FINAL REPORT
STRUCTURE FOUNDATION EXPLORATION
BRIDGE – FRA-71-0296 (L&R) OVER IORY RAILROAD LINE
FRA-71-0.00 IMPROVEMENTS
FRANKLIN COUNTY, OHIO
PID#: 93496

For:

Mead & Hunt, Inc.
5900 Wilcox Place
Dublin, OH 43016

Submitted by:

NEAS Inc.
National Engineering & Architectural Services Inc.

2800 Corporate Exchange Drive, Suite 240
Columbus, OH 43231

March 27, 2017

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PHOTOGRAPHS

LIST OF EXHIBITS

LIST OF APPENDICES

FINAL REPORT
STRUCTURE FOUNDATION EXPLORATION
BRIDGE–FRA-71-0296 (L&R) OVER IORY RAILROAD LINE
FRA-71-0.00 IMPROVEMENTS
FRANKLIN COUNTY, OHIO
PID#: 93496

EXECUTIVE SUMMARY

This report presents the results of a structure foundation exploration for widening twin, three-span bridge structures, FRA-71-0296 (L&R), carrying Interstate-71 (IR-71) over the Indiana & Ohio Railway (IORY) railroad line, in southwestern Franklin County. The bridge widening is a component of the larger widening program, FRA-71-0.00, that includes ~6 miles of roadway and widening of one additional bridge and one bridge replacement.

The upgrade to Bridge FRA-71-0296 will be designed using the Load Factor Design (LFD) method as set forth in the American Association of State Highway and Transportation Officials (AASHTO) Publication *AASHTO Standard Specifications for Highway Bridges 7th Edition (with 2015 Interim Revisions)* (AASHTO, 2014) and ODOT *Bridge Design Manual*, [ODOT, 2007 (revised 2014)].

The proposed improvements to FRA-71-0296 will consist of widening both structures ~25 ft to the inside using piles for both the abutment and pier foundations.

The bridge site is located in the Darby Plain portion of the Southern Ohio Loamy Till Plain, which is part of the Central Lowlands. The area is characterized by hummocky ground moraine of moderate relief and poorly drained swales, which previously held wet prairies/meadows, and a few large streams. The surficial geology is mapped as 40 feet (ft) of Wisconsinan Loam Till, with high carbonate content, overlying up to 130 (ft) of undifferentiated till of indeterminate age characterized primarily by its high density. Bedrock consists of Devonian-age Columbus Limestone mapped at a depth of ~100 ft.

Subsurface conditions were characterized on the basis of four historical borings drilled 56 ft deep and 3 project borings drilled to 56.5 ft. Foundation conditions are good with a competent bearing horizon encountered at relatively shallow depth.

Existing shallow spread foundations will be widened as deep foundations to minimize the possibility of differential settlement between the two phases of construction. H-piles driven into hard glacial till are recommended as the deep foundation support system for the piers and abutments.

1. INTRODUCTION

1.1. General

This report presents the results of a structure foundation exploration for widening FRA-71-0296 (L&R), carrying IR-71 over the IORY Railroad line, in southwestern Franklin County. The bridge widening is a component of the larger IR-70 widening program, FRA-71-0.00, that includes ~6 miles of roadway, widening of one additional bridge and replacement of another.

The exploration was conducted in general accordance with National Engineering & Architectural Services, Inc.'s (NEAS)[1] original proposal to Mead & Hunt, Inc. dated October 9, 2013, and ODOT *Specifications for Geotechnical Explorations, 2013* (ODOT, 2013). The bridge will be designed in accordance with the LRFD method as set forth in AASHTO's Publication *Bridge Design Specifications, 7th Edition (with 2015 Interim Revisions)* (AASHTO, 2014) and ODOT *Bridge Design Manual*, [ODOT, 2007 (revised 2014)].

1.2. Proposed Construction

The existing FRA-71-0296 structures are twin, 3-span, continuous steel beam bridges with reinforced concrete decks. Shallow foundations for the existing abutments are designed for a calculated maximum bearing pressure of 1.66 tons per square foot and the piles for the pier were driven to a minimum bearing capacity of 43 tons per pile.

The proposed improvements require that both structures be widened for a distance of about 25 ft to the inside. Abutments will be widened accordingly and supported on pile foundations to minimize possible differential settlement between the new and existing segments. The pier extensions will be supported on piled foundations.

2. GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1. Geology and Physiology

The bridge site is located in the Darby Plain portion of the Southern Ohio Loamy Till Plain, which is part of the Central Lowlands (Brockman, 1998). The area is characterized by hummocky ground moraine of

[1] On October 19, 2014 Barr & Prevost Inc. (B&P) separated into two entities; Barr Engineering Inc. (BEI), the predecessor company to B&P, and Barr & Prevost, a JMT Division. BEI has retained the geotechnical exploration services for the FRA-71-0.00 project as a subcontractor to Barr & Prevost/JMT. On November 23, 2016, BEI was renamed to National Engineering & Architectures, Inc (NEAS).

moderate relief and poorly drained swale, which previously held wet prairies/meadows, and a few large streams. The terrain to the east is flat at about elevation 870 ft (US Department of the Interior, 1966). To the west the land dips down to 780 ft at Big Darby Creek approximately 1.3 miles away.

The surficial geology is mapped as 40 feet of Wisconsinan Loam Till, with high carbonate content, overlying up to 130 ft of undifferentiated till of indeterminate age characterized primarily by its high density. Bedrock consists of Devonian-age Columbus Limestone mapped at a depth of ~100 ft. [Brockman et. al., 2005 and Shrake, 1994).

2.2. Soils

Soils along the IR-71 corridor have been mapped by the Natural Resources Conservation Service (U.S. Department of Agriculture, 2013) as Udorthents-Urban land complex because of the presence of embankment fill and are not rated. Soils immediately adjacent to the corridor are mapped as Crosby silt loam 0 to 6 percent, which are all rated as very limited for local road and street construction because of flooding, frost susceptibility, and low strength.

2.3. Seismicity

Earthquake hazard analysis in this part of the country is dominated by proximity to the New Madrid Fault Zone (NMFZ) approximately 400 miles to the southwest. Possible future movements along this fault could generate earthquakes of magnitude 7.0-8.0 with a recurrence period of 500-1,500 years (USGS, 2008). The resulting ground motion would be experienced over a wide area, with the Harrisburg area located within the possible zone of influence. In addition, earthquake epicenters of lesser magnitude (< ~ magnitude 5) occurred in southern Fairfield County (~30 miles southeast) in 1848/1870 and 1967, which indicate other potential earthquake sources that are contributory to seismic risk (ODNR, 2012 and 2013[(1)]).

2.4. Hydrogeology

Surface water drainage in the area is dominated by the south flowing Big Darby Creek, a tributary to the Scioto River, located approximately 1.3 miles west. The creek is at an elevation of about 780 ft at this location and likely represents the regional ground water elevation.

No wetlands are mapped by US Fish and Wildlife Service at or immediately adjacent to the bridge site (USF&W, 2013).

The bridge site does not lie within a special flood hazard area subject to inundation by the 100-year flood based on FEMA Flood Insurance Rate map of Franklin County, (FEMA, 2008).

2.5. Mining and Oil/Gas Production

No abandoned mines are noted on ODNR's Abandoned Underground Mine Locator in the vicinity of the bridge site (ODNR, 2013[(2)]). No oil or gas wells are noted within the immediate vicinity of the bridge site (ODNR, 2013[(3)]).

2.6. Site Reconnaissance

A preliminary site reconnaissance was conducted Feb 4, 2014 during field operation planning and borehole staking at which time the ground was partially snow covered. A second inspection of the area was performed May 24, 2014.

The single IORY track parallels Harrisburg Pike approximately 600 ft to the east. The area between the track and the Pike has been developed with predominantly light commercial facilities; the area to the west is agricultural farmland. The rail line is located in a shallow (~6 ft deep) cut, and the approach embankments are on the order of 24 ft high creating ~ 25 ft of clearance above the track.

No evidence of distress or poor performance was observed at the supports that could be attributed to geotechnical factors. The bridge parapet lines appear to be straight and true which is interpreted to indicate absence of significant differential settlement (Photographs 1 and 2). Spill through slopes appear to be stable and are generally well vegetated (Photograph 3). Surface drainage is poor in the vicinity of Piers 2 (L&R) where standing water can be seen.

Widening will take place in the area between the two existing structures (Photograph 4).

Photograph 1: NB FRA-71-0296 looking north.

Photograph 2: NB FRA-71-0296 from Center Median.

Photograph 3: View of NB FRA-71-0296 from Underneath SB.

Photograph 4: Looking North from Rear Abutment – Area to be widened.

3. EXPLORATION

3.1. Historical Boring Program

Original design drawings prepared by Barrett, Cargo, Withers & Associates, Ltd., (prepared in 1962), the Soil Profile for the roadway PIC-1-3.06/FRA-1-0.00 (1962), and the report of the geotechnical exploration for the existing bridge were reviewed. The Foundation Investigation for the bridge was conducted by The H. C. Nutting Company, the results of which were contained in a reported dated August 17, 1962 [*Report of Foundation Investigation, Interstate I-71, Bridge No. FRA-1-0298 (I-71 over B&O Railroad)]*. Four borings were drilled and sampled at the bridge site. Four planned borings were deleted from the program because of the uniformity of conditions encountered in the first four. Copies of the original boring logs are provided in Appendix A and drilling information is summarized in Table 1 below. The boring locations are shown on Exhibit 1.

Table 1: Historical Boring Summary

Boring Number	Surface Elevation NGVD 29[(1)] (ft)	Station/ Offset	Depth (ft)	Bottom of Hole Elevation (ft)	Depth Bedrock Encountered (ft)	Structure
B-001-C-62	869.2	998+07, 79' L	56.5	812.7	NE	west abutment SB
B-004-C-62	870.0	999+45, 26' L	56.5	813.5	NE	east abutment SB
B-005-C-62	870.7	997+49, 36' R	56.5	814.2	NE	west abutment NB
B-008-C-62	869.8	998+85, 79' R	56.5	813.3	NE	east abutment NB

(1) NGVD 29 - 0.607=NAVD 88
NE – not encountered.

H.C. Nutting reported the following:

> "The subsurface materials at the site are glacial in origin and very uniform, consisting of a rather deep strata of glacial till, extending from beneath the surface clays to the end of the borings. There is indicated lenses of granular outwash material. These glacial deposits originate from both the Illinoian and Wisconsin ice sheets."

Key findings of the geotechnical exploration were:

- The glacial till is stratified. A ~6 ft thick surficial layer of stiff clay and silty clay (A-6a / A-6b / A-7-6) overlies a stiff sandy silt (A-4a) for a further ~ 15 ft.
- At about elevation 845 ft the till becomes hard sandy silt, or silt (A-4a and A-4b) with relatively rare lenses of dense outwash sand and gravel (A-1-b).
- Ground water was encountered at an elevation of ~862 ft.

A roadway boring for IR-71 was drilled near the rear abutment, station 997+00 CL to a depth of 17 ft. The findings were similar to those of the structure borings.

3.2. Field Exploration

Subsurface drilling or the project drilling was conducted in two phases. Boring B-040-1-14 was drilled on April 11, 2014 by Stock Drilling under subcontract to BEI (all drilling was supervised and logged by a BEI representative); borings B-040-2-14 and B-040-3-14, drilled on IORY easement, were drilled on 3/31/15 by BEI after receiving a permit from the railroad. The location of the borings are shown on Exhibit 1 and summarized below in Table 2. The Logs of the Boring are provided in Appendix A.

Table 2: Boring Summary

Boring Number	Boring Location (Lat/Long)	NAVD 88 Surface Elevation (ft)	Depth (ft)	Bottom of Hole Elevation (ft)	Depth to Groundwater (ft)	Depth to Bedrock (ft)	Structure
B-040-1-14	39.825068, -83.143810	891.0	26.5	864.5	NE	NE	SB Rear Abutment
B-040-2-14	39.824764, -83.413445	863.8	56.5	807.3	NE	NE	NB Piers 1 and 2
B-040-3-14	39.825071, -83.143191	865.0	56.5	808.5	NE	NE	SB Piers 1 and 2

NE – not encountered.

The borings were drilled using either a truck-mounted CME 750X rig with 2.25-inch inside diameter (ID) hollow stem augers (HSA) or a truck-mounted CME 55X rig with 3.25-inch ID HSA. Soil samples were recovered at 2.5-ft intervals using a split spoon sampler (AASHTO T-206 "Standard Method for Penetration Test and Split Barrel Sampling of Soils").

The standard penetration test (SPT) was conducted during sampling using an auto-hammer that was calibrated March 1, 2013 as 79% efficient (CME 750X) and January 26, 2014 as 81.2% efficient (CME 55X). Field boring logs were prepared by the field supervisor, including lithological description and standard penetration test results, recorded as blows per 6-inch increment of penetration. Groundwater observations were recorded during the investigation. Hand penetrometer testing was conducted on a majority of SPT samples prior to removal from the sampler. The boring was backfilled with soil cuttings.

3.3. Laboratory Testing Program

The laboratory testing program consisted primarily of classification testing and moisture content determinations. Data from the laboratory-testing program were incorporated onto the logs of borings (Appendix A). Soil samples are retained at the laboratory for 60 days following report submittal, after which time they will be discarded.

3.3.1. Classification Testing

Natural moisture content tests were performed on all soil samples. Representative soil samples were selected for index property (Atterberg Limits) and gradation testing for classification purposes. The results are presented on the log of the boring. Mechanical soil classification (Plastic Limit, Liquid Limit and gradation testing) was conducted on 50% of the recovered samples enabling identification and testing of all significant soil units.

Final classification of soil strata in accordance with AASHTO M-145 "Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes," as modified by ODOT "Classification of Soils" was made once laboratory test results became available. Samples that were not tested were classified visually on the basis of comparison to those that were.

3.3.2. Standard Penetration Test Results

Standard Penetration Tests (SPT) and split-barrel (commonly known as split-spoon) sampling of soils was performed at 2.5-foot intervals in all borings using a calibrated auto-hammer. The resulting N-values must then be adjusted to account for the high efficiency of the hammer, compared to those used historically when many of the correlations of N-value with engineering properties of soils were developed. Manual hammers used in the past are considered to have been approximately 60% efficient and so the field measured N-values are adjusted by a factor equal to the calibrated efficiency/60. The resulting N_{60} values are shown on the log of borings.

4. FINDINGS

The following interpretation of the subsurface conditions is based on results of the two field exploration programs, laboratory testing, and consideration of the geological history of the site.

4.1. General

The stratigraphy at the bridge site is generally consistent with the geological model discussed above, with over 50 ft of glacial till overburden encountered to the depth explored. Bedrock was not reached in any of the borings and is estimated to be on the order of 100 ft deep.

4.2. Overburden

Three distinct overburden formations are described, each of which is glacially derived till, but with differing depositional histories and properties.

4.2.1. Embankment

The rear approach embankment was explored (B-040-1-14) and found to consist of reworked glacial till comprised primarily of hard sandy silt (A-4a) with minor amounts of silt and clay (A-6a). The sample driving energy (N) averaged 23 blows per foot (bpf) which is not a high value, but the hand penetrometer readings were consistently greater than 4.5 tsf except in the more clayey soils where they were in the range 2 - 4.5+ tsf. The original ground elevation at the historical boring locations was 869 - 870 ft and is taken to be the base of the freeway embankment.

4.2.2. Railroad Fill

The two borings drilled on the IORY railroad easement found fill between the surface 863.8 ft and elevation 862.5 ft in Boring B-040-3-14 and the surface elevation 863.8 ft and 851.8 ft in Boring B-040-2-14. The fill was exclusively gravel and sand (A-1-b) in B-040-3-14 underlain by several layers of sandy silt (A-4a) interspersed with a silt and clay (A-6a) layer and a coarse and fine sand (A-3a) layer.

4.2.3. Glacial Till (1)

Below the embankment and the railroad fill is a layer of intact glacial till, extending to about elevation 845 ft, that is almost exclusively sandy silt (A-4a). It is generally logged as medium stiff to stiff with an average blow count of 18 bpf. This material is frequently mantled with a 1-3 ft layer of clay that includes a thin layer of A-7-6 on top of a thin layer of A-6a.

4.2.4. Glacial Till (2)

At elevation 844 - 845 ft a much harder till was encountered, again consisting primarily of sandy silt (A-4a), but with a blow count in the range 32-89 and an average of 61 bpf. This material was present in each of the four historical borings to the depths explored and in the two deep project borings. This is a uniform material based on liquid limit and plasticity index. Till (2) is interpreted to be an Illinoian glacial deposit and Till (1), a more recent Wisconsinan.

4.3. Groundwater

Groundwater was encountered in the historical borings as summarized below in Table 3.

Table 3: Groundwater Summary

Boring Number	Surface Elevation (ft)	Depth (ft)	Depth to Groundwater During Drilling (ft)	Elevation of Groundwater (ft)	Depth to Groundwater After 24 hrs (ft)	Elevation of Groundwater (ft)
B-001-C-62	869.2	56.5	8	861.2	4.7	864.5
B-004-C-62	870.0	56.5	7	863.0	4.4	865.6
B-005-C-62	870.7	56.5	9	861.7	-	-
B-008-C-62	869.8	56.5	16.5	853.3	7	862.8

No water was encountered in the project boring (B-040-1-14) that extended to elevation 864.5 ft. Standing water observed in the ditch next to Pier 2 is likely to be close to elevation 865 ft.

4.4. Soil Properties for Analysis

Generalized material profiles and physical properties for analysis have been developed. These are based primarily on published engineering correlations with index properties and consistency data as indicated by SPT results and hand penetrometer readings. The soil properties are shown in Table 4.

Table 4: Geotechnical Soil Properties

Soil Type	Description	Property	Value	Source
1	891 Embankment (A-4a) 869	N_{60}	23	Appendix A
		WC	9%	Appendix A
		S_u	4,500 psf	Appendix A
		c'	400 psf	GB 6
		Φ'	32º	GB 6
2	869 Glacial Till (1) (A-4a, A-7-6, A-6a) 845	N_{60}	18	Appendix A
		WC	12%	Appendix A
		S_u	3,000 psf	N_{60} Correlation
		c'	300 psf	GB 6/Estimate
		Φ'	29º	GB 6/Estimate
3	845 Glacial Till (2) (A-4c) 812	N_{60}	61	Appendix A
		WC	10%	Appendix A
		S_u	11,000 psf	N_{60} correlations
		c'	400 psf	GB 6/Estimate
		Φ'	32º	GB 6/ Estimate

The strength properties of the glacially derived materials deserve further mention. The existing pier piles were ordered to a length of 30 ft. A pile cap elevation of 861 ft would place the tip of the piles in the range of 841 - 837 ft (accounting for the method of establishing the pile order length), a depth that places them within the top of the hard till (2) that starts at 845 ft. Strength properties for Till (1) and (2) have been estimated using field test results and published correlations with various indicator parameters including N_{60} (blow counts).

The undrained shear strength has been correlated with N_{60} values for a variety of basal tills (ICE, 2012). The results of laboratory testing suggest a factor of 4.1-7.0 x N_{60} (measured in kPa: 1 kPa = 21 psf), although it is claimed that experience in the field justifies a higher value, and a factor of 9 is recommended for foundation design. This method yields shear strength values of 3,300 psf (Till 1) and 11,500 psf (Till 2) based on N_{60} values of 18 and 60 that may be used in design.

5. ANALYSIS AND RECOMMENDATIONS

5.1. Global Stability

The existing spill-through slopes extend the full distance between the two structures and have been in place for about 50 years. They appear to be performing well and no significant modification to the slopes

is planned as part of these improvements. The global stability of the abutments should, therefore, remain adequate.

5.2. Settlement

No significant additional fill or other loading of the approach embankments is anticipated and settlement will not therefore be a factor in design.

5.3. Deep Foundations

The widened structure will be supported on deep foundations that derive resistance primarily from the hard glacial till encountered beneath the site. The existing abutments are founded on shallow spread foundations bearing on the approach embankment fills. Extension of the abutments will be supported on deep foundations to reduce the potential for differential settlement between the two phases of construction.

Driven piling will, theoretically rely on friction to provide resistance since it will not be driven to refusal at bedrock. However, pier piles driven for the existing structure foundations appear to have been designed to terminate near the top of the hard glacial till layer suggesting that they are functioning primarily as end bearing piles. It is assumed that the most efficient foundation system will be obtained by driving the piles into the hard glacial till layer below elevation ~ 845 ft. The load bearing capacity of such piles was evaluated using the software solution DRIVEN v1.2, and the input/output are provided in Appendix B.

The ultimate bearing value (UBV) of abutment friction piles driven 2 ft into the hard glacial till are:

Abutments (HP 10x42): 159 kips UBV required = 2*65 = 130 kips OK

These piles derive sufficient frictional resistance before reaching the hard till. However for consistency of foundation performance it is recommended that they be supported in the same stratum as that in which the pier piles will be terminated.

Pier piles are, theoretically, required to be longer as the design loads are more than twice as high. In practice, it is expected that driving 20 ft through the hard till will be difficult and sufficient capacity will be realized at a shallower depth.

HP 10x42 piles driven into the hard glacial till may be used to support the abutment foundations, given the single pile Service Design Load of 32.5 tons (65 kips). HP12x53 piles may be used to support the Service Design Loads applied at the piers of 80 and 77.5 tons (160, 155 kips). Estimated pile lengths are shown in Table 5 based on soil properties discussed above and pile cap elevations provided by the designer.

Table 5: Estimated Pile Lengths

Location	Service Design Load (kips)	Pile Cap Elevation (ft)	Top of Hard Till Elevation (ft)	Pile Tip Elevation (ft)	Estimated Length[(1)] (ft)
Rear Abutment L&R HP-10x42	65	880	845	843	40
Pier 1 L&R HP12x53	160	860	840	823	40
Pier 2 L&R HP 12x53	155	860	840	823	40
Forward Abutment L&R HP 10x42	65	881	845	843	40

(1) Assumes 1 ft embedment in pile cap, rounded up to the next 5 ft increment.

5.4. Driveability

The driving resistance of H-piles through the hard glacial till is expected to be high and pile points are recommended to facilitate driving. Driveability is difficult to assess quantitatively as the SPT values tend to be very high. Experience in similar formations suggest that the piles may be driven with a Pileco 25/32 or Pileco 25/26 without over-stressing them or requiring unreasonably high numbers of blows. The contractor should provide an analysis to demonstrate that the equipment planned for use is capable of performing without over-stressing the piles.

5.5. Groundwater

Groundwater was encountered in the historical borings at elevations that are above the foundation level of the pier pile caps. Given the fine grained soil types, the amount of ground water flow is not expected to be large unless zones of porous soil (sand and / or gravel) are encountered. For the same reason storm water will pond readily and may be slow to drain. Contractor operations should include provision for dewatering excavations by pumping, and for protecting them from storm water inflow.

5.6. Seismic Design

ODOT has determined that the whole state lies within Seismic Zone 1. Based on the results of the subsurface exploration, the laboratory test data, and our review of the AASHTO Site Class Definition, we recommend a project site classification of C (very dense soil and rock with N>=50 or s_u >= 2ksf).

6. QUALIFICATIONS

This investigation was performed in accordance with accepted geotechnical engineering practice for the purpose of characterizing the subsurface conditions at the site of Bridge FRA-71-0296, performing geotechnical engineering analyses, and providing recommendations for the design and construction of the foundations only. The analyses and recommendations submitted in this report are based upon data obtained from borings drilled at the locations shown on Exhibit 1 and as presented on the Log of Boring (Appendix A). This report does not reflect any variations that may occur between the borings or elsewhere on the site, or variations whose nature and extent may not become evident until a later stage of construction. In the event that any changes in the nature, design or location of the proposed wall is made, the conclusions and recommendations contained in this report should not be considered valid until they are reviewed, and have been modified or verified in writing by a geotechnical engineer.

It has been a pleasure to be of service to ms consultants, inc. in performing this geotechnical exploration for Bridge FRA-71-0296 as part of the FRA-71-0.00 project.

Respectfully Submitted,

NEAS, Inc.

3/27/17

Enoch Chipukaizer
Principal

Chunmei (Melinda), Ph.D., P.E.
Geotechnical Engineer

REFERENCES

AASHTO, 2014. *AASHTO Standard Specifications for Highway Bridges 7th Edition*. American Association of State Highway and Transportation Officials, Inc., Washington, D.C.

Brockman S.C., 1998. *Physiographic Regions of Ohio*. Ohio Department of Natural Resources Division of Geological Survey.

H.C. Nutting Company (The), 1962. *Report of Foundation Investigation, Interstate I-71, Bridge No. FRA-1-0296 (I-71 over The B&O Railroad)*. August 17, 1962

Ohio Department of Natural Resources, 1994. *Reconnaissance Bedrock Geology of the Harrisburg, Ohio Quadrangle.* Division of Geological Survey. D. L. Shrake. Open-File Map: BG-B4G2.

1993. *Bedrock Topography of the Harrisburg, Ohio Quadrangle.* Division of Geological Survey, D. L. Shrake. Open-File Map: BT-B4G2.

2005. *Surficial Geology of the Springfield 30 x 60 Minute Quadrangle.* Brockman, C.S, Schumacker, G.A., Shrake, D.L. Swinford, E.M. and Larsen, G. E. SG-2. Scale 1:100,000.

2012. *Earthquake Epicenters in Ohio and Adjacent Areas.* Ohio Division of Geological Survey. Map EG-2. Scale 1:2,000,000.

2013(1). *Ohio Earthquake Epicenters.* Division of Geological Survey Interactive Map. July 17, 2013. http://www2.dnr.state.oh.us/website/geo/Earthquakes/

2013(2). *Abandoned Underground Mine Locater.* Ohio Geological Survey. May 20, 2013. http://www.dnr.state.oh.us/website/geosurvey/geosurvey_mines/disclaimer.htm

2013(3). Emergency Oil and Gas Well Locator. Ohio Geological Survey. May 20, 2013. http://www.dnr.state.oh.us/Website/Geosurvey/geosurvey_emergency_oilgas/viewer.htm

Ohio Department of Transportation. 2007. *ODOT Bridge Design Manual.* Office of Structural Engineering. April 2014 Revisions.
http://www.dot.state.oh.us/Divisions/Engineering/Structures/standard/Bridges/Pages/BDM2007.aspx

State of Ohio, 2013. FALCON Geotechnical Document Management System (GDMS). Office of Geotechnical Engineering. Files on 2506904 and 2506939 Bridge and Geotechnical Exploration.
http://www.dot.state.oh.us/Divisions/ProdMgt/Geotechnical/Pages/GDocMS.aspx#GRSR16

U.S. Department of Agriculture, 2013. Web Soil Survey, National Cooperative Soil Survey. Natural Resource Conservation Service. July 17, 2013.
http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

U.S. Department of Homeland Security, 2010. *FIRM Flood Insurance Rate Map Franklin County, Ohio and Incorporated Areas Panel 383 of 465. Map Number 39049C0383K.* Map Revised: June 17,

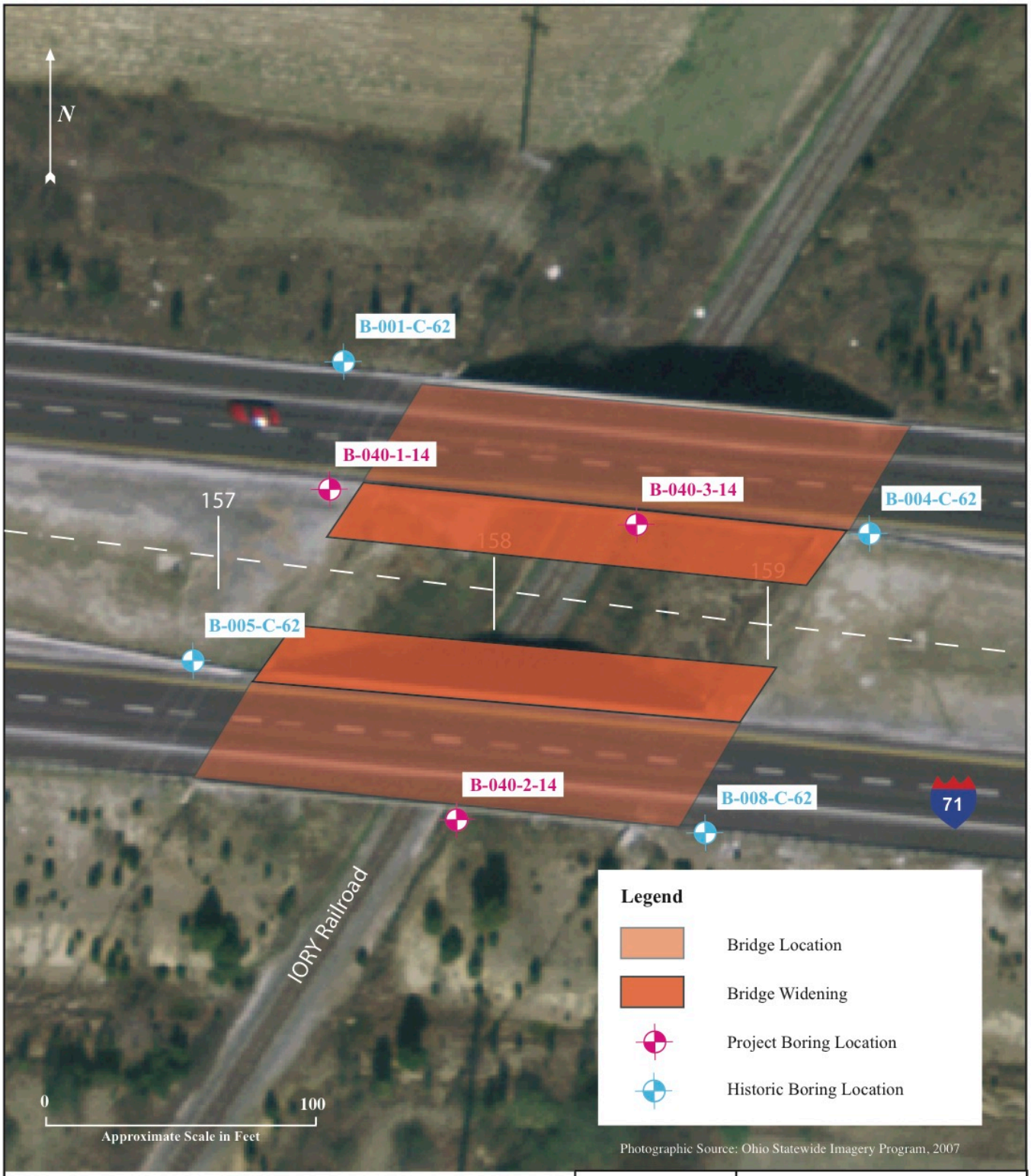
2008. Federal Emergency Management Agency. National Flood Insurance Program.

U.S. Department of the Interior, 1966. *Harrisburg Quadrangle, Ohio, 7.5 Minute Series (Topographic).* Geological Survey. N3945-W8307.5/7.5. AMS 4363 I SW-SERIES V852. 1966 (photorevised 1974).

2010. *Harrisburg Quadrangle, Ohio, 7.5-Minute Series.* Geological Survey. 2010.

U.S. Fish and Wildlife Service, 2013. National Wetlands Inventory-Wetlands Mapper-Shapefile. May 17, 2013. http://www.fws.gov/wetlands/Data/Mapper.html

U.S. Geological Survey, 2008. *Seismic Design Parameters.* V2.10 USGS SEIS-1-CD.



Area of Detail

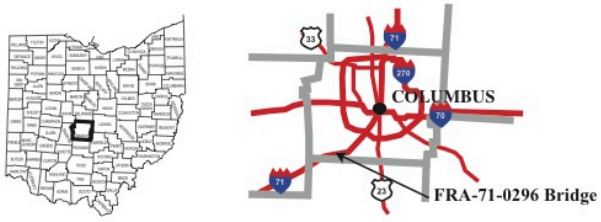


Exhibit 1

BARR ENGINEERING, INC.

Boring Locations
FRA-71-0296 L&R
Bridge over IORY Railroad

FRA-71-0.00 Improvements
PID#: 93496

APPENDIX A

LOGS OF BORINGS AND LABORATORY TESTING RESULTS

NEAS Inc.
National Engineering & Architectural Services Inc.

LEGEND

SYMBOL	DESCRIPTION	ODOT CLASSIFICATION
	Gravel and/or Stone Fragments	A-1-a
	Gravel and/or Stone Fragments with Sand	A-1-b
F.S.	Fine Sand	A-3
	Coarse and Fine Sand	A-3a
	Gravel and/or Stone Fragments with Sand and Silt	A-2-4 A-2-5
	Gravel and/or Stone Fragments with Sand, Silt and Clay	A-2-6 A-2-7
	Sandy Silt	A-4a
	Silt	A-4b
	Elastic Silt and Clay	A-5
	Silt and Clay	A-6a
	Silty Clay	A-6b
	Elastic Clay	A-7-5
	Clay	A-7-6
	Organic Silt	A-8a
	Organic Clay	A-8b

SYMBOL	DESCRIPTION	ODOT CLASSIFICATION
	Shale	Visual
	Weathered Shale	Visual
	Sandstone	Visual

GRADATION (%)

GR Gravel
CS Coarse Sand
MS Medium Sand
FS Fine Sand
SI Silt
CL Clay (<5 micron)

SAMPLER SYMBOLS

Shelby Tube

Rock Core

Split Spoon Sample (SS)

* Indicates a Sample Taken Within 3 ft of Proposed Grade

ABBREVIATIONS

LL	LIQUID LIMIT (%)	HP	HAND PENETROMETER
PI	PLASTIC INDEX (%0	PID	PHOTOIONIZATION DETECTOR
WC	MOISTURE CONTENT (%)	UC	UNCONFINED COMPRESSION
SPT	STANDARD PENETRATION TEST	ppm	PARTS PER MILLION
NP	NON PLASTIC	$\mathcal{W}$	WATER FIRST ENCOUNTERED
-200	PERCENT PASSING NO. 200 SIEVE	▼	WATER LEVEL UPON COMPLETION
N_{60}	ADJUSTED SPT RESULT		
EOB	END OF BORING		

MATERIAL CLASSIFIED BY VISUAL INSPECTION

Sod and Topsoil
Pavement or Base
Concrete

Uncontrolled Fill (Describe)

Bouldery Zone

Peat, S-Sedimentary
W-Woody F-Fibrous
L-Loamy & etc

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 2/15/17 12:17 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE BY YEAR\2015 ARCHIVE\FRA-71-0.00 2014-15\COMBINE

PROJECT: FRA-71-00.00	DRILLING FIRM / OPERATOR: STOCK / AUSTIN	DRILL RIG: CME 750X (STOCK)	STATION / OFFSET: 156+85, 20 LT	EXPLORATION ID B-040-1-14
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: B&P / Z. JEWELL	HAMMER: CME AUTOMATIC	ALIGNMENT: CL CONST. IR 71	
PID: 93496 BR ID: FRA-71-0296	DRILLING METHOD: 2.25" HSA	CALIBRATION DATE: 3/1/13	ELEVATION: 891.0 (MSL) EOB: 26.5 ft.	PAGE 1 OF 1
START: 4/11/14 END: 4/11/14	SAMPLING METHOD: SPT	ENERGY RATIO (%): 78.6	LAT / LONG: 39.825068130, -83.143810020	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
HARD, GRAYISH BROWN, **SANDY SILT**, SOME CLAY, LITTLE GRAVEL, SS-1 AND SS-2 CONTAINS ROOTS, DAMP	891.0	1	4 6 6	16	72	SS-1	4.5+	12	11	18	35	24	23	14	9	11	A-4a (5)	
@2.5'; SS-2 BECOMES GRAY		3	9 9 6	20	44	SS-2	4.5+	-	-	-	-	-	-	-	-	9	A-4a (V)	
		6	8 8 10	24	22	SS-3	4.5+	-	-	-	-	-	-	-	-	8	A-4a (V)	
		8	9 6 10	21	28	SS-4	4.5+	-	-	-	-	-	-	-	-	9	A-4a (V)	
@10.0'; SS-5 BECOMES GRAY MOTTLED WITH BROWN		11	8 9 15	31	56	SS-5	4.5+	15	11	16	34	24	22	14	8	9	A-4a (5)	
		13	4 8 11	25	44	SS-6	4.5+	-	-	-	-	-	-	-	-	10	A-4a (V)	
VERY STIFF TO HARD, BROWN MOTTLED WITH GRAY, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, DAMP	876.5 875.0	16	8 7 8	20	100	SS-7	2.0 - 4.5+	7	10	14	37	32	28	17	11	14	A-6a (7)	
VERY STIFF TO HARD, DARK GRAY MOTTLED WITH BROWN, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, DAMP	874.0						3.5 - 4.25	1	3	6	35	55	-	-	-	23	A-6b (V)	
HARD, ORANGISH BROWN MOTTLED WITH GRAYISH BROWN, **SANDY SILT**, SOME CLAY, LITTLE GRAVEL, DAMP	869.0	18	5 6 8	18	67	SS-8	4.5+	-	-	-	-	-	-	-	-	15	A-4a (V)	
		21	8 15 8	30	83	SS-9	3.5 - 4.5+	11	11	16	34	28	25	15	10	11	A-4a (5)	
HARD, GRAY, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, DAMP	866.5	23	5 5 18	30	100	SS-10	4.5+	-	-	-	-	-	-	-	-	18	A-6a (V)	
VERY STIFF, DARK GRAY MOTTLED WITH ORANGISH BROWN, **CLAY**, SOME SILT, TRACE SAND, TRACE GRAVEL, MOIST	864.5	26	3 5 7	16	100	SS-11	3.25 - 3.5	1	2	7	31	59	54	19	35	23	A-7-6 (19)	
	EOB																	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SHOVELED SOIL CUTTINGS

PROJECT: FRA-71-00.00
TYPE: BRIDGE
PID: 93496 BR ID: FRA-71-0296
START: 3/31/15 END: 3/31/15

DRILLING FIRM / OPERATOR: BARR / J.GILBERT
SAMPLING FIRM / LOGGER: BARR / Z.JEWELL
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: CME 55X
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 1/26/14
ENERGY RATIO (%): 81.2

STATION / OFFSET: 157+97, 81 RT
ALIGNMENT: CL CONST. IR 71
ELEVATION: 863.8 (MSL) EOB: 56.5 ft.
LAT / LONG: 39.824764000, -83.413445000

EXPLORATION ID B-040-2-14

MATERIAL DESCRIPTION AND NOTES	ELEV. 863.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
VERY SOFT TO SOFT, GRAYISH BROWN, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, CONTAINS MANY ROOT HAIRS AND COAL FRAGMENTS, WET **(FILL)**	861.8	1	WOH WOH 4	5	50	SS-1	0.2 - 0.25	-	-	-	-	-	-	-	-	31	A-6a (V)	
SOFT TO STIFF, GRAYISH BROWN, **SANDY SILT**, LITTLE CLAY, LITTLE GRAVEL, MOIST **(POSSIBLE FILL)**	858.8	3	2 1 2	4	100	SS-2	0.25 - 1.25	12	13	16	39	20	21	14	7	15	A-4a (5)	
LOOSE, DARK BROWN, **COARSE AND FINE SAND**, LITTLE GRAVEL, LITTLE SILT, TRACE CLAY, (GRAVEL IS DEGRADING SANDSTONE), DAMP **(POSSIBLE FILL)**	858.3	5	5 6 6	16	28	SS-3	-	-	-	-	-	-	-	-	-	6	A-3a (V)	
							4.25	-	-	-	-	-	-	-	-	12	A-4a (V)	
VERY STIFF TO HARD, GRAYISH BROWN, **SANDY SILT**, SOME GRAVEL, LITTLE CLAY, DAMP **(POSSIBLE FILL)**		8	5 5 8	18	83	SS-4	3.75 - 4.2	-	-	-	-	-	-	-	-	11	A-4a (V)	
@10.0'; SS-5 CHANGES TO VERY SOFT, BROWN, LITTLE GRAVEL, WET	851.8	11	WOH WOH 2	3	56	SS-5	-	20	10	15	36	19	21	14	7	21	A-4a (4)	
VERY STIFF TO HARD, GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, DAMP TO MOIST		13	4 7 7	19	67	SS-6	4.25	-	-	-	-	-	-	-	-	11	A-4a (V)	
		16	4 4 7	15	100	SS-7	3.75 - 4.0	-	-	-	-	-	-	-	-	13	A-4a (V)	
		18	4 6 7	18	100	SS-8	2.9 - 3.25	8	11	14	39	28	24	15	9	13	A-4a (6)	
@20.0'; SS-9 BECOMES DARK GRAY		21	8 8 9	23	100	SS-9	2.5 - 4.25	-	-	-	-	-	-	-	-	12	A-4a (V)	
@22.0'; SS-10 BECOMES GRAYISH BROWN AND BROWN		23	8 10 11	28	100	SS-10	3.4 - 4.5+	-	-	-	-	-	-	-	-	12	A-4a (V)	
@25.0'; SS-11 TO SS-15 BECOME GRAY		26	13 28 39	91	100	SS-11	4.5+	-	-	-	-	-	-	-	-	8	A-4a (V)	
		28	14 24 41	88	100	SS-12	4.5+	-	-	-	-	-	-	-	-	8	A-4a (V)	

PID: 93496	BR ID: FRA-71-0296	PROJECT: FRA-71-00.00	STATION / OFFSET: 157+97, 81 RT	START: 3/31/15	END: 3/31/15	PG 2 OF 2	B-040-2-14

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
VERY STIFF TO HARD, GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, DAMP TO MOIST *(continued)*	833.8	31	11 23 30	72	100	SS-13	4.5+	6	11	17	39	27	23	13	10	8	A-4a (6)	
		32																
		33																
		34																
		35	13 27 34	83	100	SS-14	4.5+	-	-	-	-	-	-	-	-	9	A-4a (V)	
		36																
		37																
		38																
		39																
		40	16 24 26	68	100	SS-15	4.5+	-	-	-	-	-	-	-	-	9	A-4a (V)	
		41																
		42																
		43																
		44																
@45.0'; SS-16 TO SS-18 BECOME DARK GRAY		45	13 19 25	60	100	SS-16	4.5+	4	7	20	44	25	22	12	10	9	A-4a (7)	
		46																
		47																
		48																
		49																
		50	9 15 21	49	100	SS-17	4.25 - 4.5+	-	-	-	-	-	-	-	-	13	A-4a (V)	
		51																
		52																
		53																
		54																
		55	11 15 18	45	100	SS-18	4.5+	-	-	-	-	-	-	-	-	12	A-4a (V)	
	807.3	56 EOB																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SHOVELED SOIL CUTTINGS

PROJECT: FRA-71-00.00
TYPE: BRIDGE
PID: 93496 BR ID: FRA-71-0296
START: 3/31/15 END: 3/31/15

DRILLING FIRM / OPERATOR: BARR / J.GILBERT
SAMPLING FIRM / LOGGER: BARR / Z.JEWELL
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: CME 55X
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 1/26/14
ENERGY RATIO (%): 81.2

STATION / OFFSET: 158+58, 37 LT
ALIGNMENT: CL CONST. IR 71
ELEVATION: 865.0 (MSL) EOB: 56.5 ft.
LAT / LONG: 39.825071000, -83.143191000

EXPLORATION ID B-040-3-14

MATERIAL DESCRIPTION AND NOTES	ELEV. 865.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
LOOSE, GRAY, DARK GRAY AND BROWN, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, CONTAINS ROOT HAIRS AND COAL FRAGMENTS, WET **(FILL)**	862.5	1	3 4 3	9	17	SS-1	-	-	-	-	-	-	-	-	-	25	A-1-b (V)	
STIFF TO HARD, BROWN, **SANDY SILT**, LITTLE CLAY, LITTLE GRAVEL, DAMP		3	8 8 7	20	100	SS-2	1.75 - 4.5+	12	16	19	38	15	20	15	5	13	A-4a (4)	
		6	3 4 5	12	72	SS-3	3.0 - 3.5	-	-	-	-	-	-	-	-	12	A-4a (V)	
@7.5'; SS-4 NO RECOVERY		8	2 3 5	11	0	SS-4	-	-	-	-	-	-	-	-	-	-		
@10.0'; SS-5 NO RECOVERY		11	4 8 7	20	0	SS-5	-	-	-	-	-	-	-	-	-	-		
@12.5'; SS-6 TO SS-18 BECOME VERY STIFF TO HARD, DARK GRAYISH BROWN, SOME CLAY, TRACE GRAVEL, DAMP		13	5 7 7	19	100	SS-6	4.5+	9	7	15	41	28	24	14	10	12	A-4a (7)	
		16	3 4 8	16	100	SS-7	2.0 - 3.0	-	-	-	-	-	-	-	-	13	A-4a (V)	
		18	6 7 11	24	100	SS-8	4.0 - 4.5+	-	-	-	-	-	-	-	-	11	A-4a (V)	
		21	9 12 16	38	89	SS-9	4.5+	-	-	-	-	-	-	-	-	11	A-4a (V)	
		23	27 32 41	99	100	SS-10	4.5+	4	8	18	41	29	23	14	9	9	A-4a (7)	
		26	13 24 29	72	100	SS-11	4.5+	-	-	-	-	-	-	-	-	8	A-4a (V)	
		28	13 23 34	77	100	SS-12	4.5+	-	-	-	-	-	-	-	-	9	A-4a (V)	

PID: 93496	BR ID: FRA-71-0296	PROJECT: FRA-71-00.00	STATION / OFFSET: 158+58, 37 LT	START: 3/31/15	END: 3/31/15	PG 2 OF 2	B-040-3-14

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
STIFF TO HARD, BROWN, **SANDY SILT**, LITTLE CLAY, LITTLE GRAVEL, DAMP *(continued)*	835.0	31	9 12 33	61	100	SS-13	4.5+	-	-	-	-	-	-	-	-	9	A-4a (V)	
		32																
		33																
		34																
@35.0'; SS-14 BECOMES MOIST		35	13 19 25	60	100	SS-14	4.5+	-	-	-	-	-	-	-	-	15	A-4a (V)	
		36																
		37																
		38																
		39																
		40	11 15 24	53	100	SS-15	4.5+	4	8	19	43	26	21	13	8	12	A-4a (7)	
		41																
		42																
		43																
		44																
		45	8 14 22	49	100	SS-16	4.5+	-	-	-	-	-	-	-	-	14	A-4a (V)	
		46																
		47																
		48																
		49																
		50	5 15 20	47	100	SS-17	4.5+	-	-	-	-	-	-	-	-	12	A-4a (V)	
		51																
		52																
		53																
		54																
		55	7 15 20	47	100	SS-18	4.5+	-	-	-	-	-	-	-	-	10	A-4a (V)	
	808.5	56 EOB																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SHOVELED SOIL CUTTINGS

B-001-C-62

Form No. 530—16-59

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS

LOG OF BORING

DATE STARTED 7-16-62 SAMPLER: TYPE Split Spoon DIA. 2"O.D. WATER ELEV. IMMEDIATE 861.2 CLIENT: Barrett-Cargo-Withers & Assoc.,Ltd.

DATE COMPLETED 7-17-62 CASING: LENGTH _____ DIA. 3.5"I.D.Hollow Stem Augers AFTER 24 HOURS 864.5 PROJECT: I-71, Bridge No. FRA-1-0298

BORING No. 1 STATION AND OFFSET 998+07, 79' L. of CL of SR-1 SURFACE ELEV. 869.2

ELEV.	DEPTH	SAMPLE No.	STD. PEN. (N)	% REC.	DESCRIPTION	Physical Characteristics								
						% AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C.	SHTL CLASS
869.2	0													
868.2		1	1-2	11"	Topsoil	No tests performed								
	2	2	7	4"	Brown clay, little sand, moist - stiff	0	3	8	43	46	51	32	20	A-7-6
866.7														
	4	3	9-11-11	17"	Mottled brown and gray silt and clay, little sand, little gravel, moist - stiff	18	7	10	36	29	30	14	14	A-6a
864.2														
	6	4	4-4-6	17"	Mottled brown and gray sandy silt, some sand, very moist - medium stiff	22	11	15	37	15	23	7	15	A-4a
	8													
	10	5	5-8-9	18"	Brown sandy silt, with sand seams, little gravel, very moist - medium stiff	17	24	20	28	11	18	4	12	A-4a
	12	6	6-11-12	15"	Brown sandy silt, some gravel, moist - stiff	20	11	13	83	18	20	6	11	A-4a
	14	7	8-8-9	16"	do do	21	9	15	35	20	22	8	13	A-4a
	16	8	6-8-12	17"	Brownish gray sandy silt, little gravel, moist - stiff	15	10	13	37	25	22	8	13	A-4a
	18	9	7-8-11	18"	do do	20	10	15	35	20	23	9	12	A-4a
	20	10	10-12-14	17½"	Brown sandy silt, little gravel, moist - stiff	14	7	16	40	23	24	10	12	A-4a
	22													
	24													
	26	11	13-24-41	18"	Brownish gray sandy silt, little gravel, moist - very stiff	17	7	14	39	23	24	10	10	A-4a
	28													
	30													
		12	29-40	12"	Brownish gray sandy silt, trace of gravel, moist - very stiff	9	8	18	44	21	21	8	10	A-4a
	32													
	34													

B-001-C-62

Form No. 530—16-59

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS

LOG OF BORING

DATE STARTED 7-16-62 SAMPLER: TYPE Split Spoon DIA. 2"O.D. WATER ELEV. IMMEDIATE 961.2 CLIENT: Barrett-Cargo-Withers & Assoc.,Ltd.

DATE COMPLETED 7-17-62 CASING: LENGTH _____ DIA. 3.5"I.D.Hollow Stem Augers AFTER 24 HOURS 864.5 PROJECT: I-71, Bridge No. FRA-1-0298

BORING No. 1 STATION AND OFFSET 998+07, 79' L. of CL of SR-1 SURFACE ELEV. 869.2

ELEV.	DEPTH	SAMPLE No.	STD. PEN. (N)	% REC.	DESCRIPTION	Physical Characteristics % AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C	SHTL CLASS
	34													
	36	13	23-31-46	18"	Brown sandy silt, trace of gravel, moist - very stiff	7	8	17	42	26	21	8	10	A-4a
	38													
	40													
	42	14	18-20-25	18"	Brownish gray sandy silt, little gravel, moist - very stiff	10	8	17	41	24	21	8	10	A-4a
	44													
	46	15	16-17-20	18"	do do	16	8	16	38	22	20	7	10	A-4a
	48													
	50													
	52	16	16-23-31	18"	Brown sandy silt, little gravel, moist - stiff	11	8	18	40	23	20	8	10	A-4a
	54													
812.7	56	17	10-16-26	18"	do do	13	8	18	39	22	20	8	11	A-4a
	58				Boring completed									
	60													
	62													
	64													
	66													
	68													

B-004-C-62

Form No. 530—16-5

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS

LOG OF BORING

DATE STARTED 7-11-62 SAMPLER: TYPE Split Spoon DIA. 2"O.D. WATER ELEV. IMMEDIATE 863.0 CLIENT: Barrett-Cargo-Withers & Assoc.,Ltd.

DATE COMPLETED 7-12-62 CASING: LENGTH _____ DIA. 3.5"I.D.Hollow Stem Augers AFTER 24 HOURS 865.6 PROJECT: I-71, Bridge No. FRA-1-0298

BORING No. 4 STATION AND OFFSET 999+45, 36' L. of CL of SR-1 SURFACE ELEV. 870.0

ELEV.	DEPTH	SAMPLE No.	STD. PEN. (N)	% REC.	DESCRIPTION	Physical Characteristics								
						% AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C.	SHTL CLASS
870.0	0													
869.0		1	1-3	10"	Topsoil	No tests performed								
	2	2	6	5"	Dark brown clay,little sand,moist-stiff	0	3	8	43	46	52	32	22	A-7-6
867.0		3	8-10-14	16"	Mottled brown and gray clay,little sand, moist - very stiff	0	2	8	39	51	47	29	16	A-7-6
	4	4	6-6-7	14"	Mottled brown and gray silty clay,little sand,trace of gravel,moist-very stiff	9	3	8	41	39	39	25	16	A-6b
865.9														
864.5		5	4	4"	Mottled brown and gray sandy silt,little gravel, moist - stiff	15	11	15	42	17	22	7	15	A-4a
	6	6	4-4	12"	Brown silt,and sand, trace of gravel, wet - loose	6	7	28	52	7	19	3	20	A-4b
862.5														
	8	7	3-3-7	17"	Brown sandy silt, some gravel, very moist - medium stiff	28	13	14	30	15	19	6	12	A-4a
	10													
	12	8	4-7-9	16"	Brown sandy silt,some gravel, moist - stiff	20	11	13	38	18	21	7	10	A-4a
	14	9	6-7-8	14"	do do	28	7	10	35	20	21	8	11	A-4a
855.0														
	16	10	4-8-11	18"	Brownish gray silt, some sand, trace of gravel, moist - stiff	6	9	13	51	21	22	6	13	A-4b
852.5														
	18	11	5-7-9	18"	Brownish gray sandy silt, trace of gravel, moist - stiff	9	9	14	49	19	24	10	13	A-4a
	20													
	22	12	9-10-9	17½"	Brownish gray sandy silt, little gravel, moist - stiff	15	15	14	33	23	21	6	9	A-4a
	24													
	26	13	10-13-22	18"	Brownish gray sandy silt,trace of gravel, moist - stiff	7	9	16	45	23	21	8	11	A-4a
	28													
	30													
	32	14	29-45	12"	Brown sandy silt, trace of gravel, moist - very stiff	8	9	18	43	22	20	8	10	A-4a
	34													

B-004-C-62

Form No. 530—16-59

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS

LOG OF BORING

DATE STARTED 7-11-62 SAMPLER: TYPE Split Spoon DIA. 2"O.D. WATER ELEV. IMMEDIATE 863.0 CLIENT: Barrett-Cargo-Withers & Assoc., Ltd.

DATE COMPLETED 7-12-62 CASING: LENGTH _____ DIA. 3.5"I.D.Hollow Stem Augers AFTER 24 HOURS 865.6 PROJECT: I-71, Bridge No. FRA-1-0298

BORING No. 4 STATION AND OFFSET 999+45,36' L. of CL of SR-1 SURFACE ELEV. 870.0

ELEV.	DEPTH	SAMPLE No.	STD. PEN. (N)	% REC.	DESCRIPTION	Physical Characteristics								
						% AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C	SHTL CLASS
	34													
	36	15	29-51	12"	Brown sandy silt, trace of gravel, moist - very stiff	8	8	17	42	25	21	9	10	A-4a
	38													
	40													
	42	16	20-35-51	18"	do do	9	7	17	42	25	21	9	9	A-4a
	44													
	46	17	23-36-53	18"	Brownish gray sandy silt, little gravel, moist - stiff	12	8	17	41	22	21	9	9	A-4a
	48													
	50													
	52	18	17-30-47	18"	Brownish gray sandy silt, little gravel, moist - very stiff	11	8	18	39	24	20	8	10	A-4a
	54													
813.5	56	19	16-22-32	18"	do do	15	9	17	38	21	20	8	11	A-4a
	58				Boring completed									
	60													
	62													
	64													
	66													
	68													

B-005-C-62

Form No. 530—16-5

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS

LOG OF BORING

DATE STARTED 7-17-62 SAMPLER: TYPE Split Spoon DIA. 2"O.D. WATER ELEV. IMMEDIATE 861.7 CLIENT: Barrett-Cargo-Withers & Assoc.,Ltd.

DATE COMPLETED 7-18-62 CASING: LENGTH _____ DIA. 3.5"I.D.Hollow Stem Augers AFTER _____ HOURS _____ PROJECT: I-71,Bridge No. FRA-1-0298

BORING No. 5 STATION AND OFFSET 997+49, 36' R. of CL of SR-1 SURFACE ELEV. 870.7

ELEV.	DEPTH	SAMPLE No.	STD. PEN. (N)	% REC.	DESCRIPTION	Physical Characteristics								
						% AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C.	SHTL CLASS
870.7	0													
870.2		1	1	5"	Topsoil	No tests performed								
	2	2	3-7	10"	Brown clay,little sand, moist-medium stiff	0	4	10	37	49	44	24	17	A-7-6
868.2														
	4	3	9-14-15	16½"	Mottled brown and gray silt and clay, some sand, some gravel, moist - stiff	23	9	11	33	24	27	11	13	A-6a
865.7														
	6	4	6-7-8	17"	Mottled brown and gray sandy silt, trace of gravel, moist - stiff	9	13	14	40	24	24	9	15	A-4a
863.2	8													
		5	15-19-24	14"	Brown gravelly sand, some clay, moist-dense	49	18	13	16	4	18	3	11	A-1-b
860.7	10													
		6	10-11-13	17"	Brown sandy silt,little gravel, moist - very stiff	20	13	15	36	16	20	7	9	A-4a
	12													
	14	7	9-11-13	17"	Brown sandy silt,little gravel, moist - stiff	12	12	13	43	20	22	8	10	A-4a
	16	8	5-8-9	18"	Gray sandy silt,some gravel,moist-stiff	21	10	14	35	20	22	9	12	A-4a
	18													
		9	5-7-9	16"	Brownish gray sandy silt,trace of gravel, moist - stiff	10	9	15	48	18	24	10	12	A-4a
	20													
		10	6-18-10	18"	do do	9	10	18	38	25	23	9	12	A-4a
	22													
	24													
845.7														
844.7	26	11	22-37	12"	Brownish gray gravelly sand, some silt, moist - very dense	35	29	16	14	6	18	4	7	A-1-b
		12	50	4"	Brownish gray sandy silt, moist - very stiff (Visual)	Insufficient sample for testing								A-4a
	28													
	30													
		13	27-49	12"	Brownish gray sandy silt,some gravel, moist - very stiff	21	8	15	44	12	21	8	8	A-4a
	32													
	34													

B-005-C-62

Form No. 530—16-59

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS

LOG OF BORING

DATE STARTED 7-17-62 SAMPLER: TYPE Split Spoon DIA. 2"O.D. WATER ELEV. IMMEDIATE 861.7 CLIENT: Barrett-Cargo-Withers & Assoc.,Ltd.

DATE COMPLETED 7-18-62 CASING: LENGTH _____ DIA. 3.5"I.D.Hollow Stem Augers AFTER _____ HOURS _____ PROJECT: I-71,Bridge No.FRA-1-0298

BORING No. 5 STATION AND OFFSET 997+49, 36' R. of CL of SR-1 SURFACE ELEV. 870.0

ELEV.	DEPTH	SAMPLE No.	STD. PEN. (N)	% REC.	DESCRIPTION	Physical Characteristics								
						% AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C.	SHTL CLASS
835.7	34													
	36	14	12-35-45	18"	Brownish gray silt, some sand, little gravel, moist - very stiff	10	9	17	50	14	22	9	9	A-4b
	38													
	40													
	42	15	11-16-23	18"	Brownish gray silt,some sand, little gravel, moist - stiff	11	8	17	50	14	22	9	11	A-4b
	44													
	46	16	10-15-20	18"	do do	10	8	18	50	14	20	7	11	A-4b
	48													
820.7	50													
	52	17	13-16-22	18"	Brownish gray sandy silt, little gravel, moist - stiff	12	7	17	42	22	21	8	12	A-4a
	54													
814.2	56	18	13-17-24	18"	do do	12	8	18	41	21	21	8	10	A-4a
	58				Boring completed									
	60													
	62													
	64													
	66													
	68													

B-008-C-62

Form No. 530—16-5

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS

LOG OF BORING

DATE STARTED 7-13-62 SAMPLER: TYPE Split Spoon DIA. 2"O.D. WATER ELEV. IMMEDIATE 853.3 CLIENT: Barrett-Cargo-Withers & Assoc.,Ltd.

DATE COMPLETED 7-13-62 CASING: LENGTH ____ DIA. 3.5"I.D.Hollow Stem Augers AFTER 24 HOURS 862.8 PROJECT: I-71, Bridge No. FRA-1-0298

BORING No. 8 STATION AND OFFSET 998+85, 79' R. of CL of SR-1 SURFACE ELEV. 869.8

ELEV.	DEPTH	SAMPLE No.	STD. PEN. (N)	% REC.	DESCRIPTION	Physical Characteristics								
						% AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C.	SHTL CLASS
869.8	0													
868.8		1	2-4	10"	Topsoil	No tests performed								
	2	2	14	4"	Mottled brown clay,little sand,moist-stiff	0	4	8	44	44	42	26	13	A-7-6
866.8		S-1 T		18"	Brown clay,little sand, moist - stiff	0	2	9	37	52	55	32	20	A-7-6
866.3	4	B			Mottled brown silty clay,little sand, moist - stiff	0	6	12	45	37	36	19	12	A-6b
		3	10-10-11	15"	Mottled brown and gray silt and clay, some sand, some gravel, moist - stiff	23	9	11	34	23	28	12	11	A-6a
	6	4	5-9-11	17"	Brown silt and clay, some sand, trace of gravel, moist - stiff	8	12	14	40	26	27	11	10	A-6a
862.8														
	8	S-2		18"	Brown sandy silt, little gravel, moist - stiff	13	14	15	37	21	20	6	12	A-4a
	10	5	7-6-8	18"	do do	15	13	16	39	17	20	6	11	A-4a
	12													
	14	6	6-8-9	17"	Brownish gray sandy silt, some gravel, moist - stiff	27	8	11	35	19	21	7	11	A-4a
	16	S-3		8"	Brownish gray sandy silt, trace of gravel, moist - stiff	9	11	16	39	25	23	9	10	A-4a
	18	7	16-16-18	16"	Brownish gray sandy silt,trace of gravel, moist - very stiff	23	10	17	34	16	21	7	13	A-4a
	20	8	5-8-11	18"	Brownish gray sandy silt,some gravel, moist - stiff	23	10	17	34	16	21	7	13	A-4a
	22	9	5-9-11	18"	Brownish gray sandy silt,little gravel, moist - stiff	14	9	15	46	16	22	8	13	A-4a
	24													
	26	10	12-19-32	18"	Brownish gray sandy silt,little gravel, moist - very stiff	10	9	17	40	24	23	10	10	A-4a
	28													
	30													
		11	30-44	12"	do do	11	8	18	40	23	22	9	9	A-4a
	32													
	34													

B-008-C-62

Form No. 530—16-5

THE H. C. NUTTING COMPANY

4120 AIRPORT ROAD
CINCINNATI 26, OHIO

TESTING ENGINEERS AND SOILS CONSULTANTS

LOG OF BORING

DATE STARTED 7-13-62 SAMPLER: TYPE Split Spoon DIA. 2"O.D. WATER ELEV. IMMEDIATE 853.3 CLIENT: Barrett-Cargo-Withers & Assoc.,Ltd.

DATE COMPLETED 7-13-62 CASING: LENGTH _____ DIA. 3.5"I.D.Hollow Stem Augers AFTER 24 HOURS 862.8 PROJECT: I-71,Bridge No.FRA-1-0298

BORING No. 8 STATION AND OFFSET 998+85, 79' R. of CL of SR-1 SURFACE ELEV. 869.8

ELEV.	DEPTH	SAMPLE No.	STD. PEN. (N)	% REC.	DESCRIPTION	Physical Characteristics								
						% AGG.	% C.S.	% F.S.	% SILT	% CLAY	L.L.	P.I.	W.C.	SHTL CLASS
	34													
	36	12	21-27-39	17½"	Brownish gray sandy silt,trace of gravel, moist - hard	4	6	18	44	28	23	10	10	A-4a
	38													
	40													
	42	13	17-31-45	18"	Brownish gray sandy silt,trace of gravel, moist - very stiff	8	8	17	43	24	23	10	10	A-4a
	44													
	46	14	16-26-35	18"	Brownish gray sandy silt, little gravel, moist - very stiff	17	7	16	38	22	22	9	10	A-4a
	48													
	50													
	52	15	15-29-40	18"	do do	11	8	17	42	22	21	9	10	A-4a
	54													
813.3	56	16	13-15-17	18"	do do	12	8	18	40	22	21	8	8	A-4a
	58				Boring completed									
	60													
	62													
	65													
	66													
	68													

APPENDIX B

CALCULATIONS

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename:
Project Name: FRA-71-0296 CSX Project Date: 05/25/2014
Project Client: ODOT MH
Computed By: se
Project Manager: jep

PILE INFORMATION

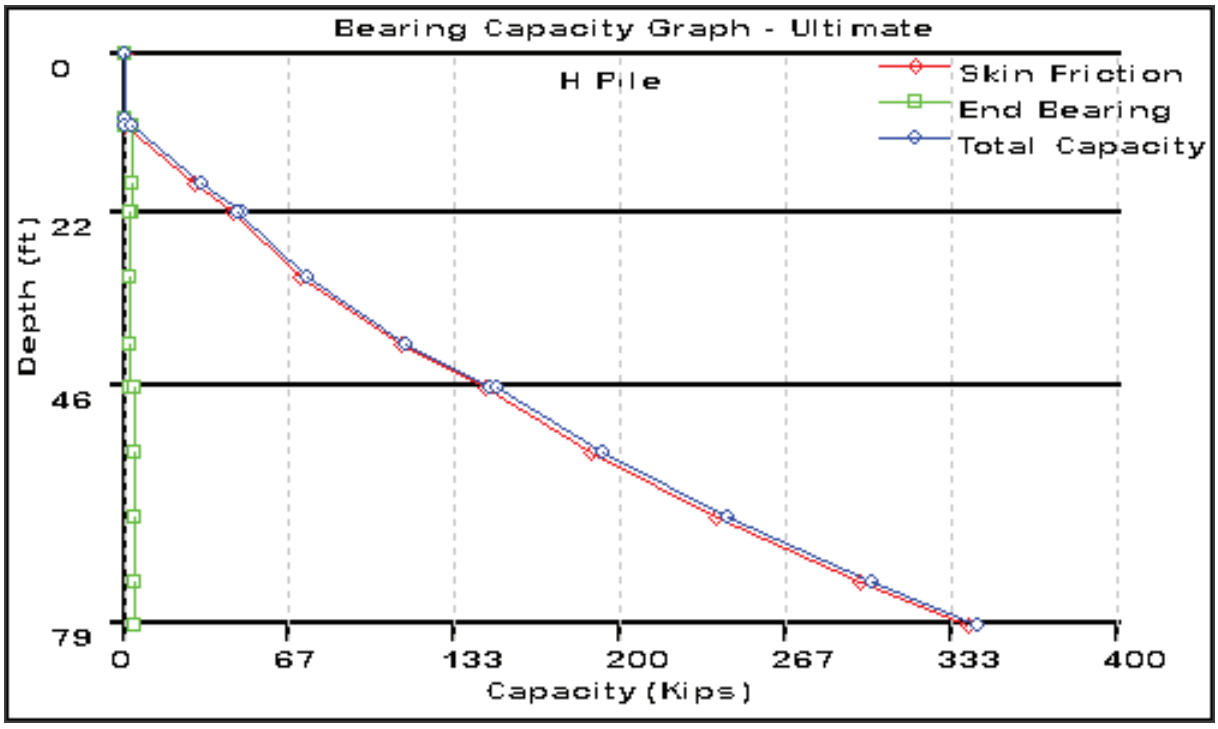
Pile Type: H Pile - HP10X42
Top of Pile: 10.00 ft
Perimeter Analysis: Box
Tip Analysis: Pile Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	26.00 ft
	- Driving/Restrike	26.00 ft
	- Ultimate:	26.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesive	22.00 ft	0.00%	125.00 pcf	4500.00 psf	T-80 Same
2	Cohesive	24.00 ft	0.00%	125.00 pcf	3000.00 psf	T-80 Same
3	Cohesive	33.00 ft	0.00%	130.00 pcf	6000.00 psf	T-80 Same



ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
9.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
9.99 ft	0.00 Kips	0.00 Kips	0.00 Kips
10.00 ft	0.00 Kips	3.49 Kips	3.49 Kips
18.01 ft	28.27 Kips	3.49 Kips	31.76 Kips
21.99 ft	43.87 Kips	3.49 Kips	47.36 Kips
22.01 ft	43.94 Kips	2.32 Kips	46.27 Kips
31.01 ft	71.30 Kips	2.32 Kips	73.63 Kips
40.01 ft	111.38 Kips	2.32 Kips	113.70 Kips
45.99 ft	145.03 Kips	2.32 Kips	147.36 Kips
46.01 ft	145.14 Kips	4.65 Kips	149.79 Kips
55.01 ft	187.77 Kips	4.65 Kips	192.42 Kips
64.01 ft	238.15 Kips	4.65 Kips	242.80 Kips
73.01 ft	296.29 Kips	4.65 Kips	300.94 Kips
78.99 ft	339.22 Kips	4.65 Kips	343.87 Kips

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: Z:\Users\stu\FRA70csx_pier_tot_11k.dvn
Project Name: FRA-71-0296 CSX Project Date: 05/25/2014
Project Client: ODOT MH
Computed By: se
Project Manager: jep

PILE INFORMATION

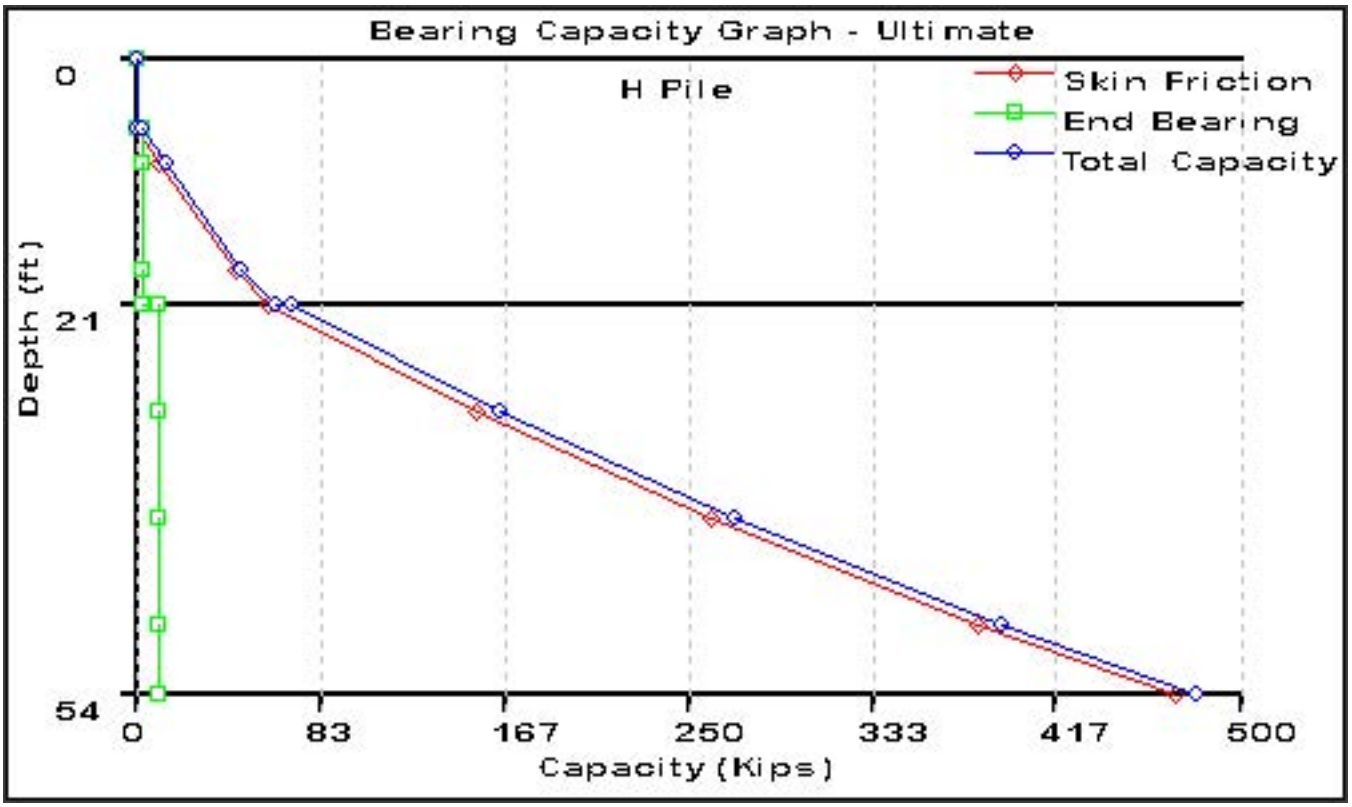
Pile Type: H Pile - HP12X53
Top of Pile: 6.00 ft
Perimeter Analysis: Box
Tip Analysis: Pile Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	1.00 ft
	- Driving/Restrike	1.00 ft
	- Ultimate:	1.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesive	21.00 ft	0.00%	125.00 pcf	3000.00 psf	T-80 Same
2	Cohesive	33.00 ft	0.00%	130.00 pcf	11000.00 psf	T-80 Same



ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
5.99 ft	0.00 Kips	0.00 Kips	0.00 Kips
6.00 ft	0.00 Kips	2.91 Kips	2.91 Kips
9.01 ft	10.85 Kips	2.91 Kips	13.76 Kips
18.01 ft	45.16 Kips	2.91 Kips	48.07 Kips
20.99 ft	59.90 Kips	2.91 Kips	62.80 Kips
21.01 ft	60.05 Kips	10.66 Kips	70.71 Kips
30.01 ft	153.62 Kips	10.66 Kips	164.27 Kips
39.01 ft	259.88 Kips	10.66 Kips	270.54 Kips
48.01 ft	381.30 Kips	10.66 Kips	391.96 Kips
53.99 ft	469.90 Kips	10.66 Kips	480.56 Kips