Structure Geotechnical Report

US 51 over ICRR

Route FAP 322 (US 51)

Section 3VB-2

Jackson County, Illinois

Proposed SN 039-0084

Prepared For:

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Millennia Project No. MG 23035.12/MG24067.02

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Structure Geotechnical Report
US 51 over ICRR
Route FAP 322, Section 3VB-2
Proposed SN 039-0084
Jackson County, Illinois

1.0 Project Description and Proposed Structure Information

1.1 Introduction

This report summarizes the results of a geotechnical investigation performed for the design of the replacement structure for the existing bridge carrying US 51 over the Illinois Central Railroad (ICRR), approximately three miles north of DeSoto, Illinois. The purpose of this study was to provide a geotechnical assessment for the proposed new structure based on subsurface conditions encountered at the borings performed by the Illinois Department of Transportation (IDOT) in 2021 and by Terracon in 2025. This report describes the exploration procedures used, presents the field and laboratory data, includes an assessment of the subsurface conditions in the area, and provides geotechnical recommendations for design and construction.

1.2 Project Description

The project consists of the removal and replacement of the existing US 51 bridge over ICRR in Jackson County, Illinois. The general site area is shown on the attached Vicinity Map, Figure 1 in Appendix A. The approximate locations of the borings performed for this study are presented on the Type, Size and Location (TSL) Plan, Figure 2 in Appendix A. The TSL was prepared by TWM, Inc.

The ICRR line is oriented roughly north and south beneath the existing US 51 overpass structure. The original bridge was built in 1926 and reconstructed in 1983. The existing bridge, SN 039-0052, is a three-span structure measuring approximately 151 feet long and 38 feet wide. The abutments and interior piers are supported by steel H-piles. It is our understanding that the existing structure will be replaced by a three-span bridge using integral abutments. Based on the information provided, it appears that staged construction will be required to maintain traffic during construction.

1.3 Proposed Structure Information

The proposed structure, SN 039-0084, will be a three-span bridge supported by steel H-piles at the abutments and drilled shafts at the interior piers. The bridge length will be approximately 177 feet from abutment to abutment, with a deck width of approximately 43 feet. The superstructure will be supported by integral abutments. The preliminary TSL indicates the roadway profile across the bridge will increase by approximately 14 inches. No information is currently available for the embankments, so it is assumed that grade changes will not exceed 14 inches. The TSL indicates the existing 2H:1V endslopes will be extended up to the new abutments.

Factored loads for the bridge provided by TWM are presented in the following table.

Table 1.1
Factored Axial Loads by Foundation Location (kips)

Load Limit State	West Abutment	Pier 1	Pier 2	East Abutment
Strength I	1,076	2,088	2,088	1,076

2.0 Subsurface Exploration and Laboratory Testing

2.1 Subsurface Exploration (by others)

From May 3 to May 7, 2021, IDOT District 9 personnel conducted a subsurface exploration at the site, consisting of three structure borings designated as 1-S, 2-S, and 3-S. On January 9, 2025, Terracon drilled two additional borings designated as B-4S and B-5S. The approximate locations of the borings are indicated on the TSL, Figure 2 in Appendix A.

The borings were advanced using hollow-stem auger, solid-stem auger, and rock core drilling methods. Samples were obtained at 2.5-foot intervals until bedrock was encountered in Borings 1-S, 2-S, and 3-S. Split-spoon samples were recovered using a 2-inch outside-diameter, split-barrel sampler, driven by a 140-pound automatic hammer. Unconfined compression tests were performed on selected split-spoon samples using a Rimac field testing machine. Borings B-4S and B-5S were drilled with no sampling to bedrock, followed by rock coring. The soil sampling sequence for each boring and resulting unconfined compressive strengths are reported on the boring logs in Appendix B.

The underlying bedrock was cored for a depth of about 10 to 20 feet at all boring locations. The core samples recovered were measured in the field for percent recovery and RQD value. Rock coring equipment and methods are recorded on the boring logs, along with material descriptions. Photographs were taken of the rock core samples and are included in Appendix B with the core logs.

2.2 Laboratory Testing (by others)

A laboratory testing program consisting of natural moisture contents and unconfined compressive strength of rock core specimens was conducted by IDOT and Terracon to determine selected engineering properties of the obtained samples. The results of the individual tests are presented on the boring logs in Appendix B.

2.3 Data

The results of the field tests and measurements were recorded on field logs and appropriate data sheets in the field. These data sheets and logs contain information concerning the drilling methods, samples attempted and recovered, indications of the presence of various subsurface materials, and the observation of groundwater. The field logs and data sheets also contain the engineer’s interpretations of the conditions between samples, based on the performance of the equipment and cuttings brought to the surface by the drilling tools.

The boring logs are an interpretation of the subsurface conditions based on a combination of the field and laboratory data. The analyses and conclusions contained in this report are based on these field and laboratory test results and on the interpretations of the subsurface conditions as reported in the Boring Logs. Only data pertinent to the objectives of this report have been included on these Logs; therefore, these records should not be used for other purposes.

3.0 Subsurface Conditions

Details of the subsurface conditions encountered at the borings are shown on the boring logs. The general subsurface conditions encountered and their pertinent engineering characteristics are described in the following paragraphs. Conditions represented by the borings should be considered applicable only at the boring locations on the dates shown; the reported conditions may be different at other locations and at other times.

3.1 Generalized Subsurface Profile

The soils at the site are predominantly made up of cohesive soils overlying bedrock. The upper approximately 25 feet is most likely embankment material from the original road construction. The possible fill was visually classified as silty clay. Below this is approximately 15 feet of natural cohesive soil, generally consisting of silty clay. The standard penetration test N-values range from 3 to 25 blows per foot (bpf), unconfined compressive strength values obtained from Rimac testing range from 0.2 to 3.1 tons per square foot (tsf). Moisture contents range from 15 to 37 percent.

Bedrock consisting of sandstone was encountered at all but one of the boring locations, at elevations ranging from 402.1 to 399.3. Shale was encountered at Boring B-5S at an elevation of 387.9. All of the borings were advanced into bedrock, for total rock core lengths varying from 10.0 to 20.0 feet. The bedrock was cored at each boring to the elevations presented in the table below.

Table 3.1
Approximate Bedrock Elevations

Boring No.	Approximate Top of Bedrock Elevation (ft.)
1-S	401.0
2-S	402.1
3-S	400.5
B-4S	399.3
B-5S	387.9

The rock cores recovered at the site consist of sandstone, clay shale, shale, and limestone. The sandstone and shale were observed to be moderately hard and weathered. The clay shale was of low hardness, highly weathered, and contained some coal. The limestone was hard. Core recoveries varied from 0 to 100 percent, and Rock Quality Designation (RQD) values varied from 0 to 95 percent. A majority of the lower recovery and RQD values resulted from a malfunction with the coring equipment at Boring 2-S. Uniaxial compressive strength testing performed on select samples of the rock cores yielded compressive strength values that range from 72 to 12,986 psi. Summaries of the rock core compressive strength testing and rock core photographs are presented in Appendix B.

3.2 Groundwater

Groundwater was observed during drilling at boring 3-S, at a depth of 43.5 feet (Elevation 398.0). Groundwater was not encountered at the other borings prior to introducing drilling fluids as part of the rock coring process. The presence or absence of groundwater at a particular location does not necessarily indicate that groundwater will be present or absent at that location at other times. Groundwater levels may vary significantly over time due to the effect of seasonal variations in precipitation, or other factors not evident at the time of exploration.

4.0 Geotechnical Evaluations

4.1 Earthwork and Slope Stability

Millennia performed slope stability assessments to verify the new integral abutments would be adequately supported by the proposed end slopes. End slopes are currently planned for 2H:1V inclinations, extending up from approximate railroad grade to the new abutments. The new integral abutments will be set approximately 13 feet outside of the existing abutments.

The parameters used for the stability assessments were based on the results of the field and laboratory investigations, along with Millennia's experience in the area, and are shown on the Slope Stability Profiles provided in Appendix C.

The global stability assessments were conducted for short term (undrained, or total stress), long term (drained, or effective stress), and seismic conditions using SLOPE/W, a computer program from GeoStudio. The results are summarized in the following table:

Table 4.1
Summary of Global Stability Results

Analysis Location	Minimum Computed Factor of Safety		
	Short Term	Long Term	Seismic
East Abutment End Slope	2.1	1.5	1.0
West Abutment End Slope	2.4	1.5	1.1

The minimum desired safety factor with regard to the potential for massive, global slope failure is 1.5 for static conditions. For the seismic condition, a factor of safety 1.0 or greater is desired. On this basis, the results of the stability assessments at the sections summarized above are considered acceptable for the short term, long term, and seismic conditions.

Some of the silty soils can be potentially erosive, a mechanism of soil movement unrelated to global stability. Future erosion and shallow, superficial slumps are always a possibility, despite the results of advanced computer modeling for slope stability. Maintaining healthy vegetation, along with appropriate erosion control practices, will reduce the potential for these issues to become problematic.

In addition, the geotechnical conditions between the boring locations are essentially unknown. If the contractor exposes conditions during excavation and other earthwork activities that differ from those indicated at the boring locations, Millennia should be notified to assess the effect (if any) of the unanticipated conditions upon the findings of the global slope stability assessment.

4.2 Settlement

The proposed grade changes will be minimal for the new bridge profile. Therefore, issues related to settlement are not anticipated and have not been evaluated.

4.3 Seismicity

Although several significant areas of seismic activity are present in the central United States, the site area is most directly affected by the New Madrid and Wabash Seismic Zones, located in south and east-central Illinois. Seismic design parameters for this site have been determined using the IDOT 2024 Seismic Manual – DRAFT Sections 1, 2, 3, 4 and 8. The seismic data required for TSL plans is presented below.

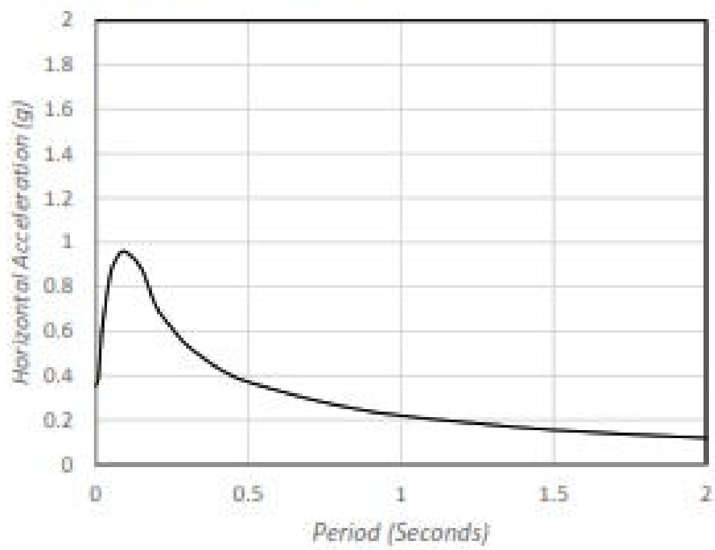
Seismic Data

2023 AASHTO Seismic Hazard

Site Class: C

Latitude: 37.8525° N, Longitude: -89.2317° W

Performance Level: Operational



*Vertical Acceleration = $^2/_3$ * Horizontal Acceleration*

SD1 = 0.221g

SDC = B

Based on published information and the IDOT Liquefaction Design Guide, liquefaction analyses are typically performed for the upper 60 feet of a soil profile, since the effects of liquefaction are unlikely to manifest below that depth. The results of the analysis yielded values that appear to provide a factor of safety that is resistant to liquefaction. The potential for liquefaction may be ignored for this project. Appendix D includes the Liquefaction Analysis spreadsheets for each boring.

4.4 Mining Activity

A review of underground coal mines and industrial mineral mines was made using the Illinois State Geological Survey (ISGS) ILMINES website for mapped mines in Illinois. Based on this information, portions of the existing structure have been undermined, and the proposed abutments will be located above an inactive underground coal mine. The mine boundary is shown on the figure included in Appendix E. It should be noted that the location of features, including mine boundaries, may be offset by 500 feet or more. In addition, the plotted mine boundaries are not always based on a final mine map, and undocumented mines are occasionally discovered.

The mine was known as the Ward Mine (ISGS Index No. 267), operated by Chicago Fuel Company from 1902 to 1925. The mining operations removed coal from the Herrin Coal Seam. The coal was approximately 85 feet below ground surface and averaged 6 to 7 feet in thickness.

Subsidence is the surface manifestation of the collapse or failure of the structural support at the mine level. Subsidence may manifest itself as vertical movements ranging from a few inches to two or three feet and as lateral or rotational ground movements that can result in significant architectural or even structural damage. Railroad, agricultural, residential and some commercial developments are common in the area of the project site. Many builders and owners in the area are unaware of, or ignore, the risks associated with subsidence and build without modifications to the design of their structures. Most owners manage the risk for damage through mine subsidence insurance policies.

The risk of subsidence is difficult to quantify without extensive studies. A study of the mine workings would require drilling several borings into the mine and viewing the mine openings with a borehole camera. Soil and rock samples could be taken at each borehole and the engineering properties of the materials could be measured. Geophysical techniques, such as seismic reflection or refraction techniques, could also be used to help define the mine limits. A study of this type is costly and is rarely performed.

5.0 Foundation Evaluations and Design Recommendations

5.1 Driven Piles

The bridge structures may be supported on driven pile foundations. Pile capacities and driving depths have been assessed using the IDOT pile design spreadsheet “Pile Capacity and Length Estimates." Steel H-piles and metal shell piles are both considered to be feasible for this site. However, metal shell piles are not recommended because of the proximity of rock where a possibility of pile damage during driving may occur. Hard driving is anticipated to penetrate a sufficient distance into sandstone to achieve the maximum factored capacity, particularly for the heavier sections. Numerous available pile sections may be suitable, and final selection would be based on availability and structural requirements such as pile spacing, installation requirements, etc.

The abutments have been assessed for selected pile sections. Copies of a typical input spreadsheet giving the input parameters for each substructure, and the corresponding summary sheets for the various pile types that are analyzed by the spreadsheet, are included in Appendix F. These tables provide the pile embedment length to develop various capacities, up to that approaching the factored design capacity of the pile. The tables were prepared for pile lengths corresponding to selected depths of the input stratigraphy. Data for key assumptions such as pile cutoff elevation and ground surface elevation against pile driving were provided to Millennia by TWM.

Integral abutments are being considered for the new bridge structures. The pile selections were determined using the IDOT Integral Abutment Feasibility Analysis spreadsheet.

The piles exhibited in the tables in Appendix F are the pile sections that are readily available in accordance with the IDOT Geotechnical Manual. The tables on the following pages summarize the information provided in Appendix F. Steel H-piles should be driven into rock to their maximum required bearing, as indicated on the IDOT pile design length spreadsheets. It should be noted that H-Piles driven into sandstone may run shorter (or longer) than the IDOT pile design length spreadsheets estimate. The piles should be fitted with reinforced tips to reduce the potential for damage during driving.

Table 5.1
Estimated Pile Lengths – East Abutment (Boring 2-S)

Pile Type and Size	Nominal Required Bearing (kips)	Factored Resistance Available (kips)	Estimated Pile Length (ft)	Pile Cutoff Elevation (ft)
HP 8x36	271	149	38	438.09
HP 10x42	335	184	38	438.09
HP 10x57	454	250	40	438.09
HP 12x53	418	230	39	438.09
HP 12x63	497	273	39	438.09
HP 12x74	589	324	40	438.09
HP 12x84	664	365	41	438.09
HP 14x73	578	318	39	438.09
HP 14x89	705	388	40	438.09
HP 14x102	810	445	41	438.09
HP 14x117	929	511	42	438.09

Table 5.2
Estimated Pile Lengths – West Abutment (Boring 3-S)

Pile Type and Size	Nominal Required Bearing (kips)	Factored Resistance Available (kips)	Estimated Pile Length (ft)	Pile Cutoff Elevation (ft)
HP 8x36	286	157	40	437.98
HP 10x42	335	184	40	437.98
HP 10x57	454	250	41	437.98
HP 12x53	418	230	40	437.98
HP 12x63	497	273	40	437.98
HP 12x74	589	324	41	437.98
HP 12x84	664	365	42	437.98
HP 14x73	578	318	40	437.98
HP 14x89	705	388	41	437.98
HP 14x102	810	445	42	437.98
HP 14x117	929	511	43	437.98

5.2 Drilled Shafts

Millenia understands that drilled shafts are being considered as the foundation element for the interior bridge piers. Limited data was available from the rock cores collected during the 2021 subsurface exploration. Therefore, additional rock cores were obtained (by others) near the proposed locations for Pier 1 and Pier 2, in order to evaluate the existence of voids, seams, or other discontinuities within and below the planned bearing elevation of the drilled shaft foundations. Samples of the bedrock were also tested for uniaxial compressive strength.

Drilled shafts may be designed for side resistance within the bedrock socket in conjunction with tip resistance, if needed. The recommended side and tip resistance values for the bedrock socket are presented in the following tables.

Table 5.3
Factored Side Resistance in Bedrock – Pier 1

Material	Elevation Range (ft.)	Nominal Side Resistance (ksf)	Geotechnical Resistance Factor (φ)	Factored Side Resistance (ksf)
Sandstone	400-390	6.5	0.55	3.6
Clay Shale and Coal	390 and below	2.9	0.45	1.3

Table 5.4
Factored Tip Resistance in Bedrock – Pier 1

Material	Elevation Range (ft.)	Nominal Tip Resistance (ksf)	Geotechnical Resistance Factor (φ)	Factored Tip Resistance (ksf)
Clay Shale and Coal	390 and below	46.8	0.40	20.0

Table 5.5
Factored Side Resistance in Bedrock – Pier 2

Material	Elevation Range (ft.)	Nominal Side Resistance (ksf)	Geotechnical Resistance Factor (φ)	Factored Side Resistance (ksf)
Shale	388-378	2.9	0.45	1.3
Limestone	378-368	16.5	0.50	8.3

Table 5.6
Factored Tip Resistance in Bedrock – Pier 2

Material	Elevation Range (ft.)	Nominal Tip Resistance (ksf)	Geotechnical Resistance Factor (φ)	Factored Tip Resistance (ksf)
Shale	388-378	46.8	0.40	20.0
Limestone	378-368	137.5	0.50	68.7

It should be assumed that the upper 2 feet of the socket will not contribute to side resistance in consideration of uncertainties caused by the potential for weathering of the upper bedrock surface. Uplift resistance of the shaft should only rely on the bedrock socket side friction. An uplift resistance factor of 0.40 is recommended based on AASHTO LRFD Bridge Design Specifications (2020).

Assuming that the drilled shafts are properly installed as discussed herein, total shaft settlement should be less than approximately 1 inch, with differential settlements up to approximately half the total.

Because of the variability in weathering, rock type and hardness, shafts should be designed to penetrate the bedrock at least two shaft diameters, regardless of applied load. Shafts should be constructed no closer than three shaft diameters, center to center, so that stress overlap at the bearing level and possible installation problems associated with caving can be avoided.

5.3 Lateral Load Capacity Considerations

Lateral load resistance and induced lateral deflection are typically assessed using finite difference computer models based on the lateral modulus-of-subgrade reaction, such as LPILE. Recommended design values for driven pile foundations are presented in tables on the following pages.

Table 5.7
Parameters for Use in LPILE Analysis – East Abutment

Elevation (ft)	LPILE Soil Type	Effective Unit Weight (pcf)	Undrained Cohesion (psf)	Unaxial Compressrive Strength (psi)	Strain at 50% Maximum Stress	Angle of Internal Friction (degrees)	p-y Soil Modulus K_{static} (pci)
439-435	Stiff Clay w/o Free Water	120	1,000	N/A	0.009	N/A	350
435-430	Stiff Clay w/o Free Water	120	1,500	N/A	0.007	N/A	500
430-425	Soft Clay (Matlock)	120	500	N/A	0.020	N/A	30
425-400	Stiff Clay w/o Free Water	120	1,000	N/A	0.009	N/A	350

pcf = pounds per cubic foot psf = pounds per square foot psi = pounds per square inch pci = pounds per cubic inch
*= submerged value

Table 5.8
Parameters for Use in LPILE Analysis – West Abutment

Elevation (ft)	LPILE Soil Type	Effective Unit Weight (pcf)	Undrained Cohesion (psf)	Unaxial Compressrive Strength (psi)	Strain at 50% Maximum Stress	Angle of Internal Friction (degrees)	p-y Soil Modulus K_{static} (pci)
439-435	Stiff Clay w/o Free Water	120	3,000	N/A	0.005	N/A	1,000
435-432	Stiff Clay w/o Free Water	120	1,250	N/A	0.008	N/A	425
432-430	Stiff Clay w/o Free Water	120	2,500	N/A	0.006	N/A	850
430-420	Stiff Clay w/o Free Water	120	1,250	N/A	0.008	N/A	425
420-417	Soft Clay (Matlock)	120	500	N/A	0.020	N/A	30
417-400	Stiff Clay w/o Free Water	120	1,250	N/A	0.008	N/A	425

pcf = pounds per cubic foot psf = pounds per square foot psi = pounds per square inch pci = pounds per cubic inch
*= submerged value

Table 5.9
Parameters for Use in LPILE Analysis – Pier 1

Elevation (ft)	LPILE Soil Type	Effective Unit Weight (pcf)	Undrained Cohesion (psf)	Unaxial Compressrive Strength (psi)	Strain at 50% Maximum Stress	Angle of Internal Friction (degrees)	p-y Soil Modulus K_{static} (pci)
410-400	Stiff Clay w/o Free Water	120	1,750	N/A	0.004	N/A	575
400-390	Strong Rock (Limestone)	145	N/A	1,300	N/A	N/A	N/A
390-380	Stiff Clay w/o Free Water	125	5,200	N/A	0.004	N/A	1,500

pcf = pounds per cubic foot psf = pounds per square foot psi = pounds per square inch pci = pounds per cubic inch
*= submerged value

Table 5.10
Parameters for Use in LPILE Analysis – Pier 2

Elevation (ft)	LPILE Soil Type	Effective Unit Weight (pcf)	Undrained Cohesion (psf)	Unaxial Compressrive Strength (psi)	Strain at 50% Maximum Stress	Angle of Internal Friction (degrees)	p-y Soil Modulus K_{static} (pci)
410-388	Stiff Clay w/o Free Water	120	1,000	N/A	0.009	N/A	350
388-378	Stiff Clay w/o Free Water	125	5,200	N/A	0.004	N/A	1,500
Below 378	Strong Rock (Limestone)	145	N/A	10,000	N/A	N/A	N/A

pcf = pounds per cubic foot psf = pounds per square foot psi = pounds per square inch pci = pounds per cubic inch *= submerged value

Piles and drilled shafts should be maintained at a spacing no closer than three pile diameters, center-to-center, so that stress overlap at the bearing level can be avoided, to reduce lateral capacity interaction, and so that possible installation problems associated with one structural member do not impact the integrity of the adjacent member.

6.0 Construction Considerations

6.1 Temporary Sheeting and Soil Retention

The construction activities should be performed in accordance with the current IDOT Standard Specifications for Road and Bridge Construction. Trenching, excavating, and bracing should be performed in accordance with Occupational Safety and Health Administration (OSHA) regulations, and other applicable regulatory agencies. In accordance with the OSHA excavation standards, the soil at the site is considered to be Type B, which requires a side slope for excavations no steeper than 1.0H:1.0V. However, worker safety and classification of the excavation soil is the responsibility of the contractor. The excavation side slopes for structure foundations may interfere with existing utilities. This will require a temporary soil retention system such as a cantilever sheet pile wall, sheeting, or other temporary support.

Traffic along US 51 will be maintained by utilizing staged construction. It appears as though either a temporary sheet pile, which includes cantilever temporary sheet piling, or a soil retention system, will be feasible at the abutments. Cantilever sheet pile systems may be designed using IDOT Design Guide 3.13.1 – Temporary Sheet Piling Design. If sheet pile designs are selected, designers should note bedrock elevations. Temporary soil retention systems should be designed by an Illinois licensed structural engineer retained by the construction contractor.

6.2 Driven Pile Installation

The driven piles are to be furnished and installed according to the requirements of Section 512 of the IDOT Specifications. Millennia recommends that at least one test pile be driven at each substructure location, in accordance with Section 512.15. The piles should be fitted with reinforced tips to reduce the potential for damage during driving. Piles set in rock are to be installed in accordance with 512.17 of the IDOT Specifications.

6.3 Drilled Shaft Construction

Drilled shaft construction should be performed in accordance with Section 516 of the IDOT Specifications. It is recommended that drilled shaft construction be performed by an experienced, knowledgeable contractor familiar with the conditions in the project area. Groundwater seepage and caving of the drilled shaft excavations could be problematic without appropriate planning. The contractor should be prepared to handle water seepage and sloughing of the walls. The use of permanent casing construction methods may be required at the pier locations.

Shafts should be cast the same day drilled to reduce the potential for bearing surface deterioration and caving. For stable, relatively dry holes, the base of each shaft excavation should be pumped as necessary to prevent the accumulation of water. For relatively dry holes, the concrete may be placed by central drop free-fall using a funnel. The concrete should be vibrated near the surface to obtain a consolidated placement. Concrete should be placed by tremie methods when more than two inches of water is present in the excavation.

6.4 Subgrade, Fill, and Backfill

Earthwork activities including backfill and fill should be performed in accordance with Section 205 of the IDOT Specifications.

7.0 Closing

This report has been prepared for the exclusive use of Oates Associates, Inc., and the Illinois Department of Transportation for use in the design and construction of the proposed new structure carrying US 51 over the Illinois Central Railroad (ICRR) in Jackson County, Illinois. This report has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made to the professional advice and recommendations included herein. This report is not for use by parties other than those named or for purposes other than those stated herein. It may not contain sufficient information for the use of other parties or for other purposes.

If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed by Millennia to determine the applicability of the analyses and recommendations considering the changed conditions and time lapse. The report should also be reviewed by Millennia if changes occur in structure locations, sizes, and types, or in the planned loads, elevations, grading plans, and project concepts.

These analyses and recommendations are based on data obtained from the borings performed for this study and other pertinent information presented herein. This report does not reflect any variations between, beyond, or below the borings. Should such variations become evident, it may be necessary to re-evaluate the recommendations of this report after performing on-site observation during the construction period and noting the characteristics of any such variation.

We appreciate this opportunity to be of service to you and would be pleased to discuss any aspect of this report with you at your convenience.

Sincerely,

Millennia Professional Services

Joseph L. Olson, P.E.
Senior Geotechnical Engineer

Date signed: 5/2/2025
License expires: 11/30/2025

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Appendix A

Vicinity Map, Figure 1
Type, Size and Location Plan w/ Boring Locations, Figure 2
Subsurface Profile, Figure 3

Millennia Professional Services

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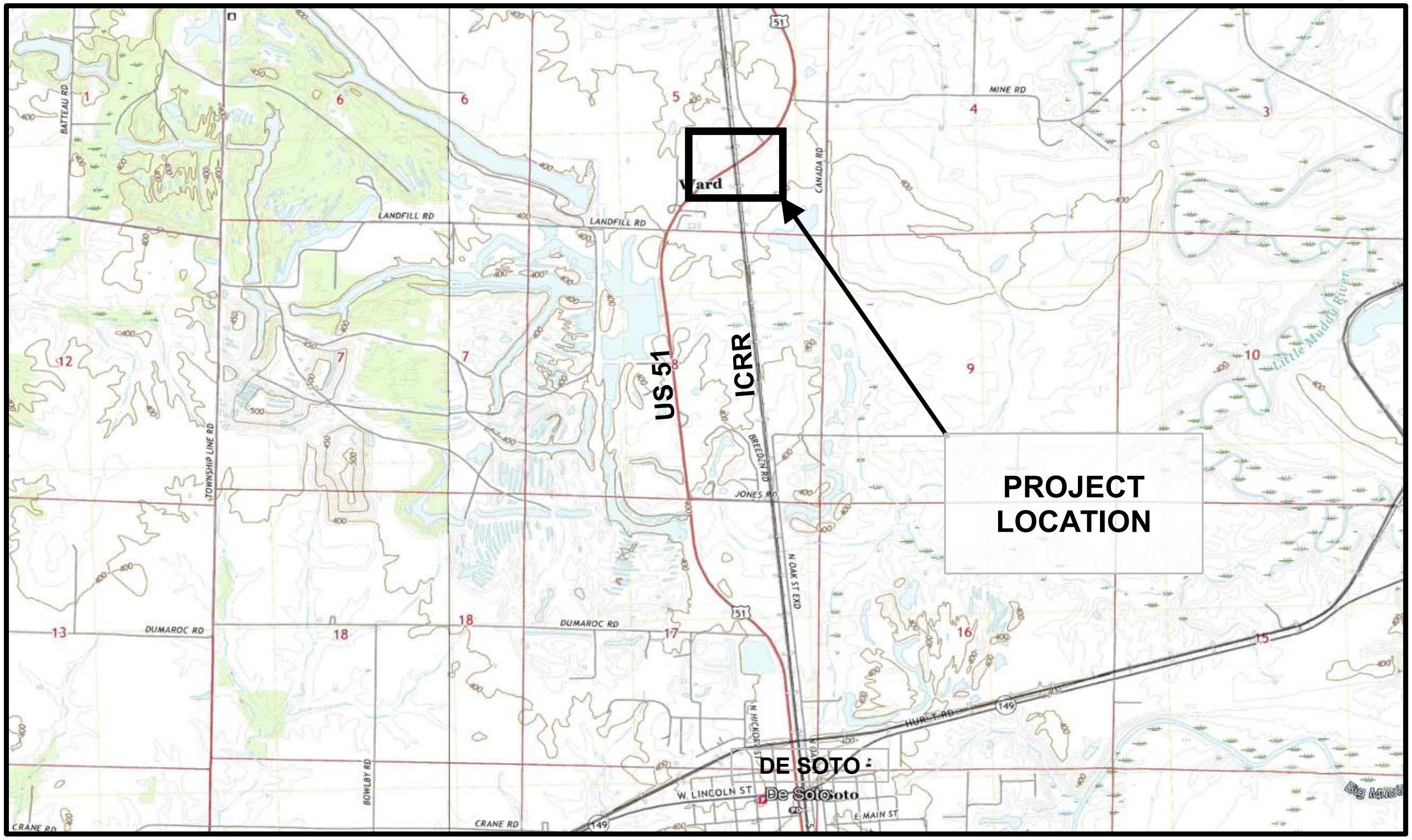


N	FIGURE 1: VICINITY MAP			
	US 51 over ICRR Jackson County, Illinois			
	Drawn by:	J. Stauffer	Checked by:	J. Olson
Image obtained from USGS TopoView *Not to scale	Project No.:	MG23035.12	Date:	1/22/2023

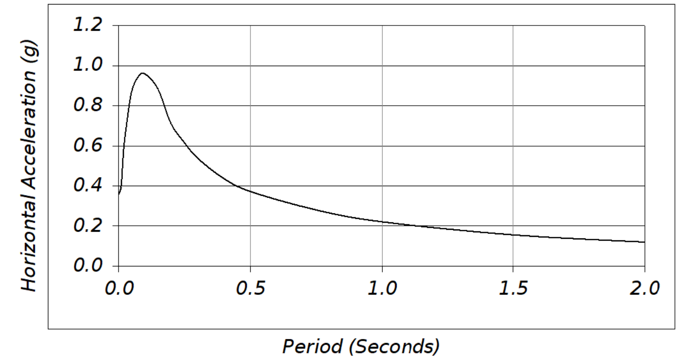
Bench Mark: Chiseled "square" on N.W. wingwall of S.N. 039-0052, Elev. 441.75

Existing Structure: SN 039-0052 was reconstructed in 1983 as F.A.P. Rte 322, Sect. 3VB-2. It is a three-span PPC deck-beam bridge supported by reinforced concrete stub abutments and hammerhead piers supported on steel H-Piles. The back-to-back abutment length is 151'-0" and the out-to-out deck width is 38'-0". The structure is skewed 29°37'40" left forward. Staged construction will be utilized to maintain traffic.

Salvage: None

SEISMIC DATA

2023 AASHTO Seismic Hazard
Site Class C
Latitude 37.85° N, Longitude 89.23° W
Operational Category: Recovery
Performance Level: Operational
SD1 = 0.221g
SDC B



HIGHWAY CLASSIFICATION

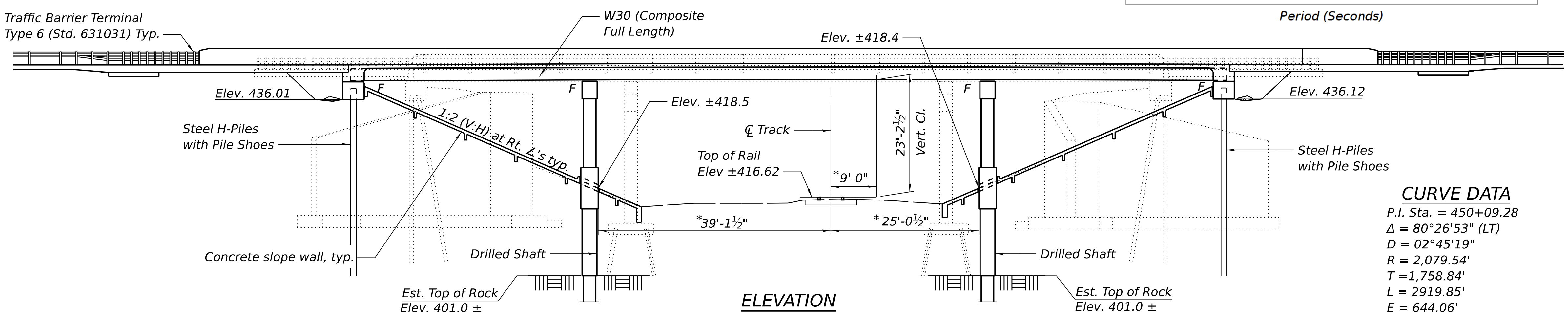
F.A.P. Rte. 322 - U.S. 51
Functional Class: Other Principal Arterial
ADT: 5,400 (2021); 6,860 (2045)
ADTT: 420 (2021); 530 (2045)
DHV: 615 (2045)
Design Speed: 60 m.p.h
Posted Speed: 55 m.p.h.
Two-Way Traffic
Directional Distribution: 50:50

LOADING HL-93

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

DESIGN SPECIFICATIONS

2020 AASHTO LRFD Bridge Design Specifications, 9th Edition
2023 AASHTO Guide Specifications for LRFD Seismic Bridge Design, 3rd Edition



ELEVATION

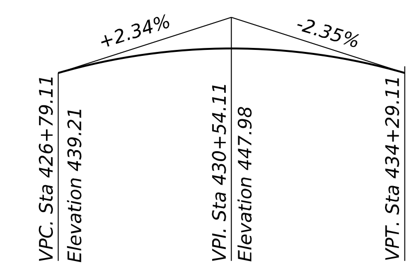
Looking North

* At Right Angle to Tracks

No freefall deck drains will be permitted in the span over the tracks or within 10 ft. of cross arms of a railroad pole line.

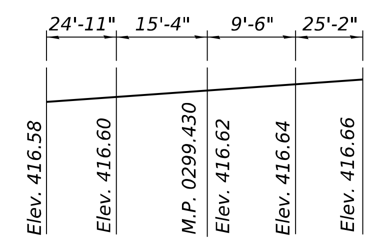
CURVE DATA

P.I. Sta. = 450+09.28
Δ = 80°26'53" (LT)
D = 02°45'19"
R = 2,079.54'
T =1,758.84'
L = 2919.85'
E = 644.06'
e = 5.0%
T.R. = 39.9'
S.E. Run = 133'
P.C. Sta. = 432+50.44
P.T. Sta. = 461+70.28
S.E. Attained from Sta. 431+44.04 to Sta. 433+16.94



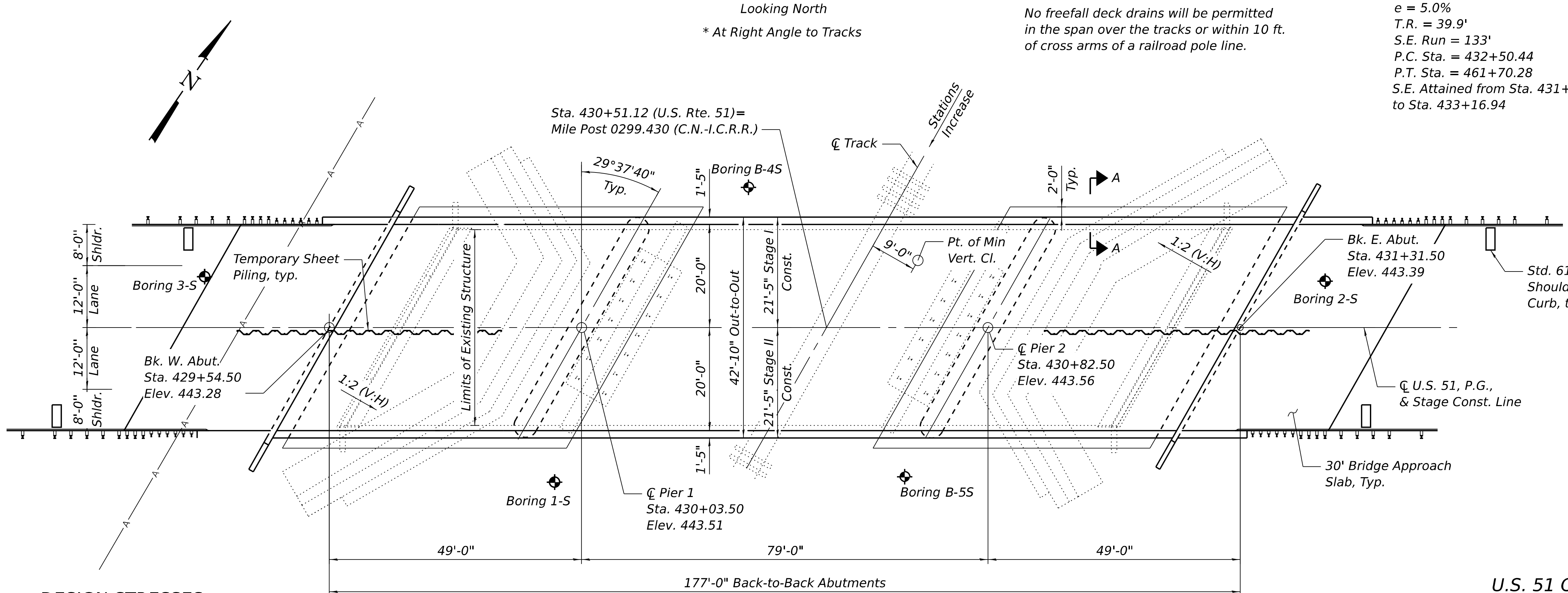
PROFILE GRADE

(Along ℄ F.A.P. Rte. 322)

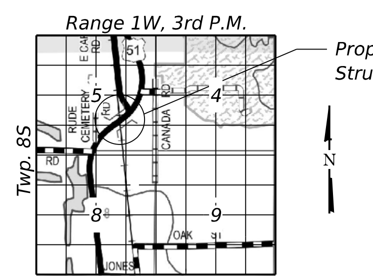


PROFILE GRADE

(Looking West)
Top of Rail C.N.I.C. Railroad



PLAN



LOCATION SKETCH

DESIGN STRESSES

FIELD UNITS

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

Note:
All structural steel shall be galvanized

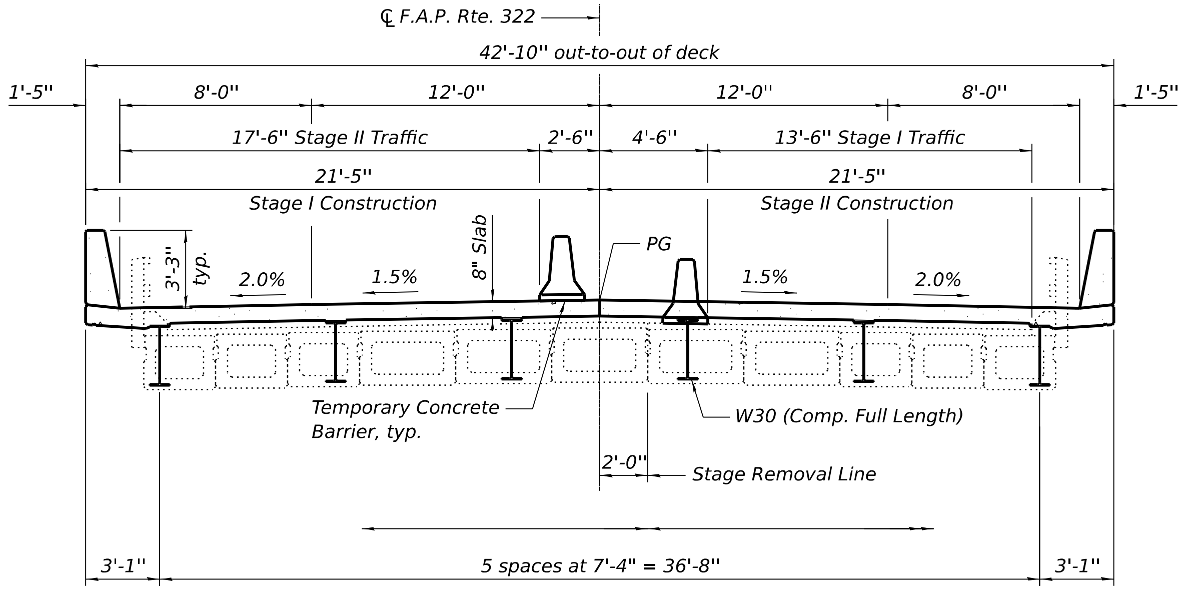
GENERAL PLAN & ELEVATION
U.S. 51 OVER CANADIAN NATIONAL-ILL. CENTRAL R.R.
F.A.P. RTE 322 - SEC. 3VB-3
JACKSON COUNTY
STA. 430+51.12
STRUCTURE NO. 039-0084

MODEL: Default
FILE NAME: P:\2022\220197\A - US 51 over ICRR Bridge Replacement (Phase I)\4 CADD - DWG\4.4 Struc\TSL\0390084-78937-001-TSL.dgn

TWM, INC. WWW.TWM-INC.COM IL DESIGN FIRM LICENSE NO: 184-001220	USER NAME =	DESIGNED - TCS	REVISED -	STATE OF ILLINOIS DEPARTMENT OF TRANSPORTATION	GENERAL PLAN & ELEVATION STRUCTURE NO. 039-0084
ENGINEERING GEOSPATIAL SERVICES		CHECKED - BWP	REVISED -		
	PLOT SCALE =	DRAWN - TCS	REVISED -		
	PLOT DATE =	CHECKED - BWP	REVISED -		SHEET 1 OF 2 SHEETS

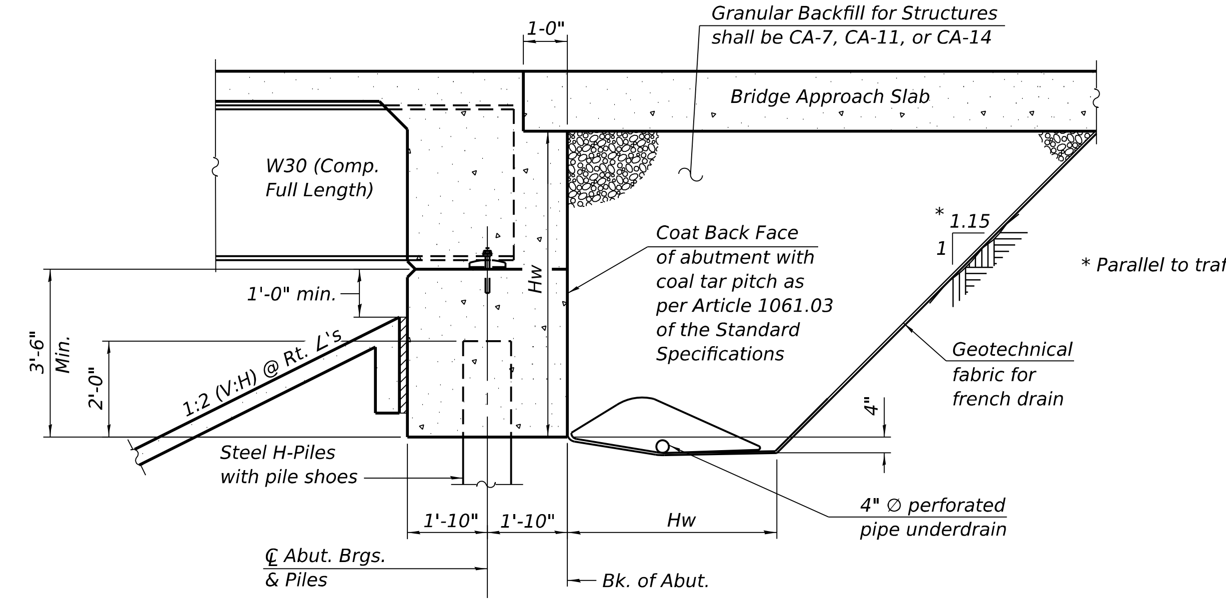
F.A.P. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
322	3VB-3	JACKSON		
		CONTRACT NO. 78937		
	ILLINOIS	FED. AID PROJECT		

2/15/2024 4:24:50 PM



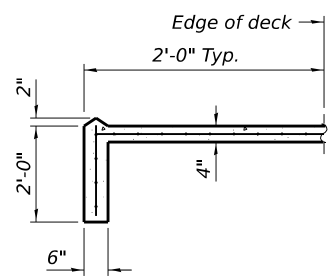
CROSS SECTION

(Looking East)

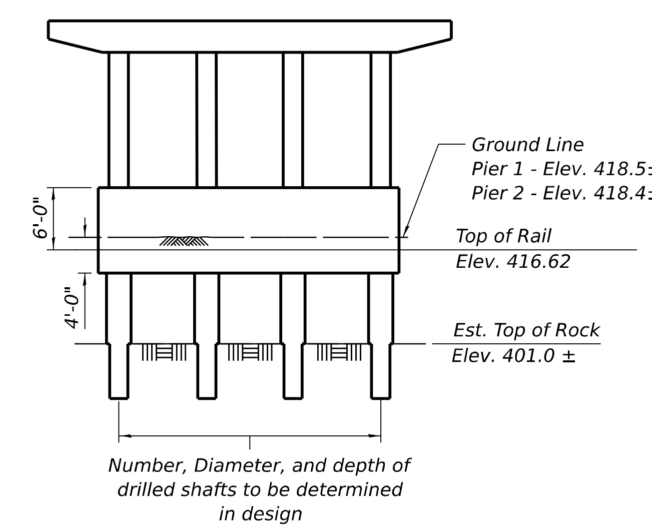


SECTION THRU INTEGRAL ABUTMENT

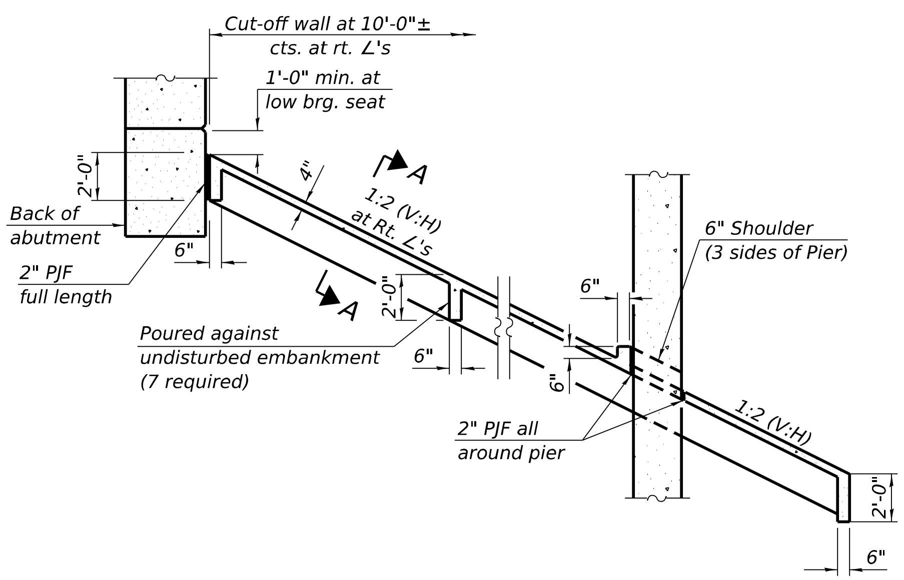
(Horiz. dim. at Rt. ∠'s)



SECTION A-A



PIER SKETCH



SECTION THRU CONCRETE SLOPEWALL

DETAILS

U.S. 51 OVER CANADIAN NATIONAL - ILL. CENTRAL R.R.

F.A.P. RTE 322 - SEC. 3VB-3

JACKSON COUNTY

STA. 430+51.12

STRUCTURE NO. 039-0084

TWM, INC. WWW.TWM-INC.COM ENGINEERING GEOSPATIAL SERVICES IL DESIGN FIRM LICENSE NO: 184-001220

USER NAME =	DESIGNED - TCS	REVISED -	
	CHECKED - BWP	REVISED -	
PLOT SCALE =	DRAWN - TCS	REVISED -	
PLOT DATE =	CHECKED - BWP	REVISED -	

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

DETAILS
STRUCTURE NO. 039-0084

SHEET 2 OF 2 SHEETS

F.A.P. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
322	3VB-3	JACKSON		
		CONTRACT NO. 78937		
		ILLINOIS	FED. AID PROJECT	

MODEL: Default
FILE NAME: P:\2022\220197\A - US 51 over ICRR Bridge Replacement (Phase I)\4 CADD - DWG\4.4 Struc\TSL\0390084-78937-002-Cross Section.dgn

2/15/2024 3:52:57 PM

MILLENNIA PROFESSIONAL SERVICES
www.millennia.pro

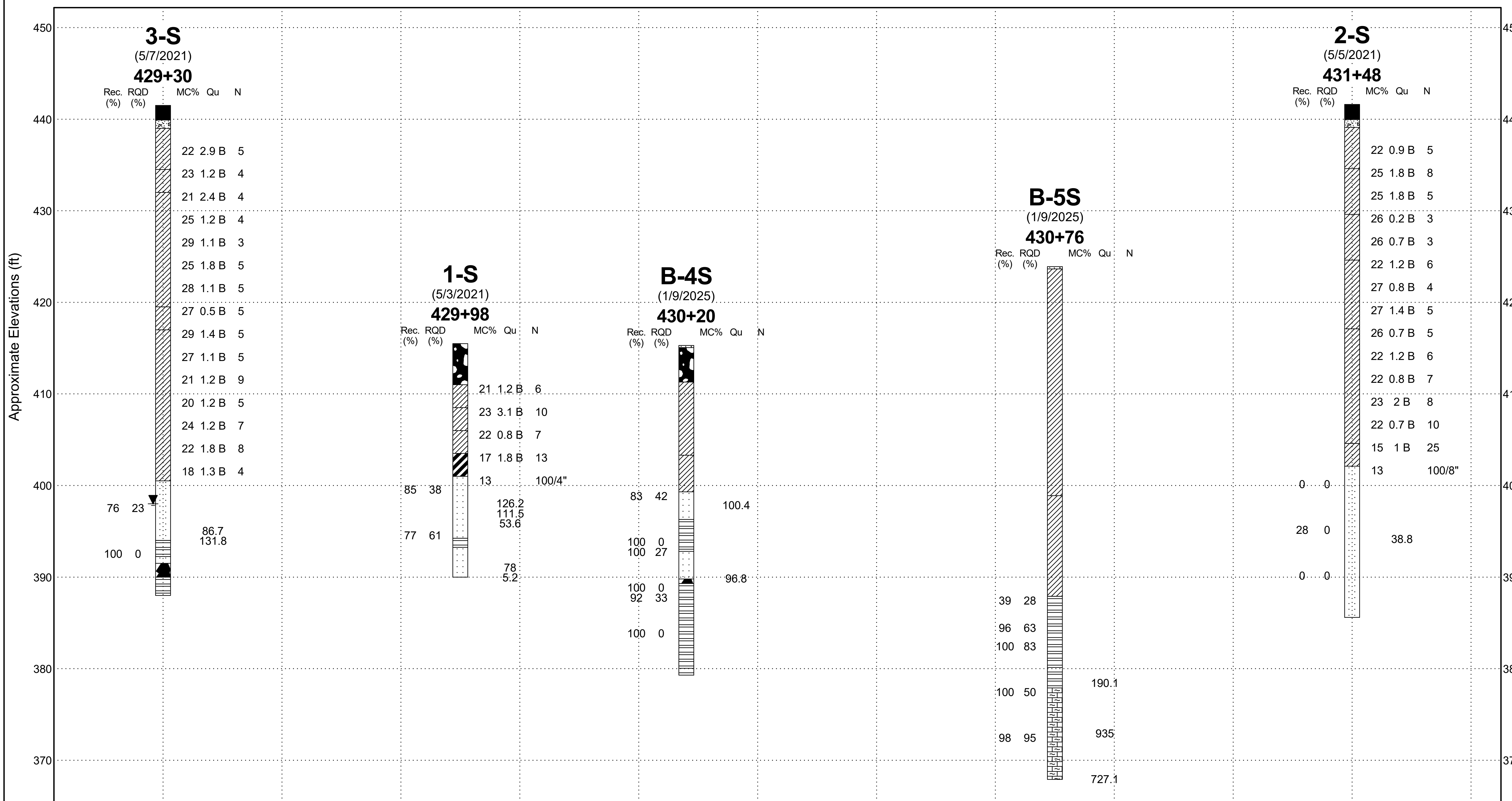
COUNTY	Jackson
SECTION	3VB-2 (Ex.)
ROUTE	US 51
MPS PROJECT NO.	24067.02

SUBSURFACE PROFILE

FIGURE 3

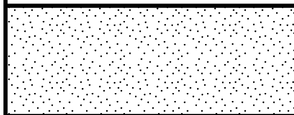
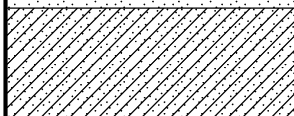
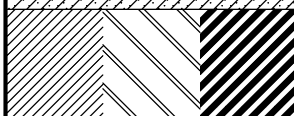
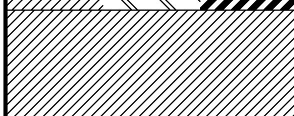
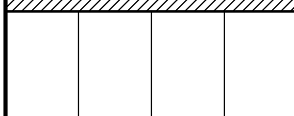
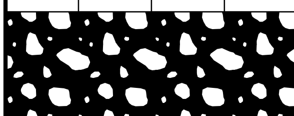
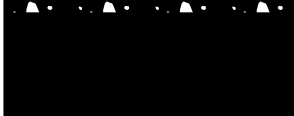
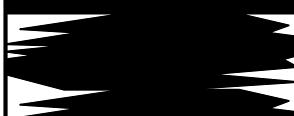
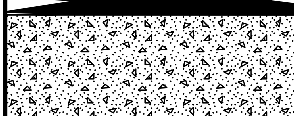
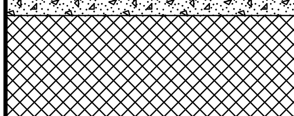
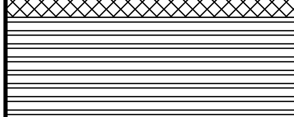
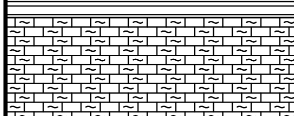
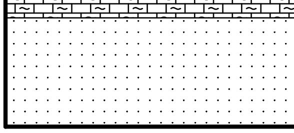
LEGEND
EL = Elevation (ft)
D = Depth Below Existing Ground Surface (ft)
N = SPT N-Value (AASHTO T206)
Qu = Unconfined compressive Strength (tsf)
Failure Mode (B= Bulge, S= shear, P= penetrometer)
MC% = Moisture Content Percentage

WATER TABLE LEGEND
▼ = First Encountered
▽ = Upon Completion
▽ = After __ hours



Horizontal Scale for Reference Only. Actual Conditions Between and Below Borings are Unknown, and are Subject to Change. "Material Graphics Key" is Attached for Reference.

MATERIAL GRAPHICS KEY

GRAPHIC SYMBOLS	TYPICAL DESCRIPTIONS
	SAND, LOAMY SAND
	SANDY CLAY, SANDY CLAY LOAM, SANDY LOAM
	CLAY (low to high plasticity, if applicable)
	CLAY LOAM, SILTY CLAY SILTY CLAY LOAM
	SILT, SILT LOAM
	AGGREGATE FILL
	ASPHALT
	COAL
	CONCRETE
	EXISTING FILL, POSSIBLE FILL
	SHALE, WEATHERED SHALE, CLAY SHALE
	LIMESTONE, WEATHERED LIMESTONE
	SANDSTONE, WEATHERED SANDSTONE

NOTE: CONDITIONS BETWEEN AND BELOW BORINGS ARE UNKNOWN. MATERIAL CLASSIFICAITONS ARE BASED UPON BORINGS PERFORMED FOR THIS SURVEY, AND ARE SUBJECT TO CHANGE.

Appendix B

Boring Logs

Illinois Department of Transportation
Division of Highways
District 9

SOIL BORING LOG

Date 5/3/21

ROUTE US 51 **DESCRIPTION** US 51 over ICRR **LOGGED BY** L. Estel

SECTION 3VB-2 (Ex.) **LOCATION** 3 mi. N of Desoto (near Ex. Pier #1), **SEC.** 5, **TWP.** 8S, **RNG.** 1W, **PM**

COUNTY Jackson **DRILLING METHOD** Hollow Stem Auger (8" O.D., 3.25" I.D.) **HAMMER TYPE** Auto SPT 140 lb (HE = 86.5%)

STRUCT. NO. 039-0052
Station 430+42.72

BORING NO. 1-S
Station 429+98
Offset 30.0ft Rt
Ground Surface Elev. 415.5 ft

Surface Water Elev. ft
Stream Bed Elev. ft

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

Description	Elev.	DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)
Track Ballast Aggregate	411.00				
Stiff Brown and mottled dark Brown, Moist SILTY CLAY		-5	1		
			2	1.2	21
			4	B	
V. Stiff Brown, Moist SILTY CLAY	408.50		2		
			4	3.1	23
			6	B	
M. Stiff Brown, Moist SILTY CLAY	406.00	-10	1		
			3	0.8	22
			4	B	
Stiff Brown, Moist CLAY with rounded Pebbles	403.50		2		
			5	1.8	17
			8	B	
Hard Brown, Dry SANDSTONE	401.00	-15	100/4"		
					13
Borehole continued with rock coring.					
		-20			

Bottom of hole @ 25.5 ft

No free water encountered

To Convert "N" values to "N60", multiply by 1.44; Hammer

Efficiency = 86.5%

Ground surface elevation referenced to BM 039-0052, Cut Square on NW Hub Guard SN 039-0052; EL. 441.75

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer, E-Estimated)
Abbreviations W.O.H - Sampler Advanced By Weight of Hammer, W.O.P - Advanced by Weight of Pipe, B.S. - Before Seating
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)

File Name S:\MATERIALS GEOTECHNICAL UNIT\GINT\PROJECTS\PROJECTS FILE\JACKSON\STRUCTURES\039-0052 US 51 OVER ICRR.GPJ Data Template D6TEMPLT.GDT Date Printed 1/12/22
Latitude 37 51 08.36 Longitude -89 13 54.37 Datum NAD83 Job Number

Illinois Department of Transportation
Division of Highways
District 9

ROCK CORE LOG

Date 5/3/21

ROUTE US 51 **DESCRIPTION** US 51 over ICRR **LOGGED BY** L. Estel

SECTION 3VB-2 (Ex.) **LOCATION** 3 mi. N of Desoto (near Ex. Pier #1), **SEC.** 5, **TWP.** 8S, **RNG.** 1W, **PM**

COUNTY Jackson **CORING METHOD** Conventional rotary with polymer modified water

STRUCT. NO. 039-0052
Station 430+42.72

CORING BARREL TYPE & SIZE NV3 5FT NWJ

Core Diameter 2 **in**
Top of Rock Elev. 401.00 **ft**
Begin Core Elev. 400.00 **ft**

BORING NO. 1-S
Station 429+98
Offset 30.0ft Rt
Ground Surface Elev. 415.5 **ft**

Description	Elev.	DEPTH (ft)	CORE (#)	RECOVERY (%)	R.Q.D. (%)	CORE TIME (min/ft)	STRENGTH (tsf)
Hard Brown, Dry SANDSTONE (Field Hardness: Moderately Hard)			1	85	38	5	126.2 111.5 53.6
		-20					
Hard Brown, Dry SANDSTONE (Field Hardness: Moderately Hard)	394.25		2	77	61	5	
Hard Grey, Dry CLAY SHALE (Field Hardness: Low Hardness)	393.25						
Hard Brown, Dry SANDSTONE (Field Hardness: Moderately Hard)	390.00	-25					78 5.2
Bottom of hole @ 25.5 ft Ground surface elevation referenced to BM 039-0052, Cut Square on NW Hub Guard SN 039-0052; EL. 441.75		-30 -35					

Color pictures of the cores Yes, attached
Cores will be stored for examination until 5 years after construction
The "Strength" column represents the uniaxial compressive strength of the core sample (ASTM D-2938)
RQD is the ratio of the total length of sound core specimens >4" to total length of core run

BBS, form 138 (Rev. 8-99)

Illinois Department of Transportation
District Nine Materials
Unconfined Compressive Strength

US 51
Jackson Co. 039-0052
Boring 1-S
5-3-21 Lab # 016

15.5'

Boring #	Specimen#	Thickness	L/D ratio	Depth	Unconfined Reading	Compressive Str (psi)
1-S	1	4.0”	2.25:1	17’	4,360	1,753 psi
1-S	2	4.0”	2.25:1	17.25’	3,850	1,548 psi
1-S	3	3.9”	2.19:1	18’	1,850	744 psi
1-S	4	3.8”	2.13:1	24’	2,695	1,084 psi
1-S	5	3.2”	*1.80:1	24.5’	180	72 psi

*Desirable specimen length to diameter ratios are between 2.0:1 and 2.5:1. The results may differ from results obtained from a test specimen that meets the requirements.

Foundation Core Instructions
for the diameter
(Pounds divided by 2.487)=psi

Use 1.78"

$$\frac{\pi d^2}{4} = 2.487$$

Illinois Department of Transportation
Division of Highways
District 9

SOIL BORING LOG

Date 5/5/21

ROUTE US 51 **DESCRIPTION** US 51 over ICRR **LOGGED BY** L. Estel

SECTION 3VB-2 (Ex.) **LOCATION** 3 mi. N of Desoto (near Ex. E. Abut.), **SEC.** 5, **TWP.** 8S, **RNG.** 1W, **PM**

COUNTY Jackson **DRILLING METHOD** Hollow Stem Auger (8" O.D., 3.25" I.D.) **HAMMER TYPE** Auto SPT 140 lb (HE = 86.5%)

STRUCT. NO. 039-0052
Station 430+42.72

BORING NO. 2-S
Station 431+48
Offset 9.0ft Lt
Ground Surface Elev. 441.6 ft

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

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

Description	Elev. (ft)	DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)
Cored Pavement, 19.75 in. HMA over 10 in. CONCRETE	439.10				
M. Stiff Tan/Brown, Moist SILTY CLAY		-5	1		
			2	0.9	22
	434.60		3	B	
Stiff Brown and mottled Red, Moist SILTY CLAY			1		
			4	1.8	25
			4	B	
		-10	1		
			2	1.8	25
	429.60		3	B	
V. Soft Grey, Moist SILTY CLAY			1		
			1	0.2	26
	427.10		2	B	
M. Stiff Grey, Moist SILTY CLAY		-15	WOH		
			1	0.7	26
	424.60		2	B	
Stiff Grey, Moist SILTY CLAY			1		
			2	1.2	22
	422.10		4	B	
		-20	1		

Description	Elev. (ft)	DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)
M. Stiff Grey with specks of Brown, Moist SILTY CLAY *(continued)*			1	0.8	27
	419.60		3	B	
Stiff Grey with specks of Brown, Moist SILTY CLAY			1		
			2	1.4	27
	417.10		3	B	
M. Stiff Brown, Moist SILTY CLAY		-25	1		
			2	0.7	26
	414.60		3	B	
Stiff Brown, Moist SILTY CLAY			1		
			3	1.2	22
	412.10		3	B	
M. Stiff Brown, Moist SILTY CLAY		-30	1		
			3	0.8	22
	409.60		4	B	
Stiff Brown, Moist SILTY CLAY			1		
			4	2.0	23
	407.10		4	B	
M. Stiff Brown, Moist SILTY CLAY		-35	2		
			4	0.7	22
	404.60		6	B	
M. Stiff Brown, Moist SILTY CLAY LOAM			2		
			10	1.0	15
	402.10		15	B	
		-40	100/8"		

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer, E-Estimated)
Abbreviations W.O.H - Sampler Advanced By Weight of Hammer, W.O.P - Advanced by Weight of Pipe, B.S. - Before Seating
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)

File Name S:\MATERIALS GEOTECHNICAL UNIT\GINT\PROJECTS\PROJECTS FILE\JACKSON\STRUCTURES\039-0052 US 51 OVER ICRR.GPJ Data Template D6TEMPLT.GDT Date Printed 1/13/22
Latitude 37 51 09.51 Longitude -89 13 53.12 Datum NAD83 Job Number

Illinois Department of Transportation
Division of Highways
District 9

SOIL BORING LOG

Date 5/5/21

ROUTE US 51 **DESCRIPTION** US 51 over ICRR **LOGGED BY** L. Estel

SECTION 3VB-2 (Ex.) **LOCATION** 3 mi. N of Desoto (near Ex. E. Abut.), **SEC.** 5, **TWP.** 8S, **RNG.** 1W, **PM**

COUNTY Jackson **DRILLING METHOD** Hollow Stem Auger (8" O.D., 3.25" I.D.) **HAMMER TYPE** Auto SPT 140 lb (HE = 86.5%)

STRUCT. NO. 039-0052
Station 430+42.72

BORING NO. 2-S
Station 431+48
Offset 9.0ft Lt
Ground Surface Elev. 441.6 ft

Surface Water Elev. ft
Stream Bed Elev. ft

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

Description	DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)
Hard Reddish Brown, Moist Weathered SANDSTONE 400.60				13
No free water encountered				
To Convert "N" values to "N60", multiply by 1.44; Hammer Efficiency = 86.5%				
Ground surface elevation referenced to BM 039-0052, Cut Square on NW Hub Guard SN 039-0052; EL. 441.75. *(continued)*	-45			
Borehole continued with rock coring.				
	-50			
	-55			
	-60			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer, E-Estimated)
Abbreviations W.O.H - Sampler Advanced By Weight of Hammer, W.O.P - Advanced by Weight of Pipe, B.S. - Before Seating
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
District 9

ROCK CORE LOG

Date 5/5/21

ROUTE US 51 **DESCRIPTION** US 51 over ICRR **LOGGED BY** L. Estel

SECTION 3VB-2 (Ex.) **LOCATION** 3 mi. N of Desoto (near Ex. E. Abut.), **SEC.** 5, **TWP.** 8S, **RNG.** 1W, **PM**

COUNTY Jackson **CORING METHOD** Conventional rotary with polymer modified water

STRUCT. NO. 039-0052
Station 430+42.72

BORING NO. 2-S
Station 431+48
Offset 9.0ft Lt
Ground Surface Elev. 441.6 ft

CORING BARREL TYPE & SIZE NV3 5FT NWJ

Core Diameter 2 in
Top of Rock Elev. 402.10 ft
Begin Core Elev. 400.60 ft

Description	Elev.	DEPTH (ft)	CORE (#)	RECOVERY (%)	R.Q.D. (%)	CORE TIME (min/ft)	STRENGTH (tsf)
Hard Reddish Brown, Dry SANDSTONE with CLAY SHALE Coring malfunction lead to poor recovery. See Borings 1-S & 3-S for additional foundation information.	400.60		1	0	0	10	
		-45					
			2	28	0	10	38.8
		-50					
			3	0	0	10	
		-55					
	385.60						
Bottom of hole @ 56.0 ft No free water encountered To Convert "N" values to "N60", multiply by 1.44; Hammer Efficiency = 86.5% Ground surface elevation referenced to BM 039-0052, Cut Square on NW Hub Guard SN 039-0052; EL. 441.75							
		-60					

Color pictures of the cores Yes, attached
Cores will be stored for examination until 5 years after construction
The "Strength" column represents the uniaxial compressive strength of the core sample (ASTM D-2938)
RQD is the ratio of the total length of sound core specimens >4" to total length of core run

Illinois Department of Transportation
District Nine Materials
Unconfined Compressive Strength

US 51
Jackson Co. 039-0052
Boring 2-S
5-5-21 Lab #17

Boring #	Specimen#	Thickness	L/D ratio	Depth	Unconfined Reading	Compression Str (psi)
2-S	1	3.0”	*1.7:1	46.5’	1,340	539

*Desirable specimen length to diameter ratios are between 2.0:1 and 2.5:1. The results may differ from results obtained from a test specimen that meets the requirements.

Foundation Core Instructions
for the diameter
(Pounds divided by 2.487)=psi

Use 1.78"

$$\frac{\pi d^2}{4} = 2.487$$

Illinois Department of Transportation
Division of Highways
District 9

SOIL BORING LOG

Date 5/7/21

ROUTE US 51 **DESCRIPTION** US 51 over ICRR **LOGGED BY** L. Estel

SECTION 3VB-2 (Ex.) **LOCATION** 3 mi. N of Desoto (near Ex. W. Abut.), **SEC.** 5, **TWP.** 8S, **RNG.** 1W, **PM**

COUNTY Jackson **DRILLING METHOD** Hollow Stem Auger (8" O.D., 3.25" I.D.) **HAMMER TYPE** Auto SPT 140 lb (HE = 86.5%)

STRUCT. NO. 039-0052
Station 430+42.72

BORING NO. 3-S
Station 429+30
Offset 10.0ft Lt
Ground Surface Elev. 441.5 ft

Surface Water Elev. ______ ft
Stream Bed Elev. ______ ft

Groundwater Elev.:
First Encounter 398.0 ft
Upon Completion ______ ft
After ____ **Hrs.** ______ ft

Description	Elev. (ft)	DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)
Cored Pavement, 19" HMA over 10.5" CONCRETE	439.00				
V. Stiff Brown, Moist SILTY CLAY		-5	1, 2, 3	2.9 B	22
	434.50				
Stiff Brown and Grey, Moist SILTY CLAY			1, 1, 3	1.2 B	23
	432.00				
V. Stiff Brown and Grey with specks of Red, Moist SILTY CLAY		-10	1, 1, 3	2.4 B	21
	429.50				
Stiff Brown with specks of Red, Moist CLAY			1, 1, 3	1.2 B	25
(Brown and Grey with specks of Red)		-15	1, 1, 2	1.1 B	29
(Brown with specks of Red)			WOH, 2, 3	1.8 B	25
	422.00	-20	1		

Description	Elev. (ft)	DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)
Stiff Grey with streaks of Black, Moist SILTY CLAY *(continued)*			2, 3	1.1 B	28
	419.50				
M. Stiff Grey, Moist with V. Moist SILTY CLAY			1, 2, 3	0.5 B	27 & 37
	417.00				
Stiff Grey with specks of Brown, Moist SILTY CLAY		-25	1, 2, 3	1.4 B	29
			1, 2, 3	1.1 B	27
(Brown)		-30	1, 4, 5	1.2 B	21
(Brown and Grey with specks of Black)			1, 2, 3	1.2 B	20
(Brown with streaks of Black)		-35	1, 3, 4	1.2 B	24
			1, 3, 5	1.8 B	22
		-40	1		

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer, E-Estimated)
Abbreviations W.O.H - Sampler Advanced By Weight of Hammer, W.O.P - Advanced by Weight of Pipe, B.S. - Before Seating
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
District 9

SOIL BORING LOG

Date 5/7/21

ROUTE US 51 **DESCRIPTION** US 51 over ICRR **LOGGED BY** L. Estel

SECTION 3VB-2 (Ex.) **LOCATION** 3 mi. N of Desoto (near Ex. W. Abut.), **SEC.** 5, **TWP.** 8S, **RNG.** 1W, **PM**

COUNTY Jackson **DRILLING METHOD** Hollow Stem Auger (8" O.D., 3.25" I.D.) **HAMMER TYPE** Auto SPT 140 lb (HE = 86.5%)

STRUCT. NO. 039-0052
Station 430+42.72

BORING NO. 3-S
Station 429+30
Offset 10.0ft Lt
Ground Surface Elev. 441.5 ft

Surface Water Elev. ft
Stream Bed Elev. ft

Groundwater Elev.:
▽ **First Encounter** 398.0 ft
▼ **Upon Completion** ft
▼ **After** Hrs. ft

Description	DEPTH (ft)	BLOWS	UCS Qu (tsf)	MOIST (%)
(Brown with streaks of Black) *(continued)* 400.50		2 2	1.3 B	18
Hard Brownish Red, Dry Weathered SANDSTONE				
Bottom of hole @ 53.5 ft				
To Convert "N" values to "N60" multiply by 1.44; Hammer Efficiency = 86.5%	▽ 398.00			
Ground surface elevation referenced to BM 039-0052, Cut Square on NW Hub Guard SN 039-0052; EL. 441.75.	-45			
Borehole continued with rock coring.				
	-50			
	-55			
	-60			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer, E-Estimated)
Abbreviations W.O.H - Sampler Advanced By Weight of Hammer, W.O.P - Advanced by Weight of Pipe, B.S. - Before Seating
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
District 9

ROCK CORE LOG

Date 5/7/21

ROUTE US 51 **DESCRIPTION** US 51 over ICRR **LOGGED BY** L. Estel

SECTION 3VB-2 (Ex.) **LOCATION** 3 mi. N of Desoto (near Ex. W. Abut.), **SEC.** 5, **TWP.** 8S, **RNG.** 1W, **PM**

COUNTY Jackson **CORING METHOD** Conventional rotary with polymer modified water

STRUCT. NO. 039-0052
Station 430+42.72

BORING NO. 3-S
Station 429+30
Offset 10.0ft Lt
Ground Surface Elev. 441.5 ft

CORING BARREL TYPE & SIZE NV3 5FT NWJ

Core Diameter 2 in
Top of Rock Elev. 400.50 ft
Begin Core Elev. 398.00 ft

Description	Elev.	DEPTH (ft)	CORE (#)	RECOVERY (%)	R.Q.D. (%)	CORE TIME (min/ft)	STRENGTH (tsf)
Hard Brownish Red, Dry SANDSTONE (Field Hardness: Moderately Hard)	398.00		1	76	23	10	
		-45					86.7
	394.00						131.8
Hard Grey, Dry CLAY SHALE (Field Hardness: Low)							
			2	100	0	10	
	392.25						
Hard Brown, Dry SANDSTONE (Field Hardness: Low)							
	391.50	-50					
Hard Black, Dry COAL							
	390.00						
Hard Grey, Dry CLAY SHALE (Field Hardness: Low)							
	388.00						
		-55					
Bottom of hole @ 53.5 ft							
Ground surface elevation referenced to BM 039-0052, Cut Square on NW Hub Guard SN 039-0052; EL. 441.75.							
		-60					

Color pictures of the cores Yes, attached
Cores will be stored for examination until 5 years after construction
The "Strength" column represents the uniaxial compressive strength of the core sample (ASTM D-2938)
RQD is the ratio of the total length of sound core specimens >4" to total length of core run

Illinois Department of Transportation
District Nine Materials
Unconfined Compressive Strength

US 51
Jackson Co. 039-0052
Boring 3-S
5-7-21 Lab #18

Boring #	Specimen#	Thickness	L/D ratio	Depth	Unconfined Reading	Compression Str (psi)
3-S	1	3.4”	*1.9:1	45.5’	2,995	1,204
3-S	2	3.8”	2.1:1	47.0’	4,550	1,830

*Desirable specimen length to diameter ratios are between 2.0:1 and 2.5:1. The results may differ from results obtained from a test specimen that meets the requirements.

Foundation Core Instructions
for the diameter
(Pounds divided by 2.487)=psi

Use 1.78"

$$\frac{\pi d^2}{4} = 2.487$$

Illinois Department of Transportation
Division of Highways
Terracon

SOIL BORING LOG

Date 1/9/25

ROUTE US 51 **DESCRIPTION** Structure Over ICRR **LOGGED BY** KEG

SECTION 3VB-3 **LOCATION** 3 mi N of Desoto, Lat. 37.8525 Long. -89.2318, **SEC.** 5, **TWP.** 8S, **RNG.** 1W

COUNTY Jackson **DRILLING METHOD** SSA + NQ2 Rock Coring @ 16ft **HAMMER TYPE**

STRUCT. NO. 039-0052
Station 430+42.72

BORING NO. B-4S
Station 430+20
Offset 28.0 ft LT
Ground Surface Elev. 415.30 ft

Surface Water Elev. ft
Stream Bed Elev. ft

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

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
TOPSOIL, approximately 3 inches	415.05				
Track Ballast Aggregate	411.30				
Brown SILTY CLAY trace sand		-5			
		-10			
	403.30				
Brown SILTY CLAY with gravel		-15			
	399.30				
Brown, SANDSTONE, Fine Grained (Field Hardness: Moderately Hard) Borehole continued with rock coring Bottom of hole @ 36 feet No free water encountered		-20			

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Elevation referenced to BM 039-0052, EL. 441.75				
	-25			
	-30			
	-35			
End of Boring				
	-40			

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
District 9

ROCK CORE LOG

Date 1/9/25

ROUTE US 51 **DESCRIPTION** Structure over ICRR **LOGGED BY** KEG

SECTION 3VB-3 **LOCATION** 3 mi N of Desoto, Lat. 37.8525 Long. -89.2318, **SEC.** 5, **TWP.** 8S, **RNG.** 1W, **PM**

COUNTY Jackson **CORING METHOD** NQ2 Rock Coring

STRUCT. NO. 039-0052
Station 430+42.72

BORING NO. B-4S
Station 430+20
Offset 28.0ft LT
Ground Surface Elev. 415.3 ft

CORING BARREL TYPE & SIZE ______

Core Diameter 2 in
Top of Rock Elev. 399.30 ft
Begin Core Elev. 399.30 ft

Description	Elev.	DEPTH (ft)	CORE (#)	RECOVERY (%)	R.Q.D. (%)	CORE TIME (min/ft)	STRENGTH (tsf)
Brown, SANDSTONE, Fine Grained (Field Hardness: Moderately Hard)	396.30		R-1	83	42		100.4
M. Stiff, Tan Clay	395.70						
Gray, CLAY SHALE (Field Hardness: Low Hardness)		-20					
			R-2	100	0		
	392.80		R-3	100	27		
Red Brown, SANDSTONE, Fine Grained (Field Hardness: Moderately Hard)	389.80	-25					96.8
Black, COAL	389.30						
Gray, SHALE (Field Hardness: Low Hardness)			R-4	100	0		
			R-5	92	33		
		-30					
			R-6	100	0		
Bottom of hole @ 36 feet		-35					
Elevation referenced to BM 039-0052, EL. 441.75 End of Boring	379.30						

Color pictures of the cores Yes
Cores will be stored for examination until 5 years
The "Strength" column represents the uniaxial compressive strength of the core sample (ASTM D-2938)
RQD is the ratio of the total length of sound core specimens >4" to total length of core run

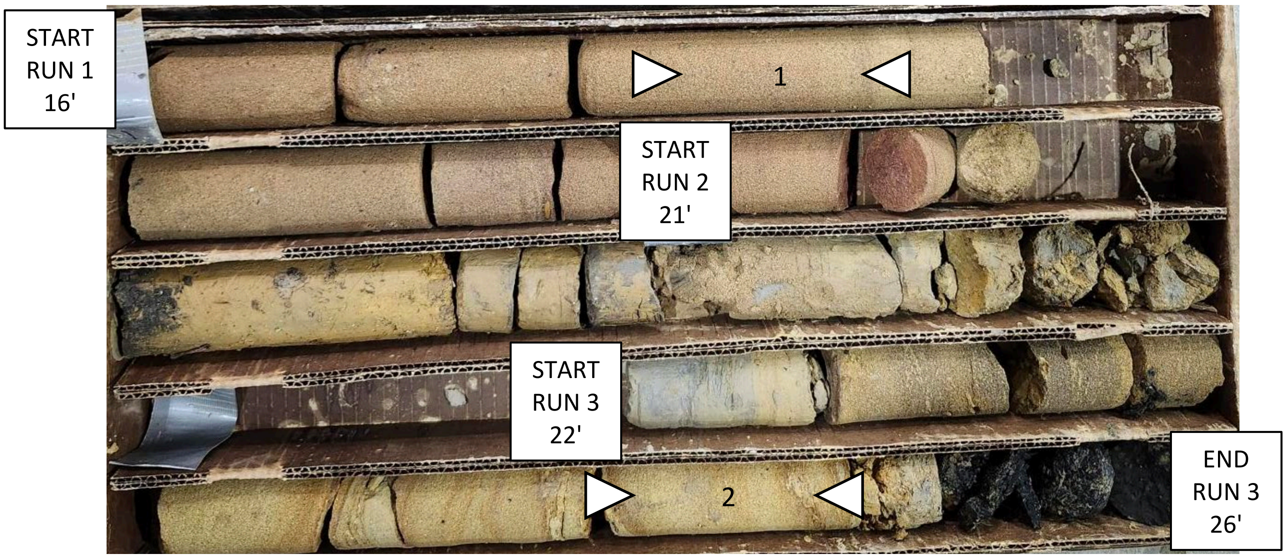
BBS, form 138 (Rev. 8-99)

Illinois Department of Transportation

District Nine Materials

Unconfined Compressive Strength

Route:	US 51 over Canadian National-ICRR	**Lab#:**	
County:	Jackson County	**Date Drilled:**	1/21/2025
Structure:	039-0052	**Boring:**	B-4S



Boring	Specimen #	Thickness (in.)	L/D Ratio	Depth	Load (lbs)	USC (psi)
B-4S	1	4.08	2.1	17	4,230	1,395
B-4S	2	3.31	1.7	25	4,180	1,344

*Desirable specimen length to diameter (L/D) ratios are between 2.0:1 and 2.5:1. The results may differ from results obtained from a test specimen that meets the requirements.

Illinois Department of Transportation
District Nine Materials
Unconfined Compressive Strength

Route:	US 51 over Canadian National-ICRR	**Lab#:**	
County:	Jackson County	**Date Drilled:**	1/9/2025
Structure:	039-0052	**Boring:**	B-4S Continued

Boring	Specimen #	Thickness (in.)	L/D Ratio	Depth	Load (lbs)	USC (psi)

*Desirable specimen length to diameter (L/D) ratios are between 2.0:1 and 2.5:1. The results may differ from results obtained from a test specimen that meets the requirements.

Illinois Department of Transportation
Division of Highways
Terracon

SOIL BORING LOG

Date 1/9/25

ROUTE US 51 DESCRIPTION Structure over ICRR LOGGED BY KEG

SECTION 3VB-3 LOCATION 3 mi N of Desoto, Lat. 37.8524 Long. -89.2315, **SEC.** 5, **TWP.** 8S, **RNG.** 1W

COUNTY Jackson DRILLING METHOD SSA + NQ2 Rock Coring @ 36ft HAMMER TYPE

STRUCT. NO. 039-0052
Station 430+42.72

BORING NO. B-5S
Station 430+76
Offset 51.0 ft RT
Ground Surface Elev. 423.90 ft

Surface Water Elev. ft
Stream Bed Elev. ft

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

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
TOPSOIL, approximately 3 inches	423.65				
Brown SILTY CLAY trace sand					
		-5			
		-10			
		-15			
		-20			

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Brown SILTY CLAY trace sand *(continued)*	398.90	-25			
Brown SILTY CLAY with gravel					
		-30			
		-35			
	387.90				
Gray, SHALE (Field Hardness: Medium Hardness)					
Borehole continued with rock coring					
Bottom of hole @ 36 feet					
No free water encountered					
Elevation referenced to BM 039-0052, EL. 441.75		-40			

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
District 9

ROCK CORE LOG

Date 1/9/25

ROUTE US 51 **DESCRIPTION** Structure over ICRR **LOGGED BY** KEG

SECTION 3VB-3 **LOCATION** 3 mi N of Desoto, Lat. 37.8524 Long. -89.2315, **SEC.** 5, **TWP.** 8S, **RNG.** 1W, **PM**

COUNTY Jackson **CORING METHOD** NQ2 Rock Coring

STRUCT. NO. 039-0052
Station 430+42.72

BORING NO. B-5S
Station 430+76
Offset 51.0ft RT
Ground Surface Elev. 423.9 ft

CORING BARREL TYPE & SIZE

Core Diameter 2 in
Top of Rock Elev. 387.90 ft
Begin Core Elev. 387.90 ft

Description	Elev.	DEPTH (ft)	CORE (#)	RECOVERY (%)	R.Q.D. (%)	CORE TIME (min/ft)	STRENGTH (tsf)
Gray, SHALE (Field Hardness: Medium Hardness)			R-1	39	28		
		-40	R-2	96	63		
		-45	R-3	100	83		190.1
	377.90						
Gray, LIMESTONE (Field Hardness: Hard)		-50	R-4	100	50		935
		-55	R-5	98	95		727.1
Bottom of hole @ 36 feet Elevation referenced to BM 039-0052, EL. 441.75 End of Boring	367.90						

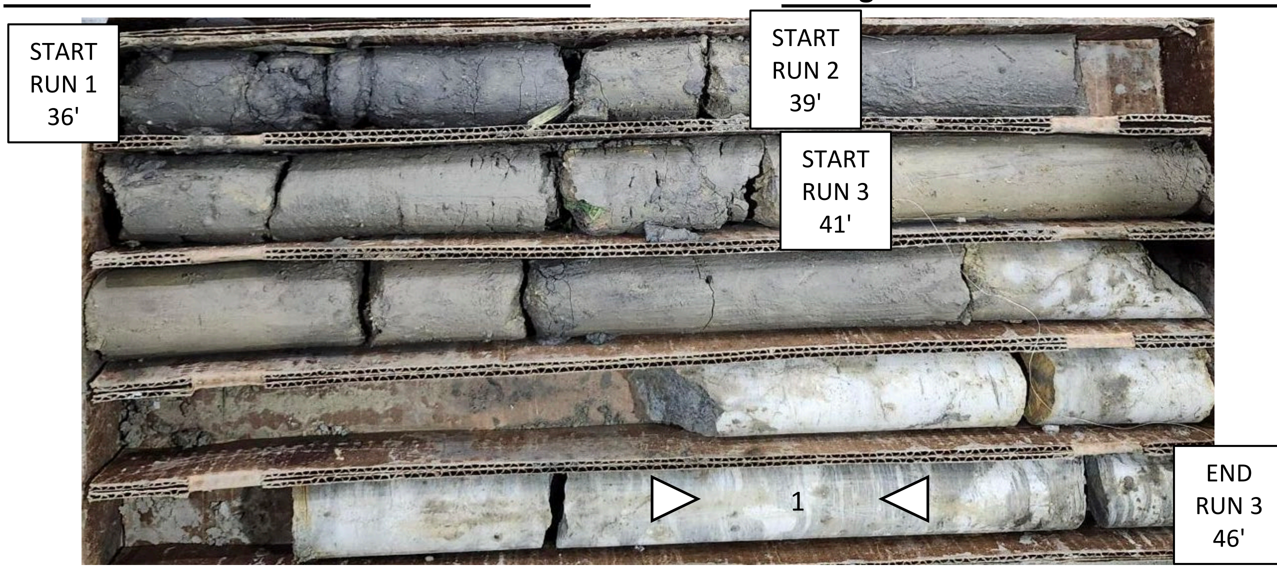
Color pictures of the cores Yes
Cores will be stored for examination until 5 years
The "Strength" column represents the uniaxial compressive strength of the core sample (ASTM D-2938)
RQD is the ratio of the total length of sound core specimens >4" to total length of core run

Illinois Department of Transportation

District Nine Materials

Unconfined Compressive Strength

Route:	US 51 over Canadian National-ICRR	**Lab#:**	
County:	Jackson County	**Date Drilled:**	1/10/2025
Structure:	039-0052	**Boring:**	B-5S



Boring	Specimen #	Thickness (in.)	L/D Ratio	Depth	Load (lbs)	USC (psi)
B-5S	1	3.48	1.8	45	8,210	2,640

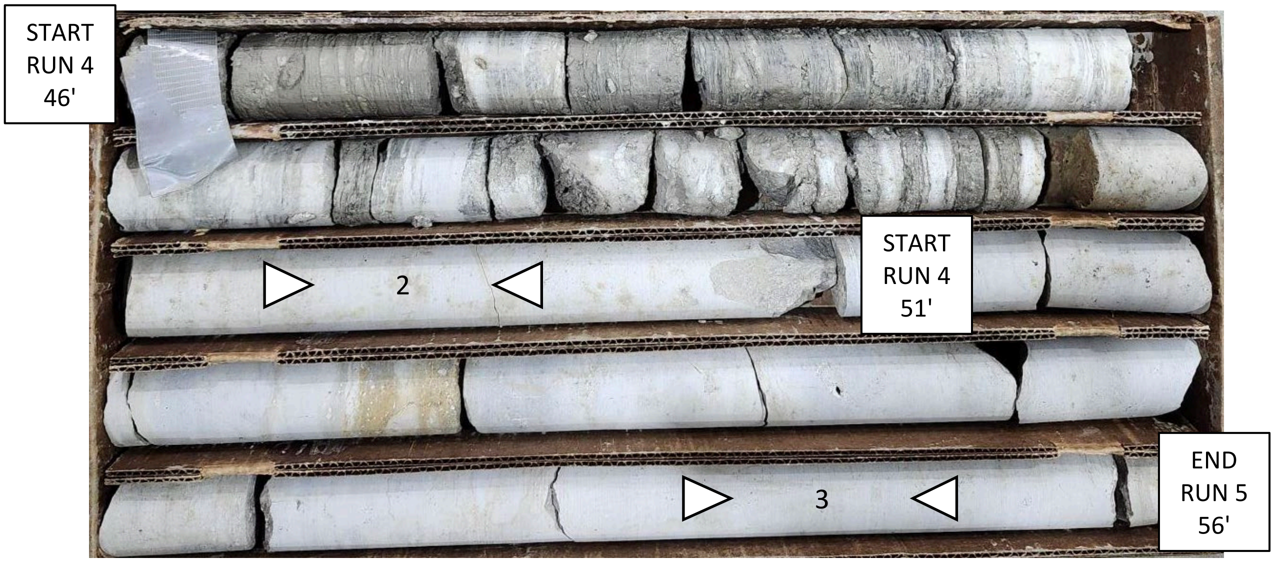
*Desirable specimen length to diameter (L/D) ratios are between 2.0:1 and 2.5:1. The results may differ from results obtained from a test specimen that meets the requirements.

Illinois Department of Transportation

District Nine Materials

Unconfined Compressive Strength

Route:	US 51 over Canadian National-ICRR	**Lab#:**	
County:	Jackson County	**Date Drilled:**	1/10/2025
Structure:	039-0052	**Boring:**	B-5S Continued



Boring	Specimen #	Thickness (in.)	L/D Ratio	Depth	Load (lbs)	USC (psi)
B-5S	2	4.37	2.2	50.5	40,390	12,986
B-5S	3	4.17	2.1	55.5	31,410	10,099

*Desirable specimen length to diameter (L/D) ratios are between 2.0:1 and 2.5:1. The results may differ from results obtained from a test specimen that meets the requirements.

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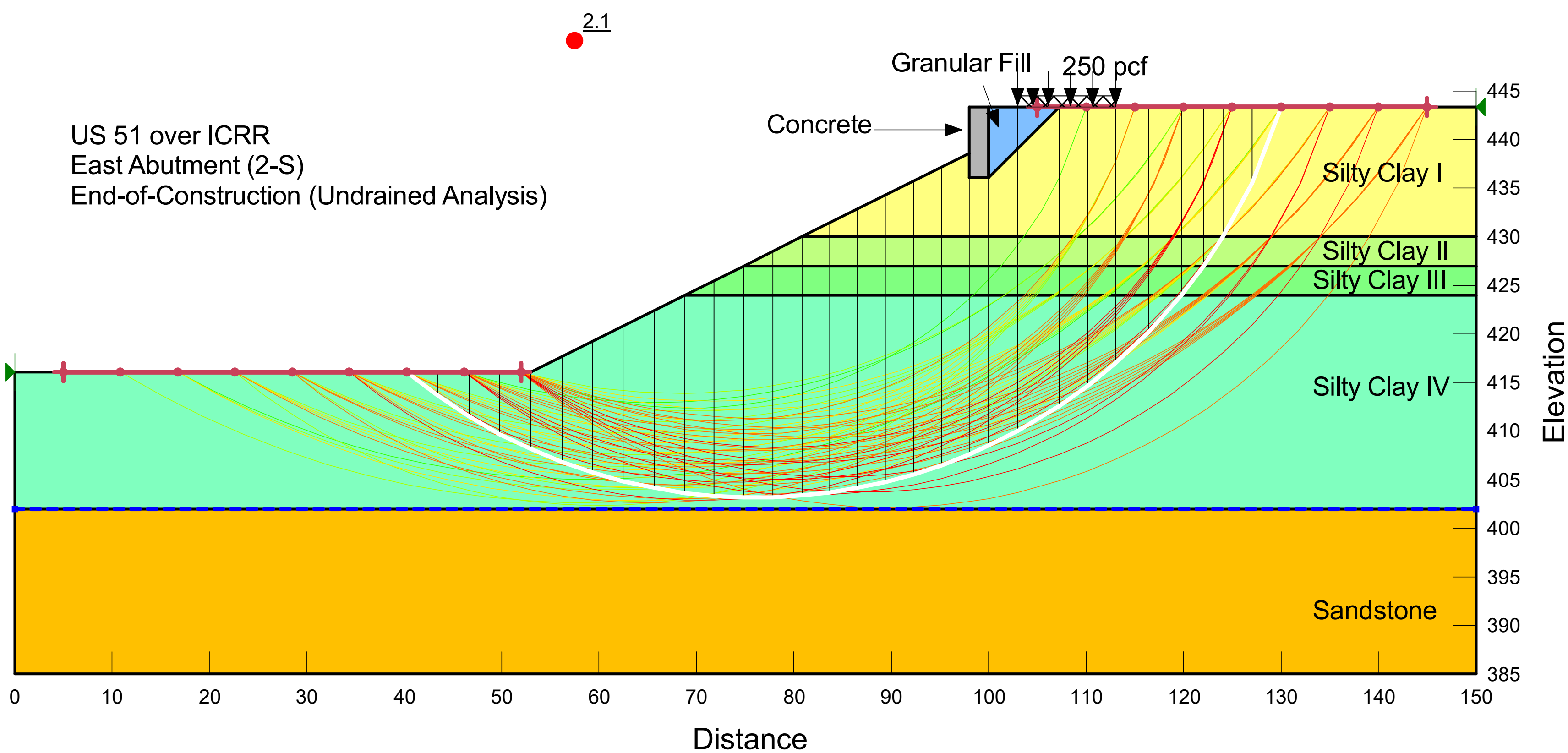
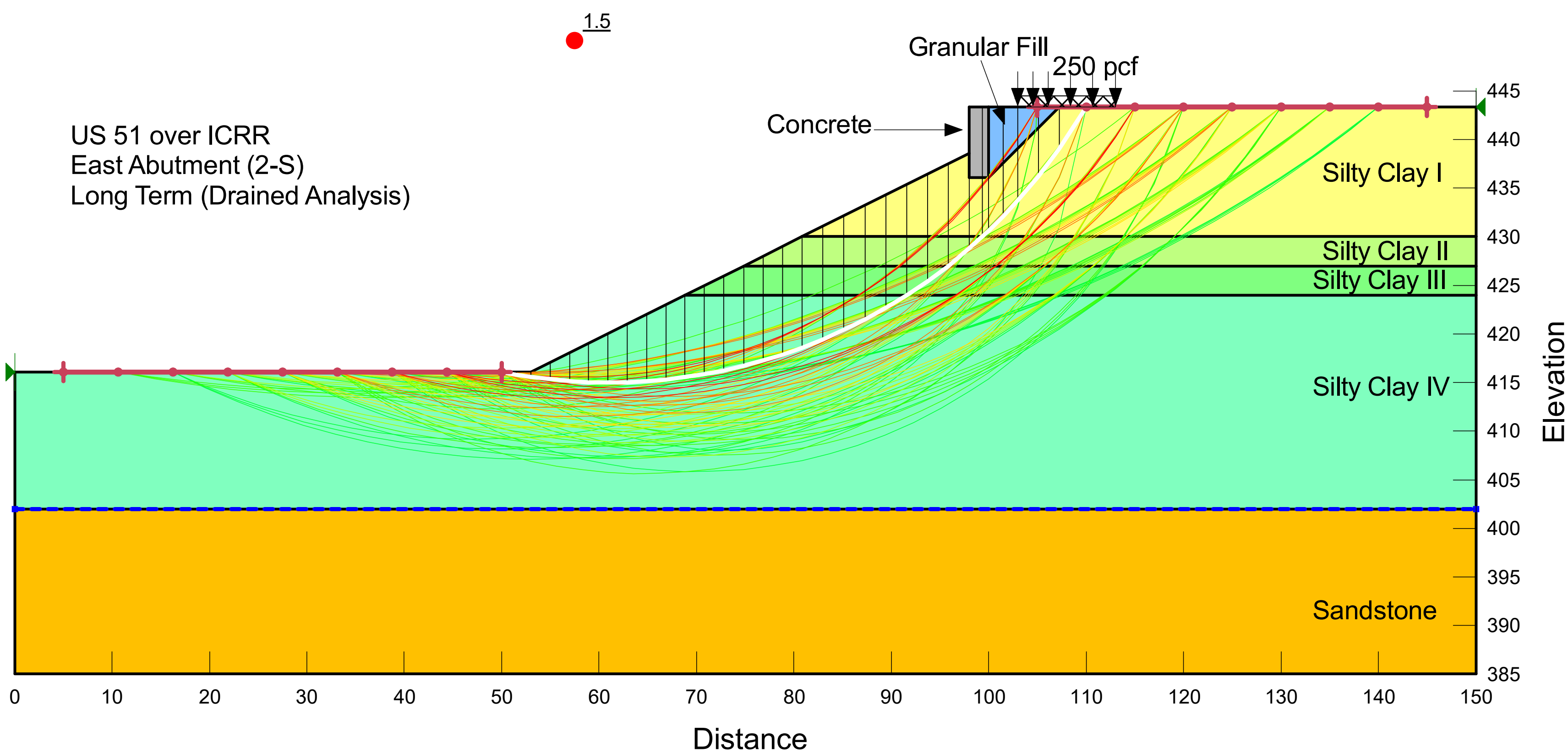
Appendix C

Slope Stability Profiles

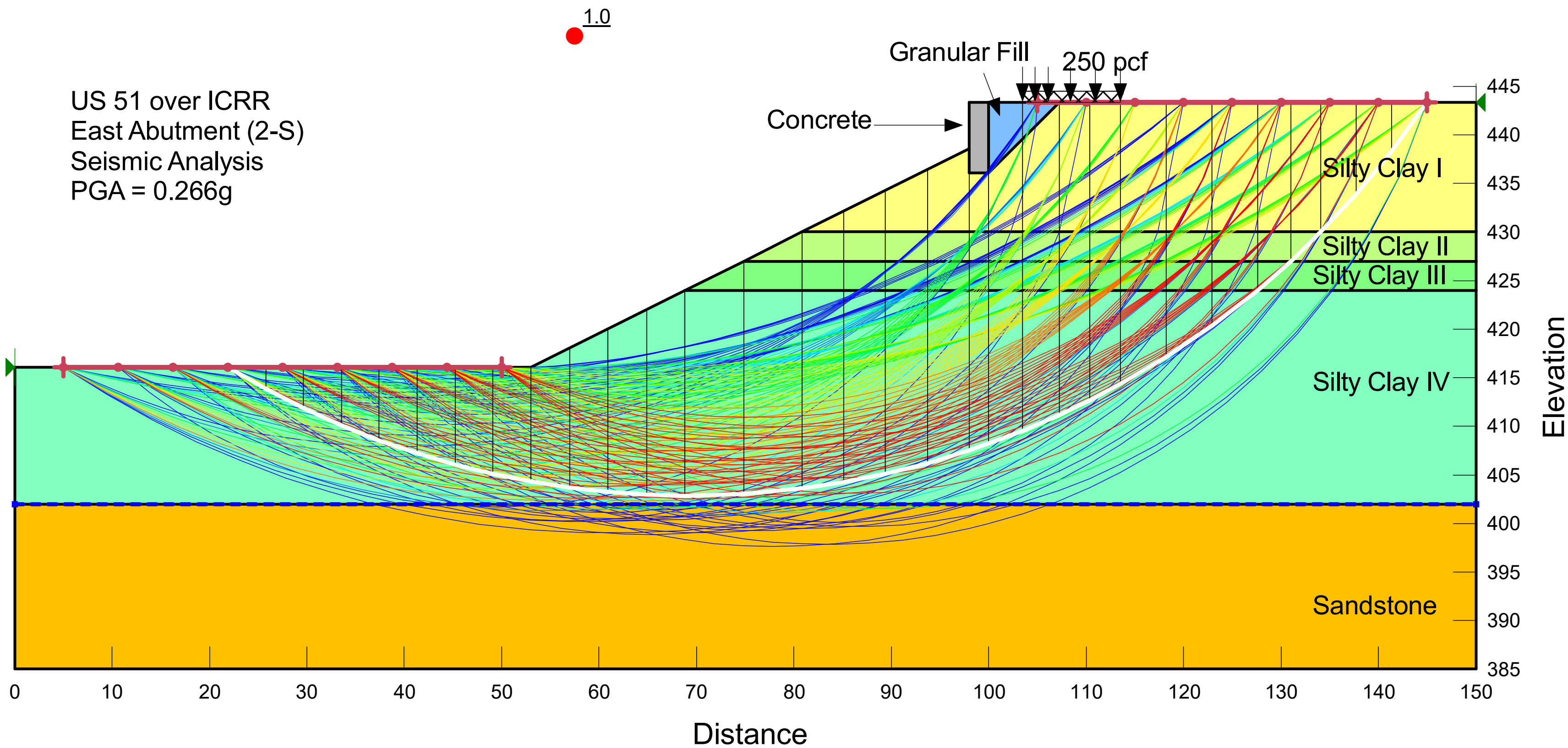
Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Cohesion (psf)
Concrete	145			5,000
Fill	130	0	34	
Sandstone	145			5,000
Silty Clay I	120			1,500
Silty Clay II	120			200
Silty Clay III	120			700
Silty Clay IV	120			1,100

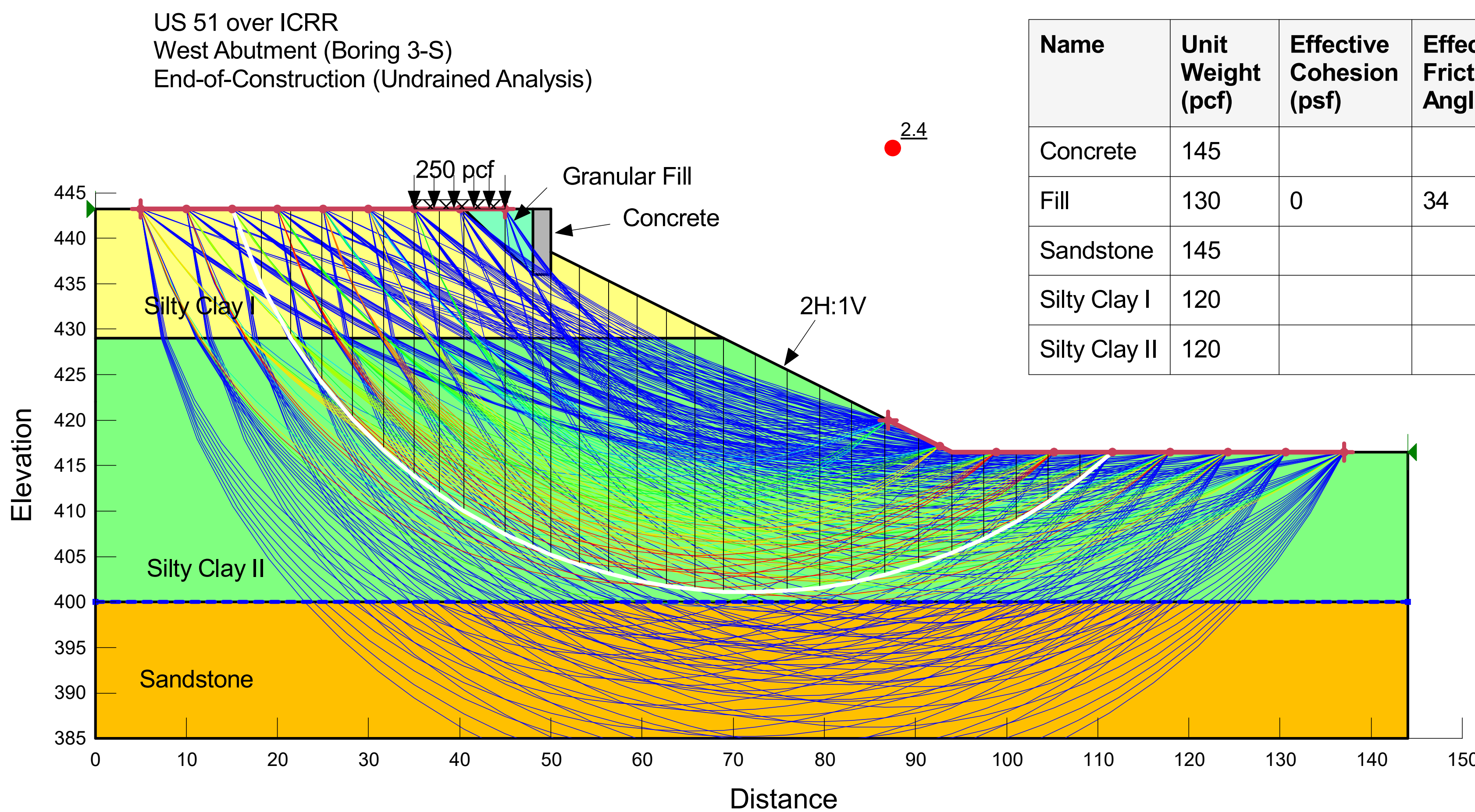


Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
Concrete	145	5,000	40
Fill	130	0	34
Sandstone	145	5,000	40
Silty Clay I	120	100	28
Silty Clay II	120	50	28
Silty Clay III	120	75	28
Silty Clay IV	120	100	28



Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Cohesion (psf)
Concrete	145			5,000
Fill	130	0	34	
Sandstone	145			5,000
Silty Clay I	120			1,200
Silty Clay II	120			160
Silty Clay III	120			560
Silty Clay IV	120			880

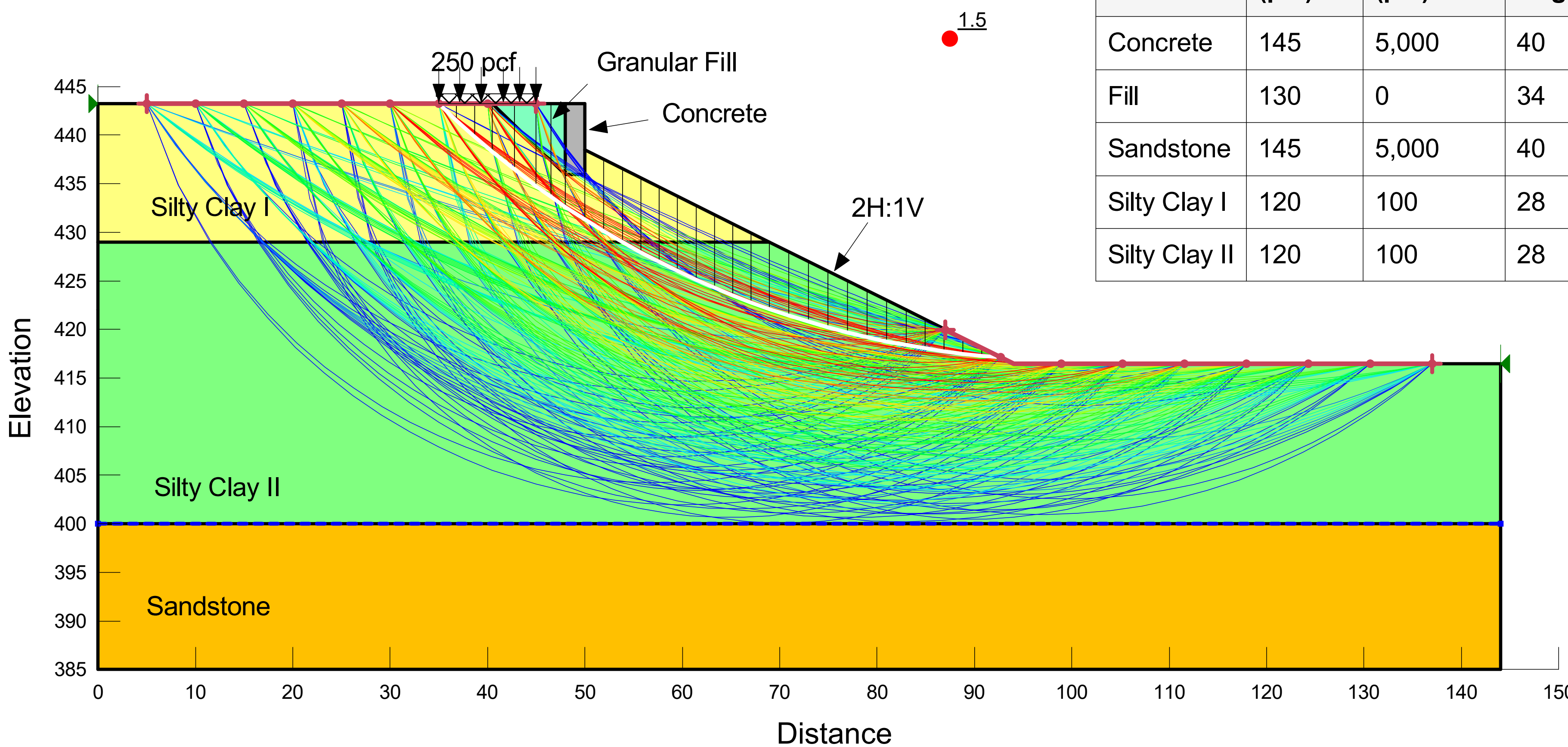




Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Cohesion (psf)
Concrete	145			5,000
Fill	130	0	34	
Sandstone	145			5,000
Silty Clay I	120			2,000
Silty Clay II	120			1,200

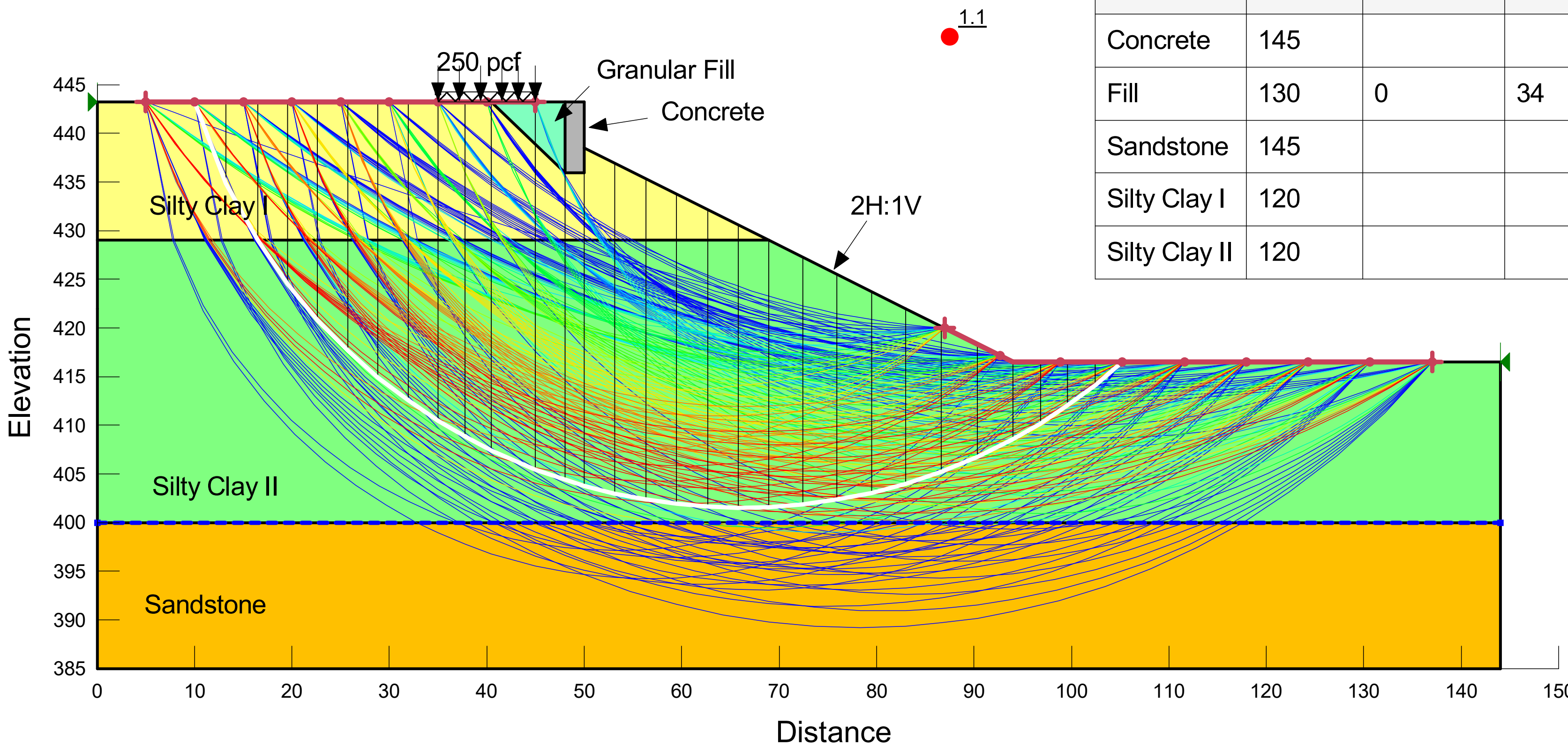
US 51 over ICRR
West Abutment (Boring 3-S)
Long Term (Drained Analysis)

Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
Concrete	145	5,000	40
Fill	130	0	34
Sandstone	145	5,000	40
Silty Clay I	120	100	28
Silty Clay II	120	100	28



US 51 over ICRR
West Abutment (Boring 3-S)
Seismic Analysis
PGA = 0.266g

Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Cohesion (psf)
Concrete	145			5,000
Fill	130	0	34	
Sandstone	145			5,000
Silty Clay I	120			1,600
Silty Clay II	120			960



Appendix D

Liquefaction Analysis Spreadsheets

LIQUEFACTION ANALYSIS

REFERENCE BORING NUMBER ==================================== 1-S
ELEVATION OF BORING GROUND SURFACE ========================= 415.50 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ====================== 17.50 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ================== 13.00 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.361
EARTHQUAKE MOMENT MAGNITUDE =============================== 7.6
FINISHED GRADE FILL OR CUT FROM BORING SURFACE =============== -4.50 FT. (Cut Depth)
HAMMER EFFICIENCY== 87 %
BOREHOLE DIAMETER== 8 IN.
SAMPLING METHOD== Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = **0.979**

AVG. SHEAR WAVE VELOCITY (top 40')
$V^*_{s,40'}$ = **656** FT./SEC.

PGA CALCULATOR
Earthquake Moment Magnitude = 7.59
Source-To-Site Distance, R (km) = 122.46
Ground Motion Prediction Equations = NMSZ
PGA = **0.133**

	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
411	4.5	6	1.2				21	0.124	0.558	12.339	12.339	0.134								
408.5	7	10	3.1				23	0.135	0.896	19.148	19.148	0.205	0.135	0.338	0.338	1.500	**0.301**	0.997	**0.234**	**N.L. (1)**
406	9.5	7	0.8				22	0.119	1.193	12.814	12.814	0.139	0.119	0.635	0.635	1.350	**0.183**	0.993	**0.233**	**N.L. (1)**
403.5	12	13	1.8				17	0.128	1.513	24.265	24.265	0.278	0.128	0.955	0.955	1.291	**0.352**	0.988	**0.232**	**N.L. (1)**
401	14.5	100					13	0.147	1.881	######	201.584	1.482	0.147	1.323	1.323	1.208	**1.753**	0.982	**0.231**	**N.L. (1)**

* 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

Illinois Department of Transportation

LIQUEFACTION ANALYSIS

REFERENCE BORING NUMBER ==================================== 2-S
ELEVATION OF BORING GROUND SURFACE ========================= 441.60 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ====================== 43.60 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ================== 43.60 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.361
EARTHQUAKE MOMENT MAGNITUDE =============================== 7.6
FINISHED GRADE FILL OR CUT FROM BORING SURFACE =============== 0.00 FT.
HAMMER EFFICIENCY== 87 %
BOREHOLE DIAMETER== 8 IN.
SAMPLING METHOD== Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = **0.979**

AVG. SHEAR WAVE VELOCITY (top 40')
$V^{*}_{s,40'}$ = **434** FT./SEC.

PGA CALCULATOR
Earthquake Moment Magnitude = 7.59
Source-To-Site Distance, R (km) = 122.46
Ground Motion Prediction Equations = NMSZ
PGA = **0.133**

	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
437.1	4.5	5	0.9				22	0.120	0.540	10.343	10.343	0.116	0.120	0.540	0.540	1.376	**0.157**	0.955	**0.224**	**N.L. (1)**
434.6	7	8	1.8				25	0.128	0.860	15.124	15.124	0.161	0.128	0.860	0.860	1.268	**0.200**	0.925	**0.217**	**N.L. (1)**
432.1	9.5	5	1.8				25	0.128	1.180	9.185	9.185	0.106	0.128	1.180	1.180	1.142	**0.119**	0.890	**0.209**	**N.L. (1)**
429.6	12	3	0.2				26	0.104	1.440	5.457	5.457	0.076	0.104	1.440	1.440	1.082	**0.080**	0.852	**0.200**	**N.L. (1)**
427.1	14.5	3	0.7				26	0.117	1.733	5.294	5.294	0.074	0.117	1.733	1.733	1.042	**0.076**	0.812	**0.190**	**N.L. (1)**
424.6	17	6	1.2				22	0.124	2.043	10.159	10.159	0.115	0.124	2.043	2.043	1.009	**0.113**	0.770	**0.181**	**N.L. (1)**
422.1	19.5	4	0.8				27	0.119	2.340	6.490	6.490	0.084	0.119	2.340	2.340	0.980	**0.080**	0.728	**0.171**	**N.L. (1)**
419.6	22	5	1.4				27	0.125	2.653	7.733	7.733	0.094	0.125	2.653	2.653	0.952	**0.087**	0.688	**0.162**	**N.L. (1)**
417.1	24.5	5	0.7				26	0.117	2.945	7.395	7.395	0.091	0.117	2.945	2.945	0.932	**0.083**	0.651	**0.153**	**N.L. (1)**
414.6	27	6	1.2				22	0.124	3.255	8.461	8.461	0.100	0.124	3.255	3.255	0.909	**0.089**	0.617	**0.145**	**N.L. (1)**
412.1	29.5	7	0.8				22	0.119	3.553	9.440	9.440	0.108	0.119	3.553	3.553	0.889	**0.094**	0.587	**0.138**	**N.L. (1)**
409.6	32	8	2				23	0.130	3.878	10.287	10.287	0.116	0.130	3.878	3.878	0.869	**0.098**	0.562	**0.132**	**N.L. (1)**
407.1	34.5	10	0.7				22	0.117	4.170	12.344	12.344	0.134	0.117	4.170	4.170	0.847	**0.111**	0.540	**0.127**	**N.L. (1)**
404.6	37	25	1				15	0.122	4.475	31.396	31.396	0.612	0.122	4.475	4.475	0.761	**0.456**	0.522	**0.123**	**N.L. (1)**
402.1	39.5	100					13	0.147	4.843	######	133.448	0.973	0.147	4.843	4.843	0.719	**0.685**	0.508	**0.119**	**N.L. (1)**

* 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

Illinois Department of Transportation

LIQUEFACTION ANALYSIS

REFERENCE BORING NUMBER ==================================== 3-S
ELEVATION OF BORING GROUND SURFACE ========================= 441.50 FT.
DEPTH TO GROUNDWATER - DURING DRILLING ====================== 43.50 FT. (Below Boring Ground Surface)
DEPTH TO GROUNDWATER - DURING EARTHQUAKE ================== 43.50 FT. (Below Finished Grade Cut or Fill Surface)
PEAK HORIZ. GROUND SURFACE ACCELERATION COEFFICIENT (As) ===== 0.390
EARTHQUAKE MOMENT MAGNITUDE =============================== 7.6
FINISHED GRADE FILL OR CUT FROM BORING SURFACE =============== 0.00 FT.
HAMMER EFFICIENCY=== 87 %
BOREHOLE DIAMETER=== 8 IN.
SAMPLING METHOD=== Sampler w/out Liners

EQ MAGNITUDE SCALING FACTOR
(MSF) = **0.979**

AVG. SHEAR WAVE VELOCITY (top 40')
$V^*_{s,40'}$ = **384** FT./SEC.

PGA CALCULATOR
Earthquake Moment Magnitude = 7.59
Source-To-Site Distance, R (km) = 122.46
Ground Motion Prediction Equations = NMSZ
PGA = **0.133**

	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
437	4.5	5	2.9				22	0.134	0.603	10.136	10.136	0.114	0.134	0.603	0.603	1.339	**0.150**	0.935	**0.237**	**N.L. (1)**
434.5	7	4	1.2				23	0.124	0.913	7.381	7.381	0.091	0.124	0.913	0.913	1.199	**0.107**	0.893	**0.226**	**N.L. (1)**
432	9.5	4	2.4				21	0.132	1.243	7.226	7.226	0.090	0.132	1.243	1.243	1.121	**0.098**	0.847	**0.215**	**N.L. (1)**
429.5	12	4	1.2				25	0.124	1.553	7.075	7.075	0.088	0.124	1.553	1.553	1.069	**0.092**	0.800	**0.203**	**N.L. (1)**
427	14.5	3	1.1				29	0.123	1.861	5.140	5.140	0.073	0.123	1.861	1.861	1.027	**0.073**	0.751	**0.191**	**N.L. (1)**
424.5	17	5	1.8				25	0.128	2.181	8.219	8.219	0.098	0.128	2.181	2.181	0.994	**0.095**	0.704	**0.179**	**N.L. (1)**
422	19.5	5	1.1				28	0.123	2.488	7.873	7.873	0.095	0.123	2.488	2.488	0.966	**0.090**	0.660	**0.167**	**N.L. (1)**
419.5	22	5	0.5				27	0.114	2.773	7.558	7.558	0.092	0.114	2.773	2.773	0.944	**0.085**	0.619	**0.157**	**N.L. (1)**
417	24.5	5	1.4				29	0.125	3.086	7.210	7.210	0.089	0.125	3.086	3.086	0.923	**0.081**	0.583	**0.148**	**N.L. (1)**
414.5	27	5	1.1				27	0.123	3.393	6.887	6.887	0.087	0.123	3.393	3.393	0.905	**0.077**	0.551	**0.140**	**N.L. (1)**
412	29.5	9	1.2				21	0.124	3.703	11.845	11.845	0.130	0.124	3.703	3.703	0.873	**0.111**	0.525	**0.133**	**N.L. (1)**
409.5	32	5	1.2				20	0.124	4.013	6.297	6.297	0.082	0.124	4.013	4.013	0.876	**0.070**	0.502	**0.127**	**N.L. (1)**
407	34.5	7	1.2				24	0.124	4.323	8.448	8.448	0.100	0.124	4.323	4.323	0.854	**0.083**	0.484	**0.123**	**N.L. (1)**
404.5	37	8	1.8				22	0.128	4.643	9.256	9.256	0.107	0.128	4.643	4.643	0.837	**0.087**	0.469	**0.119**	**N.L. (1)**
402	39.5	4	1.3				18	0.125	4.956	4.449	4.449	0.068	0.125	4.956	4.956	0.844	**0.056**	0.457	**0.116**	**N.L. (1)**

* 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

Appendix E

Mine Activity Map

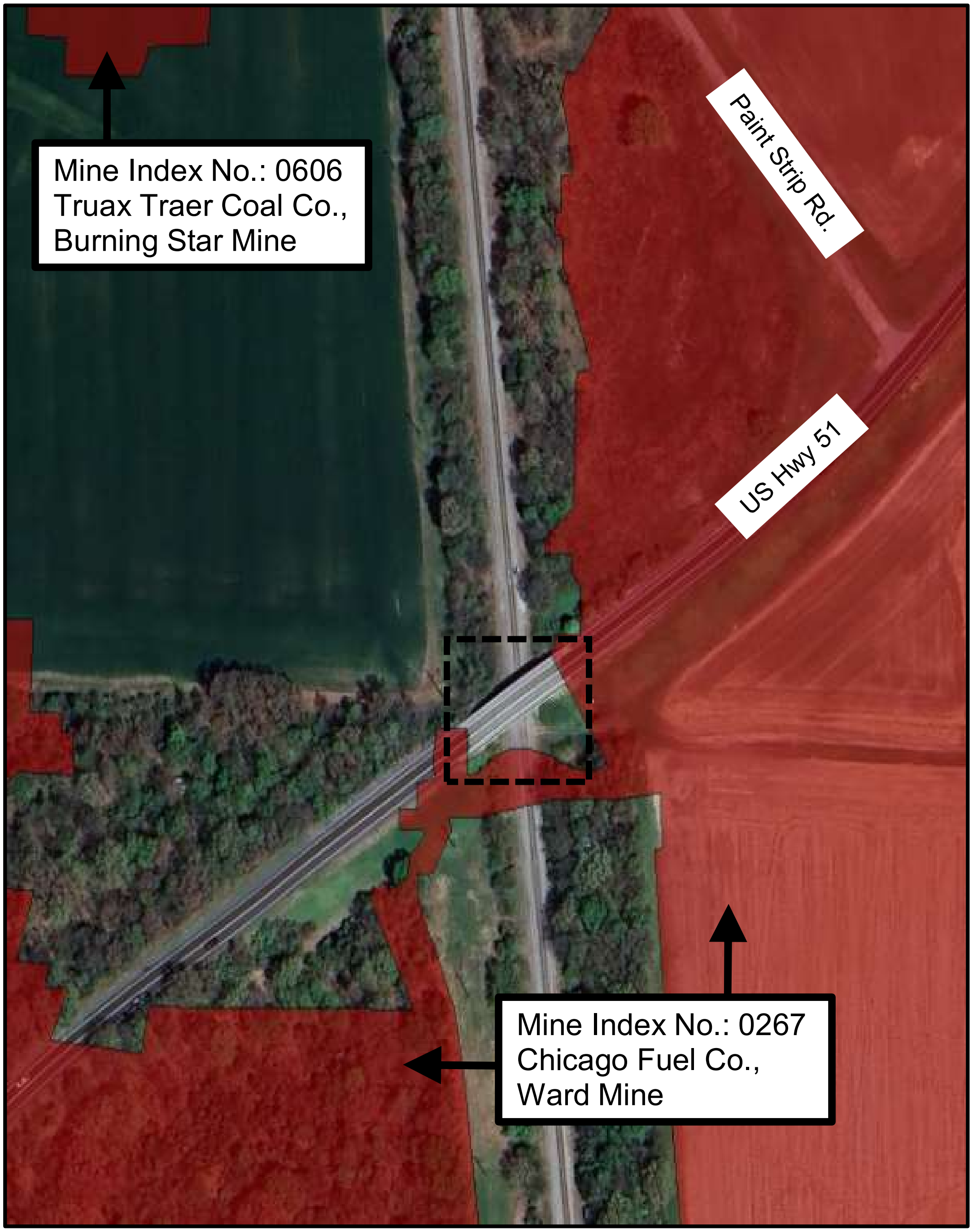
Millennia Professional Services

11 Executive Drive #12, Fairview Heights, IL

Phone: (618) 624-8610

Fax: (618) 624-8611

Project No.: MG24067.02



N	MINE ACTIVITY MAP		
	US 51 over ICRR Jackson County, Illinois		
Approximate Site Location:	Drawn by: B. Fisher	Checked by:	J. Olson
Image obtained from Google Earth *Not to scale	Project No.: MG24067.02	Date:	3/20/2025

Appendix F

Estimated Pile Length Spreadsheets

Illinois Department of Transportation

IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

SUBSTRUCTURE===================================== East Abutment
REFERENCE BORING ================================ 2-S
LRFD or ASD or SEISMIC ============================== LRFD
PILE CUTOFF ELEV. ================================== 438.09 ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING = 436.09 ft
GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) ====== None
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ================= ft
TOP ELEV. OF LIQUEF. (so layers above apply DD) =============== ft

TOTAL FACTORED SUBSTRUCTURE LOAD =============== 1076 kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)========== 49.27 ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE ======= 1
Approx. Factored Loading Applied per pile at 8 ft. Cts ============ 174.71 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ============ 65.52 KIPS

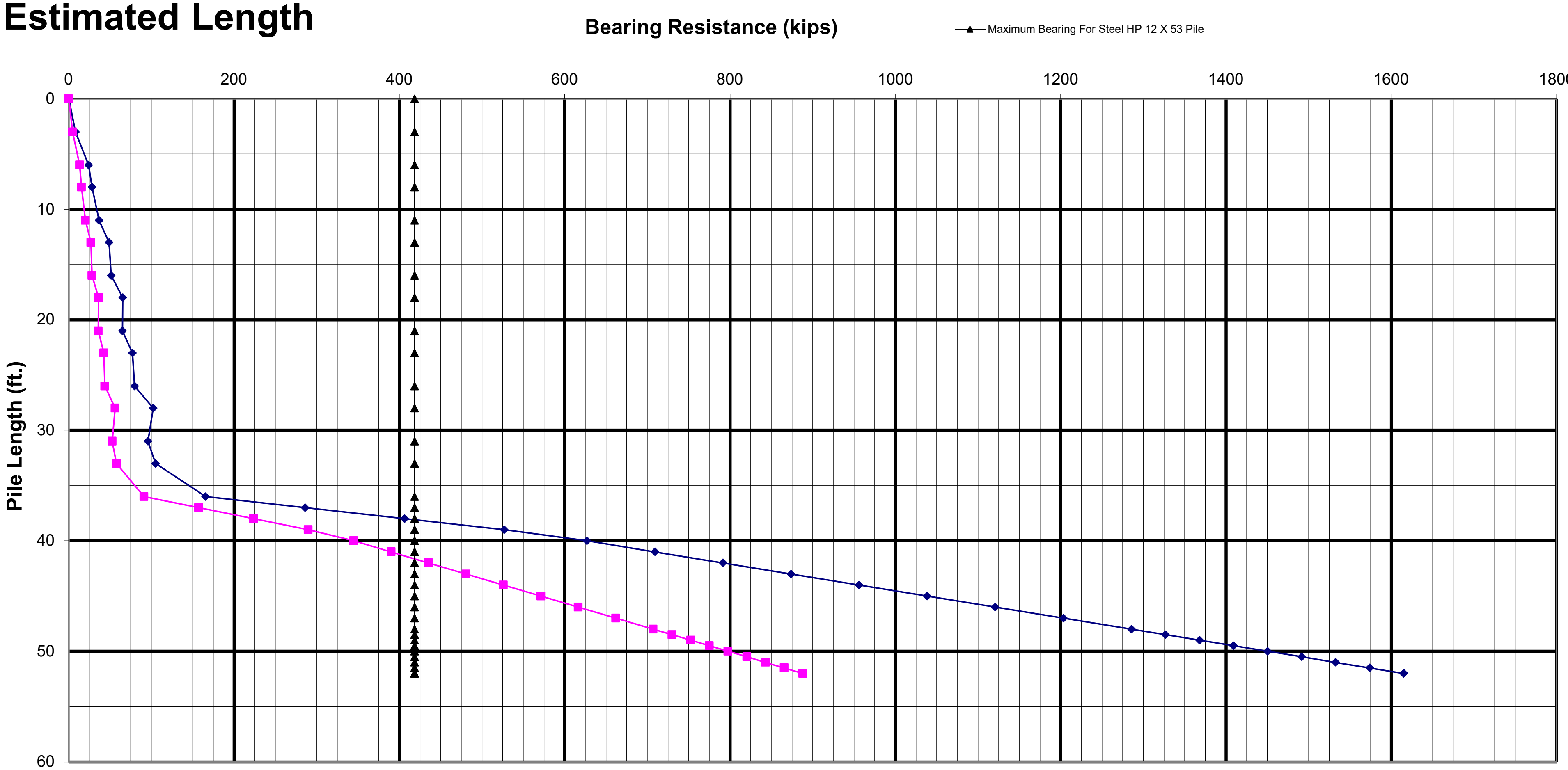
PILE TYPE AND SIZE ============= Steel HP 12 X 53
Plugged Pile Perimeter========================== 3.967 FT. Unplugged Pile Perimeter=============== 5.800 FT.
Plugged Pile End Bearing Area==================== 0.983 SQFT. Unplugged Pile End Bearing Area========= 0.108 SQFT.

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

Maximum Nominal Req'd Bearing of Pile	Maximum Nominal Req.d Bearing of Boring	Maximum Factored Resistance Available in Boring	Maximum Pile Driveable Length in Boring
418 KIPS	**418** KIPS	**230** KIPS	**39** 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.)
434.60	1.49	0.90			3.9		28.7	5.6		**8.3**	8	0	0	5	3
432.10	2.50	1.80			10.8	24.8	39.4	15.8	2.7	**24.1**	24	0	0	13	6
429.60	2.50	1.80			10.8	24.8	**28.2**	15.8	2.7	37.5	28	0	0	15	8
427.10	2.50	0.20			1.6	2.8	**36.7**	2.4	0.3	40.6	37	0	0	20	11
424.60	2.50	0.70			5.2	9.6	**48.8**	7.6	1.1	49.0	49	0	0	27	13
422.10	2.50	1.20			8.1	16.5	**51.4**	11.9	1.8	60.3	51	0	0	28	16
419.60	2.50	0.80			5.9	11.0	**65.5**	8.6	1.2	69.7	66	0	0	36	18
417.10	2.50	1.40			9.1	19.3	**65.0**	13.3	2.1	82.0	65	0	0	36	21
414.60	2.50	0.70			5.2	9.6	**77.2**	7.6	1.1	90.4	77	0	0	42	23
412.10	2.50	1.21			8.2	16.7	**79.8**	12.0	1.8	101.7	80	0	0	44	26
409.60	2.50	0.80			5.9	11.0	**102.2**	8.6	1.2	112.1	102	0	0	56	28
407.10	2.50	2.00			11.5	27.6	**95.8**	16.9	3.0	127.0	96	0	0	53	31
404.60	2.50	0.70			5.2	9.6	**105.1**	7.6	1.1	135.1	105	0	0	58	33
402.10	2.50	1.00			7.0	13.8	297.5	10.3	1.5	**165.7**	166	0	0	91	36
401.10	1.00			Sandstone	82.4	199.1	379.8	120.4	21.8	**286.1**	286	0	0	157	37
400.10	1.00			Sandstone	82.4	199.1	462.2	120.4	21.8	**406.5**	407	0	0	224	38
399.10	1.00			Sandstone	82.4	199.1	544.5	120.4	21.8	**526.9**	~~527~~	~~0~~	~~0~~	~~290~~	~~39~~
398.10	1.00			Sandstone	82.4	199.1	**626.9**	120.4	21.8	647.4	~~627~~	~~0~~	~~0~~	~~345~~	~~40~~
397.10	1.00			Sandstone	82.4	199.1	**709.2**	120.4	21.8	767.8	~~709~~	~~0~~	~~0~~	~~390~~	~~41~~
396.10	1.00			Sandstone	82.4	199.1	**791.6**	120.4	21.8	888.2	~~792~~	~~0~~	~~0~~	~~435~~	~~42~~
395.10	1.00			Sandstone	82.4	199.1	**874.0**	120.4	21.8	1008.6	~~874~~	~~0~~	~~0~~	~~481~~	~~43~~
394.10	1.00			Sandstone	82.4	199.1	**956.3**	120.4	21.8	1129.0	~~956~~	~~0~~	~~0~~	~~526~~	~~44~~
393.10	1.00			Sandstone	82.4	199.1	**1038.7**	120.4	21.8	1249.5	~~1039~~	~~0~~	~~0~~	~~571~~	~~45~~
392.10	1.00			Sandstone	82.4	199.1	**1121.0**	120.4	21.8	1369.9	~~1121~~	~~0~~	~~0~~	~~617~~	~~46~~
391.10	1.00			Sandstone	82.4	199.1	**1203.4**	120.4	21.8	1490.3	~~1203~~	~~0~~	~~0~~	~~662~~	~~47~~
390.10	1.00			Sandstone	82.4	199.1	**1285.7**	120.4	21.8	1610.7	~~1286~~	~~0~~	~~0~~	~~707~~	~~48~~
389.60	0.50			Sandstone	41.2	199.1	**1326.9**	60.2	21.8	1670.9	~~1327~~	~~0~~	~~0~~	~~730~~	~~48.5~~
389.10	0.50			Sandstone	41.2	199.1	**1368.1**	60.2	21.8	1731.1	~~1368~~	~~0~~	~~0~~	~~752~~	~~49~~
388.60	0.50			Sandstone	41.2	199.1	**1409.3**	60.2	21.8	1791.3	~~1409~~	~~0~~	~~0~~	~~775~~	~~49.5~~
388.10	0.50			Sandstone	41.2	199.1	**1450.4**	60.2	21.8	1851.6	~~1450~~	~~0~~	~~0~~	~~798~~	~~50~~
387.60	0.50			Sandstone	41.2	199.1	**1491.6**	60.2	21.8	1911.8	~~1492~~	~~0~~	~~0~~	~~820~~	~~50.5~~
387.10	0.50			Sandstone	41.2	199.1	**1532.8**	60.2	21.8	1972.0	~~1533~~	~~0~~	~~0~~	~~843~~	~~51~~
386.60	0.50			Sandstone	41.2	199.1	**1574.0**	60.2	21.8	2032.2	~~1574~~	~~0~~	~~0~~	~~866~~	~~51.5~~
386.10	0.50			Sandstone	41.2	199.1	**1615.2**	60.2	21.8	2092.4	~~1615~~	~~0~~	~~0~~	~~888~~	~~52~~
385.60	0.50			Sandstone		199.1			21.8						

Pile Bearing vs. Estimated Length



Pile Design Table for East Abutment utilizing Boring #2-S

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 8 X 36			
	271	149	38

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 10 X 42			
	86	47	33
	138	76	36
	335	184	38
Steel HP 10 X 57			
	87	48	33
	145	80	36
	454	250	40
Steel HP 12 X 53			
	105	58	33
	166	91	36
	418	230	39
Steel HP 12 X 63			
	106	58	33
	172	95	36
	497	273	39
Steel HP 12 X 74			
	108	59	33
	177	97	36
	589	324	40

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 12 X 84			
	109	60	33
	182	100	36
	664	365	41
Steel HP 14 X 73			
	116	64	31
	128	70	33
	203	112	36
	578	318	39
Steel HP 14 X 89			
	117	64	31
	129	71	33
	211	116	36
	705	388	40
Steel HP 14 X 102			
	118	65	31
	131	72	33
	217	120	36
	810	445	41
Steel HP 14 X 117			
	101	55	26
	120	66	31
	132	73	33
	225	124	36
	929	511	42

IDOT STATIC METHOD OF ESTIMATING PILE LENGTH

SUBSTRUCTURE===================================== West Abutment
REFERENCE BORING ================================ 3-S
LRFD or ASD or SEISMIC ============================== LRFD
PILE CUTOFF ELEV. ================================== 437.98 ft
GROUND SURFACE ELEV. AGAINST PILE DURING DRIVING = 435.98 ft
GEOTECHNICAL LOSS TYPE (None, Scour, Liquef., DD) ====== None
BOTTOM ELEV. OF SCOUR, LIQUEF., or DD ================= ft
TOP ELEV. OF LIQUEF. (so layers above apply DD) ============== ft

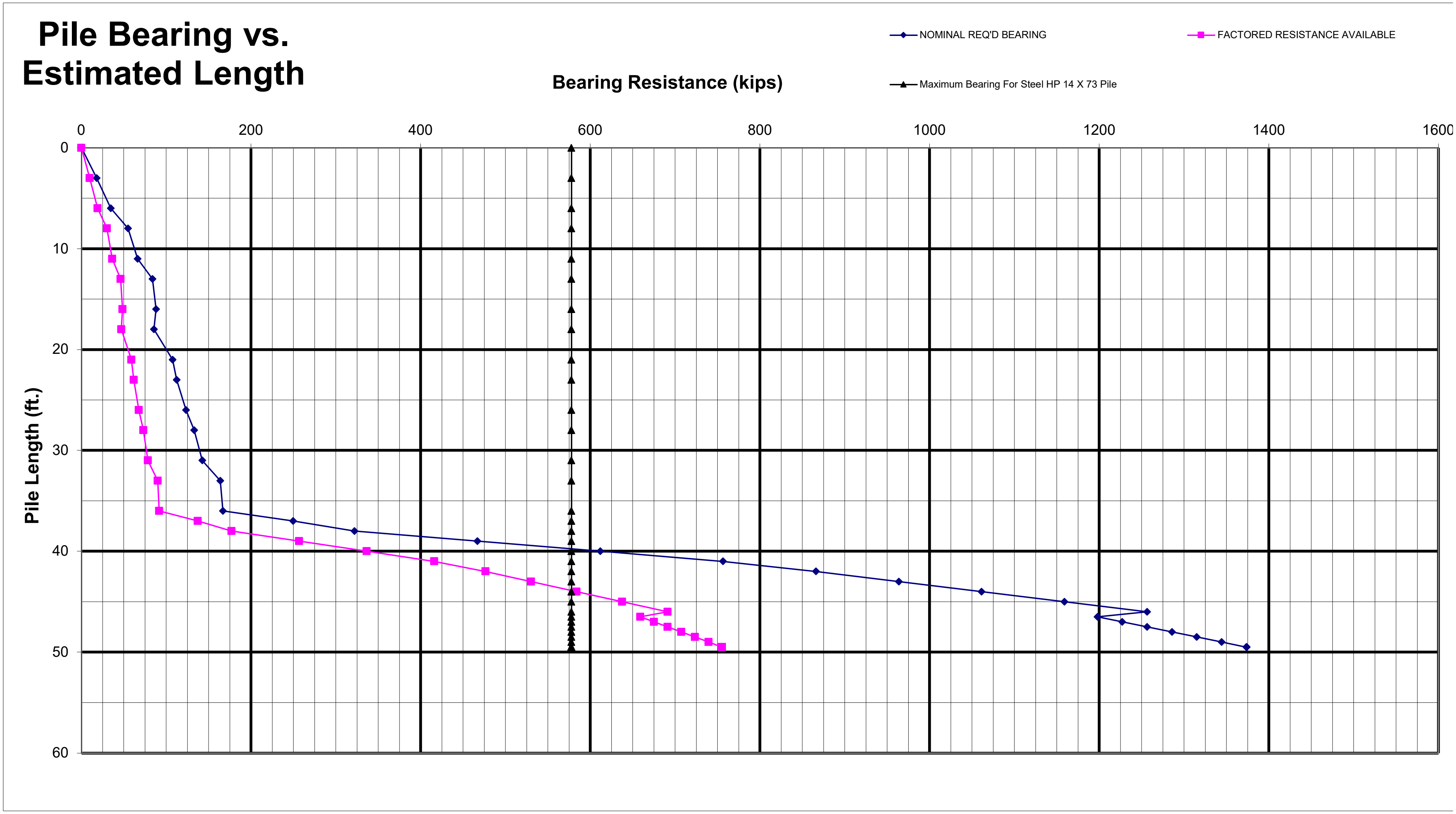
TOTAL FACTORED SUBSTRUCTURE LOAD =============== 1076 kips
TOTAL LENGTH OF SUBSTRUCTURE (along skew)========== 49.27 ft
NUMBER OF ROWS OF PILES PER SUBSTRUCTURE ======= 1
Approx. Factored Loading Applied per pile at 8 ft. Cts ============ 174.71 KIPS
Approx. Factored Loading Applied per pile at 3 ft. Cts ============ 65.52 KIPS

PILE TYPE AND SIZE ============= Steel HP 14 X 73
Plugged Pile Perimeter========================== 4.700 FT. Unplugged Pile Perimeter============== 6.975 FT.
Plugged Pile End Bearing Area==================== 1.379 SQFT. Unplugged Pile End Bearing Area======== 0.149 SQFT.

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

Maximum Nominal Req'd Bearing of Pile	Maximum Nominal Req.d Bearing of Boring	Maximum Factored Resistance Available in Boring	Maximum Pile Driveable Length in Boring
578 KIPS	**578** KIPS	**318** KIPS	**40** 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.)
434.50	1.48	2.90			10.4		33.6	15.4		***17.9***	18	0	0	10	3
432.00	2.50	1.20			9.6	23.2	66.4	14.3	2.5	***34.7***	35	0	0	19	6
429.50	2.50	2.40			15.4	46.4	58.6	22.8	5.0	***55.1***	55	0	0	30	8
427.00	2.50	1.20			9.6	23.2	***66.3***	14.3	2.5	69.1	66	0	0	36	11
424.50	2.50	1.10			9.0	21.3	88.8	13.4	2.3	***84.0***	84	0	0	46	13
422.00	2.50	1.80			12.8	34.8	***88.1***	19.0	3.7	101.5	88	0	0	48	16
419.50	2.50	1.10			9.0	21.3	***85.5***	13.4	2.3	113.6	85	0	0	47	18
417.00	2.50	0.50			4.6	9.7	***107.5***	6.8	1.0	122.2	107	0	0	59	21
414.50	2.50	1.40			10.8	27.1	***112.4***	16.0	2.9	137.6	112	0	0	62	23
412.00	2.50	1.10			9.0	21.3	***123.4***	13.4	2.3	151.2	123	0	0	68	26
409.50	2.50	1.20			9.6	23.2	***133.0***	14.3	2.5	165.5	133	0	0	73	28
407.00	2.50	1.20			9.6	23.2	***142.6***	14.3	2.5	179.8	143	0	0	78	31
404.50	2.50	1.20			9.6	23.2	***163.9***	14.3	2.5	195.3	164	0	0	90	33
402.00	2.50	1.80			12.8	34.8	***167.0***	19.0	3.7	213.2	167	0	0	92	36
400.50	1.50	1.30			6.1	25.1	427.1	9.1	2.7	***249.7***	250	0	0	137	37
400.00	0.50			Sandstone	48.8	279.1	475.9	72.4	30.1	***322.1***	322	0	0	177	38
399.00	1.00			Sandstone	97.6	279.1	573.5	144.8	30.1	***466.9***	467	0	0	257	39
398.00	1.00			Sandstone	97.6	279.1	671.1	144.8	30.1	***611.7***	~~612~~	~~0~~	~~0~~	~~336~~	~~40~~
397.00	1.00			Sandstone	97.6	279.1	768.6	144.8	30.1	***756.5***	~~757~~	~~0~~	~~0~~	~~416~~	~~41~~
396.00	1.00			Sandstone	97.6	279.1	***866.2***	144.8	30.1	901.4	~~866~~	~~0~~	~~0~~	~~476~~	~~42~~
395.00	1.00			Sandstone	97.6	279.1	***963.8***	144.8	30.1	1046.2	~~964~~	~~0~~	~~0~~	~~530~~	~~43~~
394.00	1.00			Sandstone	97.6	279.1	***1061.4***	144.8	30.1	1191.0	~~1061~~	~~0~~	~~0~~	~~584~~	~~44~~
393.00	1.00			Sandstone	97.6	279.1	***1159.0***	144.8	30.1	1335.8	~~1159~~	~~0~~	~~0~~	~~637~~	~~45~~
392.00	1.00			Sandstone	97.6	279.1	***1256.6***	144.8	30.1	1480.6	~~1257~~	~~0~~	~~0~~	~~691~~	~~46~~
391.50	0.50			Sandstone	48.8	279.1	***1198.0***	72.4	30.1	1541.5	~~1198~~	~~0~~	~~0~~	~~659~~	~~46.5~~
391.00	0.50			Shale	29.3	171.8	***1227.3***	43.4	18.5	1584.9	~~1227~~	~~0~~	~~0~~	~~675~~	~~47~~
390.50	0.50			Shale	29.3	171.8	***1256.5***	43.4	18.5	1628.3	~~1257~~	~~0~~	~~0~~	~~691~~	~~47.5~~
390.00	0.50			Shale	29.3	171.8	***1285.8***	43.4	18.5	1671.8	~~1286~~	~~0~~	~~0~~	~~707~~	~~48~~
389.50	0.50			Shale	29.3	171.8	***1315.1***	43.4	18.5	1715.2	~~1315~~	~~0~~	~~0~~	~~723~~	~~48.5~~
389.00	0.50			Shale	29.3	171.8	***1344.4***	43.4	18.5	1758.7	~~1344~~	~~0~~	~~0~~	~~739~~	~~49~~
388.50	0.50			Shale	29.3	171.8	***1373.6***	43.4	18.5	1802.1	~~1374~~	~~0~~	~~0~~	~~755~~	~~49.5~~
388.00	0.50			Shale		171.8			18.5						



Pile Bearing vs. Estimated Length
Bearing Resistance (kips)
NOMINAL REQ'D BEARING
FACTORED RESISTANCE AVAILABLE
Maximum Bearing For Steel HP 14 X 73 Pile
0
200
400
600
800
1000
1200
1400
1600
Pile Length (ft.)
0
10
20
30
40
50
60

Pile Design Table for West Abutment utilizing Boring #3-S

	Nominal Required Bearing (Kips)	Factored Resistance Available (Kips)	Estimated Pile Length (Ft.)
Steel HP 8 X 36			
	90	49	36
	137	76	37
	286	157	40
Steel HP 10 X 42			
	112	62	36
	170	94	37
	335	184	40
Steel HP 10 X 57			
	114	63	36
	177	98	37
	454	250	41
Steel HP 12 X 53			
	117	65	31
	134	74	33
	138	76	36
	204	112	37
	418	230	40
Steel HP 12 X 63			
	118	65	31
	135	74	33
	139	76	36
	211	116	37
	497	273	40
Steel HP 12 X 74			
	112	62	28
	120	66	31
	137	75	33
	141	78	36
	217	119	37
	589	324	41
Steel HP 12 X 84			
	113	62	28
	122	67	31
	139	77	33
	143	79	36
	222	122	37
	664	365	42
Steel HP 14 X 73			
	112	62	23
	123	68	26
	133	73	28
	143	78	31
	164	90	33
	167	92	36
	250	137	37
	578	318	40
Steel HP 14 X 89			
	114	63	23
	125	69	26
	135	74	28
	144	79	31
	166	91	33
	169	93	36
	258	142	37
	705	388	41
Steel HP 14 X 102			
	115	63	23
	127	70	26
	136	75	28
	146	80	31
	168	92	33
	171	94	36
	264	145	37
	810	445	42
Steel HP 14 X 117			
	117	64	23
	128	70	26
	138	76	28
	148	81	31
	170	94	33
	173	95	36
	272	150	37
	929	511	43