. Larger pile groups may be necessary to meet maximum spacing requirements at each substructure unit.

Settlement of the existing soils at the locations of the proposed north abutment backslope is anticipated. As discussed in section 4.1, downdrag forces will be considered at the north abutment location due to the anticipated settlement. The bottom elevation of the downdrag to be considered is El. 398 at the north abutment with no downdrag to be considered at the south abutment. Downdrag forces due to settlement were applied to the strength limit state loadings, used to perform the pile design analysis. As discussed in Section 4.7, downdrag forces due to liquefaction should be analyzed further when the Extreme Event I loadings are known. Downdrag due to liquefaction values were not applied to the strength limit state loadings to obtain the R_F. Scour elevations were not applied during the pile design analysis to account for scour at the abutments, since an armored embankment is being proposed. However, scour elevations were applied at the pier location at El. 394.9.

At the abutments and piers, the H-pile should be driven to refusal in the shale bedrock material. The R_F was determined by multiplying the Maximum Nominal Required Bearing ($R_{N\ MAX}$) of the pile type being considered by the Geotechnical Resistance Factor (Φ_G) of 0.55. The estimated pile lengths, pile tip elevations, and minimum pile groupings for each section are shown in Table 5.1.

Table 5.1— LRFD Pile Design

	Pile Designation	R_n Nominal Required Bearing (kips)	R_F Factored Resistance Available (kips)	Total Factored Load (kips)	Estimated Pile Length (ft)	Pile Tip El.	Min. Pile Group
North Abutment (Boring 1-S)	**Metal Shell 14" w .312" walls**	508	273	984	27	384	4
	HP 10X42	330	175	984	30	381	6
	HP 12x53	418	221	984	30	381	5
	HP 12X63	472	251	984	31	380	4
	HP 14x73	551	293	984	31	380	4
	HP 14x89	677	362	984	33	378	3
Pier (Boring 2-S)	**Metal Shell 14" w .312" walls**	465	256	1760	33	378	7
	HP 10X42	322	177	1760	37	374	10
	HP 12x53	408	224	1760	37	374	8
	HP 12X63	487	268	1760	38	373	7
	HP 14x73	568	313	1760	38	373	6
	HP 14x89	695	382	1760	40	371	5
South Abutment (Boring 2-S)	**Metal Shell 14" w .312" walls**	426	235	984	32	379	5
	HP 10X42	324	178	984	36	375	6
	HP 12x53	410	225	984	36	375	5
	HP 12X63	489	269	984	37	374	4
	HP 14x73	571	314	984	37	374	4
	HP 14x89	668	367	984	38	373	3

Although all of the above pile types are considerable options for foundation support, the structural engineer is responsible to determine what pile best suits the design. Some of the pile options may not be suitable alternatives due to spacing requirements or constructability concerns. It is recommended that if an H-pile is recommended for construction and the elevation noted above is within driving distance to shale, piles be driven 2 to 6 ft into the shale bedrock. If H-piles are chosen as a foundation type, one test pile is recommended at the north abutment. A test pile is performed prior to production driving so that actual, on-site, field data can be gathered to determine pile driving requirements for the project. This is the manner in which the Contractor's proposed equipment and methodologies identified in their Pile Installation Plan can be assessed.

6.0 CONSTRUCTION CONSIDERATIONS

6.1 Construction Activities

The construction activities should be performed in accordance with the current *IDOT Standard Specifications for Road and Bridge Construction* and any pertinent Special *Provisions or policies.*

6.2 Temporary Sheeting and Soil Retention

Temporary shoring will be required at the abutments during construction, as staged construction is anticipated for this project. The native soils indicate adequate unconfined compressive strengths and densities below approximate El. 395 at all substructure locations. If retained height is less than 15 feet and temporary shoring depths meet or exceed this elevation, IDOT temporary sheet piling design charts should be feasible at this location.

If the temporary shoring is designed to terminate prior to El. 395, low strength native soils with average unconfined compressive strengths of less than 0.5 tsf will be encountered. Therefore, if the retained height is greater than 15 feet, the IDOT Temporary Sheet Piling Design Guide and Charts show that a Cantilevered Sheet Piling System would not be feasible and a Temporary Soil Retention System will be required. An Illinois Licensed Structural Engineer is required to seal the design of the temporary soil retention system, if deemed necessary.

6.3 Underwater Structure Excavation Protection

Due to the anticipated water elevations at the bridge location, the pay item “Underwater Structure Excavation Protection” will be necessary to construct the pier. The anticipated EWSE at this location is 406.7, indicating approximately 5 ft of water during construction. In this case, since solid wall encased pile bent piers will be utilized underwater structure excavation protection is sufficient to facilitate construction.

If water elevations during construction differ significantly from the approximate EWSE, alternate construction methods may be necessary.

6.4 Site and Soil Conditions

Should any bridge or embankment design considerations assumed by either IDOT or KEG change, KEG should be contacted to determine if the recommendations stated in this report still apply.

Soils with high moisture content could complicate construction activities. Soft or disturbed areas should be undercut (typically 1 to 2 ft) and crushed rock, such as CA-6, can be used to provide a working platform.

6.5 Foundation Construction

Conventional pile driving equipment and methodologies should be assumed.

7.0 COMPUTATIONS

Computations and analyses for special circumstances, if any, are included as exhibits. Please refer to each section of the report for reference to the exhibit containing any such calculations or analysis used.

8.0 GEOTECHNICAL DATA

Soil borings can be found in Exhibit C. The Subsurface Profile can be found in Exhibit D.

9.0 LIMITATIONS

The recommendations provided herein are for the exclusive use of HLR and IDOT. They are specific only to the project described and are based on the subsurface information obtained at two boring locations within the bridge area in 2009, KEG's understanding of the project as described herein, and geotechnical engineering practice consistent with the standard of care. No other warranty is expressed or implied. KEG should be contacted if conditions encountered during construction are not consistent with those described.

EXHIBIT A

LOCATION MAP, USGS

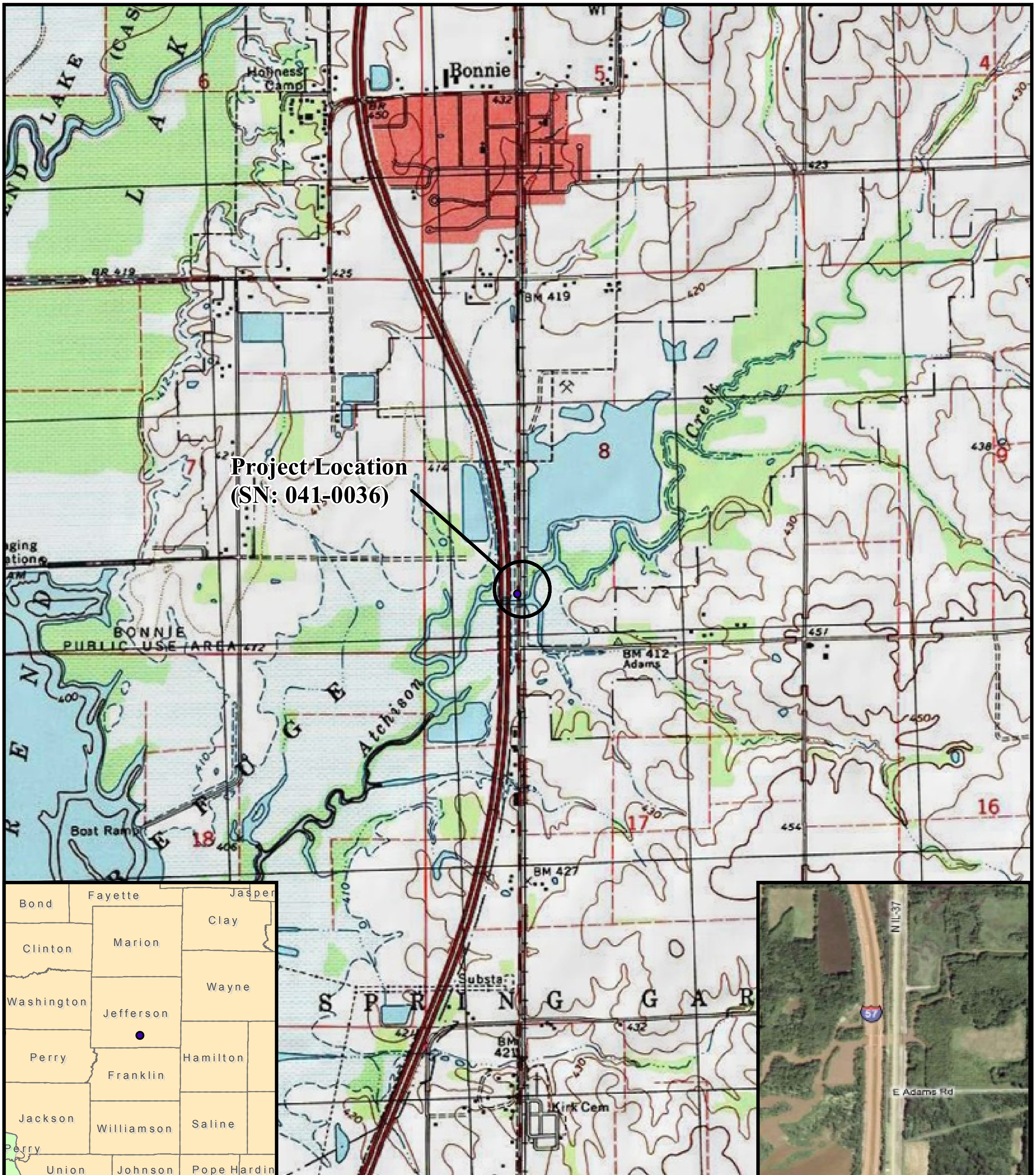

Exhibit A
Location Map
IL 37 over Atchison
Jefferson County, Illinois

N

0 500 1,000
Feet

Designed By: CHA
Drawn By: TDW
Checked By: MGM
Date: 2/3/10
Project #: 08_0060.04

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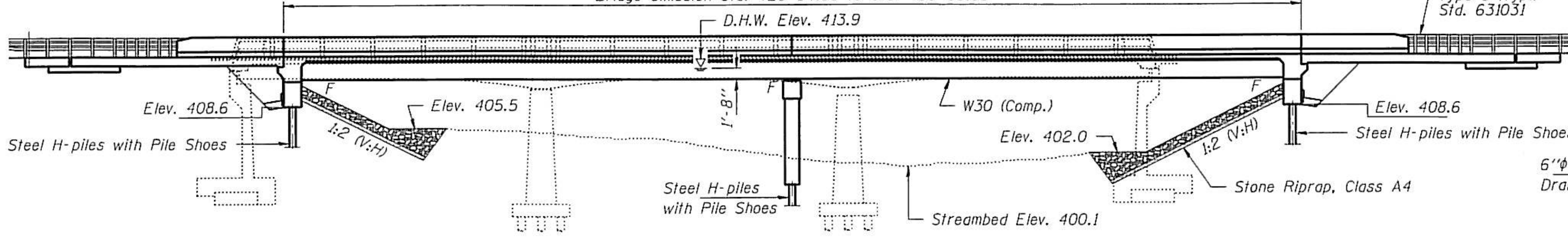
EXHIBIT B

PROVIDED, TYPE, SIZE AND LOCATION PLAN SHEET (TS&L)

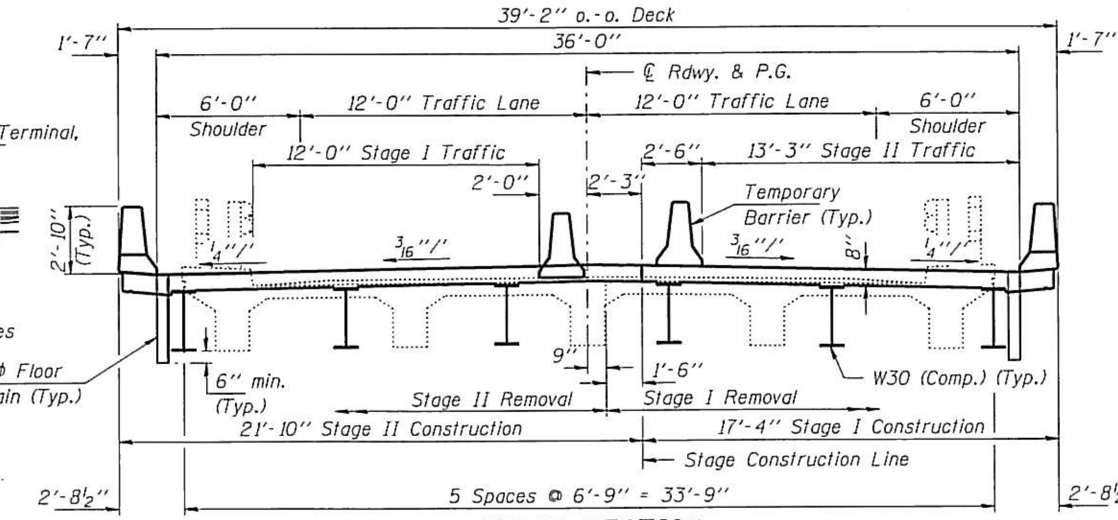
BENCHMARK: BM#J216 - NGS disk on SE wingwall 19' Lt., Sta. 430+16, Elev. 415.33.

EXISTING STRUCTURE: SN 041-0036 was originally built in 1921 as SBI Route 37 Section 2,BY. In 1952 it was reconstructed by widening the existing substructure and placing a 3-span continuous RC T-beam superstructure on top. The bridge is 129'-10" bk.-bk. and 33'-8" o.-o. Structure to be removed and replaced using stage construction to maintain one lane of traffic at all times.

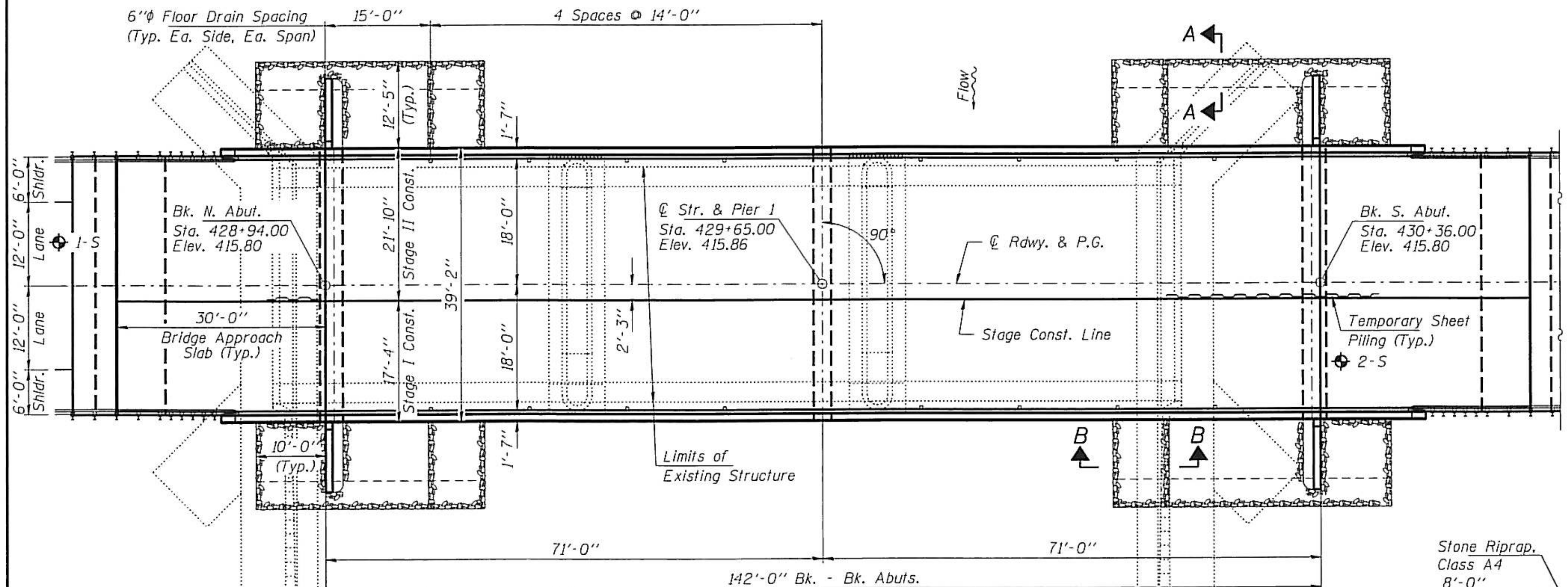
Salvage: None



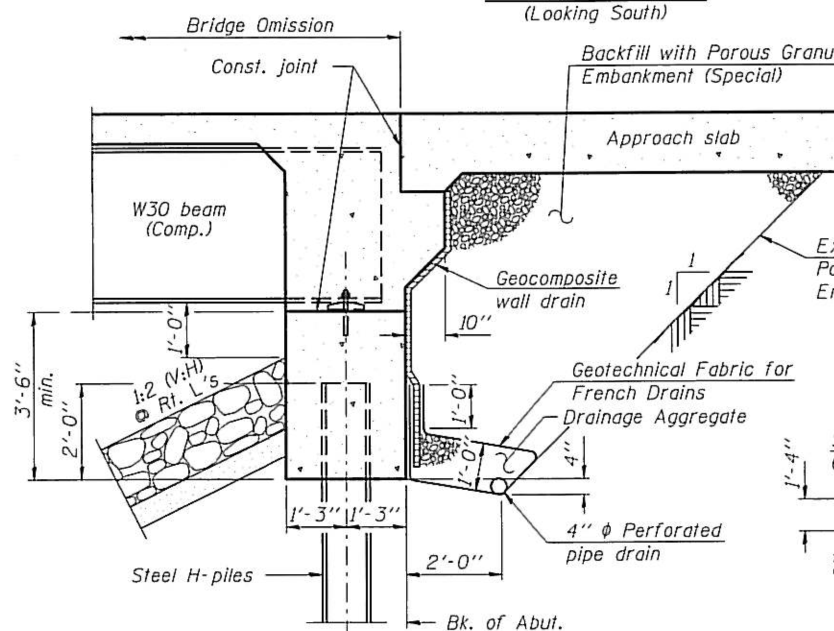
ELEVATION



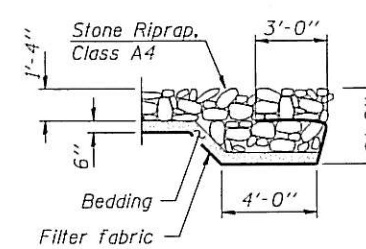
CROSS SECTION
(Looking South)



PLAN



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



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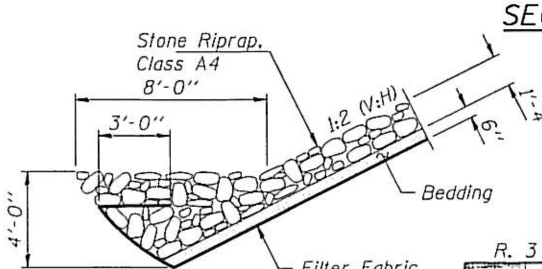
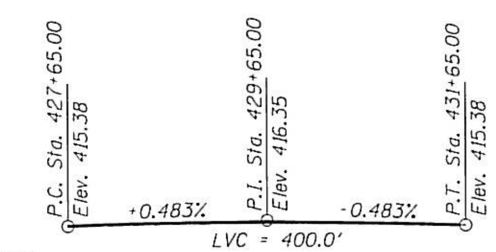
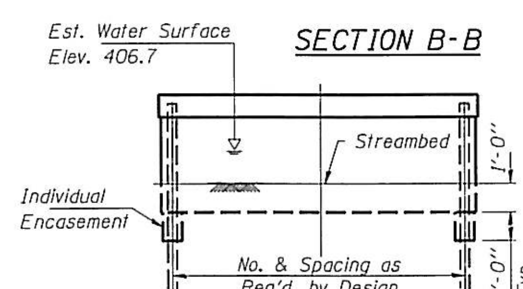


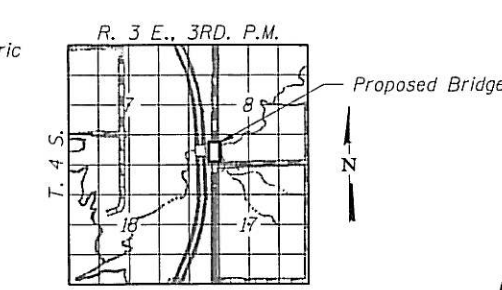
SECTION B-B



PROFILE GRADE
(along ℄ roadway)



PIER SKETCH



LOCATION SKETCH

GENERAL PLAN
IL ROUTE 37
OVER ATCHISON CREEK
FAS ROUTE 2869 - SECTION 2B-2
JEFFERSON COUNTY
STATION 429+65.00
STRUCTURE NO. 041-0110

DESIGN SPECIFICATIONS

2007 AASHTO LRFD Bridge Design Specifications with 2009 Interims

LOADING HL-93

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

DESIGN STRESSES

f'c = 3,500 psi
fy = 60,000 psi (Reinf.)
fy = 50,000 psi (Structural Steel) (M270 GR. 50)

SEISMIC DATA

Seismic Performance Zone (SPZ) = 3
Design Spectral Acceleration at 1.0 sec. (S_{D1}) = 0.462 g
Design Spectral Acceleration at 0.2 sec. (S_{DS}) = 0.869 g
Soil Site Class = E

DESIGNED	M.D.C.
CHECKED	S.M.S.
DRAWN	D.A.B.
CHECKED	M.G.B.

HIGHWAY CLASSIFICATION

FAS Route 2869 - IL 37
Functional Class: Major Collector (non-urban)
ADT: 3700 (2007) / 4850 (2025)
ADTT: 222 (6%)
Design Speed: 55 m.p.h.
Posted Speed: 55 m.p.h.
Directional Distribution: 50% / 50%

DESIGN SCOUR ELEVATION TABLE

Design Scour	N. Abut.	Pier	S. Abut.
Elevation (ft.)	408.6	394.9	408.6

WATERWAY INFORMATION

Drainage Area = 22.27 Sq. Mi. Proposed Low Grade Elev. 414.8 @ Sta. 436+50

Flood	Freq. Yr.	Q C.F.S.	Opening Sq. Ft. Exist.	Opening Sq. Ft. Prop.	Natural H.W.E.	Head - Ft. Exist.	Head - Ft. Prop.	Headwater El. Exist.	Headwater El. Prop.
	10	3350	1030	1080	412.0	0.25	0.23	412.25	412.23
Design	50	5320	1050	1110	413.9	0.63	0.56	414.53	414.46
Base	100	6190	1050	1110	414.6	0.54	0.52	415.14	415.12

HAMPTON, LENZINI AND RENWICK, INC.
CIVIL ENGINEERS - STRUCTURAL ENGINEERS - LAND SURVEYORS
3085 STEVENSON DRIVE, SUITE 201
SPRINGFIELD, ILLINOIS 62703
217.546.3400 www.hlrengineering.com
184.000959
ILLINOIS PROFESSIONAL DESIGN FIRM LS / PE / SE CORPORATION

PROJECT NUMBER: 09.0130.120 DATE: 02/10/10

FAS	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
2869	2B-2	JEFFERSON		

CONTRACT NO. 78149

FED. ROAD DIST. NO. | ILLINOIS | FED. AID PROJECT

EXHIBIT C

BORING LOGS

Illinois Department of Transportation

Memorandum

To:	Carrie Nelsen	Attn: Dave Piche
From:	Greg Smothers GSS	By: Rob Graeff
Subject:	*Boring Logs & Liquefaction Analysis	
Date:	March 10, 2009	

FAS 2869 (IL 37) over Atchison Creek
Structure 041-0036(E)
Jefferson County

Foundation boring logs have been obtained for the above listed structure and are attached.

Liquefaction Analysis
Liquefaction calculations indicate no liquefiable soils at this structure location.

Slope Stability
At the time of this report, a preliminary TSL is not available. Therefore, we are unable to provide any slope stability calculations for the proposed endslope configuration. This office should be contacted to complete the slope stability calculations when a proposed endslope configuration is determined.

Structure Geotechnical Report
Due to a current shortage of staffing, the District Nine Geotechnical Unit is unable to complete the required Structure Geotechnical Report. Any additional foundation recommendations should be evaluated by a competent consultant.

Miscellaneous
There was concrete pavement discovered in both borings at elevation 411.0.

Attachments
RG:rg

cc: Soils File

ILLINOIS DEPARTMENT OF TRANSPORTATION
District Nine Materials

Bridge Foundation Boring Log

FAS 69 (IL 37) Over Atchison Creek

Route: FAS 2869 (IL 37 | Structure Number: 041-0036 | Date: 2/24/2009

Section 2,BY | Bored By: R Moberly

County: Jefferson | Location: 8 miles South of IL 148 | Checked By: Rob Graeff

Boring No 1-S
Station 428+65
Offset 6' Lt CL
Ground Surface 415.0 Ft

Surf Wat Elev: 407.1
Ground Water Elevation
when Drilling 402.5
At Completion 401.1
At: Hrs:

		DEPTH	BLOWS	Qu tsf	W%
Asphalt over Concrete Pvmt	414.0				
Stiff, moist, grey, Silty Clay Loam A-4			2		
			4	1.4B	17
	411.5		4		
Concrete Pavement	411.0				
Stiff, moist, grey, Silt Loam A-4		5.0	1		
			3	1.4S	19
	408.0		4		
Medium, very moist, grey, Silt Loam A-4			1		
			2	0.8S	22
	405.5		3		
Very soft, wet, grey, Silt Loam A-4		10.0	WH		
			WH	0.1B	25
			WH		
			WH		
			WH	0.2B	28
	400.5		WH		
Soft, very moist, grey mottled brown, Silty Clay A-6		15.0	WH		
			WH	0.3B	28
	398.0		WH		
Medium, very moist, grey mottled brown, Silty Clay A-6			1		
			3	0.9B	25
	395.5		6		
Stiff, moist , brown mottled grey, Silty Clay Loam A-6		20.0	1		
			3	1.2B	26
			4		
			1		
			2	1.4B	26
	390.5		2		
		25.0	WH		

		DEPTH	BLOWS	Qu tsf	W%
Medium to soft, very moist, grey, Clay to Silty Clay A7-6			WH	0.5B	21
	388.0		1		
Stiff, moist, brown and grey, Sandy Clay Loam A-4			1		
			5	1.2S	17
	385.5		3		
Hard, damp, grey, Clay Loam A-6		30.0	3		
			10	5.0S	14
			15		
			4		
	382.0		22		
Hard, damp, grey, Clay Shale			78		
		35.0	100/11"		
Hard, damp, grey, Clay Shale		40.0	100/5"		
	370.0	45.0	100/4"		
Bottom of hole = 44.8 feet					
Free water observed at 12.5 feet					
Elevation referenced to BM @ SE wingwall; Elev. = 415.3 feet					
To convert "N" values to "N60" values multiply by 1.25		50.0			

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail. B-Bulge S-Shear E-Estimated P-Penetrometer)

ILLINOIS DEPARTMENT OF TRANSPORTATION
District Nine Materials

Bridge Foundation Boring Log
Sheet 1 of 1

FA 869 (IL 37) Over Atchison Creek

Route: FAS 2869 (IL 37 **Structure Number:** 041-0036 **Date:** 2/25/2009
Section 2,BY **Bored By:** R Moberly
County: Jefferson **Location:** 8 miles South of IL 148 **Checked By:** Rob Graeff

Boring No 2-S
Station 430+37
Offset 7' Rt CL
Ground Surface 414.9 Ft

Surf Wat Elev: 407.1
Ground Water Elevation
when Drilling 382.9
At Completion 399.7
At: Hrs:

Description	Elev.	DEPTH	BLOWS	Qu tsf	W%
Asphalt over Concrete Pavement	413.9				
Stiff, moist, brown, Silt Loam to Silty Clay Loam A-4			1		
			2	1.1S	19
	411.4		2		
Concrete Pavement	410.9				
Stiff, moist, grey, Silty Clay Loam A-4		5.0	1		
			3	1.2B	22
	407.9		4		
Medium, very moist, grey, Silt Loam A-4			1		
			1	0.8S	23
	405.4		2		
Medium, very moist, grey, Silty Clay Loam A-4		10.0	1		
			2	0.8B	24
	402.9		2		
Soft, very moist, grey, Silty Clay Loam A-4 with organics			WH		
			WH	0.4B	27
	400.4		1		
Very soft, very moist, grey, Silty Clay Loam A-4		15.0	WR		
			WH	0.2B	32
	397.9		WH		
Medium to soft, very moist, grey, Silty Clay Loam A-4			WH		
			WH	0.5B	22
	395.4		WH		
Medium, very moist, brown, Silty Clay Loam A-6		20.0	1		
			2	0.6B	30
	392.9		3		
Stiff, moist to very moist, brown mottled grey, Silt Loam A-4			1		
			3	1.1B	24
	390.4		4		
		25.0	1		

Description	Elev.	DEPTH	BLOWS	Qu tsf	W%
Soft, very moist, brown mottled grey, Silty Clay Loam to Clay Loam A-6			1	0.4S	20
			2		
	387.9				
Medium, very moist, grey, Clay to Silty Clay A7-6			WH		
			WH	0.9B	27
			WH		
		30.0	WH		
			WH	0.6B	35
	382.9		WH		
Medium, very moist, grey, Sand Loam to Sandy Clay Loam A-4			1		
			3	0.7S	22
	380.4		4		
Very loose, wet, grey, Fine Sand to Sand Loam A-2-4 (insufficient recovery to sample)		35.0	WH		
			WH		
	377.9		WH		
Hard, damp, grey, Weathered Clay Shale			5		
			22		
	376.4		42		
Hard, dry, grey, Clay Shale		40.0	100/3		
	369.9	45.0	100/4"		
		50.0			

Bottom of hole = 44.8 feet

Free water observed at 32.0 feet

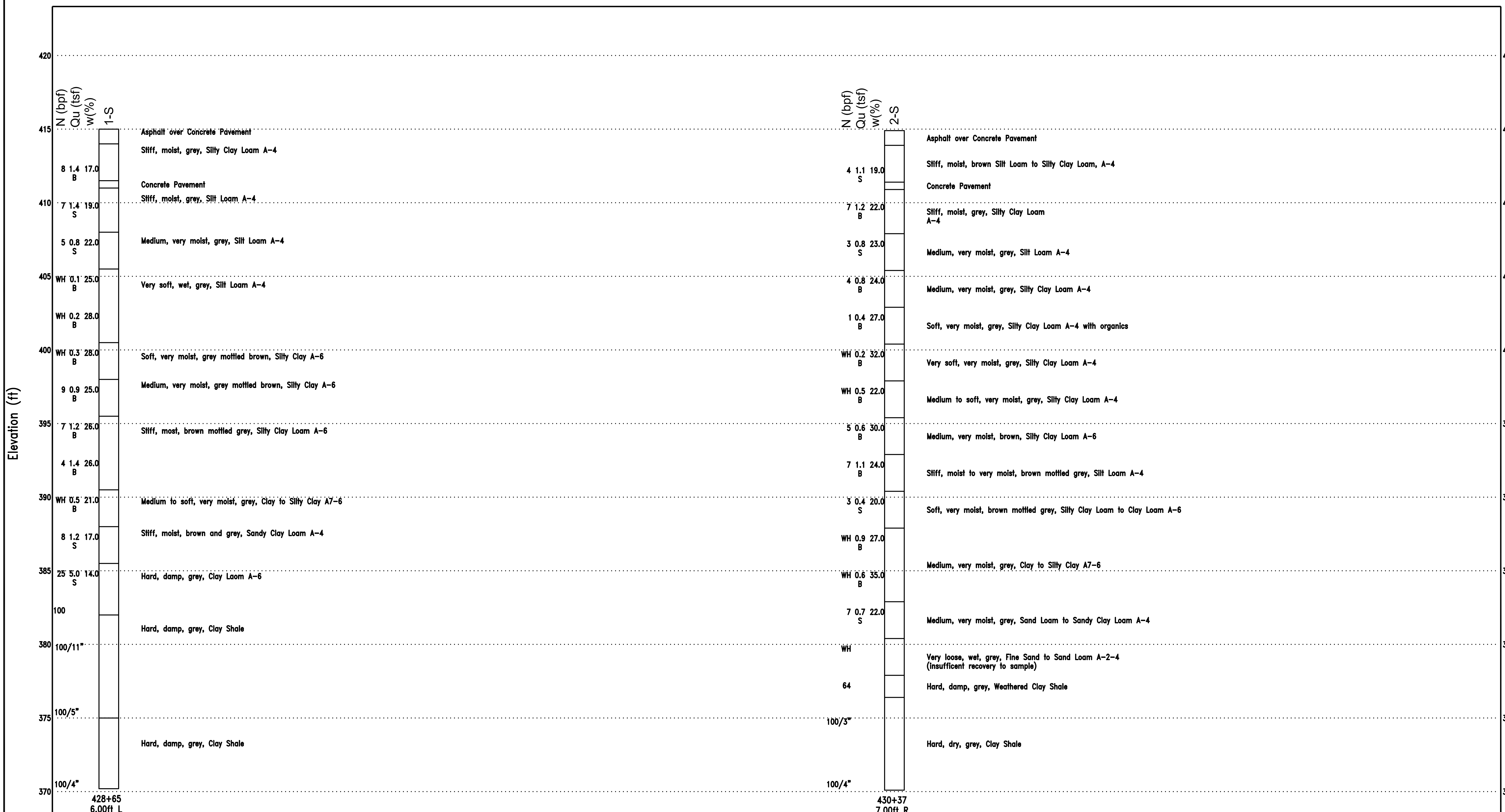
Elevation referenced to BM @ SE wingwall; Elev. = 415.3 feet

To convert "N" values to "N60" values multiply by 1.25

N-Std Pentr Test: 2" OD Sampler,140# Hammer, 30" Fall (Type Fail. B-Bulge S-Shear E-Estimated P-Penetrometer)

EXHIBIT D

SOIL PROFILE



Illinois Department of Transportation
Division of Highways

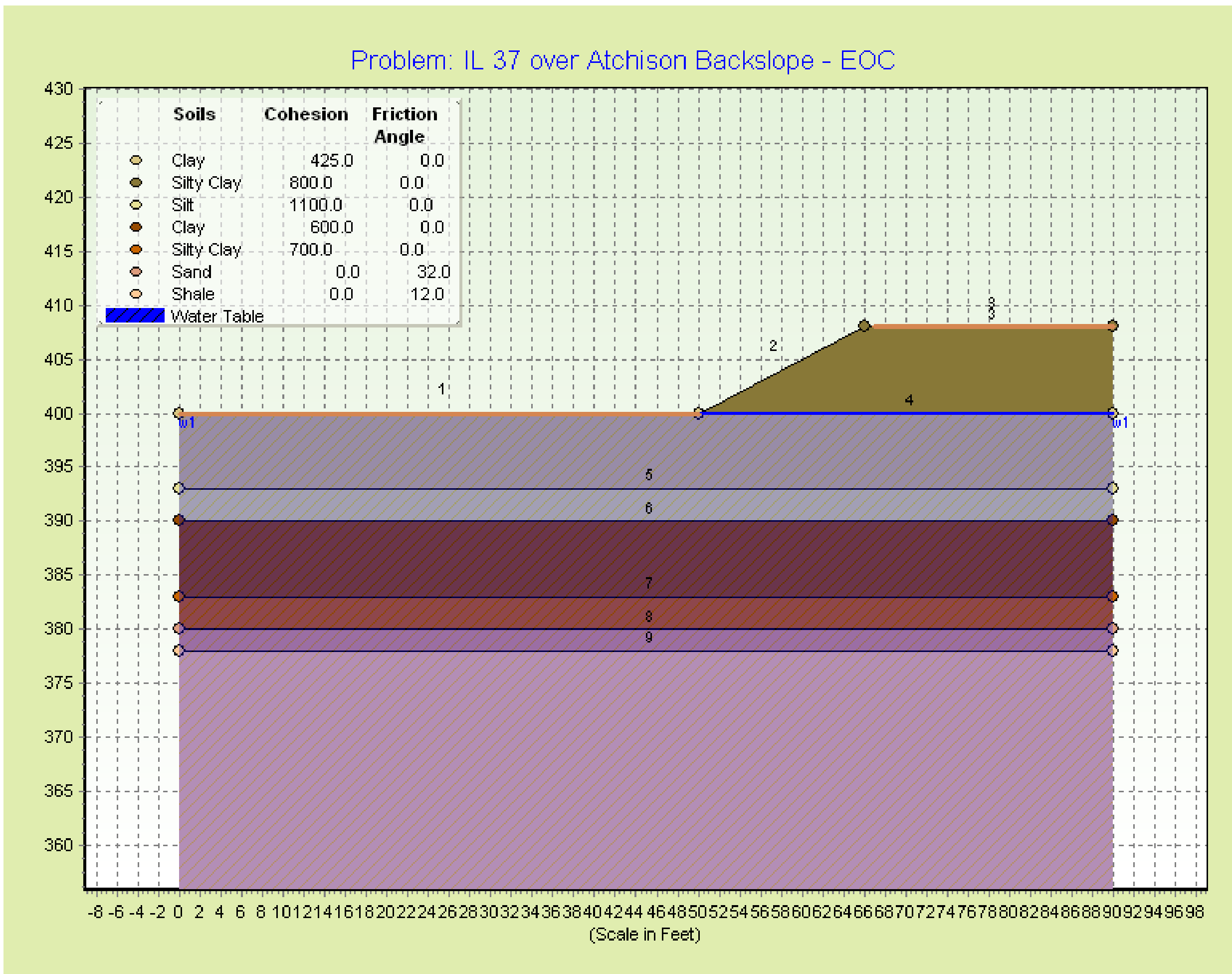
SUBSURFACE PROFILE

Route: FAS 2869 (IL 37) Over Atchison Creek
Section: 2, BY
County: Jefferson

EXHIBIT E

SLOPE STABILITY ANALYSIS

================== DATA SUMMARY ====================



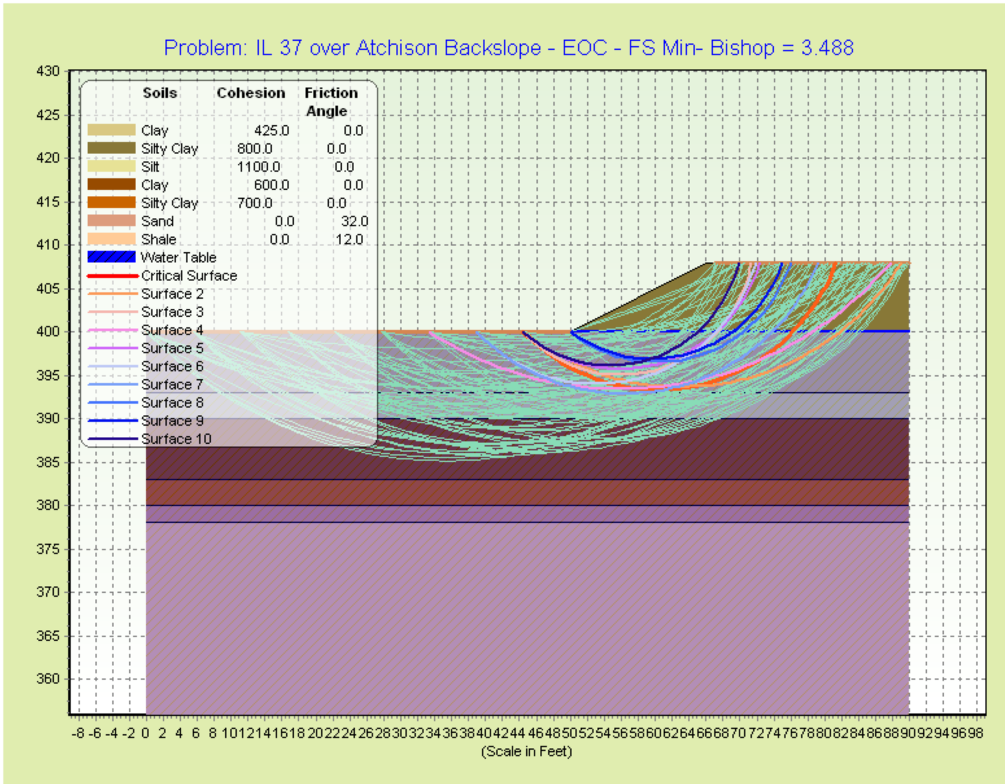
Profile Data

Segment Number	Left Extreme X	Left Extreme Y	Right Extreme X	Right Extreme Y	Soil Under Segment
1	0	400	50	400	2
2	50	400	66	408	1
3	66	408	90	408	1
4	50	400	90	400	2
5	0	393	90	393	3
6	0	390	90	390	4
7	0	383	90	383	5
8	0	380	90	380	6
9	0	378	90	378	7

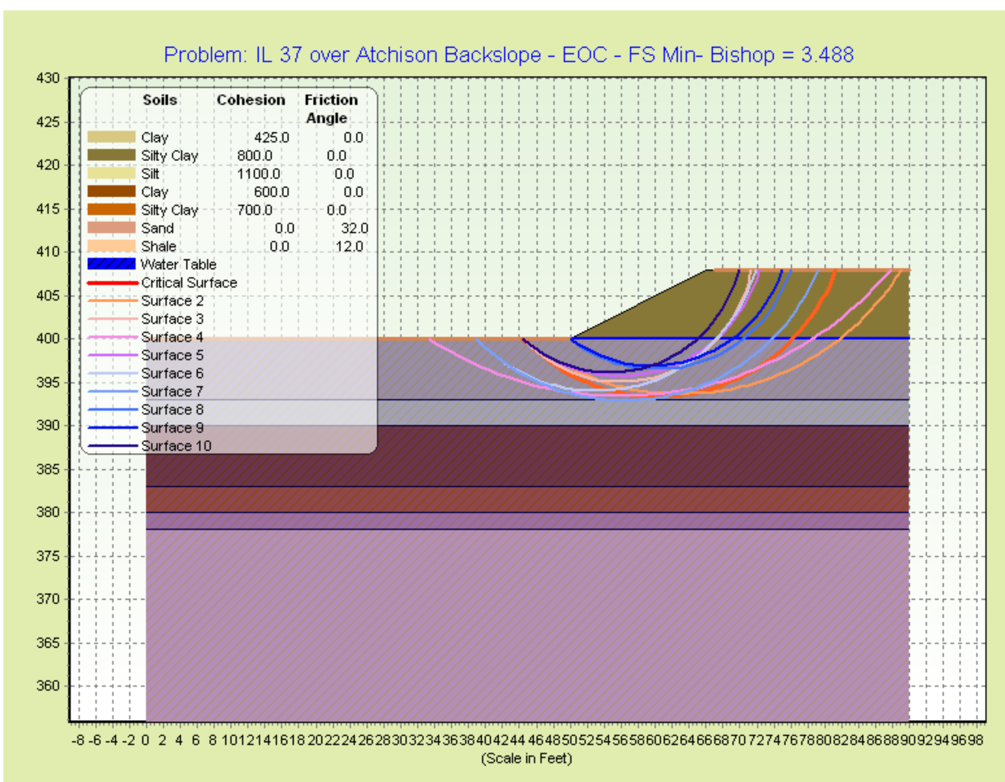
Soil Properties

Soil Number	Wet Unit Weight	Saturated Unit Weight	Cohesive Intercept	Friction Angle	Ru	Pressure Head	Water Table	Soil Name
1	110	0	800	0	0	0	0	Silty Clay
2	0	95	425	0	0	0	1	Clay
3	0	105	1100	0	0	0	1	Silt
4	0	105	600	0	0	0	1	Clay
5	0	115	700	0	0	0	1	Silty Clay
6	0	110	0	32	0	0	1	Sand
7	0	125	0	12	0	0	1	Shale

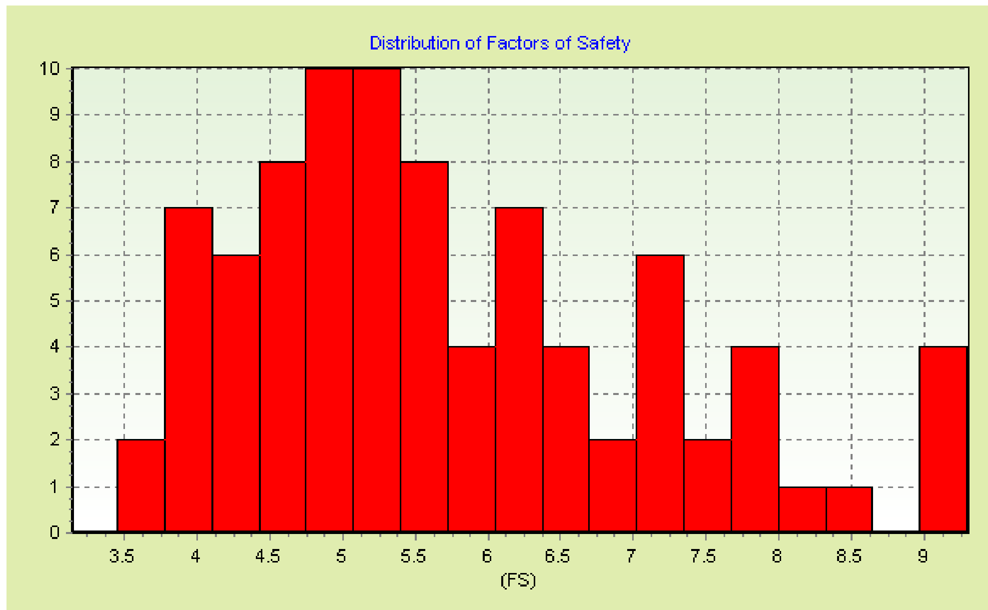
=============== All Surfaces Generated =============



=============== 10 Most Critical Surfaces ===============



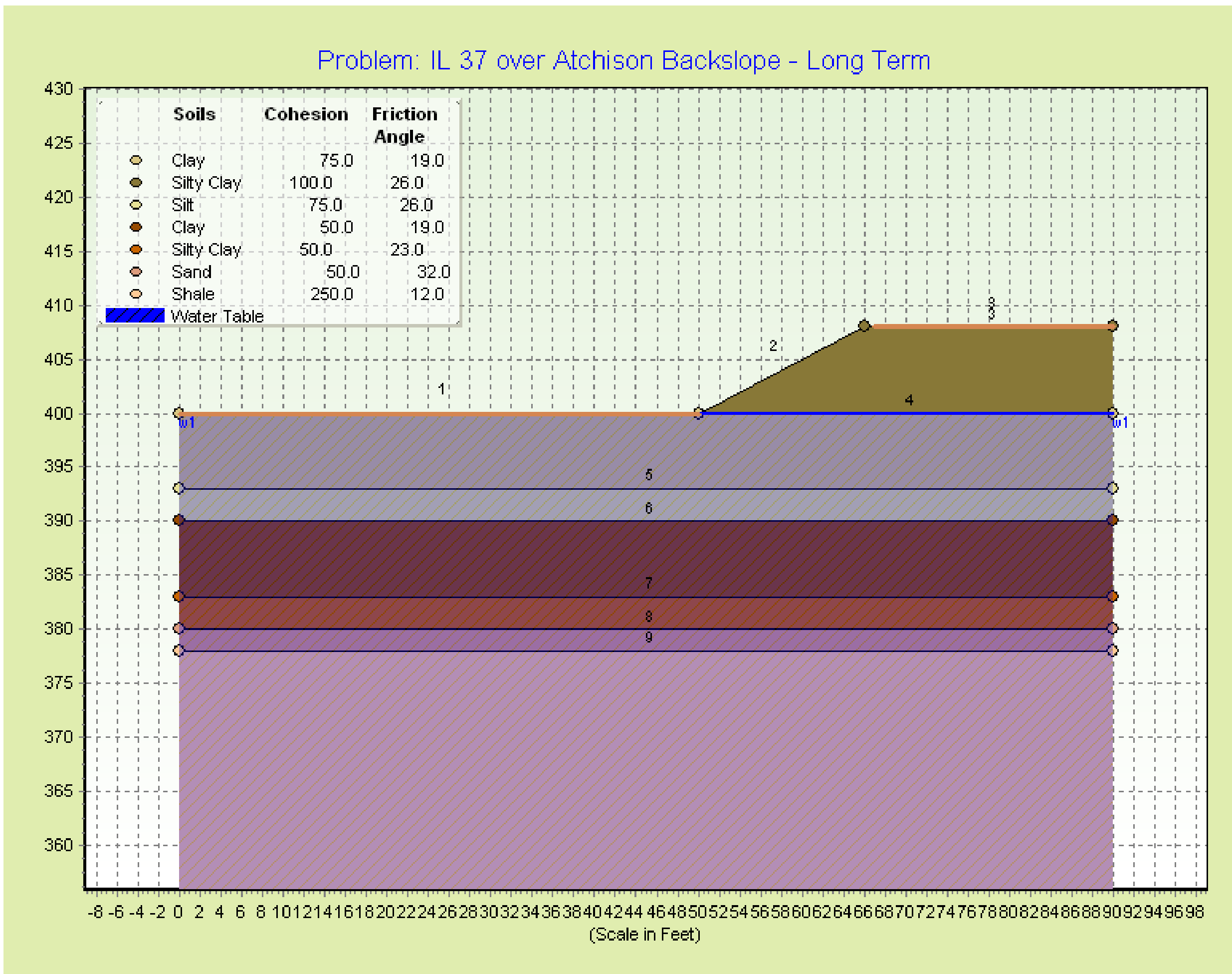
============= Factor of Safety Histogram ============



======== Factors of Safety of 10 Most Critical Surfaces =======

Surface Number	Factor of Safety
1	3.488
2	3.785
3	3.819
4	3.848
5	3.862
6	3.865
7	3.873
8	4.045
9	4.093
10	4.17

================== DATA SUMMARY ====================



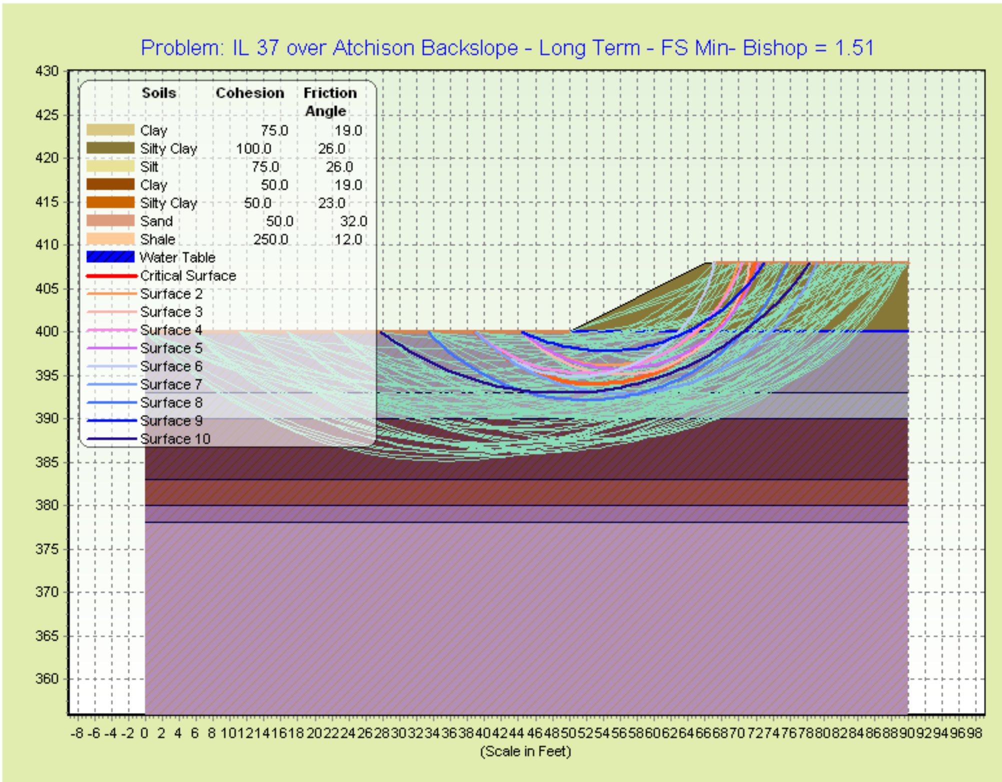
Profile Data

Segment Number	Left Extreme X	Left Extreme Y	Right Extreme X	Right Extreme Y	Soil Under Segment
1	0	400	50	400	2
2	50	400	66	408	1
3	66	408	90	408	1
4	50	400	90	400	2
5	0	393	90	393	3
6	0	390	90	390	4
7	0	383	90	383	5
8	0	380	90	380	6
9	0	378	90	378	7

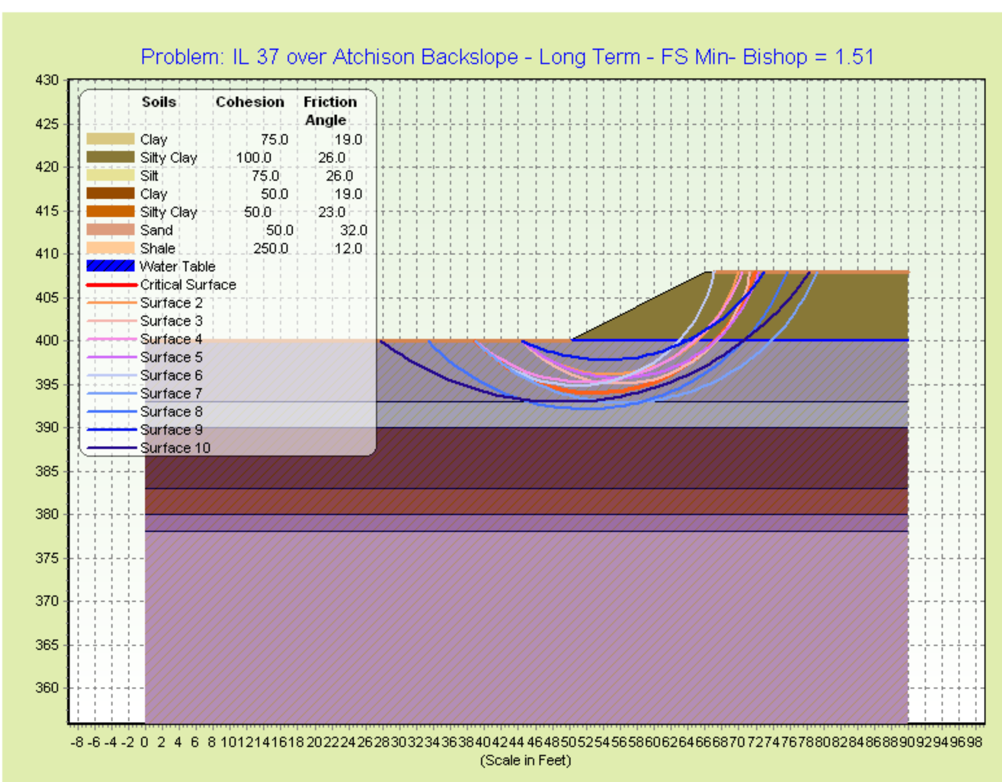
Soil Properties

Soil Number	Wet Unit Weight	Saturated Unit Weight	Cohesive Intercept	Friction Angle	Ru	Pressure Head	Water Table	Soil Name
1	125	0	100	26	0	0	0	Silty Clay
2	0	95	75	19	0	0	1	Clay
3	0	105	75	26	0	0	1	Silt
4	0	105	50	19	0	0	1	Clay
5	0	115	50	23	0	0	1	Silty Clay
6	0	110	50	32	0	0	1	Sand
7	0	125	250	12	0	0	1	Shale

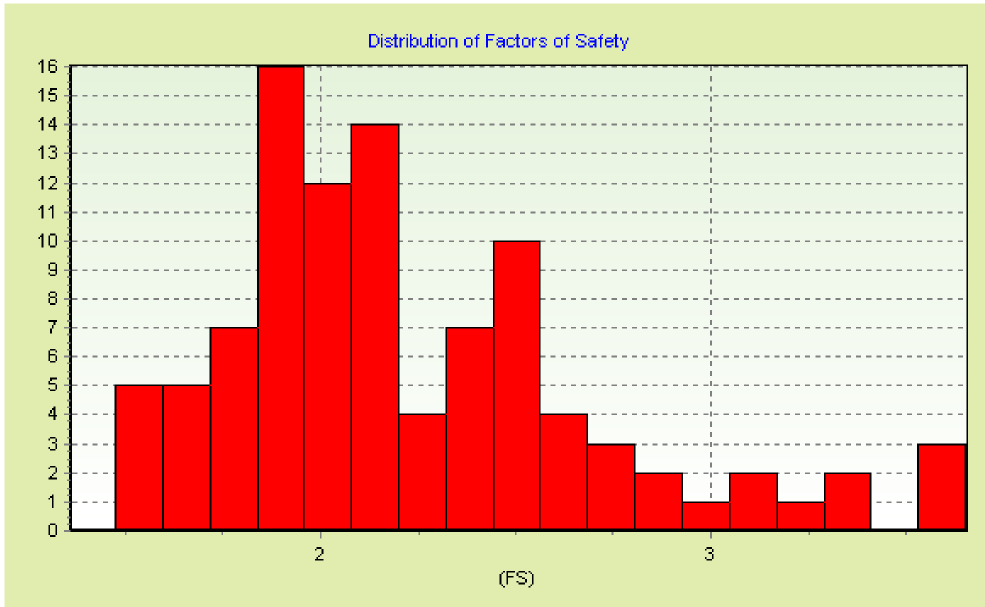
=============== All Surfaces Generated =============



=============== 10 Most Critical Surfaces ===============



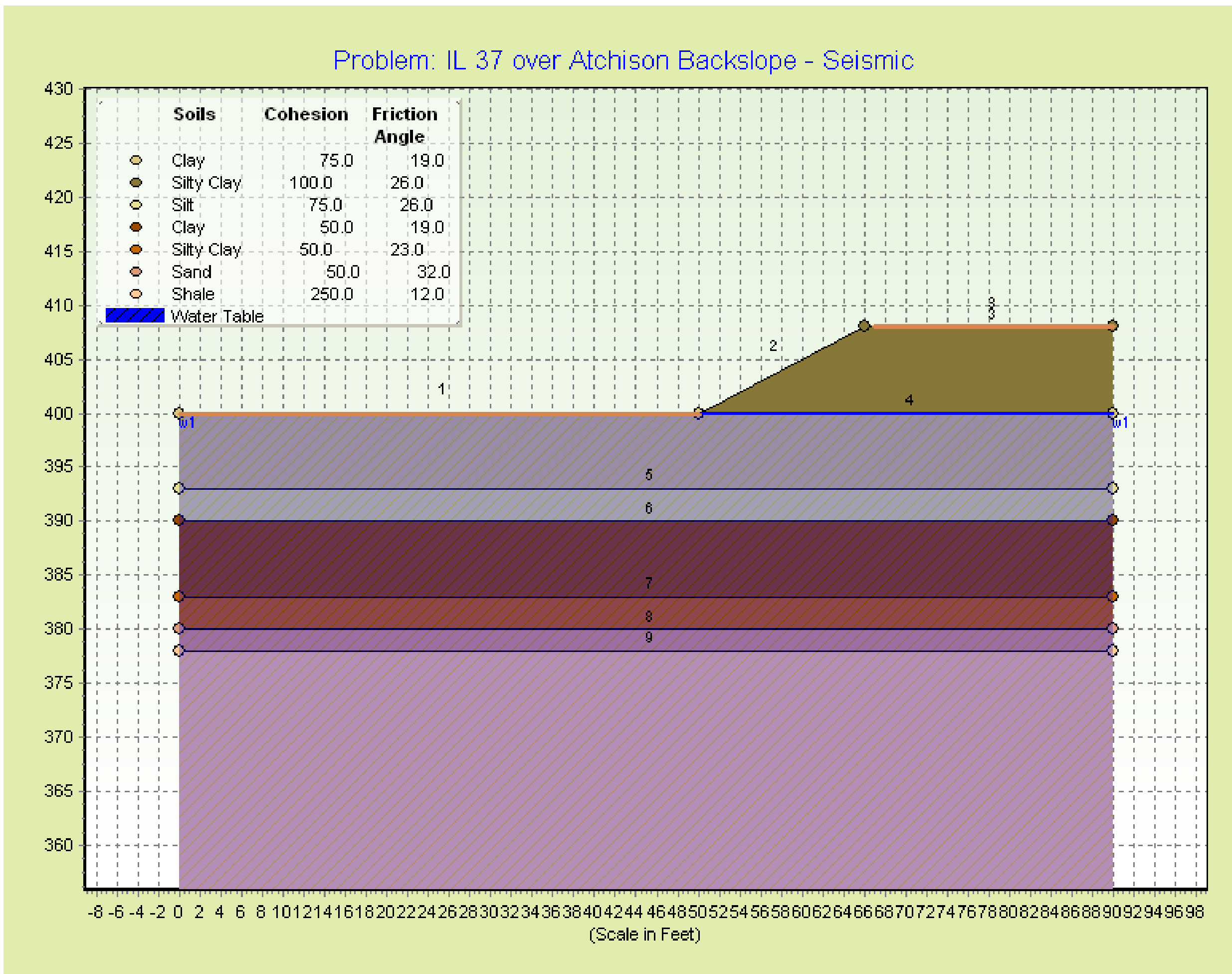
============= Factor of Safety Histogram ============



======== Factors of Safety of 10 Most Critical Surfaces =======

Surface Number	Factor of Safety
1	1.51
2	1.519
3	1.53
4	1.537
5	1.54
6	1.61
7	1.673
8	1.682
9	1.7
10	1.717

================== DATA SUMMARY =====================



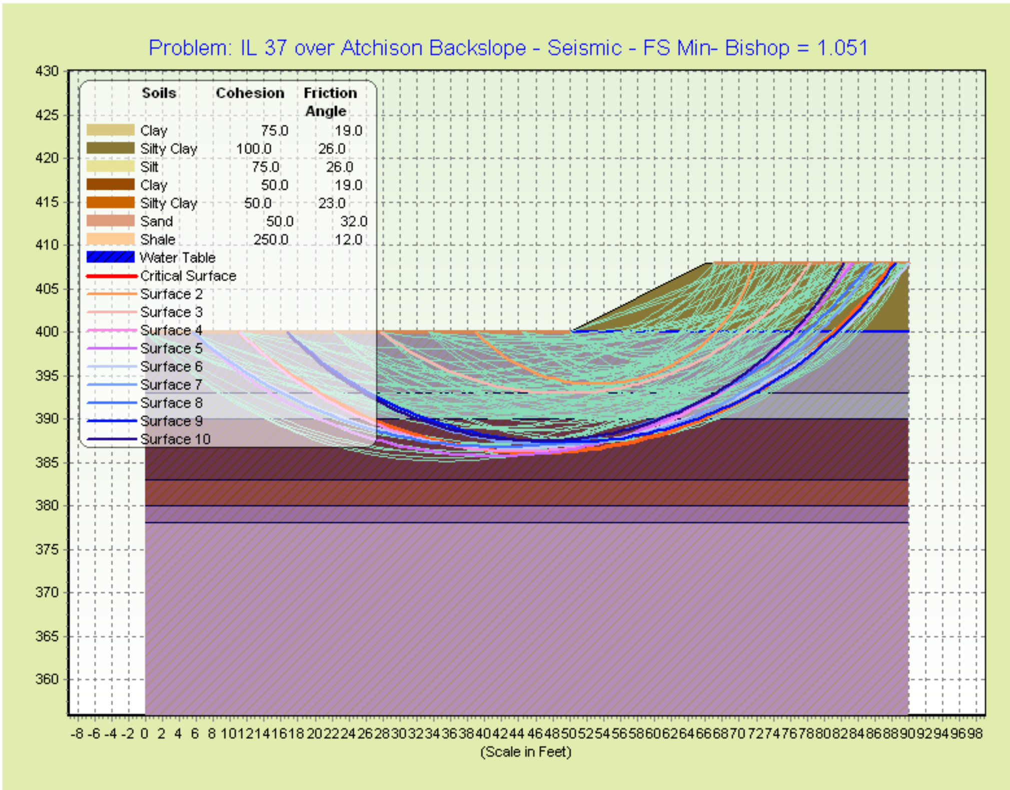
Profile Data

Segment Number	Left Extreme X	Left Extreme Y	Right Extreme X	Right Extreme Y	Soil Under Segment
1	0	400	50	400	2
2	50	400	66	408	1
3	66	408	90	408	1
4	50	400	90	400	2
5	0	393	90	393	3
6	0	390	90	390	4
7	0	383	90	383	5
8	0	380	90	380	6
9	0	378	90	378	7

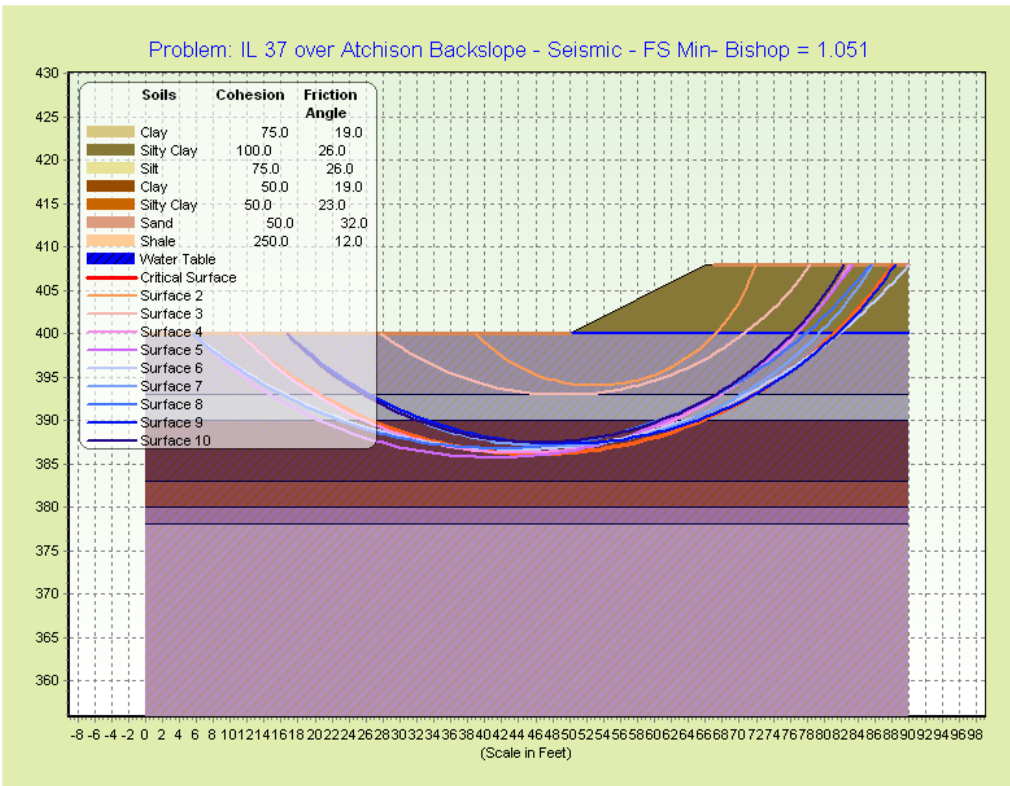
Soil Properties

Soil Number	Wet Unit Weight	Saturated Unit Weight	Cohesive Intercept	Friction Angle	Ru	Pressure Head	Water Table	Soil Name
1	125	0	100	26	0	0	0	Silty Clay
2	0	95	75	19	0	0	1	Clay
3	0	105	75	26	0	0	1	Silt
4	0	105	50	19	0	0	1	Clay
5	0	115	50	23	0	0	1	Silty Clay
6	0	110	50	32	0	0	1	Sand
7	0	125	250	12	0	0	1	Shale

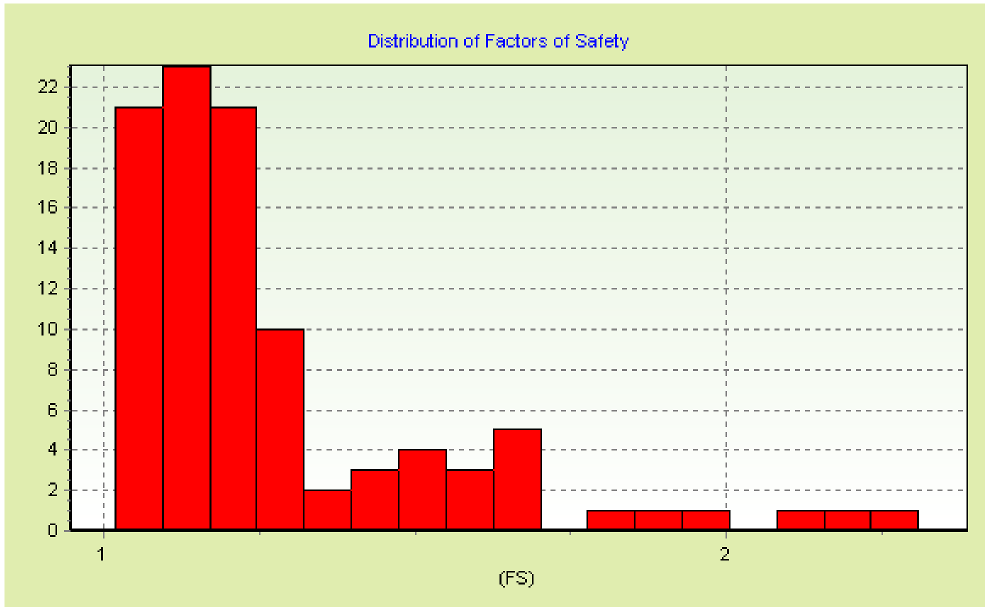
=============== All Surfaces Generated =============



=============== 10 Most Critical Surfaces ===============



============= Factor of Safety Histogram ============



======== Factors of Safety of 10 Most Critical Surfaces =======

Surface Number	Factor of Safety
1	1.051
2	1.052
3	1.058
4	1.06
5	1.061
6	1.061
7	1.061
8	1.064
9	1.065
10	1.069

EXHIBIT F

LIQUEFACTION ANALYSIS

LIQUEFACTION ANALYSIS

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

Modified 5/24/10

REFERENCE BORING NUMBER ==================================== 1-S North Abut
ELEVATION OF BORING GROUND SURFACE ========================= 415.00 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ====================== 14.00 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ================== 14.00 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.195
EARTHQUAKE MOMENT MAGNITUDE =============================== 4.8
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ============== 0.00 FT.
HAMMER EFFICIENCY== 73 %
BOREHOLE DIAMETER== 6 IN.
SAMPLING METHOD== Sampler w/out Liners

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

AVG. SHEAR WAVE VELOCITY (top 40')
$V^{*}_{s,40'}$ = **369** FT./SEC.

PGA CALCULATOR
Earthquake Moment Magnitude = 4.8
Source-To-Site Distance, R (km) = 11.1
Ground Motion Prediction Equations = CEUS
PGA = **0.195**

IF(P22="","",IF(B22>=(K$7+K$12-K$9),"N.L. (1)",IF(OR(G22>=12,AND(H22>0,I22>(

ELEV. OF SAMPLE (FT.)	BORING DATA: 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 (%)	CONDITIONS DURING DRILLING: 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 $CRR_{7.5}$	CONDITIONS DURING EARTHQUAKE: 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
411.5	3.5	8	1.4	85	0	0	17	0.125	0.438	13.491	21.189	0.231	0.125	0.438	0.438	1.500	**0.935**	0.932	**0.118**	**N.L. (1)**
409	6	7	1.4	75	0	0	19	0.125	0.750	10.446	17.535	0.187	0.125	0.750	0.750	1.336	**0.673**	0.876	**0.111**	**N.L. (1)**
406.5	8.5	5	0.8	75	0	0	22	0.119	1.048	7.126	13.551	0.146	0.119	1.048	1.048	1.196	**0.471**	0.816	**0.103**	**N.L. (1)**
404	11	1	0.1	75	0	0	25	0.098	1.293	1.426	6.711	0.085	0.098	1.293	1.293	1.110	**0.256**	0.754	**0.096**	**N.L. (1)**
401.5	13.5	1	0.2	75	0	0	28	0.104	1.553	1.399	6.679	0.085	0.104	1.553	1.553	1.068	**0.245**	0.691	**0.088**	**N.L. (1)**
399	16	1	0.3	80	0	0	28	0.046	1.668	1.406	6.688	0.085	0.046	1.668	1.792	1.052	**0.242**	0.630	**0.086**	**2.814 (C)**
396.5	18.5	9	0.9	80	0	0	25	0.058	1.813	12.523	20.027	0.216	0.058	1.813	2.093	1.047	**0.610**	0.572	**0.084**	**7.262 (D)**
394	21	7	1.2	85	0	0	26	0.061	1.965	9.565	16.478	0.175	0.061	1.965	2.402	1.021	**0.483**	0.519	**0.080**	**6.038 (C)**
391.5	23.5	4	1.4	85	0	0	26	0.063	2.123	5.342	11.411	0.126	0.063	2.123	2.715	1.000	**0.340**	0.472	**0.077**	**4.416 (C)**
389	26	1	0.5	85	0	0	21	0.051	2.250	1.311	6.573	0.084	0.051	2.250	2.999	0.988	**0.225**	0.431	**0.073**	**3.082 (C)**
386.5	28.5	8	1.2	40	0	0	17	0.061	2.403	10.225	17.271	0.184	0.061	2.403	3.307	0.966	**0.479**	0.396	**0.069**	**6.942 (C)**
384	31	25	5	65	0	0	14	0.079	2.600	34.428	46.313	0.257	0.079	2.600	3.661	0.922	**0.640**	0.368	**0.066**	**N.L. (3)**
381.5	33.5	100	5	10	0	0		0.079	2.798	######	145.015	1.060	0.079	2.798	4.014	0.895	**2.563**	0.344	**0.063**	**N.L. (3)**
379	36	100	5	10	0	0		0.079	2.995	######	140.350	1.025	0.079	2.995	4.368	0.871	**2.412**	0.325	**0.060**	**N.L. (3)**
374	41	100	5	10	0	0		0.079	3.390	######	131.866	0.962	0.079	3.390	5.075	0.829	**2.153**	0.297	**0.056**	**N.L. (3)**
369	46	100	5	10	0	0		0.079	3.785	######	124.364	0.905	0.079	3.785	5.782	0.793	**1.939**	0.280	**0.054**	**N.L. (3)**

* FACTOR OF SAFETY DESCRIPTIONS

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

L I Q U E F A C T I O N   A N A L Y S I S

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

Modified 5/24/10

REFERENCE BORING NUMBER ==================================== 1-S North Abut
ELEVATION OF BORING GROUND SURFACE ========================= 415.00 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ====================== 14.00 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ================== 14.00 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.153
EARTHQUAKE MOMENT MAGNITUDE =============================== 7.7
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ============== 0.00 FT.
HAMMER EFFICIENCY== 73 %
BOREHOLE DIAMETER== 6 IN.
SAMPLING METHOD== Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = **0.948**

AVG. SHEAR WAVE VELOCITY (top 40')
$V^{*}_{s,40'}$ = **369** FT./SEC.

PGA CALCULATOR
Earthquake Moment Magnitude = 7.7
Source-To-Site Distance, R (km) = 117.1
Ground Motion Prediction Equations = NMSZ
PGA = **0.153**

IF(P22="","",IF(B22>=(K$7+K$12-K$9),"N.L. (1)",IF(OR(G22>=12,AND(H22>0,I22>(

	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
411.5	3.5	8	1.4	85	0	0	17	0.125	0.438	13.491	21.189	0.231	0.125	0.438	0.438	1.500	**0.328**	0.950	**0.094**	**N.L. (1)**
409	6	7	1.4	75	0	0	19	0.125	0.750	10.446	17.535	0.187	0.125	0.750	0.750	1.336	**0.236**	0.910	**0.090**	**N.L. (1)**
406.5	8.5	5	0.8	75	0	0	22	0.119	1.048	7.126	13.551	0.146	0.119	1.048	1.048	1.196	**0.165**	0.866	**0.086**	**N.L. (1)**
404	11	1	0.1	75	0	0	25	0.098	1.293	1.426	6.711	0.085	0.098	1.293	1.293	1.110	**0.090**	0.821	**0.082**	**N.L. (1)**
401.5	13.5	1	0.2	75	0	0	28	0.104	1.553	1.399	6.679	0.085	0.104	1.553	1.553	1.068	**0.086**	0.775	**0.077**	**N.L. (1)**
399	16	1	0.3	80	0	0	28	0.046	1.668	1.406	6.688	0.085	0.046	1.668	1.792	1.052	**0.085**	0.731	**0.078**	**1.090 (C)**
396.5	18.5	9	0.9	80	0	0	25	0.058	1.813	12.523	20.027	0.216	0.058	1.813	2.093	1.047	**0.214**	0.689	**0.079**	**2.709 (D)**
394	21	7	1.2	85	0	0	26	0.061	1.965	9.565	16.478	0.175	0.061	1.965	2.402	1.021	**0.170**	0.650	**0.079**	**2.152 (C)**
391.5	23.5	4	1.4	85	0	0	26	0.063	2.123	5.342	11.411	0.126	0.063	2.123	2.715	1.000	**0.119**	0.616	**0.078**	**1.526 (C)**
389	26	1	0.5	85	0	0	21	0.051	2.250	1.311	6.573	0.084	0.051	2.250	2.999	0.988	**0.079**	0.586	**0.078**	**1.013 (C)**
386.5	28.5	8	1.2	40	0	0	17	0.061	2.403	10.225	17.271	0.184	0.061	2.403	3.307	0.966	**0.168**	0.561	**0.077**	**2.182 (C)**
384	31	25	5	65	0	0	14	0.079	2.600	34.428	46.313	0.257	0.079	2.600	3.661	0.922	**0.225**	0.540	**0.076**	**N.L. (3)**
381.5	33.5	100	5	10	0	0		0.079	2.798	######	145.015	1.060	0.079	2.798	4.014	0.895	**0.900**	0.523	**0.075**	**N.L. (3)**
379	36	100	5	10	0	0		0.079	2.995	######	140.350	1.025	0.079	2.995	4.368	0.871	**0.847**	0.509	**0.074**	**N.L. (3)**
374	41	100	5	10	0	0		0.079	3.390	######	131.866	0.962	0.079	3.390	5.075	0.829	**0.756**	0.489	**0.073**	**N.L. (3)**
369	46	100	5	10	0	0		0.079	3.785	######	124.364	0.905	0.079	3.785	5.782	0.793	**0.681**	0.476	**0.072**	**N.L. (3)**

* FACTOR OF SAFETY DESCRIPTIONS

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

L I Q U E F A C T I O N   A N A L Y S I S

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

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

AVG. SHEAR WAVE VELOCITY (top 40')
$V^{*}_{s,40'}$ = **270** FT./SEC.

REFERENCE BORING NUMBER ==================================== 2-S South Abut.
ELEVATION OF BORING GROUND SURFACE ========================= 414.90 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ====================== 32.00 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ================== 32.00 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.195
EARTHQUAKE MOMENT MAGNITUDE =============================== 4.8
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ============== 0.00 FT.
HAMMER EFFICIENCY== 73 %
BOREHOLE DIAMETER== 6 IN.
SAMPLING METHOD=== Sampler w/out Liners

PGA CALCULATOR
Earthquake Moment Magnitude = 4.8
Source-To-Site Distance, R (km) = 11.1
Ground Motion Prediction Equations = CEUS
PGA = **0.195**

IF(P22="","",IF(B22>=(K$7+K$12-K$9),"N.L. (1)",IF(OR(G22>=12,AND(H22>0,I22>(

ELEV. OF SAMPLE (FT.)	BORING DATA: 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 (%)	CONDITIONS DURING DRILLING: 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 $CRR_{7.5}$	CONDITIONS DURING EARTHQUAKE: 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
411.4	3.5	4	1.1	60			19	0.123	0.431	6.610	12.932	0.140	0.123	0.431	0.431	1.489	**0.563**	0.876	**0.111**	**N.L. (1)**
408.9	6	7	1.2	65			22	0.124	0.741	10.476	17.571	0.187	0.124	0.741	0.741	1.341	**0.677**	0.786	**0.100**	**N.L. (1)**
406.4	8.5	3	0.8	60			23	0.119	1.038	4.287	10.144	0.114	0.119	1.038	1.038	1.181	**0.365**	0.699	**0.089**	**N.L. (1)**
403.9	11	4	0.8	65			24	0.119	1.336	5.640	11.768	0.129	0.119	1.336	1.336	1.119	**0.390**	0.617	**0.078**	**N.L. (1)**
401.4	13.5	1	0.4	65			27	0.111	1.613	1.379	6.654	0.085	0.111	1.613	1.613	1.059	**0.243**	0.542	**0.069**	**N.L. (1)**
398.9	16	1	0.2	65	0	0	32	0.104	1.873	1.341	6.609	0.085	0.104	1.873	1.873	1.026	**0.234**	0.476	**0.060**	**N.L. (1)**
396.4	18.5	1	0.5	65	0	0	22	0.114	2.158	1.289	6.547	0.084	0.114	2.158	2.158	0.996	**0.226**	0.418	**0.053**	**N.L. (1)**
393.9	21	5	0.6	65	0	0	30	0.116	2.448	6.171	12.405	0.135	0.116	2.448	2.448	0.965	**0.352**	0.370	**0.047**	**N.L. (1)**
391.4	23.5	7	1.1	60	0	0	24	0.123	2.756	8.233	14.879	0.159	0.123	2.756	2.756	0.934	**0.401**	0.330	**0.042**	**N.L. (1)**
388.9	26	3	0.4	80	0	0	20	0.111	3.033	3.380	9.057	0.105	0.111	3.033	3.033	0.922	**0.261**	0.297	**0.038**	**N.L. (1)**
386.4	28.5	1	0.9	80	0	0	27	0.120	3.333	1.076	6.291	0.082	0.120	3.333	3.333	0.910	**0.202**	0.270	**0.034**	**N.L. (1)**
383.9	31	1	0.6	80	0	0	35	0.116	3.623	1.030	6.236	0.082	0.116	3.623	3.623	0.895	**0.197**	0.248	**0.031**	**N.L. (1)**
381.4	33.5	7	0.7	25	0	0	22	0.055	3.761	7.081	12.184	0.133	0.055	3.761	3.854	0.869	**0.312**	0.231	**0.030**	**10.400 (C)**
378.9	36	1		10				0.043	3.868	0.998	1.889	0.052	0.043	3.868	4.118	0.887	**0.125**	0.218	**0.029**	**4.310 (C)**
376.4	38.5	64		5				0.078	4.063	73.485	73.485	0.514	0.078	4.063	4.469	0.771	**1.071**	0.208	**0.029**	**N.L. (3)**
373.9	41	100		5				0.083	4.271	######	111.656	0.809	0.083	4.271	4.832	0.756	**1.652**	0.199	**0.029**	**N.L. (3)**
368.9	46	100		5				0.083	4.686	######	105.824	0.765	0.083	4.686	5.559	0.728	**1.505**	0.188	**0.028**	**N.L. (3)**

* FACTOR OF SAFETY DESCRIPTIONS

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

L I Q U E F A C T I O N   A N A L Y S I S

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

Modified 5/24/10

REFERENCE BORING NUMBER ==================================== 2-S South Abut.
ELEVATION OF BORING GROUND SURFACE ========================= 414.90 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ====================== 32.00 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ================== 32.00 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.153
EARTHQUAKE MOMENT MAGNITUDE =============================== 7.7
FINISHED GRADE FILL OR CUT FROM BORING SURFACE ============== 0.00 FT.
HAMMER EFFICIENCY== 73 %
BOREHOLE DIAMETER== 6 IN.
SAMPLING METHOD== Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = **0.948**

AVG. SHEAR WAVE VELOCITY (top 40')
$V^{*}_{s,40'}$ = **270** FT./SEC.

PGA CALCULATOR
Earthquake Moment Magnitude = 7.7
Source-To-Site Distance, R (km) = 117.1
Ground Motion Prediction Equations = NMSZ
PGA = **0.153**

IF(P22="","",IF(B22>=(K$7+K$12-K$9),"N.L. (1)",IF(OR(G22>=12,AND(H22>0,I22>(

ELEV. OF SAMPLE (FT.)	BORING DATA: 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 (%)	CONDITIONS DURING DRILLING: 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 $CRR_{7.5}$	CONDITIONS DURING EARTHQUAKE: 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
411.4	3.5	4	1.1	60			19	0.123	0.431	6.610	12.932	0.140	0.123	0.431	0.431	1.489	**0.198**	0.912	**0.091**	**N.L. (1)**
408.9	6	7	1.2	65			22	0.124	0.741	10.476	17.571	0.187	0.124	0.741	0.741	1.341	**0.238**	0.848	**0.084**	**N.L. (1)**
406.4	8.5	3	0.8	60			23	0.119	1.038	4.287	10.144	0.114	0.119	1.038	1.038	1.181	**0.128**	0.786	**0.078**	**N.L. (1)**
403.9	11	4	0.8	65			24	0.119	1.336	5.640	11.768	0.129	0.119	1.336	1.336	1.119	**0.137**	0.728	**0.072**	**N.L. (1)**
401.4	13.5	1	0.4	65			27	0.111	1.613	1.379	6.654	0.085	0.111	1.613	1.613	1.059	**0.085**	0.675	**0.067**	**N.L. (1)**
398.9	16	1	0.2	65	0	0	32	0.104	1.873	1.341	6.609	0.085	0.104	1.873	1.873	1.026	**0.082**	0.628	**0.062**	**N.L. (1)**
396.4	18.5	1	0.5	65	0	0	22	0.114	2.158	1.289	6.547	0.084	0.114	2.158	2.158	0.996	**0.079**	0.588	**0.058**	**N.L. (1)**
393.9	21	5	0.6	65	0	0	30	0.116	2.448	6.171	12.405	0.135	0.116	2.448	2.448	0.965	**0.124**	0.553	**0.055**	**N.L. (1)**
391.4	23.5	7	1.1	60	0	0	24	0.123	2.756	8.233	14.879	0.159	0.123	2.756	2.756	0.934	**0.141**	0.525	**0.052**	**N.L. (1)**
388.9	26	3	0.4	80	0	0	20	0.111	3.033	3.380	9.057	0.105	0.111	3.033	3.033	0.922	**0.092**	0.501	**0.050**	**N.L. (1)**
386.4	28.5	1	0.9	80	0	0	27	0.120	3.333	1.076	6.291	0.082	0.120	3.333	3.333	0.910	**0.071**	0.482	**0.048**	**N.L. (1)**
383.9	31	1	0.6	80	0	0	35	0.116	3.623	1.030	6.236	0.082	0.116	3.623	3.623	0.895	**0.069**	0.467	**0.046**	**N.L. (1)**
381.4	33.5	7	0.7	25	0	0	22	0.055	3.761	7.081	12.184	0.133	0.055	3.761	3.854	0.869	**0.109**	0.455	**0.046**	**2.370 (C)**
378.9	36	1		10				0.043	3.868	0.998	1.889	0.052	0.043	3.868	4.118	0.887	**0.044**	0.446	**0.047**	**0.936 (C)**
376.4	38.5	64		5				0.078	4.063	73.485	73.485	0.514	0.078	4.063	4.469	0.771	**0.376**	0.438	**0.048**	**N.L. (3)**
373.9	41	100		5				0.083	4.271	######	111.656	0.809	0.083	4.271	4.832	0.756	**0.580**	0.432	**0.049**	**N.L. (3)**
368.9	46	100		5				0.083	4.686	######	105.824	0.765	0.083	4.686	5.559	0.728	**0.528**	0.424	**0.050**	**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 OR w_c/LL $\leq$ 0.85
N.L. (3) = NOT LIQUEFIABLE, $(N_1)_{60}$ > 25
(C) = CONTRACTIVE SOIL TYPES
(D) = DILATIVE SOIL TYPES

EXHIBIT G

MODIFIED IDOT PILE LENGTH CALCULATIONS AND OUTPUT

MODIFIED IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

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

Modified 11/2009

SUBSTRUCTURE================================= NABUT
REFERENCE BORING ============================= 1-S
GROUND SURFACE ELEV. AT BORING ============== 415.00 FT.
PILE CUTOFF ELEV. ============================ 410.60 FT.
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVI 405.60 FT.
GROUND WATER ELEVATION====================== 401.00 FT.
HAMMER EFFICIENCY============================ 73 %
LRFD or ASD or SEISMIC ========================= LRFD

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

Maximum Nominal Required Bearing	Maximum Factored Resistance Available	Maximum Pile Length Driveable
705 KIPS	**351** KIPS	**33** FT.

TOTAL FACTORED SUBSTRUCTURE LOAD ========== 984 KIPS
TOTAL WIDTH OF SUBSTRUCTURE ================= 39.17 FT.
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE === 1
Approx. Factored Loading Applied per pile at 8 ft. Cts ====== 200.97 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ====== 75.36 KIPS

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.

GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) == DD
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ========== 398.00 FT.
TOP ELEV. OF LIQUEF. (so layers above apply DD) ============ 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.)
404.00	1.60	0.10			1.3		3.9	1.9		***2.2***	2	1	2	-2	7
401.50	2.50	0.20			3.9	2.6	9.1	5.8	0.3	***8.2***	8	4	8	-7	9
399.00	2.50	0.30			5.8	4.0	22.8	8.5	0.5	***17.7***	18	9	16	-15	12
396.50	2.50	0.90			15.5	11.9	42.3	23.0	1.5	***41.2***	41	9	16	-2	14
394.00	2.50	1.20			19.5	15.8	***64.4***	28.9	2.0	70.4	64	6	16	13	17
391.50	2.50	1.40			21.8	18.5	***74.4***	32.3	2.4	101.2	74	6	16	19	19
389.00	2.50	0.50			9.3	6.6	***92.9***	13.7	0.8	116.1	93	6	16	29	22
386.50	2.50	1.20			19.5	15.8	162.5	28.9	2.0	***151.4***	151	9	16	58	24
384.00	2.50	5.00	25		49.5	65.9	321.8	73.2	8.5	***238.8***	239	9	16	106	27
383.50	0.50			Shale	29.6	175.8	351.5	43.9	22.6	***282.7***	283	9	16	131	27
383.00	0.50			Shale	29.6	175.8	381.1	43.9	22.6	***326.6***	327	9	16	155	28
382.50	0.50			Shale	29.6	175.8	410.7	43.9	22.6	***370.5***	370	9	16	179	28
382.00	0.50			Shale	29.6	175.8	440.4	43.9	22.6	***414.4***	414	9	16	203	29
381.50	0.50			Shale	29.6	175.8	470.0	43.9	22.6	***458.3***	458	9	16	227	29
381.00	0.50			Shale	29.6	175.8	***499.7***	43.9	22.6	502.1	500	6	16	253	30
380.50	0.50			Shale	29.6	175.8	***529.3***	43.9	22.6	546.0	529	6	16	269	30
380.00	0.50			Shale	29.6	175.8	***558.9***	43.9	22.6	589.9	559	6	16	285	31
379.50	0.50			Shale	29.6	175.8	***588.6***	43.9	22.6	633.8	589	6	16	302	31
379.00	0.50			Shale	29.6	175.8	***618.2***	43.9	22.6	677.7	618	6	16	318	32
378.50	0.50			Shale	29.6	175.8	***647.9***	43.9	22.6	721.6	648	6	16	334	32
378.00	0.50			Shale	29.6	175.8	***677.5***	43.9	22.6	765.5	677	6	16	351	33
377.50	0.50			Shale	29.6	175.8	***707.1***	43.9	22.6	809.4	~~707~~	~~6~~	~~16~~	~~367~~	~~33~~
377.00	0.50			Shale	29.6	175.8	***736.8***	43.9	22.6	853.2	~~737~~	~~6~~	~~16~~	~~383~~	~~34~~
376.50	0.50			Shale	29.6	175.8	***766.4***	43.9	22.6	897.1	~~766~~	~~6~~	~~16~~	~~399~~	~~34~~
376.00	0.50			Shale	29.6	175.8	***796.1***	43.9	22.6	941.0	~~796~~	~~6~~	~~16~~	~~416~~	~~35~~
375.50	0.50			Shale		175.8			22.6						

Pile Design Table for NABUT utilizing Boring #1-S

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Metal Shell 12"Φ w/.25" walls			
	344	178	27
Metal Shell 14"Φ w/.312" walls			
	450	234	27
	508	266	27
Steel HP 8 X 36			
	153	70	27
	173	83	28
	190	92	28
	207	101	29
	224	110	29
	240	120	30
	257	129	30
	274	138	31
Steel HP 10 X 42			
	160	71	27
	190	87	27
	221	104	28
	248	121	28
	269	132	29
	289	144	29
	310	155	30
	330	166	30

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 10 X 57			
	165	73	27
	195	90	27
	226	107	28
	255	124	28
	276	136	29
	297	148	29
	318	159	30
	339	171	30
	360	182	31
	381	194	31
	402	205	32
	423	217	32
	444	228	33
Steel HP 12 X 53			
	192	85	27
	228	105	27
	264	124	28
	300	144	28
	336	164	29
	368	184	29
	393	198	30
	418	211	30
Steel HP 12 X 63			
	197	87	27
	234	107	27
	270	128	28
	307	148	28
	344	168	29
	373	186	29
	398	200	30
	422	214	30
	447	227	31
	472	241	31
Steel HP 12 X 74			
	201	89	27
	237	109	27
	274	130	28
	311	150	28
	348	170	29
	379	190	29
	404	203	30
	429	217	30
	455	231	31
	480	245	31
	505	259	32
	530	273	32
	556	287	33
	581	301	33
Steel HP 12 X 84			
	204	91	27
	241	111	27
	278	132	28
	315	152	28
	352	172	29
	385	193	29
	411	207	30
	436	221	30
	462	235	31
	487	249	31
	513	263	32
	539	277	32
	564	291	33
	590	305	33
	615	319	34
	641	333	34

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 14 X 73			
	233	103	27
	276	127	27
	320	151	28
	364	175	28
	407	199	29
	451	223	29
	493	249	30
	522	265	30
	551	281	31
Steel HP 14 X 89			
	239	106	27
	283	131	27
	327	155	28
	370	179	28
	414	203	29
	458	227	29
	500	253	30
	529	269	30
	559	285	31
	589	302	31
	618	318	32
	648	334	32
	677	351	33
Steel HP 14 X 102			
	243	108	27
	287	133	27
	331	157	28
	375	181	28
	419	205	29
	463	230	29
	507	256	30
	537	273	30
	567	289	31
	597	306	31
	627	322	32
	657	339	32
	687	355	33
	716	372	33
	746	388	34
	776	405	34
Steel HP 14 X 117			
	249	111	27
	293	136	27
	337	160	28
	382	185	28
	426	209	29
	471	233	29
	514	260	30
	544	277	30
	575	293	31
	605	310	31
	635	327	32
	665	343	32
	696	360	33
	726	377	33
	756	393	34
	786	410	34

MODIFIED IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

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

Modified 11/2009

SUBSTRUCTURE================================ PIER
REFERENCE BORING ============================ 2-s
GROUND SURFACE ELEV. AT BORING ============== 414.90 FT.
PILE CUTOFF ELEV. ============================ 411.00 FT.
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVI 396.00 FT.
GROUND WATER ELEVATION====================== 399.70 FT.
HAMMER EFFICIENCY=========================== 73 %
LRFD or ASD or SEISMIC ========================= LRFD

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

Maximum Nominal Required Bearing	Maximum Factored Resistance Available	Maximum Pile Length Driveable
497 KIPS	**268** KIPS	**38** FT.

TOTAL FACTORED SUBSTRUCTURE LOAD ========== 1760 KIPS
TOTAL WIDTH OF SUBSTRUCTURE ================ 39.17 FT.
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE === 1
Approx. Factored Loading Applied per pile at 8 ft. Cts ====== 359.46 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ====== 134.80 KIPS

PILE TYPE AND SIZE =========== Steel HP 12 X 63
Plugged Pile Perimeter============= 4.000 FT. Unplugged Pile Perimeter========== 5.883 FT.
Plugged Pile End Bearing Area======= 1.000 SQFT. Unplugged Pile End Bearing Area===== 0.128 SQFT.

GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) == Scour
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ========== 394.90 FT.
TOP ELEV. OF LIQUEF. (so layers above apply DD) ============ 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.)
393.90	2.10	0.60			7.7		18.0	11.4		***12.7***	13	0	0	7	17
391.40	2.50	1.10			15.4	10.3	***26.8***	22.6	1.3	34.4	27	0	0	15	20
388.90	2.50	0.40			6.4	3.7	***37.9***	9.4	0.5	44.4	38	0	0	21	22
386.40	2.50	0.90			13.1	8.4	***48.1***	19.2	1.1	63.2	48	0	0	26	25
383.90	2.50	0.60			9.2	5.6	***58.3***	13.5	0.7	76.9	58	0	0	32	27
381.40	2.50	0.70			10.5	6.6	***64.1***	15.5	0.8	91.8	64	0	0	35	30
378.90	2.50		1	Very Fine Silty Sand	0.3	1.9	187.4	0.5	0.2	***108.0***	108	0	0	59	32
378.40	0.50			Shale	25.0	124.8	212.3	36.7	15.9	***144.7***	145	0	0	80	33
377.90	0.50			Shale	25.0	124.8	237.3	36.7	15.9	***181.4***	181	0	0	100	33
377.40	0.50			Shale	25.0	124.8	262.2	36.7	15.9	***218.1***	218	0	0	120	34
376.90	0.50			Shale	25.0	124.8	287.2	36.7	15.9	***254.8***	255	0	0	140	34
376.40	0.50			Shale	25.0	124.8	312.2	36.7	15.9	***291.6***	292	0	0	160	35
375.90	0.50			Shale	25.0	124.8	337.1	36.7	15.9	***328.3***	328	0	0	181	35
375.40	0.50			Shale	25.0	124.8	***362.1***	36.7	15.9	365.0	362	0	0	199	36
374.90	0.50			Shale	25.0	124.8	***387.0***	36.7	15.9	401.7	387	0	0	213	36
374.40	0.50			Shale	25.0	124.8	***412.0***	36.7	15.9	438.4	412	0	0	227	37
373.90	0.50			Shale	25.0	124.8	***437.0***	36.7	15.9	475.1	437	0	0	240	37
373.40	0.50			Shale	25.0	124.8	***461.9***	36.7	15.9	511.8	462	0	0	254	38
372.90	0.50			Shale	25.0	124.8	***486.9***	36.7	15.9	548.5	487	0	0	268	38
372.40	0.50			Shale	25.0	124.8	***511.8***	36.7	15.9	585.2	~~512~~	~~0~~	~~0~~	~~282~~	~~39~~
371.90	0.50			Shale	25.0	124.8	***536.8***	36.7	15.9	622.0	~~537~~	~~0~~	~~0~~	~~295~~	~~39~~
371.40	0.50			Shale	25.0	124.8	***561.8***	36.7	15.9	658.7	~~562~~	~~0~~	~~0~~	~~309~~	~~40~~
370.90	0.50			Shale	25.0	124.8	***586.7***	36.7	15.9	695.4	~~587~~	~~0~~	~~0~~	~~323~~	~~40~~
370.40	0.50			Shale		124.8			15.9						

Pile Design Table for PIER utilizing Boring #2-s

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Metal Shell 12"Φ w/.25" walls			
	308	169	32
Metal Shell 14"Φ w/.25" walls			
	407	224	32
Metal Shell 14"Φ w/.312" walls			
	407	224	32
	465	256	33
Steel HP 8 X 36			
	233	128	36
	250	138	37
	267	147	37
	284	156	38
Steel HP 10 X 42			
	238	131	35
	260	143	35
	281	154	36
	301	166	36
	322	177	37

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 10 X 57			
	243	134	35
	267	147	35
	288	158	36
	309	170	36
	330	181	37
	351	193	37
	372	205	38
	393	216	38
	414	228	39
	435	239	39
Steel HP 12 X 53			
	213	117	34
	249	137	34
	285	157	35
	321	177	35
	358	197	36
	383	211	36
	408	224	37
Steel HP 12 X 63			
	218	120	34
	255	140	34
	292	160	35
	328	181	35
	362	199	36
	387	213	36
	412	227	37
	437	240	37
	462	254	38
	487	268	38
Steel HP 12 X 74			
	222	122	34
	259	142	34
	296	163	35
	333	183	35
	368	203	36
	393	216	36
	419	230	37
	444	244	37
	469	258	38
	495	272	38
	520	286	39
	545	300	39
	570	314	40
Steel HP 12 X 84			
	225	124	34
	263	144	34
	300	165	35
	337	185	35
	374	206	36
	400	220	36
	426	234	37
	451	248	37
	477	262	38
	502	276	38
	528	290	39
	553	304	39
	579	318	40

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 14 X 73			
	215	118	33
	258	142	34
	302	166	34
	345	190	35
	389	214	35
	432	238	36
	476	262	36
	510	280	37
	539	296	37
	568	313	38
Steel HP 14 X 89			
	220	121	33
	264	145	34
	308	170	34
	352	194	35
	396	218	35
	440	242	36
	484	266	36
	517	284	37
	547	301	37
	576	317	38
	606	333	38
	635	349	39
	665	366	39
	695	382	40
Steel HP 14 X 102			
	225	123	33
	269	148	34
	313	172	34
	357	196	35
	401	220	35
	445	245	36
	489	269	36
	524	288	37
	554	305	37
	584	321	38
	614	338	38
	644	354	39
	674	371	39
	704	387	40
Steel HP 14 X 117			
	230	126	33
	274	151	34
	319	175	34
	363	200	35
	408	224	35
	452	249	36
	496	273	36
	532	292	37
	562	309	37
	592	326	38
	622	342	38
	653	359	39
	683	376	39
	713	392	40

MODIFIED IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

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

Modified 11/2009

SUBSTRUCTURE================================ South Abut
REFERENCE BORING ============================ 2-S
GROUND SURFACE ELEV. AT BORING ============== 414.90 FT.
PILE CUTOFF ELEV. ============================ 410.60 FT.
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVI 405.60 FT.
GROUND WATER ELEVATION====================== 399.70 FT.
HAMMER EFFICIENCY============================ 73 %
LRFD or ASD or SEISMIC ========================== LRFD

TOTAL FACTORED SUBSTRUCTURE LOAD ========== 787 KIPS
TOTAL WIDTH OF SUBSTRUCTURE ================ 39.17 FT.
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE === 1
Approx. Factored Loading Applied per pile at 8 ft. Cts ====== 160.74 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ====== 60.28 KIPS

PILE TYPE AND SIZE =========== Metal Shell 14"Φ w/.312" walls
Pile Perimeter================= 3.665 FT.
Pile End Bearing Area============= 1.147 SQFT.

GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) == None
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ========== 395.00 FT.
TOP ELEV. OF LIQUEF. (so layers above apply DD) ============ FT.

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

Maximum Nominal Required Bearing	Maximum Factored Resistance Available	Maximum Pile Length Driveable
513 KIPS	**235** KIPS	**32** 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 SIDE RESIST. (KIPS)	NOMINAL END BRG. RESIST. (KIPS)	NOMINAL 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.)
403.90	1.70	0.80			5.8		10.1				10	0	0	6	7
401.40	2.50	0.40			4.6	4.3	12.5				12	0	0	7	9
398.90	2.50	0.20			2.4	2.1	18.1				18	0	0	10	12
396.40	2.50	0.50			5.6	5.4	24.7				25	0	0	14	14
393.90	2.50	0.60			6.6	6.4	36.7				37	0	0	20	17
391.40	2.50	1.10			11.0	11.8	40.2				40	0	0	22	19
388.90	2.50	0.40			4.6	4.3	50.1				50	0	0	28	22
386.40	2.50	0.90			9.4	9.7	56.3				56	0	0	31	24
383.90	2.50	0.60			6.6	6.4	64.0				64	0	0	35	27
381.40	2.50	0.70			7.6	7.5	71.2				71	0	0	39	29
378.90	2.50		1	Fine Sand	0.8	7.2	426.4				426	0	0	235	32
377.40	1.50			Shale	173.4	361.6	599.7				~~600~~	~~0~~	~~0~~	~~330~~	~~33~~
375.90	1.50			Shale	173.4	361.6	773.1				~~773~~	~~0~~	~~0~~	~~425~~	~~35~~
375.40	0.50			Shale	57.8	361.6	830.9				~~831~~	~~0~~	~~0~~	~~457~~	~~35~~
374.90	0.50			Shale	57.8	361.6	888.7				~~889~~	~~0~~	~~0~~	~~489~~	~~36~~
374.40	0.50			Shale	57.8	361.6	946.5				~~946~~	~~0~~	~~0~~	~~521~~	~~36~~
373.90	0.50			Shale	57.8	361.6	1004.3				~~1004~~	~~0~~	~~0~~	~~552~~	~~37~~
373.40	0.50			Shale	57.8	361.6	1062.0				~~1062~~	~~0~~	~~0~~	~~584~~	~~37~~
372.90	0.50			Shale	57.8	361.6	1119.8				~~1120~~	~~0~~	~~0~~	~~616~~	~~38~~
372.40	0.50			Shale	57.8	361.6	1177.6				~~1178~~	~~0~~	~~0~~	~~648~~	~~38~~
371.90	0.50			Shale	57.8	361.6	1235.4				~~1235~~	~~0~~	~~0~~	~~679~~	~~39~~
371.40	0.50			Shale		361.6									

Pile Design Table for South Abut utilizing Boring #2-S

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Metal Shell 12"Φ w/.25" walls			
	324	178	32
Metal Shell 14"Φ w/.312" walls			
	426	235	32
Steel HP 8 X 36			
	167	92	33
	218	120	35
	235	129	35
	252	138	36
	268	148	36
	285	157	37
Steel HP 10 X 42			
	120	66	32
	211	116	33
	282	155	35
	303	167	35
	324	178	36

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 10 X 57			
	124	68	32
	215	118	33
	290	159	35
	311	171	35
	332	182	36
	353	194	36
	374	206	37
	395	217	37
	416	229	38
	437	240	38
Steel HP 12 X 53			
	143	79	32
	252	139	33
	360	198	35
	385	212	35
	410	225	36
Steel HP 12 X 63			
	148	81	32
	258	142	33
	364	200	35
	389	214	35
	414	228	36
	439	241	36
	464	255	37
	489	269	37
Steel HP 12 X 74			
	151	83	32
	262	144	33
	370	204	35
	396	218	35
	421	231	36
	446	245	36
	471	259	37
	497	273	37
	522	287	38
	547	301	38
Steel HP 12 X 84			
	154	85	32
	266	146	33
	376	207	35
	402	221	35
	428	235	36
	453	249	36
	479	263	37
	504	277	37
	530	291	38
	556	306	38

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 14 X 73			
	175	96	32
	305	168	33
	436	240	35
	479	264	35
	512	282	36
	541	298	36
	571	314	37
Steel HP 14 X 89			
	180	99	32
	312	171	33
	443	244	35
	487	268	35
	519	286	36
	549	302	36
	579	318	37
	608	335	37
	638	351	38
	668	367	38
Steel HP 14 X 102			
	111	61	29
	184	101	32
	316	174	33
	448	247	35
	492	271	35
	527	290	36
	557	306	36
	587	323	37
	617	339	37
	647	356	38
	676	372	38
Steel HP 14 X 117			
	112	62	29
	189	104	32
	322	177	33
	456	251	35
	500	275	35
	534	294	36
	564	310	36
	595	327	37
	625	344	37
	655	360	38
	685	377	38
Timber Pile			
	140	77	32

EXHIBIT H

ESTIMATED PILE TYPES AND LENGTHS FOR MODIFIED FACTORED LOAD CONDITIONS

	Pile Designation	R_n Nominal Required Bearing (kips)	R_F Factored Resistance Available (kips)	Modified Load Condition (%)	Total Factored Load (kips)	Estimated Pile Length (ft)	Pile Tip Elevation	Min. Pile Group
North Abutment (Boring 1-S)	**Metal Shell 14” w .312” walls**	508	266	80	787	27	384	3
				90	886			4
		510	235	115	1132	29	382	5
				130	1279			5
	HP 10X42	330	166	80	787	30	381	5
				90	886			6
		312	119	115	1132	32	379	7
				130	1279			8
	HP 12X53	418	211	80	787	30	381	4
				90	886			5
		395	154	115	1132	32	379	6
				130	1279			7
	HP 12x63	472	241	80	787	31	380	4
				90	886			4
		400	156	115	1132	32	379	6
				130	1279			6
	HP 14x73	551	281	80	787	31	380	3
				90	886			4
		495	198	115	1132	32	379	5
				130	1279			5
	14x89	677	351	80	787	33	378	3
				90	886			3
		502	201	115	1132	32	379	4
				130	1279			4

Exhibit G - Estimated Pile Types and Lengths for Modified Factored Load Conditions

	Pile Designation	R_n Nominal Required Bearing (kips)	R_F Factored Resistance Available (kips)	Modified Load Condition (%)	Total Factored Load (kips)	Estimated Pile Length (ft)	Pile Tip Elevation	Min. Pile Group
Pier (Boring 2-S)	**Metal Shell 14" w .312" walls**	465	256	80	1408	33	378	6
				90	1584			7
		467	253	115	2024	30	381	8
				130	2288			10
	HP 10X42	322	177	80	1408	37	374	8
				90	1584			9
		325	174	115	2024	34	377	12
				130	2288			14
	HP 12X53	408	224	80	1408	37	374	7
				90	1584			8
		411	220	115	2024	34	377	10
				130	2288			11
	HP 12x63	487	268	80	1408	38	373	6
				90	1584			6
		491	264	115	2024	35	376	8
				130	2288			9
	HP 14x73	568	313	80	1408	38	373	5
				90	1584			6
		573	308	115	2024	35	376	7
				130	2288			8
	14x89	695	382	80	1408	40	371	4
				90	1584			5
		699	377	115	2024	37	374	6
				130	2288			7

	Pile Designation	R_n Nominal Required Bearing (kips)	R_F Factored Resistance Available (kips)	Modified Load Condition (%)	Total Factored Load (kips)	Estimated Pile Length (ft)	Pile Tip Elevation	Min. Pile Group
South Abutment (Boring 2-S)	**Metal Shell 14" w .312" walls**	426	235	80	787	32	379	4
				90	886			4
				115	1132			5
				130	1279			6
	HP 10X42	324	178	80	787	36	375	5
				90	886			5
				115	1132			7
				130	1279			8
	HP 12X53	410	225	80	787	36	375	4
				90	886			4
				115	1132			6
				130	1279			6
	HP 12x63	489	269	80	787	37	374	3
				90	886			4
				115	1132			5
				130	1279			5
	HP 14x73	571	314	80	787	37	374	3
				90	886			3
				115	1132			4
				130	1279			5
	14x89	668	367	80	787	38	373	3
				90	886			3
				115	1132			4
				130	1279			4