Resource International, Inc.

FRA-70-13.11 PROJECT 4A
FRA-70-1321R
I-70 EB OVER THE SCIOTO RIVER
PID NO. 77372
FRANKLIN COUNTY, OHIO

STRUCTURE FOUNDATION EXPLORATION REPORT (Rev. 2)

Prepared For:
GPD GROUP
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Prepared By:
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Rii Project No. W-13-045

July 2022

RESOURCE INTERNATIONAL, INC.
ISO 9001:2008
Certified QMS
An ISO 9001:2008 QMS Certified Firm

April 2, 2015 (Revised July 8, 2022)

Mr. Christopher W. Luzier, P.E.
Project Manager
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Re: Structure Foundation Exploration Report (Rev. 2)
FRA-70-13.11 Project 4A
FRA-70-1321R – I-70 EB over the Scioto River
PID No. 77372
Rii Project No. W-13-045

Mr. Luzier:

Resource International, Inc. (Rii) is pleased to submit this revised structure foundation exploration report for the above referenced project. Engineering logs have been prepared and are attached to this report along with the results of laboratory testing. This report includes recommendations for the design I-70 eastbound over the Scioto River as part of the FRA-70-13.11 Project 4A in Columbus, Ohio.

We sincerely appreciate the opportunity to be of service to you on this project. If you have any questions regarding the structure foundation exploration or this report, please contact us.

Sincerely,

RESOURCE INTERNATIONAL, INC.

Brian R. Trenner, P.E.
Director – Geotechnical Services

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Enclosure: Structure Foundation Exploration Report (Rev. 2)

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APPENDICIES

EXECUTIVE SUMMARY

Resource International, Inc. (Rii) has completed a structure foundation exploration for the design and construction of the proposed FRA-70-1321R bridge structure carrying I-70 eastbound over the Scioto River. The existing FRA-70-1321R structure is a nine-span bridge with a total length of approximately 960 feet. It is understood that the existing structure consists of a reinforced concrete deck on continuous steel girder beams, and will be removed and replaced with a five-span continuous hybrid steel plate girder with reinforced concrete deck structure, with capped pile abutments and multi-column piers, having a total length of approximately 1,075 feet and width of approximately 146 feet at the west end to 84 feet at the east end of the bridge.

Exploration and Findings

Between June 10, 2013, and May 3, 2014, six (6) structural borings, designated as B-015-7-13 through B-015-9-13 and B-016-3-13 through B-016-5-13, were advanced to completion depths ranging from 56.0 to 94.9 feet below the existing ground surface at the locations shown on the boring plan provided in Appendix I of this report. In addition to the borings performed as part of the current exploration, five (5) historic borings, designated as B-001-S-57, B-005-S-57, B-009-S-57, B-013-S-57 and B-020-S-57, were referenced along the existing bridge alignments carrying I-70 eastbound and westbound over the Scioto River. The historic borings were advanced to depths ranging from 36.0 to 63.0 feet below the existing grade at the time of the exploration.

Borings B-015-7-13 and B-016-4-13 encountered 5.0 and 12.0 inches of topsoil at the ground surface, respectively. Boring B-016-5-13 encountered 4.0 inches of asphalt overlying 6.0 inches of concrete followed by 2.0 inches of aggregate base at the ground surface. No distinctive surface materials were noted in borings B-015-8-13, B-015-9-13 and B-016-3-13, which were drilled within the Scioto River channel. However, the depth of water within the river channel ranged from 8.3 to 12.3 feet at the boring locations.

Beneath the surface materials in borings B-016-4-13 and B-016-5-13, material identified as existing fill was encountered extending to a depth of 8.0 and 28.0 feet below the ground surface, respectively. The fill material consisted of brown, dark brown, gray and brownish gray gravel with sand and silt, gravel with sand, silt and clay, sandy silt, silt and clay and silty clay (ODOT A-2-4, A-2-6, A-4a, A-6a, A-6b) and contained brick, concrete or coal fragments.

Underlying the existing fill and the surficial materials in the remaining borings, natural soils were encountered consisting of both granular and cohesive material. The granular soils were generally described as brown and gray gravel, gravel with sand, gravel with sand and silt, gravel with sand, silt and clay, coarse and fine sand and sandy silt (ODOT A-1-a, A-1-b, A-2-4, A-2-6, A-3a, A-4a). The cohesive soils were described as gray, brown, brownish gray and dark brown sandy silt, silt, silt and clay, silty clay and clay (ODOT A-4a, A-4b, A-6a, A-6b, A-7-6). A boulder zone was encountered in boring

B-015-9-13 between elevations 652.2 to 654.7 feet msl and in boring B-016-4-13 between elevations 667.0 to 669.5 feet msl. Cobbles and boulders were generally encountered above the bedrock in borings B-015-7-13 through B-016-4-13 starting at an elevation of approximately 670 feet msl.

Top of bedrock was encountered at elevations ranging from 643.8 to 660.8 feet msl. The upper portion of the bedrock encountered in the majority of the borings along the eastern half of the bridge alignment consists of gray and black shale overlying competent limestone and/or dolomite bedrock. Shale bedrock was encountered in borings B-005-S-57, B-009-S-57, B-013-S-57, B-015-9-13, B-016-4-13 and B-016-5-13 at elevations ranging from 650.8 to 660.8 feet msl. With the exception of borings B-001-S-57, B-013-S-57, B-020-S-57 and B-016-5-13, limestone/dolomite bedrock was encountered in the remaining borings at elevations ranging from 643.8 to 651.7 feet msl.

Analyses and Recommendations

Design details of the proposed structure were provided by GPD GROUP. Based on information provided, it is understood that the existing FRA-70-1321R structure will be removed and replaced with a five-span continuous hybrid steel plate girder with reinforced concrete deck structure, with capped pile abutments and multi-column piers, having a total length of approximately 1,075 feet and width of approximately 146 feet at the west end to 84 feet at the east end of the bridge. The proposed roadway profile grade of I-70 eastbound at the FRA-70-1321R structure location will be elevated approximately 5 feet above the existing profile grade at the rear abutment and 10 feet above the existing profile grade at the forward abutment.

Drilled Shaft Recommendations

It is understood that drilled shafts will be utilized at the pier substructure units. Given the proposed loading per shaft at each of the pier locations, friction bearing drilled shafts within the overburden soils and drilled shafts bearing within the weak surficial shale bedrock are not economically feasible foundation options due to the size and number of shafts that would be required to support the proposed loading. Therefore, it is recommended that the drilled shafts be extended through the surficial soils and weak surficial shale bedrock to bear on or within the underlying limestone/dolomite bedrock at the pier locations.

The following table lists the estimated elevation of the top of bedrock as well as the proposed rock sock diameter and length from the design plans and, corresponding nominal end bearing resistance to be utilized for the design of the drilled shaft foundations. A resistance factor of $\varphi_{qp} = 0.5$ at the strength limit state should be utilized for design.

Drilled Shaft Recommendations

Substructure Unit (Boring)	Top of Bedrock Elevation (feet msl)	Top of Limestone Elevation (feet msl)	Rock Socket Diameter [1] (feet)	Required Socket Length to Top of Limestone/Dolomite (feet)	Proposed Socket Length [1] (feet)	Nominal End Bearing Resistance [2] (ksf)
Pier 1 (B-015-8-13 / B-005-S-57)	652.1	651.5	5.5	0.6	9.0	2,107
Pier 2 (B-015-9-13 / B-009-S-57)	650.8	648.1	5.5	2.7	9.0	2,107
Pier 3 (B-016-3-13 / B-013-S-57)	660.8	643.8	5.5	17.0	17.0	2,107
Pier 4 (B-016-4-13 / B-013-S-57)	660.8	645.3	5.5	15.5	15.5	2,107

1. *Proposed rock socket diameter and length at each substructure unit determined from proposed plan information provided by GPD GROUP.*
2. *Nominal end bearing resistance provided is the value that should be utilized in the determination of the end bearing resistance per drilled shaft based on the proposed rock socket length and diameter.*

Given the factored end bearing resistances noted above for drilled shafts extended to bear on or within the limestone bedrock, it is anticipated that the axial resistance will be governed by structural resistance of the drilled shaft. The factored resistance per shaft provided in the design sheets should be the limiting value between the factored geotechnical resistance and the factored axial compressive resistance of the shaft.

Driven Pile Recommendations

It is understood that driven piles are to be utilized at the rear and forward abutment for the proposed structure. Given the depth of bedrock encountered in the borings performed and the required structural loading, it is recommended that steel H-piles (ODOT Item 507.06) driven to refusal on bedrock be employed for foundation support. Per Section 305.3.1.2 of the 2020 ODOT Bridge Design Manual, refusal is met during driving when the pile penetration is an inch or less after receiving at least 20 blows from the pile hammer. The following table shows recommended pile lengths and the corresponding factored structural axial resistance ($R_{R\ max}$) of steel H-piles.

FRA-70-1321R Driven Pile Recommendations

Substructure Reference	Ground Elevation [1] (feet msl)	Pile Size	Pile Elevation (feet msl)		Pile Length [3] (feet)	$R_{R\ max}$ [4] (kips/pile)	φ [5]
			Top [2]	Tip			
Rear Abutment (B-015-7-13 / B-001-S-57)	721.8 / 723.4	HP 12x53 [6]	715.5	651.3	65	380	N/A
Forward Abutment (B-016-5-13 / B-020-S-57)	740.1 / 725.4	HP 12x53	720.0	655.2	65	380	N/A

1. *Ground elevation listed is the ground elevation at the boring location.*
2. *The top of pile elevation corresponds to the pile cutoff elevation, which is 1.0-foot above the proposed bottom of footing elevation.*
3. *Per Section 305.3.5.2 of the 2020 ODOT BDM, the estimated pile length was determined as the pile cutoff elevation (top) minus the pile tip elevation, rounded up to the nearest 5.0 feet. Since the rounded length adds less than 1.0-foot, the estimated length has been increased an additional 5.0 feet.*
4. *The factored structural axial resistance for H-piles is based on the structural limit state of the steel H-pile section per Section 305.3.3 of the 2020 ODOT BDM.*
5. *For H-piles driven to refusal on bedrock, no geotechnical resistance factor should be applied to the factored structural axial resistance values presented, as the values presented account for the structural resistance factor, φ_c = 0.50, for H-piles subject to damage due to severe driving conditions.*
6. *A steel pile point is recommended to protect the tips of the H-piles during pile installation where the piles will be end bearing on limestone bedrock.*

Please note that this executive summary does not contain all the information presented in the report. The unabridged subsurface exploration report should be read in its entirety to obtain a more complete understanding of the information presented.

1.0 INTRODUCTION

The overall purpose of this project is to provide detailed subsurface information and recommendations for the design and construction of the FRA-70-12.68/13.11/14.05C (Project 4R/4H/4A) projects in Columbus, Ohio. The projects represent the central portion of FRA-70-8.93 (PID 77369) I-70/71 south innerbelt improvements project. The FRA-70-13.11 (Project 4A) phase will consist of all work associated with the construction of I-70 eastbound, starting just west of the FRA-70-1321R bridge structure over the Scioto River and extending east to just east of High Street. The proposed I-70 eastbound will consist of two-lane mainline travel lanes with shoulders from the beginning of the project limits to just east of the FRA-70-1358R bridge structure, where it will merge with Ramp C5. From this point to just west of High Street, I-70 eastbound will be reconstructed as part of the FRA-70-12.68 Project 4R under a separate contract. Some additional work along I-70 eastbound will be required to the east and west of High Street to complete the final configuration of the highway in this area. This project includes the replacement of two (2) bridge structures along I-70 eastbound as well as the construction of one (1) new retaining wall between Front Street and High Street.

This report is a presentation of the structure foundation exploration performed for the design and construction of the proposed FRA-70-1321R bridge structure carrying I-70 eastbound over the Scioto River, as shown on the vicinity map and boring plan presented in Appendix I. The existing FRA-70-1321R structure is a nine-span bridge with a total length of approximately 960 feet. It is understood that the existing structure consists of a reinforced concrete deck on continuous steel girder beams, and will be removed and replaced with a five-span continuous hybrid steel plate girder with reinforced concrete deck structure, with capped pile abutments and multi-column piers, having a total length of approximately 1,075 feet and width of approximately 146 feet at the west end to 84 feet at the east end of the bridge. The proposed I-70 eastbound roadway profile grade at structure FRA-70-1321R will be elevated approximately 5 feet above the existing profile grade at the rear abutment and 10 feet above the existing profile grade at the forward abutment.

2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 Site Geology

Both the Illinoian and Wisconsinan glaciers advanced over two-thirds of the State of Ohio, leaving behind glacial features such as moraines, kame deposits, lacustrine deposits and outwash terraces. The glacial and non-glacial regions comprise five physiographic sections based on geological age, depositional process and geomorphic occurrence (physical features or landforms). The project area lies within the Columbus Lowland District of the Till Plains Section. This area is characterized by flat to gently rolling ground moraine deposits from the Late Wisconsinan age. The site topography exhibits moderate to high relief. The ground moraine deposits are composed primarily of silty loam till (Darby, Bellefontaine, Centerburg, Grand Lake, Arcanum, Knightstown

Tills), with smaller alluvium and outwash deposits bordering the Scioto River, its tributaries and floodplain areas. A ground moraine is the sheet of debris left after the steady retreat of glacial ice. The debris left behind ranges in composition from clay size particles to boulders (including silt, sand, and gravel). Outwash deposits consist of undifferentiated sand and gravel deposited by meltwater in front of glacial ice, and often occurs as valley terraces or low plains. Alluvium and alluvial terrace deposits range in composition from silty clay size particles to cobbles, usually deposited in present and former floodplain areas.

According to the bedrock geology and topography maps obtained from the Ohio Department of Natural Resources (ODNR), the underlying bedrock consists predominantly of the Middle to Lower Devonian-aged Columbus Limestone. This formation is further subdivided into two members in the central portion of the state, known as the Delhi and Bellepoint Members. The Delhi Member consists of light gray, finely to coarsely crystalline, irregularly bedded, fossiliferous limestone. The Bellepoint Member consists of variable brown, finely crystalline, massively bedded limy dolomite. Both of these members contain chert nodules. Just east of the Scioto River, the underlying bedrock consists of the Upper Devonian Ohio Shale Formation overlying the Middle Devonian-aged Delaware Limestone Formation. The Ohio Shale formation consists of brownish black to greenish gray, thinly bedded, fissile, carbonaceous shale. The Delaware Limestone consists of bluish gray, thin to medium bedded dolomitic limestone with nodules and layers of chert. Regionally, the bedrock surface forms a broad valley aligned roughly north-to-south beneath the Scioto River. According to bedrock topography mapping, the elevation of the bedrock surface ranges from approximately 600 feet mean sea level (msl) in the valley to approximately 625 feet msl near the project limits.

2.2 Existing Conditions

The existing I-70 eastbound bridge structure carries a total of four lanes of traffic over the Scioto River, including two lanes from I-70 eastbound, one lane from I-71 northbound and one lane from SR-315 southbound, all of which converge at the west end of the structure. The Scioto River in the vicinity of the structure is approximately 450 feet wide with tree-lined banks and is aligned north-to-south underneath the I-70 eastbound bridge and bends to the northeast just north of the bridge crossing. The terrain at the east and west end of the existing structure is elevated approximately 25 to 35 feet above the river channel and the surrounding area on either side of the river channel is relatively flat-lying.

3.0 EXPLORATION

Between June 10, 2013, and May 3, 2014, six (6) structural borings, designated as B-015-7-13 through B-015-9-13 and B-016-3-13 through B-016-5-13, were obtained along the proposed alignment of the adjacent FRA-70-1321A bridge structure at the locations shown on the boring plan provided in Appendix I of this report and

summarized in Table 1. Borings B-015-8-13, B-015-9-13 and B-016-3-13 were performed from a barge within the Scioto River and extended to depths ranging from 56.0 to 65.2 feet below the riverbed elevation. Boring B-015-7-13 was performed at the top of the west bank of the Scioto River and was extended to a depth of 80.5 feet below existing grade. Boring B-016-4-13 was performed at the eastern bank of the Scioto River, just off the Lower Scioto Greenway bike trail, and was extended to a depth of 61.5 feet below existing grade. Boring B-016-5-13 was performed through the abandoned Mound Street Roadway at the top of the embankment, just south of the bridge over I-70, and was extended to a depth of 94.9 feet below existing grade.

Table 1. Test Boring Summary

Boring Number	Station [1]	Offset [1]	Latitude	Longitude	Ground Elevation (feet msl)	Boring Depth (feet)
B-015-7-13	5051+29.66	9.8' Rt.	39.950618516	-83.014254653	721.8	80.5
B-015-8-13	5053+52.86	39.9' Lt.	39.951030331	-83.013640823	692.5	56.0
B-015-9-13	5055+67.30	34.3' Lt.	39.951307453	-83.012965722	691.2	65.2
B-016-3-13	5058+05.01	33.7' Lt.	39.951627935	-83.012227140	685.0	58.6
B-016-4-13	5059+89.96	2.4' Rt.	39.951803928	-83.011598406	705.0	61.5
B-016-5-13	5062+32.40	14.0' Rt.	39.952081479	-83.010812274	740.1	94.9

1. The station and offset are referenced to the proposed baseline of Ramp C5.

The boring locations were determined and located in the field by Rii representatives. Rii utilized a handheld GPS unit to obtain northing and easting coordinates of the boring locations. Ground surface elevations at the boring locations were interpolated using topographic mapping information provided by GPD GROUP.

The borings were drilled using an all-terrain vehicle (ATV) mounted rotary drilling machine, utilizing either a 3.25-inch or 4.25-inch inside diameter, continuous hollow stem auger to advance the holes. Standard penetration testing (SPT) and split-spoon sampling were performed in the borings at 2.5-foot increments of depth to 30.0 feet and at 5.0-foot increments thereafter to the top of bedrock. For foundation elements subject to scour, continuous sampling and SPT testing were conducted in borings B-113-6-13 through B-113-8-13 for a 6.0-foot interval below the riverbed elevation. The SPT, per the American Society for Testing and Materials (ASTM) designation D1586, is conducted using a 140-pound hammer falling 30.0 inches to drive a 2.0-inch outside diameter split spoon sampler 18.0 inches. Rii utilized a calibrated automatic drop hammer to generate consistent energy transfer to the sampler. Driving resistance is recorded on the boring logs in terms of blow per 6.0-inch interval of the driving distance. The second and third intervals are added to obtain the number of blows per foot (N). Standard penetration blow counts aid in determining soil properties applicable in

foundation system design. Measured blow count (N) values are corrected to an equivalent (60%) energy ratio, N_{60}, by the following equation. Both values are represented on boring logs in Appendix III.

$$N_{60} = N_m*(ER/60)$$

Where:
N_m = measured N value
ER = drill rod energy ratio, expressed as a percent, for the system used

The hammer for the CME 750 and CME 750X drill rigs used were calibrated on April 26, 2013, and have drill rod energy ratios of 82.6 and 86.8 percent, respectively.

Hand penetrometer readings, which provide a rough estimate of the unconfined compressive strength of the soil, were reported on the boring logs in units of tons per square foot (tsf) and were utilized to classify the consistency of the cohesive soil in each layer. An indirect estimate of the unconfined compressive strength of the cohesive split spoon samples can also be made from a correlation with the blow counts (N_{60}). Please note that split spoon samples are considered to be disturbed and the laboratory determination of their shear strengths may vary from undisturbed conditions.

During drilling, Rii personnel prepared field logs showing the encountered subsurface conditions. Soil samples obtained from the drilling operation were preserved and sealed in glass jars and delivered to the soil laboratory. In the laboratory, the soil samples were visually classified and select samples were tested, as noted in Table 2.

Table 2. Laboratory Test Schedule

Laboratory Test	Test Designation	Number of Tests Performed
Natural Moisture Content	ASTM D2216	104
Plastic and Liquid Limits	AASHTO T89, T90	39
Gradation – Sieve/Hydrometer	AASHTO T88	45
Unconfined Compressive Strength of Intact Rock	ASTM D7012	12
Determination of the Point Load Strength Index of Rock	ASTM D5731	1

The tests performed are necessary to classify existing soil according to the Ohio Department of Transportation (ODOT) classification system and to estimate engineering properties of importance in determining foundation design and construction recommendations. Results of the laboratory testing are presented on the boring logs in Appendix III. A description of the soil terms used throughout this report is presented in Appendix II.

The depth to bedrock was determined by auger refusal. The depth to bedrock was determined by split spoon sampler refusal or auger refusal. Split spoon sampler refusal is defined as exceeding 50 blows from the hammer with less than 6.0 inches of penetration by the split spoon sampler. Auger refusal is defined as no or insignificant observable advancement of the augers with the weight of the drill rig driving the augers.

Where borings were extended into the competent bedrock (after encountering auger refusal), an NQ or HQ-sized double-tube diamond bit core barrel (utilizing wire line equipment) was used to core the bedrock. Coring produced 1.85 or 2.45 inch diameter cores, for NQ and HQ-sized cores, respectively, from which the type of rock and its geological characteristics were determined.

Rock cores were logged in the field and visually classified in the laboratory. They were analyzed to identify the type of rock, color, mineral content, bedding planes and other geological and mechanical features of interest in this project. The Rock Quality Designation (RQD) for each rock core run was calculated according to the following equation:

$$RQD = \frac{\sum \text{segments equal to or longer than 4.0 inches}}{\text{core run length}} \text{ x } 100$$

In addition to the borings performed for the current exploration, historic borings performed in 1957 by the Department of Highways as part of the FRA-40-12.30 project were obtained from the construction documents on record. Five (5) borings, designated as B-001-S-57, B-005-S-57, B-009-S-57, B-013-S-57 and B-020-S-57, were obtained along the entire length of the existing bridge alignments carrying I-70 eastbound and westbound over the Scioto River. The borings were extended to depths ranging from 36.0 to 63.0 feet below the existing grade at the time of the exploration. Please note that the elevations provided on the historic boring logs are referenced to the North American Datum (NAD) 27. The current design survey is referenced to NAD 83. The NAD 27 datum is 0.6 feet lower than the NAD 83 datum. **Therefore, all elevations noted in this report with respect to the historic borings are adjusted to the current NAD 83 datum.** The historic boring locations are shown on the boring plan provided in Appendix I, and the historic boring logs are provided in Appendix IV.

4.0 FINDINGS

Interpreted engineering logs have been prepared based on the field logs, visual examination of samples and laboratory test results. Classification follows the respective version of the ODOT Specifications for Geotechnical Explorations (SGE) at the time the exploration borings were performed. The following is a summary of what was found in the test borings and what is represented on the boring logs.

4.1 Surface Materials

Borings B-015-7-13 and B-016-4-13 encountered 5.0 and 12.0 inches of topsoil at the ground surface, respectively. Boring B-016-5-13 encountered 4.0 inches of asphalt overlying 6.0 inches of concrete followed by 2.0 inches of aggregate base at the ground surface. No distinctive surface materials were noted in borings B-015-8-13, B-015-9-13 and B-016-3-13 as these were performed within the Scioto River channel. However, the depth of water within the river channel ranged from 8.3 to 12.3 feet. Surface materials were not noted in the 1957 boring logs.

4.2 Subsurface Soils

Beneath the surface materials in borings B-016-4-13 and B-016-5-13, material identified as existing fill was encountered extending to a depth of 8.0 and 28.0 feet below the ground surface, respectively. The fill material consisted of brown, dark brown, gray and brownish gray gravel with sand and silt, gravel with sand, silt and clay, sandy silt, silt and clay and silty clay (ODOT A-2-4, A-2-6, A-4a, A-6a, A-6b) and contained brick, concrete or coal fragments.

Underlying the existing fill and the surficial materials in the remaining borings, natural soils were encountered consisting of both granular and cohesive material. The granular soils were generally described as brown and gray gravel, gravel with sand, gravel with sand and silt, gravel with sand, silt and clay, coarse and fine sand and sandy silt (ODOT A-1-a, A-1-b, A-2-4, A-2-6, A-3a, A-4a). The cohesive soils were described as gray, brown, brownish gray and dark brown sandy silt, silt, silt and clay, silty clay and clay (ODOT A-4a, A-4b, A-6a, A-6b, A-7-6). A boulder zone was encountered in boring B-015-9-13 between elevations 652.2 to 654.7 feet msl and in boring B-016-4-13 between elevations 667.0 to 669.5 feet msl. Cobbles and boulders were generally encountered above the bedrock in borings B-015-7-13 through B-016-4-13 starting at an elevation of approximately 670 feet msl.

The relative density of granular soils is primarily derived from SPT blow counts (N_{60}). Based on the SPT blow counts obtained, the granular soil encountered ranged from very loose (N_{60} < 5 blows per foot [bpf]) to very dense (N_{60} > 50 bpf). Overall blow counts recorded from the SPT sampling ranged from 3 bpf to split spoon sampler refusal. The shear strength and consistency of the cohesive soils are primarily derived from the hand penetrometer values (HP). The cohesive soil encountered ranged from very soft (HP $\leq$ 0.25 tsf) to hard (HP > 4.0 tsf). The unconfined compressive strength of the cohesive soil samples tested, obtained from the hand penetrometer, ranged from 0.25 to over 4.5 tsf (limit of instrument).

Natural moisture contents of the soil samples tested ranged from 5 to 72 percent. Organics and wood fragments were present in the soil samples recovered in boring B-015-9-13 between elevation 665.2 and 681.0 feet msl, which had moisture contents ranging from 33 to 72 percent. The natural moisture content of the cohesive soil

samples tested for plasticity index ranged from 10 percent below to 11 percent above their corresponding plastic limits. In general, the soil exhibited natural moisture contents considered to be significantly below to significantly above optimum moisture levels.

4.3 Bedrock

Bedrock was encountered in the borings as presented in Table 3.

Table 3. Top of Bedrock Elevations

Boring Number	Ground Surface Elevation (feet msl)	Top of Bedrock		Top of Bedrock Core (Auger Refusal)	
		Depth (feet)	Elevation (feet msl)	Depth (feet)	Elevation (feet msl)
B-015-7-13	721.8	70.5	651.3	70.5	651.3
B-001-S-57	723.4	N/A	N/A	N/A	N/A
B-015-8-13	692.5	40.8	651.7	40.3	652.2
B-015-9-13	691.2	39.0	652.2	40.2	651.0
B-005-S-57	681.1	29.0	652.1	29.6	651.5
B-016-3-13	685.0	41.2	643.8	41.2	643.8
B-009-S-57	685.5	34.7	650.8	34.7	650.8
B-016-4-13	705.0	45.5	659.5	45.5	659.5
B-013-S-57	690.8	30.0	660.8	30.5	660.3
B-016-5-13	740.1	84.9	655.2	84.9	655.2
B-020-S-57	725.4	N/A	N/A	N/A	N/A

Top of bedrock was encountered at elevations ranging from 643.8 to 660.8 feet msl. The upper portion of the bedrock encountered in the majority of the borings along the eastern half of the bridge alignment consists of gray and black shale overlying competent limestone and/or dolomite bedrock. Table 4 tabulates the depth and elevation that the surficial shale bedrock was encountered as well as the top of competent limestone/dolomite bedrock. Shale bedrock was encountered in borings B-005-S-57, B-009-S-57, B-013-S-57, B-015-9-13, B-016-4-13 and B-016-5-13 at elevations ranging from 650.8 to 660.8 feet msl. With the exception of borings B-001-S-57, B-013-S-57, B-020-S-57 and B-016-5-13, limestone/dolomite bedrock was encountered in the remaining borings at elevations ranging from 643.8 to 651.7 feet msl.

Table 4. Bedrock Types

Boring Number	Ground Surface Elevation (feet msl)	Top of Shale		Top of Limestone/Dolomite	
		Depth (feet)	Elevation (feet msl)	Depth (feet)	Elevation (feet msl)
B-015-7-13	721.8	N/A	N/A	70.5	651.3
B-001-S-57	723.4	N/A	N/A	N/A	N/A
B-015-8-13	692.5	N/A	N/A	40.8	651.7
B-015-9-13	691.2	39.0	652.2	43.8	647.4
B-005-S-57	681.1	29.0	652.1	29.6	651.5
B-016-3-13	685.0	N/A	N/A	41.2	643.8
B-009-S-57	685.5	34.7	650.8	37.4	648.1
B-016-4-13	705.0	45.5	659.5	59.7	645.3
B-013-S-57	690.8	30.0	660.8	N/A	N/A
B-016-5-13	740.1	84.9	655.2	N/A	N/A
B-020-S-57	725.4	N/A	N/A	N/A	N/A

The cored bedrock recovered from the current exploration borings consists of shale, dolomite and limestone. The shale is described as black and gray, unweathered to highly weathered, very weak to slightly strong, very thin bedded to thinly laminated, fissile, friable and fractured to highly fractured with open, slightly rough to rough apertures. The limestone is generally described as gray, dark gray and brown, unweathered to slightly weathered, strong to very strong, thin to very thick bedded, dolomitic, pyritic, cherty, calcareous, crystalline, fossiliferous, stylolitic and slightly to highly fractured with open, slightly rough to rough apertures. The dolomite is described as brown and gray, slightly weathered, strong, very thin to medium bedded, siliceous, crystalline, cherty and moderately fractured to fractured with open, slightly rough to rough apertures and contained calcite/pyrite deposits as well as chert nodules and lenses.

The percent recovery, RQD values and unconfined compressive strengths of the bedrock core runs from the current exploration borings are summarized in Table 5.

Table 5. Rock Core Summary

Boring	Core No.	Depth (feet)	Recovery (%)	RQD (%)	Unconfined Compressive Strength
B-015-7-13	RC-1	70.5 to 75.5	97	58	q_u @ 72.1' = 12,300 psi
	RC-2	75.5 to 80.5	95	58	N/A
B-015-8-13	RC-1	40.3 to 43.0	88	70	N/A
	RC-2	43.0 to 48.0	100	100	q_u @ 45.2' = 12,610 psi
	RC-3	48.0 to 53.0	100	100	q_u @ 48.0' = 13,340 psi
	RC-4	53.0 to 56.0	93	85	q_u @ 53.4' = 7,502 psi
B-015-9-13	RC-3	40.2 to 45.2	28	26	q_u @ 43.7' = 14,655 psi
	RC-4	45.2 to 50.2	97	97	q_u @ 45.2' = 15,790 psi
	RC-5	50.2 to 55.2	97	77	q_u @ 52.1' = 14,472 psi
	RC-6	55.2 to 60.2	100	96	q_u @ 57.2' = 16,970 psi
	RC-7	60.2 to 65.2	100	93	N/A
B-016-3-13	RC-1	41.2 to 43.6	92	83	q_u @ 42.6' = 8,481 psi
	RC-2	43.6 to 48.6	97	96	q_u @ 45.5' = 12,584 psi
	RC-3	48.6 to 53.6	100	100	q_u @ 48.6' = 11,889 psi
	RC-4	53.6 to 58.6	98	98	N/A
B-016-4-13	RC-2	45.5 to 46.5	98	0	N/A
	RC-3	46.5 to 51.5	40	0	N/A
	RC-4	51.5 to 56.5	100	45	q_u @ 52.5' to 56.0' = 380 psi [1]
	RC-5	56.5 to 61.5	63	33	q_u @ 59.8' = 12,760 psi
B-016-5-13	RC-1	84.9 to 85.9	42	0	N/A
	RC-2	85.9 to 90.9	30	0	N/A
	RC-3	90.9 to 94.9	31	0	N/A

1. *Represents the mean unconfined compressive strength of shale sample based on correlations with the mean point load strength index.*

It should be noted that bedrock experiences mechanical breaks during the drilling and coring processes. Rii attempted to account for fresh, manmade breaks during tabulation of the RQD analysis. The zone within borings B-015-9-13 and B-016-4-13 where boulders were encountered, requiring rock coring techniques to advance through these zones, are not included in the RQD tabulation above. The quality of the cored bedrock, according to the RQD values, ranged from very poor (25 < RQD ≤ 50%) to excellent (RQD > 90%). Please note that the first core run in borings B-015-8-13, B-015-9-13, B-016-3-13, B-016-4-13 and B-016-5-13 were less than 3.0-feet in length in order to position the core barrel such that subsequent 5.0-foot core runs could be obtained. Due to the short length of these core runs, the resulting RQD values may not be representative of the respective bedrock stratum.

4.4 Groundwater

Groundwater was encountered in the borings as presented in Table 6.

Table 6. Groundwater

Boring Number	Ground Elevation (feet msl)	Initial Groundwater		Upon Completion	
		Depth (feet)	Elevation (feet msl)	Depth (feet)	Elevation (feet msl)
B-015-7-13	721.8	30.0	691.8	N/A [1]	N/A
B-015-8-13	692.5	N/A [2]	700.8	N/A [2]	700.8
B-015-9-13	691.2	N/A [2]	700.7	N/A [2]	700.7
B-016-3-13	685.0	N/A [2]	697.3	N/A [2]	697.3
B-016-4-13	705.0	15.5	689.5	N/A [1]	N/A
B-016-5-13	740.1	48.5	691.6	N/A [1]	N/A

1. *The groundwater level at completion could not be obtained due to the addition of mud or water as a drilling fluid.*
2. *Water elevation listed is the surface elevation of the Scioto River at the respective boring location at the time of drilling; therefore, no depth is associated with the elevation listed.*

Groundwater was encountered initially during drilling in boring B-015-7-13 at the west bank of the river was at a depth of 30.0 feet below the ground surface, which corresponds to an elevation of 691.8 feet msl, and groundwater was encountered initially during drilling in borings B-016-4-13 and B-016-5-13 at the east bank of the river was at a depth of 15.5 and 48.5 feet, which corresponds to an elevation of 689.5 and 691.6 feet msl, respectively. As previously noted, borings B-015-8-13, B-015-9-13 and B-016-3-13 were drilled within the Scioto River. Water was encountered at the existing Scioto River surface, which was determined to be at an elevation ranging from 697.3 to 700.8 feet msl at the time of the drilling. The groundwater levels at the completion of drilling could not be measured due to the addition of mud to counteract heaving sands and water as a circulating fluid during the rock coring process.

Please note that short-term water level readings, especially in cohesive soils, are not necessarily an accurate indication of the actual groundwater level. In addition, groundwater levels or the presence of groundwater are considered to be dependent on seasonal fluctuations in precipitation.

A more comprehensive description of what was encountered during the drilling process may be found on the boring logs in Appendix III.

4.5 Historic Borings

In general, the historic borings encountered granular soils with intermittent seams of cohesive material overlying shale and limestone bedrock. The granular soils were generally described as loose to very dense brown and gray gravel, gravel with sand, gravel with sand and silt, fine sand and coarse and fine sand (ODOT A-1-a, A-1-b, A-2-4, A-3, A-3a), and the cohesive soils were generally described as hard gray and brown sandy silt and silt and clay (ODOT A-4a, A-6a). Shale bedrock was encountered in borings B-005-S-57, B-009-S-57 and B-013-S-57 at an elevation of 652.1, 650.8 and 660.8 feet msl, respectively. Limestone bedrock was encountered below the shale bedrock in borings B-005-S-57 and B-009-S-57 at an elevation of 651.5 and 648.1 feet msl, respectively. A boulder zone was encountered in boring B-001-S-57 between elevations 660.4 and 666.4 feet msl. Groundwater levels were not noted on the boring logs performed during the 1957 investigation. In general, the subsurface conditions encountered in the historic borings matched relatively closely with the subsurface conditions encountered in the current exploration borings.

5.0 ANALYSES AND RECOMMENDATIONS

Data obtained from the review of existing geotechnical information have been used to determine the foundation support capabilities and the settlement potential for the soil encountered at the site. These parameters have been used to provide guidelines for the design of foundation systems for the subject bridge, as well as the construction specifications related to the placement of foundation systems and general earthwork recommendations, which are discussed in the following paragraphs.

Design details of the proposed structure were provided by GPD GROUP. Based on information provided, it is understood that the existing FRA-70-1321R structure will be removed and replaced with a five-span continuous hybrid steel plate girder with reinforced concrete deck structure, with capped pile abutments and multi-column piers, having a total length of approximately 1,075 feet and width of approximately 146 feet at the west end to 84 feet at the east end of the bridge. The proposed roadway profile grade of I-70 eastbound at the FRA-70-1321R structure location will be elevated approximately 5 feet above the existing profile grade at the rear abutment and 10 feet above the existing profile grade at the forward abutment.

Proposed structural data was obtained from design details provided by GPD GROUP and are included in Table 7.

Table 7. Structure and Bridge Design Elevations

Substructure Unit	Structure Component [1]	Elevation [1] (feet msl)	Design Maximum Factored Load
Rear Abutment (B-015-7-13 / B-001-S-57)	Bottom of Footing	714.5	341 kips/pile
Pier 1 (B-015-8-13 / B-005-S-57)	Top of Shaft	697.2	3,054 kips/shaft
Pier 2 (B-015-9-13 / B-009-S-57)	Top of Shaft	697.2	2,786 kips/shaft
Pier 3 (B-016-3-13 / B-013-S-57)	Top of Shaft	697.2	2,611 kips/shaft
Pier 4 (B-016-4-13 / B-013-S-57)	Top of Shaft	708.0	2,702 kips/shaft
Forward Abutment (B-016-5-13 / B-020-S-57)	Bottom of Footing	719.0	325 kips/pile

1. *Proposed bottom of footing and top of shaft elevations and structural loading based on structure information provided by GPD GROUP.*

5.1 Drilled Shaft Recommendations

It is understood that drilled shafts will be utilized at the pier substructure units. Given the proposed loading per shaft at each of the pier locations, friction bearing drilled shafts within the overburden soils and drilled shafts bearing within the weak surficial shale bedrock are not economically feasible foundation options due to the size and number of shafts that would be required to support the proposed loading. Therefore, it is recommended that the drilled shafts be extended through the surficial soils and weak surficial shale bedrock to bear on or within the underlying limestone/dolomite bedrock at the pier locations.

Per Section 10.8.3.5.4c of the AASHTO LRDF Bridge Design Specifications (BDS), a minimum rock socket length of 1.5 times the diameter of the drilled shaft within the rock socket ($1.5B_{RS}$) is required to utilize the full end bearing resistance within the bedrock unit that the shafts are end bearing in/on. However, based on discussions with the ODOT Office of Geotechnical Engineering (OGE), a reduced tip resistance can be utilized for shafts not extended to the required minimum socket length of $1.5B_{RS}$ into bedrock.

Using equation 10.8.3.5.4c-1 of the AASHTO LRFD BDS, the nominal end bearing resistance for drilled shafts socketed a minimum of $1.5B_{RS}$ into intact rock is 2.5 times the unconfined compressive strength of the bedrock unit that the shaft tip is bearing on or within. Based on unconfined compression tests performed on limestone rock cores obtained from the borings performed at the subject piers, the unconfined compressive

strength ranges from 7,502 to 16,970 psi. Using equation 10.8.3.5.4c-1 and the limiting unconfined compressive strength from the given range for the limestone bedrock, it is recommended that drilled shaft foundations socketed a minimum of $1.5B_{RS}$ into the bedrock to bear on or within the competent limestone bedrock be proportioned for a nominal end bearing resistance of 2,701 ksf at the strength limit state.

Where lateral load demands do not require a rock socket length of $1.5B_{RS}$, the socket length can be reduced or the shaft can bear on the bedrock surface with no rock socket. If the rock socket is reduced to a length less than $1.5B_{RS}$, a reduced nominal end bearing resistance should be utilized based on equations 10.8.3.5.4c-2 and 10.8.3.5.4c-3 of the AASHTO LRFD BDS, which is as follows:

$$q_p = A + q_u\left[m_b\left(\frac{A}{q_u}\right) + s\right]^a$$

In which:

$$A = \sigma'_{vb} + q_u\left[m_b\left(\frac{\sigma'_{vb}}{q_u}\right) + s\right]^a$$

Where:

σ'_{vb} = vertical effective stress at the socket bearing (tip) elevation (ksf)

s, a and m_b = Hoek-Brown strength parameters for fractured rock mass determined from GSI in accordance with Section 10.4.6.4 of the AASHTO LRFD BDS

q_u = unconfined compressive strength of intact rock (ksf)

Based on discussions with ODOT OGE, the condition of the rock mass for the determination of the GSI rating should consider the limestone to have a “closed” joint condition, a “blocky” structure and a “good” joint surface condition. Using this description for the structure and surface conditions of the rock mass, a GSI rating of 70 was determined from Figure 10.4.6.4-1 of the AASHTO LRFD BDS, and the Hoek-Brown strength parameters s, a and m_b were calculated as 0.036, 0.50 and 3.08, respectively. The vertical effective stress was estimated considering 45 feet of soil overburden with a buoyant unit weight of 57.6 pcf. Using the above noted equations and the limiting unconfined compressive strength from the given range for the limestone bedrock, it is recommended that drilled shaft foundations bearing on or within the competent limestone bedrock with a socket length less than $1.5B_{RS}$ into the bedrock be proportioned for a nominal end bearing resistance of 1,116 ksf at the strength limit state.

Based on plan information provided by GPD GROUP, the shaft diameter within the overburden soils will be 6.0 feet, and the shaft diameter within the rock socket will be 5.5 feet. Table 8 lists the estimated elevation of the top of bedrock as well as the proposed rock sock diameter and length from the design plans and, corresponding nominal end bearing resistance to be utilized for the design of the drilled shaft foundations. A resistance factor of $\varphi_{qp} = 0.5$ at the strength limit state should be utilized for design.

Table 8. Drilled Shaft Recommendations

Substructure Unit (Boring)	Top of Bedrock Elevation (feet msl)	Top of Limestone Elevation (feet msl)	Rock Socket Diameter [1] (feet)	Required Socket Length to Top of Limestone/Dolomite (feet)	Proposed Socket Length [1] (feet)	Nominal End Bearing Resistance [2] (ksf)
Pier 1 (B-015-8-13 / B-005-S-57)	652.1	651.5	5.5	0.6	9.0	2,107
Pier 2 (B-015-9-13 / B-009-S-57)	650.8	648.1	5.5	2.7	9.0	2,107
Pier 3 (B-016-3-13 / B-013-S-57)	660.8	643.8	5.5	17.0	17.0	2,107
Pier 4 (B-016-4-13 / B-013-S-57)	660.8	645.3	5.5	15.5	15.5	2,107

1. *Proposed rock socket diameter and length at each substructure unit determined from proposed plan information provided by GPD GROUP.*
2. *Nominal end bearing resistance provided is the value that should be utilized in the determination of the end bearing resistance per drilled shaft based on the proposed rock socket length and diameter.*

If lateral analysis of the drilled shafts foundations indicates that the rock socket length can be reduced based on the lateral load demands, then the rock socket length may be reduced from those shown in the current design plans. If the rock socket is reduced to a length less than $1.5B_{RS}$, then the reduced bearing resistance of 1,116 ksf should be utilized for design.

Given the factored end bearing resistances noted above for drilled shafts extended to bear on or within the limestone bedrock, it is anticipated that the axial resistance will be governed by structural resistance of the drilled shaft. The factored resistance per shaft provided in the design sheets should be the limiting value between the factored geotechnical resistance and the factored axial compressive resistance of the shaft.

Drilled shafts designed in accordance with the requirements presented above should experience a maximum settlement estimated to be less than 0.5 inches. Group settlement of the shafts, socketed into bedrock, is considered negligible for a minimum spacing of 2.0 shaft diameters center-to-center. Drilled shaft calculations are provided in Appendix VI.

5.1.1 Drilled Shaft Considerations

The minimum requirements for proper inspection of drilled shaft construction are as follows:

- A qualified inspector should record the material types being removed from the hole as excavation proceeds.
- When the bearing material has been encountered and identified and/or the design tip elevation has been reached, the shaft walls and base should be observed for anomalies, unexpected soft soil conditions, obstructions or caving.
- Concrete placed freefall should not be allowed to hit the sidewalls of the excavation or the rebar cage and should not pass through any water.
- Structural stability of the rebar cage should be maintained during the concrete pour to prevent buckling.
- The volume of concrete should be checked to ensure voids did not result during extraction of the casing (if utilized).
- The placement of all concrete for the drilled shafts shall follow the American Concrete Institute's Design and Construction of Drilled Piers (ACI 336.3R-93).
- If concrete is placed by tremie method, it must be done so with an adequate head to displace water or slurry if groundwater has entered the caisson (all tremie procedures shall follow applicable ACI specifications).
- Pulling casing with insufficient concrete inside should be avoided.
- The bottom of drilled shaft excavation should be clean and free of all loose material. Any loose material observed should be removed using a clean-out bucket (muck bucket).

The use of casing for drilled shafts is recommended under any of the following conditions:

- Caving material is encountered at any time during the drilling of the shaft.
- Groundwater is encountered at any time during the drilling of the shaft, or groundwater seepage occurs in the drilled shaft.
- Down hole inspection is planned (casing is required for this instance).

In addition, it is recommended that if casing is used, it be pulled immediately after the concrete is placed, allowing for re-use of the casing and eliminating reduction of side resistance (between soil and concrete).

It is anticipated that conventional drilled shaft equipment (with a standard soil bit) will be able to penetrate the upper soils to the bedrock depths provided in Table 3. However, depending on the conditions encountered, additional effort may be needed at or above this depth, and within the noted cobble and boulder zones. Below the depths noted, it will likely be necessary to employ more specialized drilling techniques, such as the use of rock teeth or a rock bit. The ability to penetrate the bedrock will be entirely dependent on the drilled shaft contractor and the equipment employed. It is the responsibility of the contractor to determine the most effective excavation procedures. The elevation and hardness of bedrock is subject to change within the project area.

5.2 Driven Pile Recommendations

It is understood that driven piles are to be utilized at the rear and forward abutment of the proposed structure. Given the depth of bedrock encountered in the borings performed and the required structural loading, it is recommended that steel H-piles (ODOT Item 507.06) driven to refusal on bedrock be employed for foundation support. Per Section 305.3.1.2 of the 2020 ODOT Bridge Design Manual, refusal is met during driving when the pile penetration is an inch or less after receiving at least 20 blows from the pile hammer. Table 9 shows recommended pile lengths and the corresponding factored structural axial resistance ($R_{R\,max}$) of steel H-piles. For H-piles driven to refusal on bedrock, no geotechnical resistance factor should be applied to the factored structural axial resistance values presented, as the values presented account for the structural resistance factor, $\varphi_c = 0.50$, for H-piles subject to damage due to severe driving conditions.

Table 9. FRA-70-1321R Driven Pile Recommendations

Substructure Reference	Ground Elevation [1] (feet msl)	Pile Size	Pile Elevation (feet msl)		Pile Length [3] (feet)	$R_{R\ max}$ [4] (kips/pile)	φ [5]
			Top [2]	Tip			
Rear Abutment (B-015-7-13 / B-001-S-57)	721.8 / 723.4	HP 12x53 [6]	715.5	651.3	70	380	N/A
Forward Abutment (B-016-5-13 / B-020-S-57)	740.1 / 725.4	HP 12x53	720.0	655.2	70	380	N/A

1. *Ground elevation listed is the ground elevation at the boring location.*
2. *The top of pile elevation corresponds to the pile cutoff elevation, which is 1.0-foot above the proposed bottom of footing elevation.*
3. *Per Section 305.3.5.2 of the 2020 ODOT BDM, the estimated pile length was determined as the pile cutoff elevation (top) minus the pile tip elevation, rounded up to the nearest 5.0 feet. Since the rounded length adds less than 1.0-foot, the estimated length has been increased an additional 5.0 feet.*
4. *The factored structural axial resistance for H-piles is based on the structural limit state of the steel H-pile section per Section 305.3.3 of the 2020 ODOT BDM.*
5. *For H-piles driven to refusal on bedrock, no geotechnical resistance factor should be applied to the factored structural axial resistance values presented, as the values presented account for the structural resistance factor, φ_c = 0.50, for H-piles subject to damage due to severe driving conditions.*
6. *A steel pile point is recommended to protect the tips of the H-piles during pile installation where the piles will be end bearing on limestone bedrock.*

Per Section 305.3.3 of the 2020 ODOT BDM, the factored resistance of H-piles driven to refusal on bedrock is typically governed by the structural resistance of the pile element. The factored structural axial resistances listed in Table 9 consider an axially loaded pile with negligible moment, no appreciable loss of section due to deterioration throughout the life of the structure, a steel yield strength of 50 ksi, a structural resistance factor for H-piles subject to damage due to severe driving conditions (LRFD 6.5.4.2: φ_c = 0.50) and a pile fully braced along its length. **The factored structural axial resistance should not be used for piles that are subjected to bending moments or are not supported by soil for their entire length.** Static or dynamic load testing is not required for H-piles driven to refusal on bedrock. It is anticipated that the piles will be able to be driven a short distance into the surficial bedrock before satisfying the driving conditions that meet the refusal criterion. Due to the weathered, variable nature of the upper portion of the bedrock, it is estimated that refusal will be met within the upper 3.0 to 5.0 feet of the surficial bedrock. Settlement is estimated to be less than 1.0 inch for H-piles driven to refusal on bedrock.

5.2.1 Driveability

A drivability analysis was performed in accordance with Section 10.7.8 of the AASHTO LRFD BDS using the GRLWEAP software program, and the results are provided in Appendix VII. In the driveability analysis, a Delmag 19-42 hammer with a rated energy of approximately 43,000 ft-lbs was used in conjunction with the H-pile sections. Based on the results of this analysis, driving stresses induced on the H-piles **would not exceed** 90 percent of the yield stress of the steel (f_y = 50 ksi, 0.9f_y = 45 ksi) if driven through the overburden soils to the bedrock elevation provided in Table 9. Care should be taken during pile driving operations when approaching the bedrock, and when extending the piles into the surficial bedrock material, to ensure that the driving stresses induced on the pile elements do not exceed the maximum allowable value of 90 percent of the yield stress of the steel, subsequently damaging the pile elements. Pile driving should be terminated upon achieving the required 20 blows from the pile hammer with an inch or less of penetration to reduce the possibility of damaging the pile element.

Per Section 305.3.5.6 of the 2020 ODOT BDM, steel pile points **should be used** when the piles are driven to bear on strong bedrock (limestone or dolomite), and steel pile points **should not be used** when the piles are driven to bear on shale bedrock. However, if it is elected to use pile points for the piles driven to refusal on shale bedrock encountered at the forward abutment, then the piles will likely penetrate a short distance into the surficial bedrock prior to satisfying the refusal criterion. Given the condition of the shale bedrock encountered in boring B-016-5-13, performed near the proposed forward abutment substructure location, it is estimated that the piles will be able to penetrate 3.0 to 5.0 feet into the shale bedrock prior to satisfying the refusal criterion if steel pile points are utilized at these locations.

5.3 Lateral Design

If lateral loads or moments are expected to be applied on the foundation elements, they should be analyzed to verify the shaft or pile has enough lateral and bending resistance against these loads. A boring-by-boring tabulation of parameters that should be used for lateral loading design is provided in Appendix VIII. In order to evaluate the lateral capacity, it is recommended that a derivation of COM624, such as LPILE, be utilized to determine the proper embedment depth and cross section (for drilled shafts) required to resist the lateral load for a given end condition and deflection. Table 10 lists the eleven different soil types internal to the LPILE program. These strata were utilized to define the soil strata in the soil profile for each boring provided in Appendix VIII.

Table 10. Subsurface Strata Description

Strata	Description
1	Soft Clay
2	Stiff Clay with Water
3	Stiff Clay without Free Water
4	Sand (Reese)
5	User Defined
6	Vuggy Limestone (Strong Rock)
7	Silt (with cohesion and internal friction angle)
8	API Sand
9	Weak Rock
10	Liquefiable Sand (Rollins)
11	Stiff Clay without free water with a specified initial K (Brown)

5.4 Lateral Earth Pressure

For the soil types encountered in the borings, the "in-situ" unit weight (γ), cohesion (c), effective angle of friction (φ'), and lateral earth pressure coefficients for at-rest conditions (k_o), active conditions (k_a), and passive conditions (k_p) have been estimated and are provided in Table 11 and Table 12.

Table 11. Estimated Undrained (Short-term) Soil Parameters for Design

Soil Type	γ (pcf) [1]	c (psf)	φ	k_a	k_o	k_p
Soft to Stiff Cohesive Soil	115	1,000	0°	N/A	N/A	N/A
Very Stiff to Hard Cohesive Soil	120	3,000	0°	N/A	N/A	N/A
Loose Granular Soil	120	0	28°	0.32	0.53	5.07
Medium Dense to Dense Granular Soil	130	0	32°	0.27	0.47	6.82
Very Dense Granular Soil	135	0	35°	0.24	0.43	8.56
Compacted Cohesive Engineered Fill	120	2,000	0°	N/A	N/A	N/A
Compacted Granular Engineered Fill	130	0	33°	0.26	0.46	7.41

1. *When below groundwater table, use effective unit weight, $\gamma' = \gamma - 62.4$ pcf and add hydrostatic water pressure.*

Table 12. Estimated Drained (Long-term) Soil Parameters for Design

Soil Type	γ (pcf) [1]	c (psf)	φ'	k_a	k_o	k_p
Soft to Stiff Cohesive Soil	115	0	24°	0.37	0.59	3.97
Very Stiff to Hard Cohesive Soil	120	100	28°	0.32	0.53	5.07
Loose Granular Soil	120	0	28°	0.32	0.53	5.07
Medium Dense to Dense Granular Soil	130	0	32°	0.27	0.47	6.82
Very Dense Granular Soil	135	0	35°	0.24	0.43	8.56
Compacted Cohesive Engineered Fill	120	200	28°	0.32	0.53	5.07
Compacted Granular Engineered Fill	130	0	33°	0.26	0.46	7.41

1. *When below groundwater table, use effective unit weight, $\gamma' = \gamma - 62.4$ pcf and add hydrostatic water pressure.*

These parameters are considered appropriate for the design of all subsurface structures and any excavation support systems. Subsurface structures (where the top of the structure is restrained from movement) should be designed based on at-rest conditions (k_o). For proposed temporary retaining structures (where the top of the structure is allowed to move), earth pressure distributions should be based on active (k_a) and passive (k_p) conditions. The values in this table have been estimated from correlation charts based on minimum standards specified for compacted engineered fill materials. These recommendations do not take into consideration the effect of any surcharge loading or a sloped ground surface (a flat surface is considered). Earth pressures on excavation support systems will be dependent on the type of sheeting and method of bracing or anchorage.

5.5 Scour Data

Continuous sampling was performed starting at the top of the riverbed elevation in borings B-015-8-13 through B-016-3-13 for a minimum 6.0-foot interval to determine the D_{50} of the riverbed soil. The riverbed soils are classified as gravel, gravel and sand, gravel with sand, silt and clay, sandy silt, silt and clay and silty clay (ODOT A-1-a, A-1-b, A-2-6, A-4a, A-6a, A-6b). Based upon the grain size analysis performed, the D_{50} of the riverbed material is summarized in Table 13.

Table 13. Scour Data Summary

Soil Type	Range of D_{50} (millimeters)
A-1-a	3.594 – 5.839
A-1-b	0.972 – 5.202
A-2-6	0.602 – 2.586
A-4a	0.139 – 0.147
A-6a	0.355 – 0.397
A-6b	0.026 – 0.136

5.6 Construction Considerations

All site work shall conform to local codes and to the latest ODOT Construction and Materials Specifications (CMS), including that all excavation and embankment preparation and construction should follow ODOT Item 200 (Earthwork).

5.6.1 Excavation Considerations

All excavations should be shored / braced or laid back at a safe angle in accordance to Occupational Safety and Health Administration (OSHA) guidelines. During excavation, if slopes cannot be laid back to OSHA Standards due to adjacent structures or other obstructions, temporary shoring may be required. The following table should be utilized as a general guide for implementing OSHA guidelines when estimating excavation back slopes at the various boring locations. Actual excavation back slopes must be field verified by qualified personnel at the time of excavation in strict accordance with OSHA guidelines.

Table 14. Excavation Back Slopes

Soil	Maximum Back Slope	Notes
Soft to Medium Stiff Cohesive	1.5 : 1.0	Above Ground Water Table and No Seepage
Stiff Cohesive	1.0 : 1.0	Above Ground Water Table and No Seepage
Very Stiff to Hard Cohesive	0.75 : 1.0	Above Ground Water Table and No Seepage
All Granular & Cohesive Soil Below Ground Water Table or with Seepage	1.5 : 1.0	None
Rock to 3.0' +/- below Auger Refusal	0.75 : 1.0	Above Ground Water Table and No Seepage
Stable Rock	Vertical	Above Ground Water Table and No Seepage

5.6.2 Groundwater Considerations

Based on the groundwater observations made during drilling, groundwater is anticipated to be encountered during construction of the drilled shafts. Where groundwater is encountered, proper groundwater control should be employed and maintained to prevent disturbance to excavation bottoms consisting of cohesive soil, and to prevent the possible development of a quick or "boiling" condition where soft silts and/or fine sands are encountered. It is preferable that the groundwater level, if encountered, be maintained at least 36 inches below the deepest excavation. In the case of drilled shafts, the utilization of casing will be required below the water table to maintain an open hole and prevent the sidewalls from collapse. In addition, concrete placed below the water table should be placed by tremie method using a rigid tremie pipe. Any seepage or groundwater encountered at this site should be able to be controlled by pumping from temporary sumps. Note that determining and maintaining actual groundwater levels during construction is the responsibility of the contractor.

6.0 LIMITATIONS OF STUDY

The above recommendations are predicated upon construction inspection by a qualified soil technician under the direct supervision of a professional geotechnical engineer. Adequate testing and inspection during construction are considered necessary to assure an adequate foundation system and are part of these recommendations.

The recommendations for this project were developed utilizing soil and bedrock information obtained from the test borings that were made at the proposed site for the current investigation. Resource International is not responsible for the data, conclusions, opinions or recommendations made by others during previous investigations at this site. At this time we would like to point out that soil borings only depict the soil and bedrock conditions at the specific locations and time at which they were made. The conditions at other locations on the site may differ from those occurring at the boring locations.

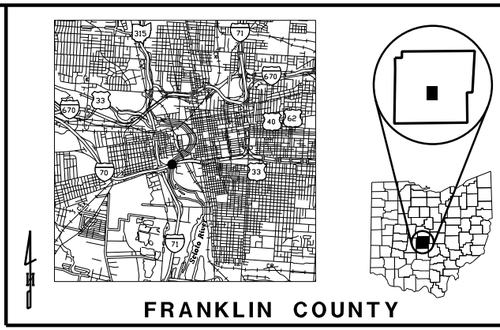
The conclusions and recommendations herein have been based upon the available soil and bedrock information and the design details furnished by a representative of the owner of the proposed project. Any revision in the plans for the proposed construction from those anticipated in this report should be brought to the attention of the geotechnical engineer to determine whether any changes in the foundation or earthwork recommendations are necessary. If deviations from the noted subsurface conditions are encountered during construction, they should also be brought to the attention of the geotechnical engineer.

The scope of our services does not include any environmental assessment or investigation for the presence or absence of hazardous or toxic materials in the soil, groundwater or surface water within or beyond the site studied. Any statements in this report or on the test boring logs regarding odors, staining of soils or other unusual conditions observed are strictly for the information of our client.

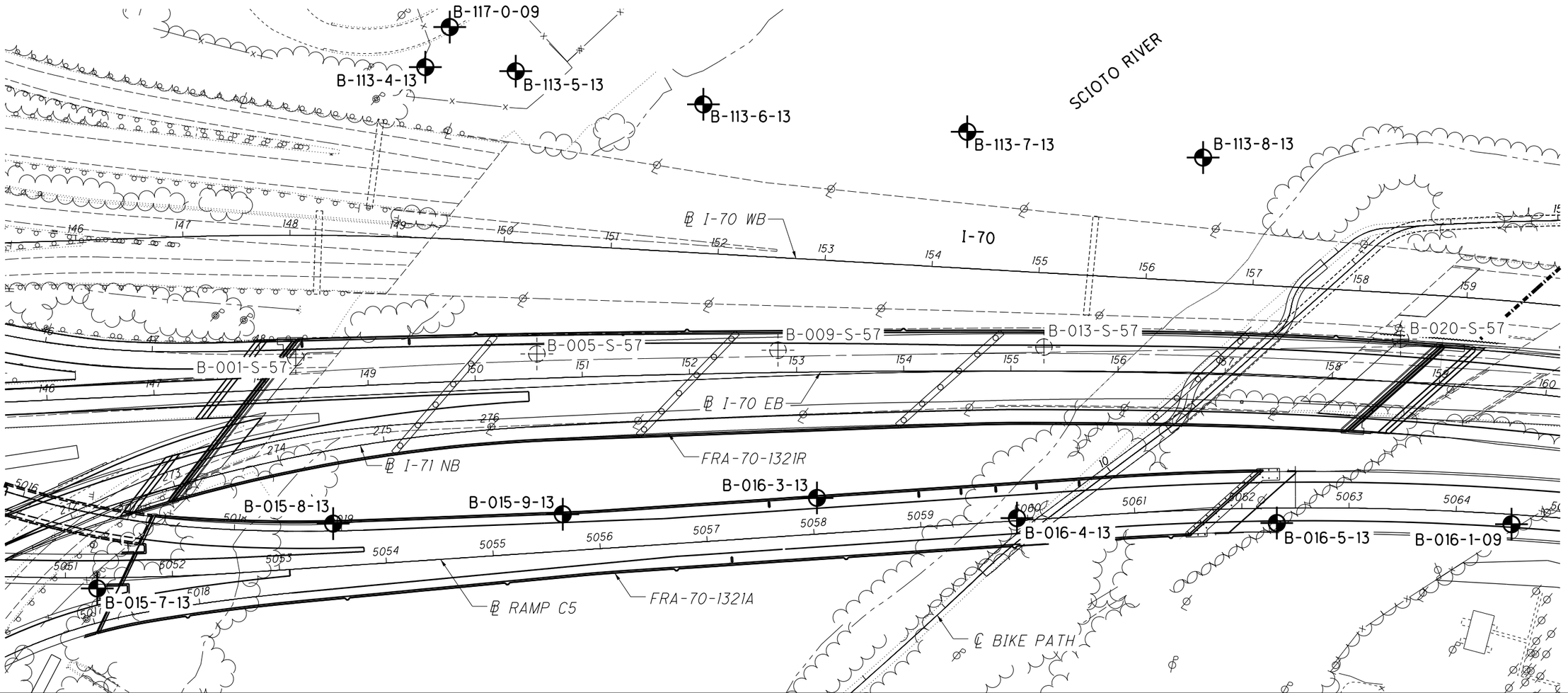
Our professional services have been performed, our findings obtained and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. Resource International is not responsible for the conclusions, opinions or recommendations made by others based upon the data included.

APPENDIX I

VICINITY MAP AND BORING PLAN



VICINITY MAP



BORING PLAN

FRA-70-1321R

FRANKLIN COUNTY, OHIO

RII PROJECT NO.
W-13-045

SCALE: 1"=100'
0 50 100

DRAWN
RRM

REVIEWED
BRT

DATE
6-26-2020

RESOURCE INTERNATIONAL, INC.

APPENDIX II

DESCRIPTION OF SOIL TERMS

DESCRIPTION OF SOIL TERMS

The following terminology was used to describe soils throughout this report and is generally adapted from ASTM 2487/2488 and ODOT Specifications for Geotechnical Explorations.

Granular Soils – ODOT A-1, A-2, A-3, A-4 (non-plastic)
The relative compactness of granular soils is described as:

Description	Blows per foot – SPT (N_{60})		
Very Loose	Below		5
Loose	5	-	10
Medium Dense	11	-	30
Dense	31	-	50
Very Dense	Over		50

Cohesive Soils – ODOT A-4, A-5, A-6, A-7, A-8
The relative consistency of cohesive soils is described as:

Description	Unconfined Compression (tsf)		
Very Soft	Less than		0.25
Soft	0.25	-	0.5
Medium Stiff	0.5	-	1.0
Stiff	1.0	-	2.0
Very Stiff	2.0	-	4.0
Hard	Over		4.0

Gradation - The following size-related denominations are used to describe soils:

Soil Fraction		Size
Boulders		Larger than 12”
Cobbles		12” to 3”
Gravel	coarse	3” to ¾“
	fine	¾” to 2.0 mm (¾” to #10 Sieve)
Sand	coarse	2.0 mm to 0.42 mm (#10 to #40 Sieve)
	fine	0.42 mm to 0.074 mm (#40 to #200 Sieve)
Silt		0.074 mm to 0.005 mm (#200 to 0.005 mm)
Clay		Smaller than 0.005 mm

Modifiers of Components - The following modifiers indicate the range of percentages of the minor soil components:

Term	Range		
Trace	0%	-	10%
Little	10%	-	20%
Some	20%	-	35%
And	35%	-	50%

Moisture Table - The following moisture-related denominations are used to describe cohesive soils:

Term	Range - ODOT
Dry	Well below Plastic Limit
Damp	Below Plastic Limit
Moist	Above PL to 3% below LL
Wet	3% below LL to above LL

Organic Content – The following terms are used to describe organic soils:

Term	Organic Content (%)
Slightly organic	2-4
Moderately organic	4-10
Highly organic	>10

Bedrock – The following terms are used to describe the relative strength of bedrock:

Description	Field Parameter
Very Weak	Can be carved with knife and scratched by fingernail. Pieces 1 in. thick can be broken by finger pressure.
Weak	Can be grooved or gouged with knife readily. Small, thin pieces can be broken by finger pressure.
Slightly Strong	Can be grooved or gouged 0.05 in deep with knife. 1 in. size pieces from hard blows of geologist hammer.
Moderately Strong	Can be scratched with knife or pick. 1/4 in. size grooves or gouges from blows of geologist hammer.
Strong	Can be scratched with knife or pick with difficulty. Hard hammer blows to detach hand specimen.
Very Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to detach hand specimen.
Extremely Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to chip hand specimen.

CLASSIFICATION OF SOILS

Ohio Department of Transportation

(The classification of a soil is found by proceeding from top to bottom of the chart.
The first classification that the test data fits is the correct classification.)

SYMBOL	DESCRIPTION	Classifcation		LL_O/LL x 100*	% Pass #40	% Pass #200	Liquid Limit (LL)	Plastic Index (PI)	Group Index Max.	REMARKS
		AASHTO	OHIO							
	Gravel and/or Stone Fragments	A-1-a			30 Max.	15 Max.		6 Max.	0	Min. of 50% combined gravel, cobble and boulder sizes
	Gravel and/or Stone Fragments with Sand	A-1-b			50 Max.	25 Max.		6 Max.	0	
	Fine Sand	A-3			51 Min.	10 Max.	NON-PLASTIC		0	
	Coarse and Fine Sand	--	A-3a			35 Max.		6 Max.	0	Min. of 50% combined coarse and fine sand sizes
	Gravel and/or Stone Fragments with Sand and Silt	A-2-4				35 Max.	40 Max.	10 Max.	0	
		A-2-5					41 Min.			
	Gravel and/or Stone Fragments with Sand, Silt and Clay	A-2-6				35 Max.	40 Max.	11 Min.	4	
		A-2-7					41 Min.			
	Sandy Silt	A-4	A-4a	76 Min.		36 Min.	40 Max.	10 Max.	8	Less than 50% silt sizes
	Silt	A-4	A-4b	76 Min.		50 Min.	40 Max.	10 Max.	8	50% or more silt sizes
	Elastic Silt and Clay	A-5		76 Min.		36 Min.	41 Min.	10 Max.	12	
	Silt and Clay	A-6	A-6a	76 Min.		36 Min.	40 Max.	11 - 15	10	
	Silty Clay	A-6	A-6b	76 Min.		36 Min.	40 Max.	16 Min.	16	
	Elastic Clay	A-7-5		76 Min.		36 Min.	41 Min.	$\leq$LL-30	20	
	Clay	A-7-6		76 Min.		36 Min.	41 Min.	>LL-30	20	
	Organic Silt	A-8	A-8a	75 Max.		36 Min.				W/o organics would classify as A-4a or A-4b
	Organic Clay	A-8	A-8b	75 Max.		36 Min.				W/o organics would classify as A-5, A-6a, A-6b, A-7-5 or A-7-6

MATERIAL CLASSIFIED BY VISUAL INSPECTION

 Sod and Topsoil

 Pavement or Base

 Uncontrolled Fill (Describe)

 Bouldery Zone

Peat

* Only perform the oven-dried liquid limit test and this calculation if organic material is present in the sample.

DESCRIPTION OF ROCK TERMS

The following terminology was used to describe the rock throughout this report and is generally adapted from ASTM D5878 and the ODOT Specifications for Geotechnical Explorations.

Weathering – Describes the degree of weathering of the rock mass:

Description	Field Parameter
Unweathered	No evidence of any chemical or mechanical alteration of the rock mass. Mineral crystals have a right appearance with no discoloration. Fractures show little or not staining on surfaces.
Slightly Weathered	Slight discoloration of the rock surface with minor alterations along discontinuities. Less than 10% of the rock volume presents alteration.
Moderately Weathered	Portions of the rock mass are discolored as evident by a dull appearance. Surfaces may have a pitted appearance with weathering "halos" evident. Isolated zones of varying rock strengths due to alteration may be present. 10 to 15% of the rock volume presents alterations.
Highly Weathered	Entire rock mass appears discolored and dull. Some pockets of slightly to moderately weathered rock may be present and some areas of severely weathered materials may be present.
Severely Weathered	Majority of the rock mass reduced to a soil-like state with relic rock structure discernable. Zones of more resistant rock may be present but the material can generally be molded and crumbled by hand pressures.

Strength of Bedrock – The following terms are used to describe the relative strength of bedrock:

Description	Field Parameter
Very Weak	Can be carved with knife and scratched by fingernail. Pieces 1 in. thick can be broken by finger pressure.
Weak	Can be grooved or gouged with knife readily. Small, thin pieces can be broken by finger pressure.
Slightly Strong	Can be grooved or gouged 0.05 in deep with knife. 1 in. size pieces from hard blows of geologist hammer.
Moderately Strong	Can be scratched with knife or pick. 1/4 in. size grooves or gouges from blows of geologist hammer.
Strong	Can be scratched with knife or pick with difficulty. Hard hammer blows to detach hand specimen.
Very Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to detach hand specimen.
Extremely Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to chip hand specimen.

Bedding Thickness – Description of bedding thickness as the average perpendicular distances between bedding surfaces:

Description	Thickness
Very Thick	Greater than 36 inches
Thick	18 to 36 inches
Medium	10 to 18 inches
Thin	2 to 10 inches
Very Thin	0.4 to 2 inches
Laminated	0.1 to 0.4 inches
Thinly Laminated	Less than 0.1 inches

Fracturing – Describes the degree and condition of fracturing (fault, joint, or shear):

Degree of Fracturing

Description	Spacing
Unfractured	Greater than 10 feet
Intact	3 to 10 feet
Slightly Fractured	1 to 3 feet
Moderately Fractured	

Aperture Width

Description	Width
Open	Greater than 0.2 inches
Narrow	0.05 to 0.2 inches
Tight	Less than 0.05 inches

Surface Roughness

Description	Criteria
Very Rough	Near vertical steps and ridges occur on surface
Slightly Rough	Asperities on the surfaces distinguishable
Slickensided	Surface has smooth, glassy finish, evidence of Striations

RQD – Rock Quality Designation (calculation shown in report) and Rock Quality (ODOT, GB 3, January 13, 2006):

RQD %	Rock Index Property Classification (based on RQD, not slake durability index)
0 – 25%	Very Poor
26 – 50%	Poor
51 – 70%	Fair
71 – 85%	Good
86 – 100%	Very Good

APPENDIX III

PROJECT BORING LOGS:

B-015-7-13 through B-015-9-13 and B-016-3-13 through B-016-5-13

BORING LOGS

Definitions of Abbreviations

AS = Auger sample

GI = Group index as determined from the Ohio Department of Transportation classification system

HP = Unconfined compressive strength as determined by a hand penetrometer (tons per square foot)

LL_o = Oven-dried liquid limit as determined by ASTM D4318. Per ASTM D2487, if LL_o/LL is less than 75 percent, soil is classified as "organic".

LOI = Percent organic content (by weight) as determined by ASTM D2974 (loss on ignition test)

PID = Photo-ionization detector reading (parts per million)

QR = Unconfined compressive strength of intact rock core sample as determined by ASTM D2938 (pounds per square inch)

QU = Unconfined compressive strength of soil sample as determined by ASTM D2166 (pounds per square foot)

RC = Rock core sample

REC = Ratio of total length of recovered soil or rock to the total sample length, expressed as a percentage

RQD = Rock quality designation – estimate of the degree of jointing or fracture in a rock mass, expressed as a percentage:

$$\frac{\sum \text{segments equal to or longer than 4.0 inches}}{\text{core run length}} \times 100$$

S = Sulfate content (parts per million)

SPT = Standard penetration test blow counts, per ASTM D1586. Driving resistance recorded in terms of blows per 6-inch interval while letting a 140-pound hammer free fall 30 inches to drive a 2-inch outer diameter (O.D.) split spoon sampler a total of 18 inches. The second and third intervals are added to obtain the number of blows per foot (N_m).

N_{60} = Measured blow counts corrected to an equivalent (60 percent) energy ratio (ER) by the following equation: $N_{60} = N_m*(ER/60)$

SS = Split spoon sample

2S = For instances of no recovery from standard SS interval, a 2.5 inch O.D. split spoon is driven the full length of the standard SS interval plus an additional 6.0 inches to obtain a representative sample. Only the final 6.0 inches of sample is retained. Blow counts from 2S sampling are not correlated with N_{60} values.

3S = Same as 2S, but using a 3.0 inch O.D. split spoon sampler.

TR = Top of rock

W = Initial water level measured during drilling

▼ = Water level measured at completion of drilling

Classification Test Data

Gradation (as defined on Description of Soil Terms):

GR = % Gravel
SA = % Sand
SI = % Silt
CL = % Clay

Atterberg Limits:

LL = Liquid limit
PL = Plastic limit
PI = Plasticity Index

WC = Water content (%)

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / S.M.	DRILL RIG: CME-750 (SN 98048)	STATION / OFFSET: 5051+29.66 / 9.8' RT	**EXPLORATION ID B-015-7-13**	
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL RAMP C5		
PID: 77372 BR ID: FRA-70-1301A	DRILLING METHOD: 3.25" HSA / RC	CALIBRATION DATE: 4/26/13	ELEVATION: 721.8 (MSL) EOB: 80.5 ft.		PAGE 1 OF 3
START: 6/10/13 END: 6/13/13	SAMPLING METHOD: SPT / NQ	ENERGY RATIO (%): 82.6	LAT / LONG: 39.950618516, -83.014254653		

MATERIAL DESCRIPTION AND NOTES	ELEV. 721.8	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
0.4' - TOPSOIL (5.0")	721.4																	
HARD, BROWN **CLAY**, SOME FINE GRAVEL, SOME FINE TO COARSE SAND, LITTLE SILT, DRY.	718.8	1	4 15 12	37	50	SS-1	4.5+	24	14	13	15	34	43	19	24	9	A-7-6 (8)	
DENSE, GRAY **GRAVEL**, LITTLE FINE TO COARSE SAND, TRACE SILT, TRACE CLAY, DAMP.	716.3	4	9 11 12	32	17	SS-2	-	-	-	-	-	-	-	-	-	6	A-1-a (V)	
STIFF TO VERY STIFF, DARK BROWN TO BROWNISH GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, SOME FINE GRAVEL, DAMP TO MOIST.		6	3 4 2	8	61	SS-3	2.00	-	-	-	-	-	-	-	-	15	A-6a (V)	
		9	2 4 4	11	67	SS-4	2.50	26	15	15	16	28	32	17	15	13	A-6a (3)	
		12	3 6 5	15	56	SS-5	2.00	-	-	-	-	-	-	-	-	20	A-6a (V)	
LOOSE TO DENSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, DAMP.	708.8	14	2 3 3	8	72	SS-6	-	-	-	-	-	-	-	-	-	17	A-2-6 (V)	
	703.8	17	3 9 5	19	44	SS-7	-	30	20	15	11	24	30	18	12	17	A-2-6 (0)	
DENSE TO VERY DENSE, GRAY **GRAVEL AND SAND**, LITTLE TO SOME SILT, TRACE CLAY, DAMP TO MOIST.		20			0	ST-8	-	-	-	-	-	-	-	-	-	-		
		22	5 18 18	50	72	SS-9	-	-	-	-	-	-	-	-	-	7	A-1-b (V)	
		24	11 21 19	55	67	SS-10	-	49	18	9	23	1	NP	NP	NP	7	A-1-b (0)	
		27	12 27 22	67	83	SS-11	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
	W	29	8 13 17	41	11	SS-12	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	

PID: 77372	BR ID: FRA-70-1301A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5051+29.66 / 9.8 RT	START: 6/10/13	END: 6/13/13	PG 2 OF 3	B-015-7-13

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
DENSE TO VERY DENSE, GRAY **GRAVEL AND SAND**, LITTLE TO SOME SILT, TRACE CLAY, DAMP TO MOIST. *(same as above)*	691.8	31																
		32																
		33																
-HEAVING SANDS ENCOUNTERED @ 33.5'		34	21 50/1"	-	100	SS-13	-	34	30	16	19	1	NP	NP	NP	15	A-1-b (0)	
-INTRODUCED MUD @ 33.5'		35																
		36																
		37																
		38																
		39	20 36 38	102	56	SS-14	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
		40																
		41																
		42																
		43																
		44	13 14 24	52	72	SS-15	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
		45																
		46																
		47																
	674.8	48																
HARD, GRAY **SILTY CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.		49	16 19 25	61	83	SS-16	4.50	7	7	15	46	25	30	14	16	19	A-6b (10)	
		50																
		51																
		52																
	669.8	53																
VERY DENSE, GRAY **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST TO WET.		54	20 50/1"	-	171	SS-17	-	-	-	-	-	-	-	-	-	17	A-1-b (V)	
		55																
		56																
		57																
		58																
		59	30 50/1"	-	100	SS-18	-	-	-	-	-	-	-	-	-	11	A-1-b (V)	
		60																
		61																

2014 ODOT BORING LOG-RI NE BRIDGE ID - OH DOT.GDT - 3/14/15 17:33 - U:\GI\PROJECTS\2013\W-13-045.GPJ

PID: 77372	BR ID: FRA-70-1301A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5051+29.66 / 9.8 RT	START: 6/10/13	END: 6/13/13	PG 3 OF 3	B-015-7-13

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 DENSE, GRAY **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST TO WET. *(same as above)*	659.7	63																
		64	42 50/4"	-	100	SS-19	-	54	17	10	16	3	22	17	5	10	A-1-b (0)	
		65																
		66																
		67																
		68																
		69	50/5"	-	20	SS-20	-	-	-	-	-	-	-	-	-	24	A-1-b (V)	
	651.3	70																
DOLOMITE : BROWN AND GRAY, SLIGHTLY WEATHERED, STRONG, VERY THIN TO MEDIUM BEDDED, CHERTY, CRYSTALLINE,, SILICEOUS, CALCITE/PYRITE DEPOSITS, CHERT NODULES AND LENSES, MODERATELY FRACTURED TO FRACTURED, OPEN APERTURE, SLIGHTLY ROUGH TO ROUGH; RQD 58%, REC 96%. -CHERT NODULE @ 71.1' -QU @ 72.1' = 12,300 PSI		TR																
		71																
		72																
		73	58		97	RC-1											CORE	
		74																
		75																
		76																
		77																
		78	58		95	RC-2											CORE	
		79																
	641.3	80																
		EOB																

NOTES: GROUNDWATER INITIALLY ENCOUNTERED @ 30.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 188 LBS CEMENT / 50 LBS BNTONITE POWDER / 50 GAL WATER

B-015-7-13 – RC-1 – Depth from 70.5 to 75.5 feet

B-015-7-13 – RC-2 – Depth from 75.5 to 80.5 feet

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / T.F.	DRILL RIG: CME-750X (SN 310218)	STATION / OFFSET: 5053+52.86 / 39.9' LT	**EXPLORATION ID**	
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / S.B.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL RAMP C5	**B-015-8-13**	
PID: 77372 BR ID: FRA-70-1321A	DRILLING METHOD: 4.25" HSA / HQ	CALIBRATION DATE: 4/26/13	ELEVATION: 692.5 (MSL) EOB: 56.0 ft.	PAGE	
START: 5/3/14 END: 5/3/14	SAMPLING METHOD: SPT / RC	ENERGY RATIO (%): 86.8	LAT / LONG: 39.951030, -83.013641	1 OF 2	

MATERIAL DESCRIPTION AND NOTES	ELEV. 692.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE, BROWN **GRAVEL**, SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, WET.	691.0	1	12 10 2	17	33	SS-1	-	62	19	8	6	5	-	-	-	23	A-1-a (V)	
MEDIUM STIFF, BROWN **SILTY CLAY**, SOME COARSE TO FINE SAND, SOME FINE GRAVEL, MOIST.	688.0	2 3 4	WOH WOH 4	6	33	SS-2	1.00	20	10	11	26	33	38	19	19	25	A-6b (8)	
			1 2 3	7	33	SS-3	1.00	30	12	12	23	23	-	-	-	29	A-6b (V)	
LOOSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, MOIST.	685.5	5 6 7	1 2 3	7	33	SS-4	-	54	12	9	14	11	33	20	13	20	A-2-6 (0)	
MEDIUM DENSE TO VERY DENSE, BROWN **GRAVEL**, SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, WET.		8 9	1 9 10	27	0	SS-5	-	-	-	-	-	-	-	-	-	-		
-LARGE ROCK RECOVERED IN 3S-5A			13	-	50	3S-5A	-	-	-	-	-	-	-	-	-	-	A-1-a (V)	
		10 11	20 50/3"	-	100	SS-6	-	66	16	8	7	3	NP	NP	NP	19	A-1-a (0)	
-ROCK FRAGMENTS PRESENT IN SS-6 AND SS-7	678.0	12 13 14	1 5 7	17	33	SS-7	-	-	-	-	-	-	-	-	-	20	A-1-a (V)	
HARD, DARK BROWN **SILTY CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP TO MOIST.		15 16	5 7 12	27	72	SS-8	4.5+	3	7	16	40	34	32	15	17	14	A-6b (11)	
		17 18 19	15 17 17	49	44	SS-9	4.5+	-	-	-	-	-	-	-	-	16	A-6b (V)	
	670.5	20 21 22	10 15 14	42	94	SS-10	4.5+	-	-	-	-	-	-	-	-	14	A-6b (V)	
HARD, DARK BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.		23 24 25	23 23 25	69	56	SS-11	4.5+	7	8	21	34	30	28	15	13	16	A-6a (7)	
	665.5	26 27	14 50/3"	-	100	SS-12	4.5+	-	-	-	-	-	-	-	-	13	A-6a (V)	
VERY DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST.		28 29	50/2"	-	0	SS-13	-	-	-	-	-	-	-	-	-	-		

2014 ODOT BORING LOG-RII NE BRIDGE ID - OH DOT.GDT - 7/11/18 14:36 - U:\GI8\PROJECTS\2013\W-13-045.GPJ

PID: 77372	BR ID: FRA-70-1321A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5053+52.86 / 39.9 LT	START: 5/3/14	END: 5/3/14	PG 2 OF 2	B-015-8-13

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)	HOLE SEALED
VERY DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST. *(same as above)* -COBBLES PRESENT @ 30.2'	662.5	31	25 45 50	137	83	SS-14	-	53	19	9	13	6	24	19	5	12	A-1-b (0)	
		32																
		33																
		34																
		35																
		36	20 40 50/5"	-	82	SS-15	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
		37																
		38																
		39																
-SHALE FRAGMENTS PRESENT IN SS-16 AUGER REFUSAL @ 40.3' -TOP 0.5' OF RC-1 CONSISTED OF GRANITE AND SHALE FRAGMENTS	651.7	40 TR	50/1"	-	100	SS-16	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
LIMESTONE : GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, VERY STRONG, THICK TO VERY THICK BEDDED, DOLOMITIC, CALCAREOUS, CRYSTALLINE, PYRITIC, CHERTY, MODERATELY FRACTURED TO FRACTURED, OPEN APERTURES, SLIGHTLY ROUGH; RQD 94%, REC 97%.		41	70		88	RC-1											CORE	
		42																
		43																
		44																
-QU @ 45.2' = 12,610 PSI		45	100		100	SS-2											CORE	
		46																
		47																
-QU @ 48.0' = 13,340 PSI		48																
		49																
		50	100		100	RC-3											CORE	
		51																
		52																
		53																
-CHANGING TO CONGLOMERITIC @ 53.5' -QU @ 53.4' = 7,502 PSI		54	85		93	RC-4											CORE	
		55																
	636.5	56 EOB																

NOTES: ELEVATION OF SCIOTO RIVER SURFACE @ 700.8

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 188 LBS CEMENT / 50 LBS BENTONITE POWDER / 40 GAL WATER

B-015-8-13 – RC-1 and RC-2 – Depth from 40.3 to 48.0 feet

B-015-8-13 – RC-3 and RC-4 – Depth from 48.0 to 56.0 feet

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / T.F.	DRILL RIG: CME-750X (SN 310218)	STATION / OFFSET: 5055+67.30 / 34.3' LT	**EXPLORATION ID B-015-9-13**
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / S.B.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL RAMP C5	
PID: 77372 BR ID: FRA-70-1321A	DRILLING METHOD: 4.25" HSA / RC	CALIBRATION DATE: 4/26/13	ELEVATION: 691.2 (MSL) EOB: 65.2 ft.	PAGE 1 OF 3
START: 5/1/14 END: 5/3/14	SAMPLING METHOD: SPT / HQ	ENERGY RATIO (%): 86.8	LAT / LONG: 39.951307453, -83.012965722	

MATERIAL DESCRIPTION AND NOTES	ELEV. 691.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
SOFT, BROWN AND BLACK **SILT AND CLAY**, LITTLE FINE GRAVEL, LITTLE COARSE TO FINE SAND, MOIST. -ROOT FIBERS PRESENT IN SS-1	689.7	1	WOH 1 2	4	33	SS-1	0.50	28	21	13	22	16	-	-	-	23	A-6a (V)	
LOOSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, MOIST. -BRICK FRAGMENTS PRESENT IN SS-3	686.7	2 3 4	6 4 2	9	56	SS-2	-	39	15	11	20	15	34	19	15	19	A-2-6 (1)	
			1 3 3	9	39	SS-3	-	34	21	11	19	15	-	-	-	18	A-2-6 (V)	
VERY SOFT, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, SOME FINE GRAVEL, MOIST.	684.7	5 6	1 3 2	7	44	SS-4	0.25	31	18	12	23	16	34	19	15	20	A-6a (2)	
MEDIUM DENSE, BROWN TO GRAY **GRAVEL WITH SAND, SILT, AND CLAY**, MOIST.	681.0	7 8 9 10	5 4 4	12	44	SS-5	-	47	16	9	17	11	-	-	-	15	A-2-6 (V)	
					83	ST-6	-	-	-	-	-	-	-	-	-	19	A-2-6 (V)	
VERY SOFT TO SOFT, DARK BROWN TO BLACK **SILTY CLAY**, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.	677.7	11 12 13					0.50	-	-	-	-	-	-	-	-	33	A-6b (V)	
			1 1 1	3	100	SS-7	0.25	-	-	-	-	-	-	-	-	53	A-6b (V)	
LOOSE, DARK BROWN **GRAVEL WITH SAND AND SILT**, LITTLE CLAY, WET. -INTRODUCED MUD @ 14.0'	672.7	14 15 16 17 18	1 2 3	7	44	SS-8	-	20	6	42	17	15	27	21	6	26	A-2-4 (0)	
			2 2 3	7	89	SS-9	-	-	-	-	-	-	-	-	-	46	A-2-4 (V)	
LOOSE, BROWN **COARSE AND FINE SAND**, LITTLE FINE GRAVEL, TRACE SILT, TRACE CLAY, WET. -WOOD FRAGMENTS PRESENT IN SS-10 -HEAVING SAND ENCOUNTERED @ 20.5'	670.2	19 20	2 3 4	10	67	SS-10	-	20	25	38	10	7	NP	NP	NP	42	A-3a (0)	
STIFF TO VERY STIFF, GRAY AND BLACK **SILT AND CLAY**, SOME COARSE TO FINE SAND, WET. -WOOD FRAGMENTS AND ORGANICS PRESENT THROUGHOUT	665.2	21 22 23 24 25	6 5 4	13	33	SS-11	-	-	-	-	-	-	-	-	-	51	A-6a (V)	
			7 10 9	27	33	SS-12	-	-	-	-	-	-	-	-	-	72	A-6a (V)	
HARD, GRAY **SILT**, LITTLE CLAY, LITTLE COARSE TO FINE SAND, WET.	662.7	26 27 28	9 11 18	42	67	SS-13	4.5+	0	1	21	56	22	20	15	5	20	A-4b (8)	
VERY DENSE, BROWN **GRAVEL AND SAND**, TRACE SILT, TRACE CLAY, MOIST.		29	50/1"	-	0	SS-14	-	-	-	-	-	-	-	-	-	-		

PID: 77372	BR ID: FRA-70-1321A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5055+67.30 / 34.3 LT	START: 5/1/14	END: 5/3/14	PG 2 OF 3	B-015-9-13

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)	HOLE SEALED
VERY DENSE, BROWN **GRAVEL AND SAND**, TRACE SILT, TRACE CLAY, MOIST. *(same as above)*	661.2	31																
		32																
		33																
		34	37 50/3"	-	67	SS-15	-	-	-	-	-	-	-	-	-	14	A-1-b (V)	
	655.7	35																
-LARGE PIECE OF WOOD RECOVERED IN RC-1	654.7	36			75	RC-1	-	-	-	-	-	-	-	-	-	-		
			50/1"	-	0	SS-16	-	-	-	-	-	-	-	-	-	-		
GRANITE BOULDERS		37																
		38	19		29	RC-2											CORE	
	652.2	39																
SHALE : GRAY, HIGHLY WEATHERED, VERY WEAK. AUGER REFUSAL @ 40.2'		TR	20 50/3"	-	100	SS-17	-	-	-	-	-	-	-	-	-	13	Rock (V)	
		40																
-SHALE WASHED OUT DURING CORING PROCESS IN RC-3		41																
		42																
		43	26		28	RC-3											CORE	
	647.4	44																
LIMESTONE : GRAY AND BROWN, UNWEATHERED, STRONG, THICK TO VERY THICK BEDDED, DOLOMITIC, CALCAREOUS, CHERTY, PYRITIC, FOSSILIFEROUS, STYOLITIC, SLIGHTLY TO HIGHLY FRACTURED, OPEN APERTURES, SLIGHTLY ROUGH; RQD 78%, REC 84%.		45																
-QU @ 43.8' = 14,655 PSI		46																
-QU @ 45.2' = 15,790 PSI		47																
		48	97		97	RC-4											CORE	
		49																
-CONGLOMERITIC FROM 50.2' TO 51.0'		50																
		51																
-QU @ 52.1' = 14,472 PSI		52																
-CONGLOMERITIC FROM 52.0' TO 54.6'		53	77		97	RC-5											CORE	
		54																
		55																
		56																
		57																
-QU @ 57.2' = 16,970 PSI		58	96		100	RC-6											CORE	
		59																
		60																
		61																

2014 ODOT BORING LOG-RII NE BRIDGE ID - OH DOT.GDT - 3/14/15 17:33 - U:\GI\PROJECTS\2013\W-13-045.GPJ

PID: 77372	BR ID: FRA-70-1321A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5055+67.30 / 34.3 LT	START: 5/1/14	END: 5/3/14	PG 3 OF 3	B-015-9-13

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)	HOLE SEALED
LIMESTONE : GRAY AND BROWN, UNWEATHERED, STRONG, THICK TO VERY THICK BEDDED, DOLOMITIC, CALCAREOUS, CHERTY, PYRITIC, FOSSILIFEROUS, STYOLITIC, SLIGHTLY TO HIGHLY FRACTURED, OPEN APERTURES, SLIGHTLY ROUGH; RQD 78%, REC 84%. *(same as above)*	629.1	63	93		100	RC-7											CORE	
	626.0	EOB 64 65																

NOTES: ELEVATION OF SCIOTO RIVER SURFACE @ 700.7

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 188 LBS CEMENT / 50 LBS BENTONITE POWDER / 40 GAL WATER

B-015-9-13 – RC-1, RC-2, and RC-3 – Depth from 35.5 to 45.2 feet

B-015-9-13 – RC-4 and RC-5 – Depth from 45.2 to 55.2 feet

B-015-9-13 – RC-6 and RC-7 – Depth from 55.2 to 65.2 feet

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / T.F.	DRILL RIG: CME-750X (SN 310218)	STATION / OFFSET: 5058+05.01 / 33.7' LT	**EXPLORATION ID B-016-3-13**	
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / S.B.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL RAMP C5		
PID: 77372 BR ID: FRA-70-1321A	DRILLING METHOD: 4.25" HSA / RC	CALIBRATION DATE: 4/26/13	ELEVATION: 685.0 (MSL) EOB: 58.6 ft.	PAGE 1 OF 2	
START: 4/30/14 END: 5/1/14	SAMPLING METHOD: SPT / HQ	ENERGY RATIO (%): 86.8	LAT / LONG: 39.951627935, -83.012227140		

MATERIAL DESCRIPTION AND NOTES	ELEV. 685.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
VERY LOOSE, BROWNISH GRAY **GRAVEL**, SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, WET.	683.5	1	3 2 1	4	67	SS-1	-	66	16	8	7	3	NP	NP	NP	19	A-1-a (0)	
-BRICK FRAGMENTS PRESENT IN SS-1		2	1 2 1	4	50	SS-2	0.50	24	13	21	27	15	-	-	-	19	A-4a (V)	
SOFT, BROWNISH GRAY AND BLACK **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, MOIST TO WET.		3	3 5 3	12	50	SS-3	0.50	24	13	20	28	15	27	18	9	24	A-4a (2)	
-ORGANIC ODOR PRESENT IN SS-3		4																
-INTRODUCED MUD @ 4.2'	680.5	5	1 2 3	7	33	SS-4	-	42	16	17	16	9	-	-	-	18	A-1-b (V)	
LOOSE TO MEDIUM DENSE, GRAY **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST TO WET.		6	14 5 6	16	44	SS-5	-	56	9	11	16	8	31	25	6	21	A-1-b (0)	
-ORGANIC ODOR PRESENT IN SS-5		7																
		8																
		9	5 6 7	19	56	SS-6	-	-	-	-	-	-	-	-	-	22	A-1-b (V)	
	674.5	10																
MEDIUM DENSE, GRAY **GRAVEL**, LITTLE COARSE TO FINE SAND, LITTLE SILT, TRACE CLAY, MOIST.		11																
	672.0	12	22 9 9	26	100	SS-7	-	69	11	6	10	4	NP	NP	NP	11	A-1-a (0)	
MEDIUM DENSE, GRAYISH BROWN **SANDY SILT**, LITTLE FINE GRAVEL, LITTLE CLAY, WET.		13																
	669.5	14	5 2 6	12	100	SS-8	-	12	19	20	38	11	NP	NP	NP	29	A-4a (3)	
VERY DENSE, BROWN **GRAVEL AND SAND**, TRACE SILT, WET.	668.3	15																
VERY STIFF, GRAY **SANDY SILT**, LITTLE CLAY, TRACE FINE GRAVEL, DAMP.		16	7 13 37	72	61	SS-9	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
	666.5	17					4.00	-	-	-	-	-	-	-	-	12	A-4a (V)	
VERY DENSE, BROWN **GRAVEL**, SOME COARSE TO FINE SAND, TRACE SILT, MOIST.		18																
-COBBLES ENCOUNTERED @ 18.7'	664.5	19	50/5"	-	100	SS-10	-	-	-	-	-	-	-	-	-	9	A-1-a (V)	
MEDIUM DENSE TO DENSE, GRAY **GRAVEL WITH SAND AND SILT**, TRACE CLAY, MOIST.		20																
		21																
		22	10 12 16	41	33	SS-11	-	-	-	-	-	-	21	15	6	11	A-2-4 (V)	
-HEAVING SAND ENCOUNTERED @ 23.7'		23																
		24	14 8 7	22	33	SS-12	-	-	-	-	-	-	-	-	-	10	A-2-4 (V)	
	659.0	25																
VERY DENSE, GRAY **GRAVEL**, LITTLE COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MOIST.		26	50/1"	-	100	SS-13	-	-	-	-	-	-	-	-	-	5	A-1-a (V)	
-ROCK FRAGMENTS PRESENT IN SS-13		27																
		28																
		29																

PID: 77372	BR ID: FRA-70-1321A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5058+05.01 / 33.7 LT	START: 4/30/14	END: 5/1/14	PG 2 OF 2	B-016-3-13

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)	HOLE SEALED
VERY DENSE, GRAY **GRAVEL**, LITTLE COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MOIST. *(same as above)*	655.0	31																
		32	34 34 36	101	44	SS-14	-	69	11	7	8	5	NP	NP	NP	9	A-1-a (0)	
	650.0	33																
HARD, GRAY **CLAY**, "AND" SILT, SOME FINE GRAVEL, TRACE COARSE TO FINE SAND, DRY. -ROCK FRAGMENTS PRESENT IN SS-15		34																
		35																
		36	20 20 50/4"	-	94	SS-15	4.50	27	3	6	32	32	42	22	20	13	A-7-6 (10)	
		37																
		38																
		39																
		40																
AUGER REFUSAL @ 41.2'	643.8	41 TR																
LIMESTONE : GRAY, UNWEATHERED, VERY STRONG, THICK TO VERY THICK BEDDED, DOLOMITIC, CALCAREOUS, CHERTY, PYRITIC, CRYSTALLINE, SLIGHTLY TO HIGHLY FRACTURED, OPEN APERTURES, SLIGHTLY ROUGH; RQD 96%, REC 98%. -QU @ 42.6' = 8,481 PSI		42	83		92	RC-1											CORE	
		43																
		44																
-QU @ 45.5' = 12,584 PSI		45																
		46	96		97	RC-2											CORE	
		47																
		48																
-QU @ 48.6' = 11,889 PSI		49																
		50																
		51	100		100	RC-3											CORE	
		52																
		53																
		54																
-CHANGING TO CONGLOMERITIC @ 54.6'		55																
		56	98		98	RC-4											CORE	
		57																
	626.4	58 EOB																

NOTES: ELEVATION OF SCIOTO RIVER SURFACE @ 697.3

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 188 LBS CEMENT / 50 LBS BENTONITE POWDER / 40 GAL WATER

B-016-3-13 – RC-1 and RC-2 – Depth from 41.2 to 48.6 feet

B-016-3-13 – RC-3 and RC-4 – Depth from 48.6 to 58.6 feet

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / S.M./J.B.	DRILL RIG: CME-750 (SN 98048)	STATION / OFFSET: 5059+89.96 / 2.4' RT	**EXPLORATION ID B-016-4-13**
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / K.R./A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL RAMP C5	
PID: 77372 BR ID: FRA-70-1321A	DRILLING METHOD: 3.25" HSA / RC	CALIBRATION DATE: 4/26/13	ELEVATION: 705.0 (MSL) EOB: 61.5 ft.	PAGE 1 OF 3
START: 8/7/13 END: 8/22/13	SAMPLING METHOD: SPT / NQ	ENERGY RATIO (%): 82.6	LAT / LONG: 39.951803928, -83.011598406	

MATERIAL DESCRIPTION AND NOTES	ELEV. 705.0	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
1.0' - TOPSOIL (12.0")	704.0																	
FILL: STIFF, BROWN AND DARK BROWN **SILT AND CLAY**, LITTLE COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST. -BRICK AND COAL FRAGMENTS PRESENT IN SS-1	702.0	1	4 3 4	10	58	SS-1	1.75	-	-	-	-	-	-	-	-	16	A-6a (V)	
FILL: MEDIUM DENSE, BROWN AND GRAY **GRAVEL WITH SAND AND SILT**, LITTLE CLAY, DAMP TO MOIST.		4	3 5 7	17	78	SS-2	-	25	20	23	14	18	19	12	7	10	A-2-4 (0)	
-TRACE ROOT FIBERS AND BRICK FRAGMENTS PRESENT IN SS-3	697.0	7	4 4 4	11	89	SS-3	-	-	-	-	-	-	-	-	-	14	A-2-4 (V)	
VERY SOFT TO MEDIUM STIFF, BROWN **SILTY CLAY**, TRACE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -TRACE ORGANICS PRESENT IN SS-4		9	2 2 3	7	83	SS-4	0.75	1	1	7	45	46	40	18	22	29	A-6b (13)	
		12	WOH 1 1	3	100	SS-5	0.75	-	-	-	-	-	-	-	-	30	A-6b (V)	
	691.0	14			96	ST-6	0.25	-	-	-	-	-	-	-	-	34	A-6b (V)	
MEDIUM DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST TO WET.		W 15					-	-	-	-	-	-	-	-	-	27	A-1-b (V)	
		17	7 8 8	22	33	SS-7	-	-	-	-	-	-	-	-	-	19	A-1-b (V)	
-INTRODUCED MUD @ 18.5'		19	6 6 6	17	33	SS-8	-	-	-	-	-	-	-	-	-	26	A-1-b (V)	
-COBBLES ENCOUNTERED @ 20.0'		22	4 5 4	12	61	SS-9	-	64	12	6	12	6	22	22	NP	14	A-1-b (0)	
		24	4 5 4	12	33	SS-10	-	-	-	-	-	-	-	-	-	22	A-1-b (V)	
		27	4 4 6	14	39	SS-11	-	-	-	-	-	-	-	-	-	14	A-1-b (V)	
	677.0																	
MEDIUM DENSE, BROWN **GRAVEL**, SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MOIST. -COBBLES ENCOUNTERED @ 30.0'		29	13 13 8	29	100	SS-12	-	55	23	9	3	10	23	18	5	17	A-1-a (0)	

2014 ODOT BORING LOG-RII NE BRIDGE ID - OH DOT.GDT - 3/14/15 17:33 - U:\GI\PROJECTS\2013\W-13-045.GPJ

PID: 77372	BR ID: FRA-70-1321A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5059+89.96 / 2.4 RT	START: 8/7/13	END: 8/22/13	PG 2 OF 3	B-016-4-13

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
MEDIUM DENSE, BROWN **GRAVEL**, SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MOIST. *(same as above)*	675.0	31																
	673.0	32																
DENSE TO VERY DENSE, BROWN TO GRAY **GRAVEL**, SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MOIST.		33																
		34	43 50/4"	-	100	SS-13	-	-	-	-	-	-	-	-	-	13	A-1-a (V)	
		35																
-AUGER REFUSAL ENCOUNTERED @ 35.5'. ATTEMPTED 5.0' CORE RUN. GRANITE BOULDER PIECE RECOVERED IN CORE RUN. REMAINING SOIL WAS WASHED OUT DURING CORING OPERATION. CONTINUED SPT SAMPLING @ 40.5'.		36																
		37																
		38	0		28	RC-1											CORE	
		39																
		40																
		41	22 12 13	34	83	SS-14	0.00	-	-	-	-	-	-	-	-	11	A-1-a (V)	
		42																
		43																
		44	49 50/5"	-	100	SS-15	4.25	67	17	5	5	6	20	16	4	11	A-1-a (0)	
AUGER REFUSAL @ 45.5'	659.5	45																
		TR																
SHALE : BLACK AND GRAY, MODERATELY WEATHERED TO UNWEATHERED, WEAK TO SLIGHTLY STRONG, VERY THIN BEDDED TO LAMINATED, FISSILE, FRIABLE, HIGHLY FRACTURED TO FRACTURED, OPEN APERTURE, SLIGHTLY ROUGH TO ROUGH; RQD 23%, REC 65%.		46	0		98	RC-2											CORE	
-SLIGHTLY PYRITIC IN RC-3		47																
		48																
		49	0		40	RC-3											CORE	
		50																
		51																
-POINT LOAD STRENGTH @ 52.5' TO 56.0' -MEAN QU = 380 PSI		52																
		53																
		54	45		100	RC-4											CORE	
		55																
		56																
		57																
		58																
		59	33		63	RC-5											CORE	
	645.3	60																
LIMESTONE : GRAY AND DARK GRAY, SLIGHTLY WEATHERED, STONG, CRYSTALLINE, THIN BEDDED, DOLOMITIC, PYRITIC, CHERTY, SLIGHTLY FRACTURED, OPEN APPERTURE, ROUGH; RQD 91%, REC 100%.	643.5	61																
		EOB																

PID: 77372	BR ID: FRA-70-1321A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5059+89.96 / 2.4 RT	START: 8/7/13	END: 8/22/13	PG 3 OF 3	B-016-4-13

MATERIAL DESCRIPTION AND NOTES	ELEV. 642.9	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
-QU @ 59.8' = 12,760 PSI																		

NOTES: GROUNDWATER INITIALLY ENCOUNTERED @ 15.5'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 188 LBS CEMENT / 50 LBS BNTONITE POWDER / 50 GAL WATER

B-016-4-13 – RC-1 – Depth from 35.5 to 40.5 feet

B-016-4-13 – RC-2, RC-3, and RC-4 – Depth from 45.5 to 56.5 feet

B-016-4-13 – RC-5 – Depth from 56.5 to 61.5 feet

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / T.F.	DRILL RIG: CME-750X (SN 310218)	STATION / OFFSET: 5062+32.40 / 14' RT	**EXPLORATION ID B-016-5-13**	
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL RAMP C5		
PID: 77372 BR ID: FRA-70-1321A	DRILLING METHOD: 4.25" HSA / RC	CALIBRATION DATE: 4/26/13	ELEVATION: 740.1 (MSL) EOB: 94.9 ft.		PAGE 1 OF 4
START: 8/9/13 END: 8/13/13	SAMPLING METHOD: SPT / HQ	ENERGY RATIO (%): 86.8	LAT / LONG: 39.952081479, -83.010812274		

MATERIAL DESCRIPTION AND NOTES	ELEV. 740.1	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
0.3' - ASPHALT (4.0")	739.8																	
0.5' - CONCRETE (6.0")	739.3																	
0.2' - AGGREGATE BASE (2.0")	739.1																	
FILL: VERY STIFF, DARK BROWNISH GRAY TO DARK GRAYISH BROWN **SILTY CLAY**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST.		1	4 7 8	22	56	SS-1	2.75	-	-	-	-	-	-	-	-	17	A-6b (V)	
		2																
		3																
		4	4 6 9	22	61	SS-2	2.50	19	8	13	36	24	33	17	16	16	A-6b (7)	
		5																
		6	11 12 12	35	61	SS-3	3.00	-	-	-	-	-	-	-	-	13	A-6b (V)	
		7																
		8																
		9	8 10 13	33	72	SS-4	2.50	-	-	-	-	-	-	-	-	17	A-6b (V)	
	729.6	10																
FILL: MEDIUM DENSE TO DENSE, DARK BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, MOIST.		11																
		12	8 10 11	30	78	SS-5	-	28	16	24	4	28	40	19	21	17	A-2-6 (2)	
		13																
		14	5 8 11	27	83	SS-6	-	-	-	-	-	-	-	-	-	15	A-2-6 (V)	
		15																
		16																
		17	9 9 14	33	78	SS-7	-	-	-	-	-	-	-	-	-	20	A-2-6 (V)	
	722.1	18																
FILL: STIFF, DARK BROWN **SANDY SILT**, SOME FINE GRAVEL, LITTLE SILT, DAMP. -COBBLES ENCOUNTERED @ 18.5' -SLAG FRAGMENTS PRESENT IN SS-8 -BRICK AND CONCRETE FRAGMENTS PRESENT IN SS-9		19	4 6 3	13	56	SS-8	1.50	27	18	19	22	14	28	18	10	13	A-4a (0)	
		20																
		21																
		22	2 4 9	19	61	SS-9	-	-	-	-	-	-	-	-	-	14	A-4a (V)	
	717.1	23																
FILL: MEDIUM DENSE, BROWNISH GRAY TO BROWN **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP. -BRICK, COAL, CONCRETE AND CINDER FRAGMENTS PRESENT THROUGHOUT		24	18 9 10	27	39	SS-10	-	-	-	-	-	-	-	-	-	8	A-2-4 (V)	
		25																
		26																
		27	7 4 5	13	72	SS-11	-	40	20	13	18	9	26	19	7	9	A-2-4 (0)	
	712.1	28																
MEDIUM DENSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, WET.		29	7 4 5	13	72	SS-12	-	-	-	-	-	-	-	-	-	28	A-2-6 (V)	

PID: 77372	BR ID: FRA-70-1321A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5062+32.40 / 14 RT	START: 8/9/13	END: 8/13/13	PG 2 OF 4	B-016-5-13

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
MEDIUM DENSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, WET. *(same as above)*	710.1	31																
	708.1	32																
VERY DENSE, BROWN **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP.		33																
		34	2 35 17	75	56	SS-13	-	-	-	-	-	-	-	-	-	6	A-2-4 (V)	
	703.1	35																
STIFF TO VERY STIFF, BROWN **CLAY**, "AND" SILT, TRACE FINE SAND, MOIST.		36																
		37																
		38																
		39	3 5 7	17	78	SS-14	2.50	-	-	-	-	-	-	-	-	23	A-7-6 (V)	
		40																
		41																
		42																
		43																
		44	3 3 5	12	83	SS-15	2.00	0	0	4	54	42	45	22	23	28	A-7-6 (14)	
	693.1	45																
STIFF, DARK BROWNISH GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST.		46																
		47																
		48																
W		49	6 8 6	20	56	SS-16	1.50	-	-	-	-	-	-	-	-	22	A-6a (V)	
		50																
	688.1	51																
DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, MOIST.		52																
		53																
		54	10 16 9	36	56	SS-17	-	45	29	12	12	2	18	15	3	16	A-1-b (0)	
		55																
		56																
		57																
		58																
		59	10 12 13	36	83	SS-18	-	-	-	-	-	-	-	-	-	18	A-1-b (V)	
		60																
	678.1	61																

PID: 77372	BR ID: FRA-70-1321A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5062+32.40 / 14 RT	START: 8/9/13	END: 8/13/13	PG 3 OF 4	B-016-5-13

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**, LITTLE CLAY, LITTLE FINE GRAVEL, DAMP TO MOIST. *(same as above)*	678.0	63																
		64	12 28 30	84	56	SS-19	4.5+	-	-	-	-	-	-	-	-	8	A-4a (V)	
		65																
		66																
		67																
		68																
		69	11 13 25	55	50	SS-20	4.5+	11	8	22	41	18	21	13	8	12	A-4a (5)	
		70																
		71																
		72																
		73																
		74	17 24 48	104	56	SS-21	4.00	-	-	-	-	-	-	-	-	13	A-4a (V)	
		75																
		76																
	663.1	77																
VERY STIFF, GRAY **SILT**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, TRACE CLAY, WET.		78																
		79	10 22 39	88	61	SS-22	3.50	5	6	20	64	5	17	12	5	18	A-4b (7)	
		80																
		81																
	658.1	82																
HARD, GRAY **SILT AND CLAY**, TRACE COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP. -SHALE FRAGMENTS PRESENT IN SS-23		83																
AUGER REFUSAL @ 84.9'	655.2	84	25 35 50/3"	-	67	SS-23	4.5+	-	-	-	-	-	-	-	-	12	A-6a (V)	
		TR 85	0		42	RC-1											CORE	
SHALE : GRAY AND BLACK, MODERATELY TO HIGHLY WEATHERED, VERY WEAK TO SLIGHTLY STRONG, LAMINATED TO THINLY LAMINATED, FISSILE, FRIABLE, HIGHLY FRACTURED, OPEN APERTURE, ROUGH; RQD 0%, REC 32%.		86																
		87																
		88	0		30	RC-2											CORE	
		89																
		90																
-0.2' SILTSTONE LENS @ 90.9'		91																
		92																
		93	0		31	RC-3											CORE	
		94																

PID: 77372	BR ID: FRA-70-1321A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5062+32.40 / 14 RT	START: 8/9/13	END: 8/13/13	PG 4 OF 4	B-016-5-13

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
	645.8																	
	645.2	EOB																

NOTES: GROUNDWATER INITIALLY ENCOUNTERED @ 48.5'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 188 LBS CEMENT / 50 LBS BENTONITE POWDER / 50 GAL WATER

B-016-5-13 – RC-1, RC-2, and RC-3 – Depth from 84.9 to 94.9 feet

APPENDIX IV

HISTORIC BORING LOGS:

B-001-S-57 through B-020-S-57

STATE OF OHIO
DEPARTMENT OF HIGHWAYS
TESTING LABORATORY

LOG OF BORING

CO., RT. NO., SEC. FRA-40-12.30 BRIDGE NO. FRA-40-1230
REAR ABUTMENT OVER SCIOTO RIVER
LOCATION: T.H. 1 STA. 21+75 OFFSET C.L. FED. NO.

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
724.0	0			
	2			
	4			
	6			
	8			
	10			
714.0	12	18	67403	GRAY AND BROWN SILTY GRAVEL
	14			
709.0	16	45	67404	GRAVEL
	18			
704.0	20	30	67405	BROWN CLAY
	22			
	24			
699.0	26	70	67406	GRAY AND BROWN SILTY SANDY GRAVEL
	28			
	30			
694.0	32	52	67407	GRAVEL
	34			
689.0	36	38	67408	GRAVEL

7-24-57

LOG OF BORING (CONTINUED)

BRIDGE NO. FRA-40-1230 T.H. 1

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
	38			
684.0	40	74	67409	SANDY GRAVEL
	42			
	44			
680.0		90	67410	SILTY SANDY GRAVEL
	46			
	48			
674.0	50	155	67411	GRAY GRAVELLY SANDY CLAY
	52			
	54			
	56			
667.0	58			BOULDERS
	60			
	62			
661.0	64			LARGE BOULDERS BOTTOM OF HOLE
	66			
	68			
	70			
	72			
	74			
	76			
	78			
	80			
	82			

STATE OF OHIO
DEPARTMENT OF HIGHWAYS
TESTING LABORATORY

LOG OF BORING

CO., RT. NO., SEC. FRA-40-12.30 BRIDGE NO. FRA-40-1230
SECOND PIER OVER SCIOTO RIVER

LOCATION: T.H. 5 STA. 24+00 OFFSET C.L. FED. NO.

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
681.7	0			
	2			
	4			
676.4	6	24	66517	GRAY SANDY GRAVEL
	8			
	10			
671.4	12	73	66518	GRAY SILTY GRAVELLY SAND
	14			
666.4	16	180	66519	GRAY SILTY SANDY GRAVEL
663.4	18	--	---	COARSE SAND
661.4	20			
	22	117	66520	GRAY SILTY GRAVEL
	24			
656.4	26	20	----	FINE SAND, SILT AND SMALL GRAVEL
	28			
652.7	30	600	66521	WEATHERED SHALE
652.1				TOP OF ROCK
	32			HARD DENSE GRAY LIMESTONE
	34			
645.7	36			BOTTOM OF HOLE

9A
7-24-57

B-009-S-57

SHEET

STATE OF OHIO
DEPARTMENT OF HIGHWAYS
TESTING LABORATORY

LOG OF BORING

CO., RT. NO., SEC. FRA-40-12.30 BRIDGE NO. FRA-40-1230
FOURTH PIER OVER SCIOTO RIVER

LOCATION: T.H. 9 STA. 26+25 OFFSET C.L. FED. NO.

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
686.1	0			
	2			
	4			
	6			
	8			
677.4	10	39	67412	GRAY SILTY GRAVELLY SAND
	12			
672.4	14			
	16	171	67413	GRAY AND BROWN SILTY GRAVELLY SAND
669.4	18		67414	GRAVEL AND STONE FRAGMENTS
	20			
	22			
	24			
662.4	26	39	67415	SANDY GRAVEL
660.4	28	190	67416	SANDY GRAVEL
	30			
654.4	32			
	34	70	67417	GRAVEL
651.4				TOP OF ROCK
	36			FIRM GRAY CLAY SHALE

AS
7-24-67

B-009-S-57

SHEET 7

LOG OF BORING (CONTINUED)

BRIDGE NO. ERA-45-1230 T.H. 9

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
648.7	38			FIRM GRAY CLAY SHALE
646.0	40			DENSE GRAY LIMESTONE WITH DARK WAVY PARTINGS
	42			BOTTOM OF HOLE
	44			
	46			
	48			
	50			
	52			
	54			
	56			
	58			
	60			
	62			
	64			
	66			
	68			
	70			
	72			
	74			
	76			
	78			
	80			
	82			

T 24-57

B-013-S-57

SHEET 8

STATE OF OHIO
DEPARTMENT OF HIGHWAYS
TESTING LABORATORY

LOG OF BORING

CO., RT. NO., SEC. FRA -40-12.30 BRIDGE NO. FRA-40-1230
SIXTH PIER OVER SCIOTO RIVER

LOCATION: T.H. 13 STA. 28+73 OFFSET C.L. FED. NO.

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
692.4	0			
	2			
	4			
686.9	6	15	66522	GRAVEL
682.9	8	90	66523	BROWN SANDY GRAVEL
	10			
	12			
	14			
676.9	16	27	66524	GRAY AND BROWN GRAVELLY SAND
	18			
672.9	20	30	66525	BROWN AND GRAY SANDY GRAVEL
	22			
	24			
666.9				
665.9	26	200	66526	BROWN AND GRAY SANDY GRAVEL
			66527	STONE FRAGMENTS
	28			
661.4	30	200	66528	GRAY SOFT SHALE ← TOP OF ROCK
660.9	32		66529	SHALE
	34			
	36			

AB
7-24-57

B-013-S-57

LOG OF BORING (CONTINUED)

BRIDGE NO. ERA-40-1230 T.H. 13

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
	38			SHALE
652.4	40			BOTTOM OF HOLE
	42			
	44			
	46			
	48			
	50			
	52			
	54			
	56			
	58			
	60			
	62			
	64			
	66			
	68			
	70			
	72			
	74			
	76			
	78			
	80			
	82			

AB
7-29-57

STATE OF OHIO
DEPARTMENT OF HIGHWAYS
TESTING LABORATORY

LOG OF BORING

CO., RT. NO., SEC. FRA-40-12.30 BRIDGE NO. FRA-40-1230
FORWARD ABUTMENT OVER SCIOTO RIVER

LOCATION: T.H. 20 STA. 32+05 OFFSET 19' LT FED. NO.

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
726.0	0			
	2			
	4			
721.0	6	----	-----	SAND & SMALL GRAVEL
	8			
	10			
715.0	12	10	67937	SANDY GRAVEL
	14			
	16			
709.0	18	17	-----	SANDY GRAVELLY SILT
	20			
705.0	22	25	67938	SANDY GRAVELLY SILT
	24			
	26			
700.0	28	15	67939	BROWN CLAY
	30			
695.0	32	23	67940	BROWN SILTY GRAVEL
	34			
690.0	36	25	67941	GRAVEL

AB
7-24-57

B-020-S-57

SHEET //

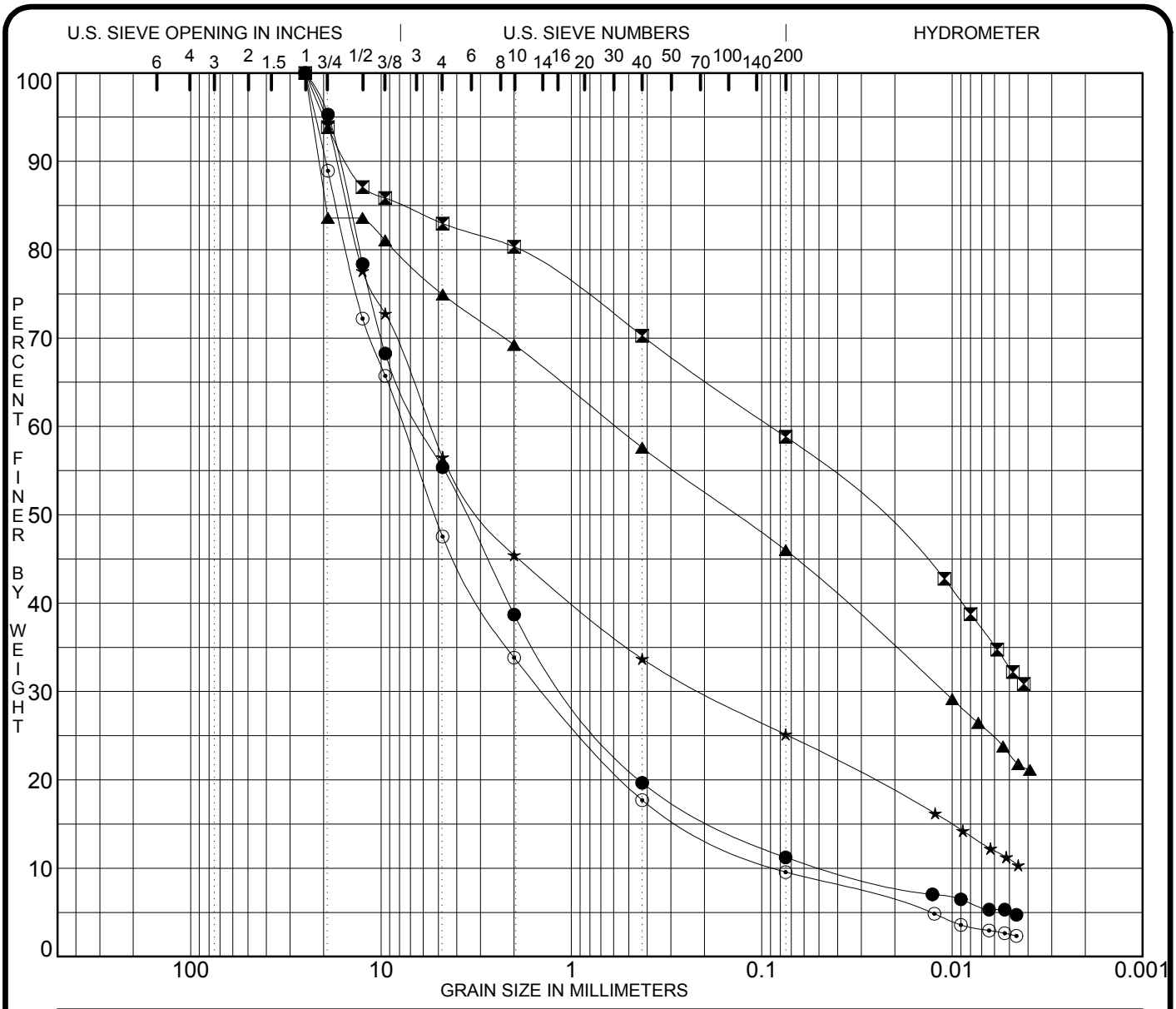
LOG OF BORING (CONTINUED)

BRIDGE NO. FRA-40-1230 T.H. 20

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
	38			
	40			
658.5		75	67942	SILTY GRAVEL
	42			BOTTOM OF HOLE
	44			
	46			
	48			
	50			
	52			
	54			
	56			
	58			
	60			
	62			
	64			
	66			
	68			
	70			
	72			
	74			
	76			
	78			
	80			
	82			

APPENDIX V

LABORATORY TEST RESULTS



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

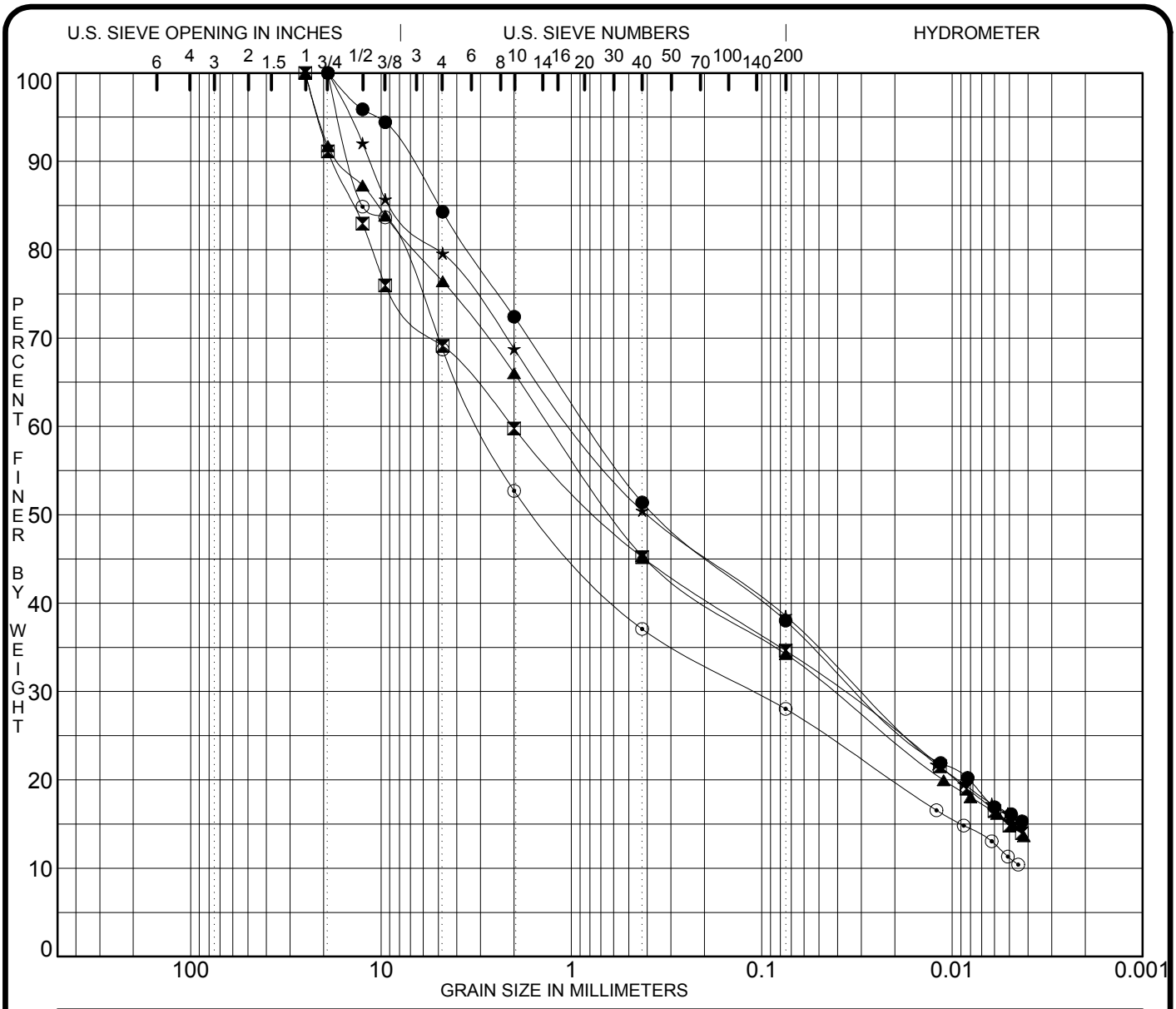
	Specimen Identification	Depth	Classification	MC%	LL	PL	PI	Cz	Cu
●	**B-015-8-13**	**0.0**		**23**				**3.58**	**136.6**
⊠	**B-015-8-13**	**1.5**	**A-6b**	**25**	**38**	**19**	**19**		
▲	**B-015-8-13**	**3.0**		**29**					
★	**B-015-8-13**	**4.5**	**A-2-6**	**20**	**33**	**20**	**13**		
⊙	**B-015-8-13**	**10.2**	**A-1-a**	**19**	**NP**	**NP**	**NP**	**3.05**	**92.8**

	Specimen Identification	D95	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	**B-015-8-13**	**18.856**	**3.594**	**0.985**	**0.0446**	**4.7**	**56.6**	**19.0**	**8.4**	**6.1**	**5.1**
⊠	**B-015-8-13**	**19.984**	**0.026**			**6.1**	**13.5**	**10.1**	**11.4**	**26.1**	**32.8**
▲	**B-015-8-13**	**22.994**	**0.136**	**0.011**		**16.4**	**14.4**	**11.6**	**11.6**	**23.1**	**22.9**
★	**B-015-8-13**	**19.724**	**2.856**	**0.201**		**5.8**	**48.8**	**11.7**	**8.6**	**14.1**	**11.0**
⊙	**B-015-8-13**	**22.086**	**5.218**	**1.385**	**0.0823**	**11.1**	**55.1**	**16.1**	**8.1**	**7.0**	**2.5**

PROJECT **FRA-70-12.68 - PHASE 4A** PROJECT NO. **W-13-045**

GRADATION CURVES

Resource International Inc



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

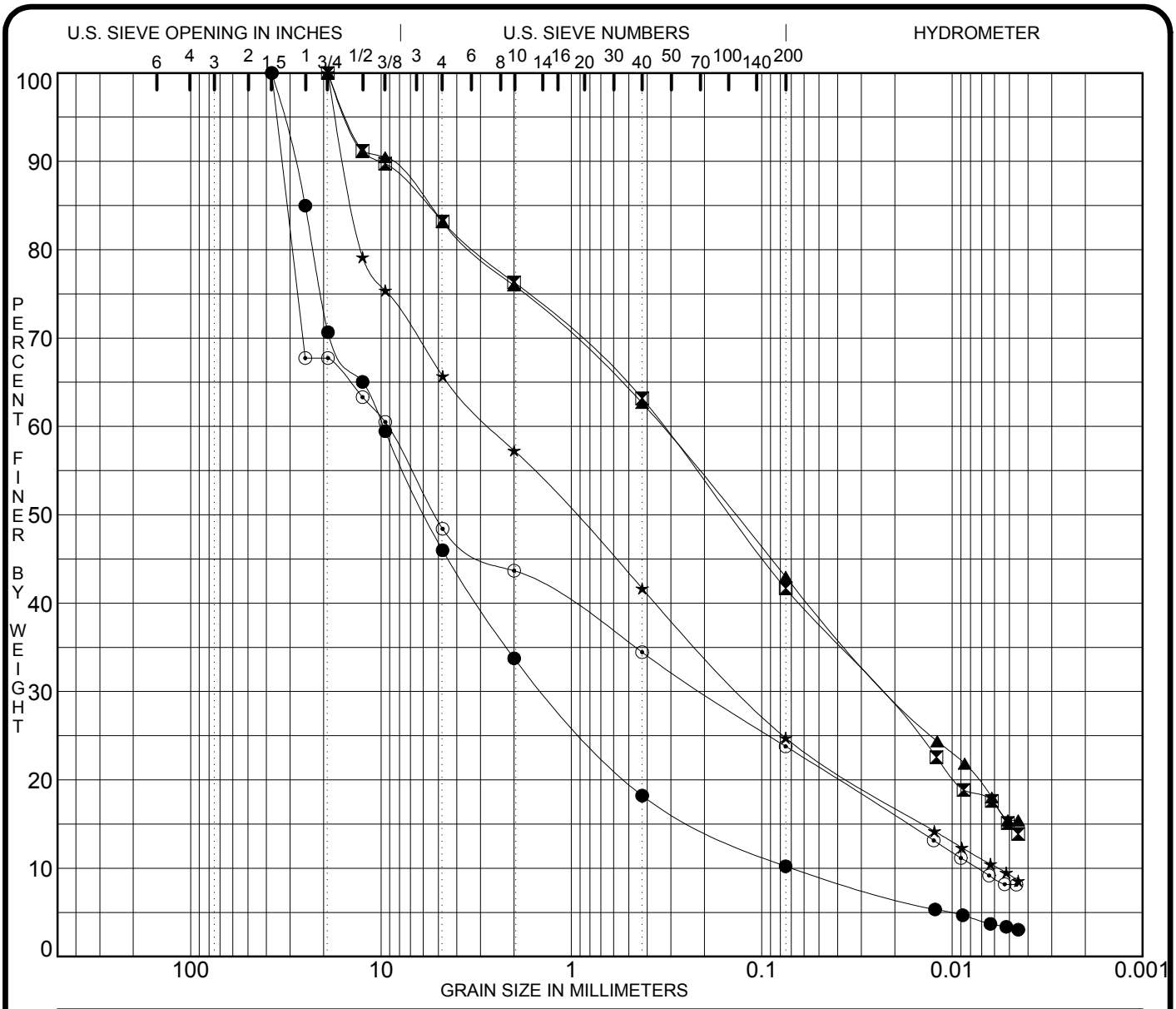
Specimen Identification	Depth	Classification	MC%	LL	PL	PI	Cz	Cu
● B-015-9-13	0.0		23					
⊠ B-015-9-13	1.5	A-2-6	19	34	19	15		
▲ B-015-9-13	3.0		18					
★ B-015-9-13	4.5	A-6a	20	34	19	15		
⊙ B-015-9-13	6.5		15					

Specimen Identification	D95	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
● B-015-9-13	10.570	0.355	0.029		0.0	27.6	21.0	13.4	21.8	16.2
⊠ B-015-9-13	21.422	0.708	0.039		8.9	31.3	14.6	10.6	19.8	14.8
▲ B-015-9-13	21.176	0.602	0.042		8.3	25.7	20.7	11.1	19.1	15.2
★ B-015-9-13	14.597	0.397	0.030		0.0	31.2	18.3	11.9	22.5	16.1
⊙ B-015-9-13	16.544	1.530	0.109		0.0	47.3	15.6	9.0	16.9	11.2

PROJECT **FRA-70-12.68 - PHASE 4A** PROJECT NO. **W-13-045**

GRADATION CURVES

Resource International Inc



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

	Specimen Identification	Depth	Classification	MC%	LL	PL	PI	Cz	Cu
●	**B-016-3-13**	**0.0**	**A-1-a**	**19**	**NP**	**NP**	**NP**	**2.81**	**141.4**
⧓	**B-016-3-13**	**1.5**		**19**					
▲	**B-016-3-13**	**3.0**	**A-4a**	**24**	**27**	**18**	**9**		
★	**B-016-3-13**	**4.5**		**18**				**1.09**	**461.1**
⊙	**B-016-3-13**	**6.0**	**A-1-b**	**21**	**31**	**25**	**6**	**0.62**	**1252.0**

	Specimen Identification	D95	D50	D30	D10	%Gravel coarse	%Gravel fine	%Sand coarse	%Sand fine	%Silt	%Clay
●	**B-016-3-13**	**32.764**	**5.839**	**1.376**	**0.0690**	**29.3**	**36.9**	**15.5**	**8.0**	**6.9**	**3.3**
⧓	**B-016-3-13**	**14.980**	**0.147**	**0.025**		**0.0**	**23.7**	**13.1**	**21.5**	**26.8**	**14.9**
▲	**B-016-3-13**	**15.036**	**0.139**	**0.021**		**0.0**	**24.0**	**13.3**	**19.7**	**27.6**	**15.4**
★	**B-016-3-13**	**17.184**	**0.971**	**0.129**	**0.0057**	**0.0**	**42.7**	**15.6**	**16.9**	**15.5**	**9.2**
⊙	**B-016-3-13**	**35.216**	**5.202**	**0.206**	**0.0074**	**32.3**	**24.1**	**9.2**	**10.7**	**15.6**	**8.2**

PROJECT **FRA-70-12.68 - PHASE 4A** PROJECT NO. **W-13-045**

GRADATION CURVES

Resource International Inc

RESOURCE INTERNATIONAL, INC.

Engineering Consultants

Unconfined Compressive Strength

of Intact Rock Core Specimens (ASTM D 7012-04)

6350 Presidential Gatew.	9885 Rockside Road	4480 Lake Forest Drive
Columbus, OH 43231	Cleveland, OH 44125	Cincinnati, Ohio 45242
Phone (614) 823-4949	Phone (216) 573-0955	Phone (513) 769-6998

Project: FRA-70-12.68 - Project 4A

Project No.: W-13-045

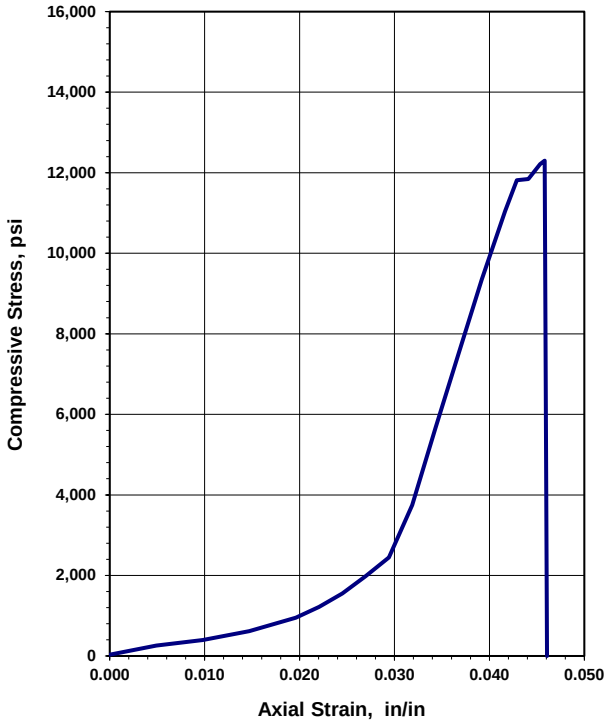
Date of Testing: 7/12/2013

Test Performed by: JJH/TK

Rock Description: DOLOMITE: Gray and brown, slightly weathered, strong.

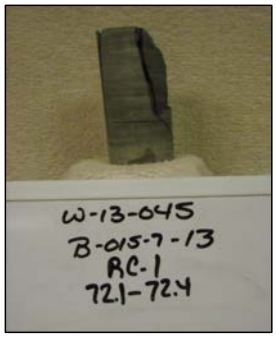
Boring No.:	B-015-7-13	Average Length:	4.081 in
Sample No:	RC-1	Average Diameter:	1.855 in
Depth (ft):	72.1	Length to diameter ratio:	2.200
Moisture condition:	As received	Cross Sectional Area:	2.701 in^2
Rate of Loading:	63.9 lbs/sec	Failure Load:	33,240 lbs
Testing Time:	520 sec	Axial Strain at Failure:	0.0458 in/in
	(Rate 2-15 minutes to failure)	Stress:	12,300 psi

Unconfined Compression Test



Before Testing

After Failure



REMARKS:

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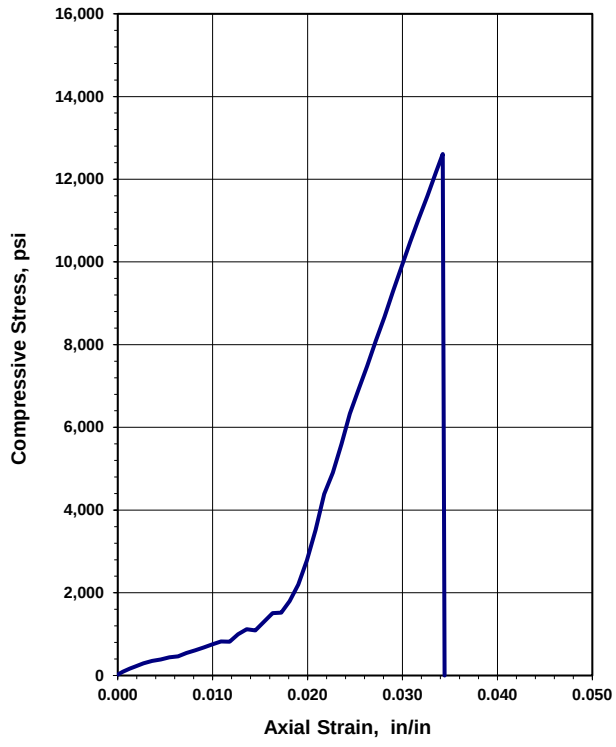
Unconfined Compressive Strength
of Intact Rock Core Specimens (ASTM D 7012-04)

Project: FRA-70-12.68 - Project 4A
Project No.: W-13-045
Date of Testing: 6/27/2014
Test Performed by: K.R./T.K.

Rock Description: LIMESTONE: Gray, unweathered to slightly weathered, very strong.

Boring No.:	B-015-8-13	Average Length:	5.518 in
Sample No:	RC-2	Average Diameter:	2.484 in
Depth (ft):	45.2	Length to diameter ratio:	2.221
Moisture condition:	Dry	Cross Sectional Area:	4.844 in^2
Rate of Loading:	86.4 lbs/sec	Failure Load:	61,100 lbs
Testing Time:	707 sec	Axial Strain at Failure:	0.0343 in/in
	(Rate 2-15 minutes to failure)	Stress:	12,610 psi

Unconfined Compression Test



Before Testing

Not Available

After Failure

Not Available

REMARKS:

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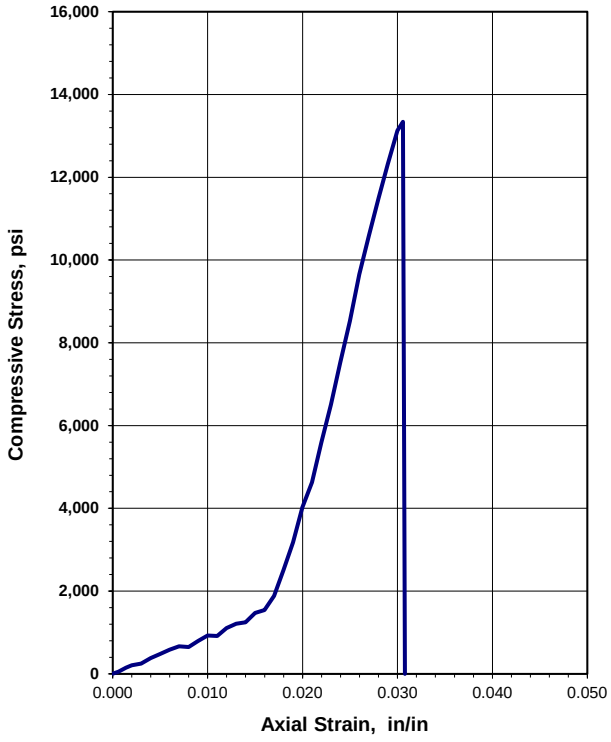
Unconfined Compressive Strength
of Intact Rock Core Specimens (ASTM D 7012-04)

Project: FRA-70-12.68 - Project 4A
Project No.: W-13-045
Date of Testing: 6/27/2014
Test Performed by: K.R./T.K.

Rock Description: LIMESTONE: Gray, unweathered to slightly weathered, very strong.

Boring No.:	B-015-8-13	Average Length:	5.003 in
Sample No:	RC-3	Average Diameter:	2.483 in
Depth (ft):	48.0	Length to diameter ratio:	2.015
Moisture condition:	Dry	Cross Sectional Area:	4.840 in^2
Rate of Loading:	97.7 lbs/sec	Failure Load:	64,580 lbs
Testing Time:	661 sec	Axial Strain at Failure:	0.0306 in/in
	(Rate 2-15 minutes to failure)	Stress:	13,340 psi

Unconfined Compression Test



Before Testing

Not Available

After Failure

Not Available

REMARKS:

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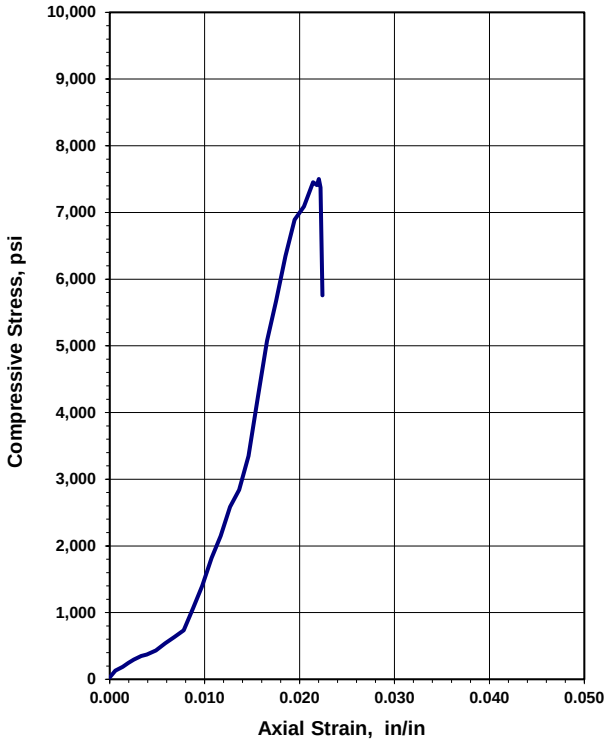
Unconfined Compressive Strength
of Intact Rock Core Specimens (ASTM D 7012-04)

Project: FRA-70-12.68 - Project 4A
Project No.: W-13-045
Date of Testing: 5/15/2014
Test Performed by: CS/TK

Rock Description: LIMESTONE: Gray, unweathered to slightly weathered, very strong.

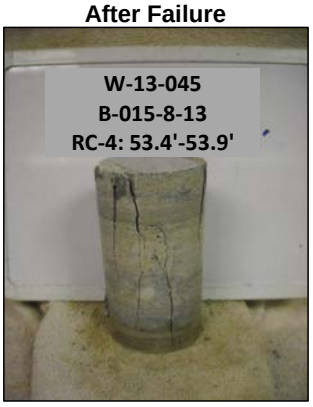
Boring No.:	B-015-8-13	Average Length:	5.132 in
Sample No:	RC-4	Average Diameter:	2.489 in
Depth (ft):	53.4	Length to diameter ratio:	2.062
Moisture condition:	Dry	Cross Sectional Area:	4.863 in^2
Rate of Loading:	63.8 lbs/sec	Failure Load:	36,490 lbs
Testing Time:	572 sec	Axial Strain at Failure:	0.0220 in/in
	(Rate 2-15 minutes to failure)	Stress:	7,502 psi

Unconfined Compression Test



Before Testing

After Failure



REMARKS: Depths shown in photos are measured from the top of the barge and have not been adjusted to the river bottom depth.

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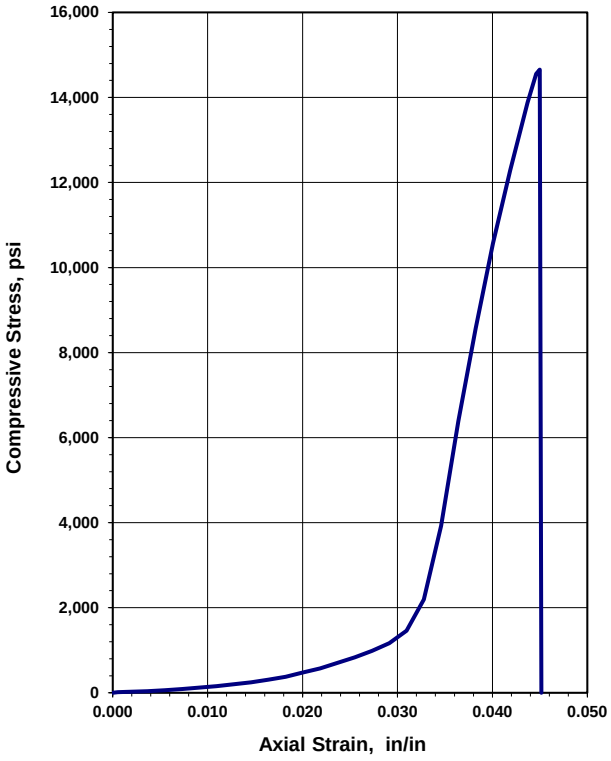
Unconfined Compressive Strength
of Intact Rock Core Specimens (ASTM D 7012-04)

Project: FRA-70-12.68 - Project 4A
Project No.: W-13-045
Date of Testing: 6/19/2014
Test Performed by: CS/TK

Rock Description: LIMESTONE: Brown, unweathered, strong, dolomitic.

Boring No.:	B-015-9-13	Average Length:	5.492 in
Sample No:	RC-3	Average Diameter:	2.493 in
Depth (ft):	43.8	Length to diameter ratio:	2.203
Moisture condition:	Dry	Cross Sectional Area:	4.879 in^2
Rate of Loading:	90.5 lbs/sec	Failure Load:	71,530 lbs
Testing Time:	790 sec	Axial Strain at Failure:	0.0450 in/in
	(Rate 2-15 minutes to failure)	Stress:	14,655 psi

Unconfined Compression Test



Before Testing

After Failure

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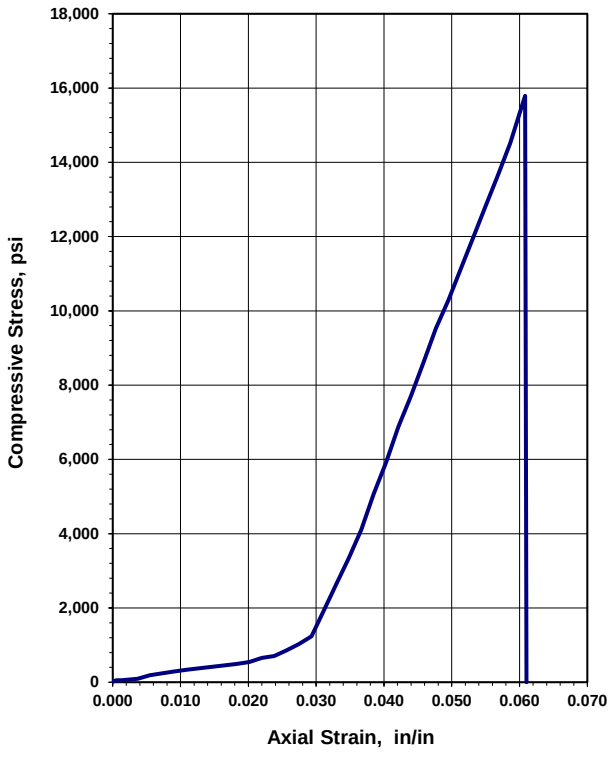
Unconfined Compressive Strength
of Intact Rock Core Specimens (ASTM D 7012-04)

Project: FRA-70-12.68 - Project 4A
Project No.: W-13-045
Date of Testing: 6/19/2014
Test Performed by: CS/TK

Rock Description: LIMESTONE: Brown, unweathered, strong, dolomitic.

Boring No.:	B-015-9-13	Average Length:	5.457 in
Sample No:	RC-4	Average Diameter:	2.491 in
Depth (ft):	45.2	Length to diameter ratio:	2.191
Moisture condition:	Dry	Cross Sectional Area:	4.871 in^2
Rate of Loading:	83.7 lbs/sec	Failure Load:	76,960 lbs
Testing Time:	919 sec	Axial Strain at Failure:	0.0608 in/in
	(Rate 2-15 minutes to failure)	Stress:	15,790 psi

Unconfined Compression Test



Before Testing

After Failure

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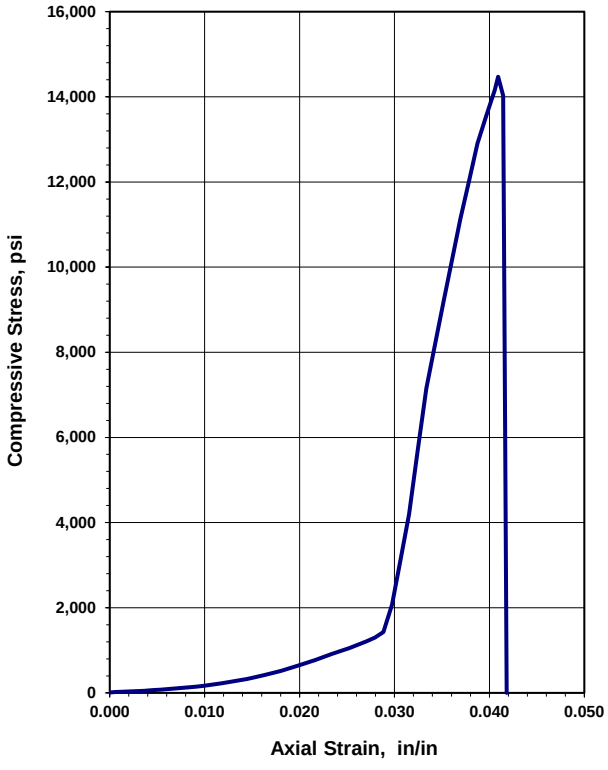
Unconfined Compressive Strength
of Intact Rock Core Specimens (ASTM D 7012-04)

Project: FRA-70-12.68 - Project 4A
Project No.: W-13-045
Date of Testing: 6/19/2014
Test Performed by: CS/TK

Rock Description: LIMESTONE: Gray, unweathered, strong, conglomeritic.

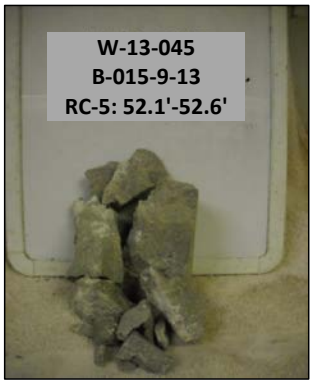
Boring No.:	B-015-9-13	Average Length:	5.548 in
Sample No:	RC-5	Average Diameter:	2.491 in
Depth (ft):	52.1	Length to diameter ratio:	2.227
Moisture condition:	Dry	Cross Sectional Area:	4.871 in^2
Rate of Loading:	98.4 lbs/sec	Failure Load:	70,520 lbs
Testing Time:	717 sec	Axial Strain at Failure:	0.0409 in/in
	(Rate 2-15 minutes to failure)	Stress:	14,472 psi

Unconfined Compression Test



Before Testing

After Failure



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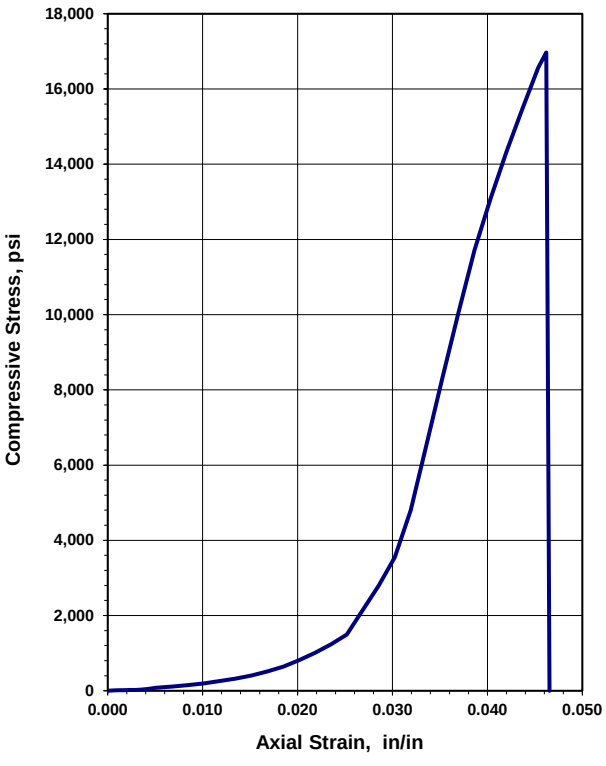
Unconfined Compressive Strength
of Intact Rock Core Specimens (ASTM D 7012-04)

Project: FRA-70-12.68 - Project 4A
Project No.: W-13-045
Date of Testing: 6/19/2014
Test Performed by: CS/TK

Rock Description: Brown Dolomitic Limestone

Boring No.:	B-015-9-13	Average Length:	5.952 in
Sample No:	RC-6	Average Diameter:	2.494 in
Depth (ft):	57.2	Length to diameter ratio:	2.387
Moisture condition:	Dry	Cross Sectional Area:	4.883 in^2
Rate of Loading:	106.7 lbs/sec	Failure Load:	82,900 lbs
Testing Time:	777 sec	Axial Strain at Failure:	0.0462 in/in
	(Rate 2-15 minutes to failure)	Stress:	16,970 psi

Unconfined Compression Test



Before Testing

After Failure

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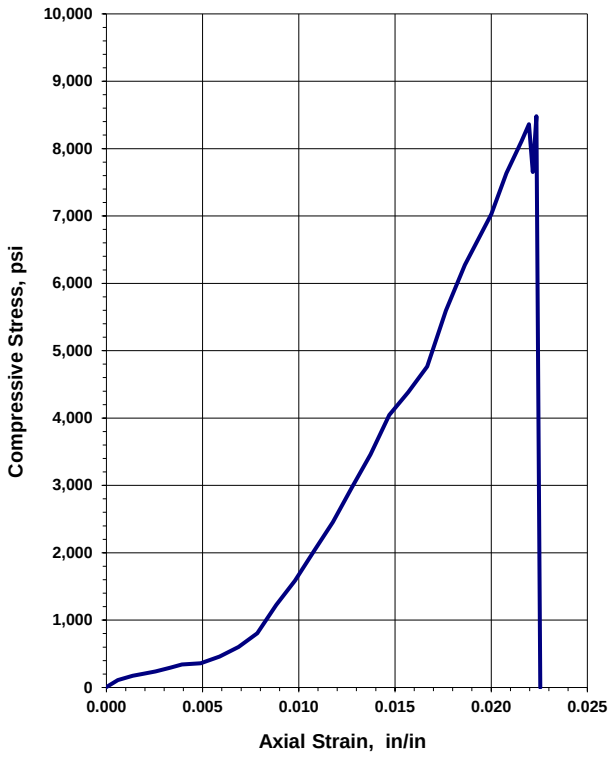
Unconfined Compressive Strength
of Intact Rock Core Specimens (ASTM D 7012-04)

Project: FRA-70-12.68 - Project 4A
Project No.: W-13-045
Date of Testing: 5/15/2014
Test Performed by: CS/TK

Rock Description: LIMESTONE: Gray, unweathered, very strong, dolomitic.

Boring No.:	B-016-3-13	Average Length:	5.099 in
Sample No:	RC-1	Average Diameter:	2.485 in
Depth (ft):	42.6	Length to diameter ratio:	2.052
Moisture condition:	Dry	Cross Sectional Area:	4.848 in^2
Rate of Loading:	73.2 lbs/sec	Failure Load:	41,120 lbs
Testing Time:	562 sec	Axial Strain at Failure:	0.0224 in/in
	(Rate 2-15 minutes to failure)	Stress:	8,481 psi

Unconfined Compression Test



Before Testing

After Failure

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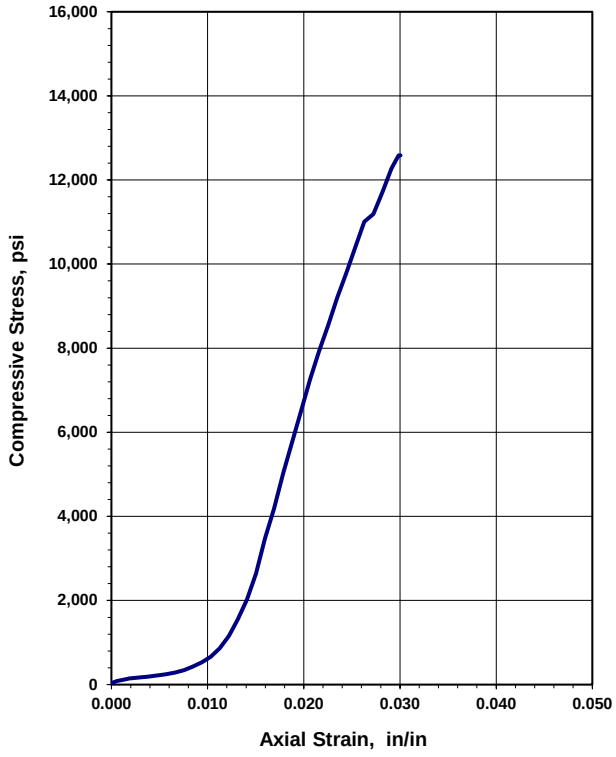
Unconfined Compressive Strength
of Intact Rock Core Specimens (ASTM D 7012-04)

Project: FRA-70-12.68 - Project 4A
Project No.: W-13-045
Date of Testing: 5/15/2014
Test Performed by: CS/TK

Rock Description: LIMESTONE: Gray, unweathered, very strong, dolomitic.

Boring No.:	B-016-3-13	Average Length:	5.324 in
Sample No:	RC-2	Average Diameter:	2.487 in
Depth (ft):	45.5	Length to diameter ratio:	2.141
Moisture condition:	Dry	Cross Sectional Area:	4.855 in^2
Rate of Loading:	82.9 lbs/sec	Failure Load:	61,120 lbs
Testing Time:	737 sec	Axial Strain at Failure:	0.0301 in/in
	(Rate 2-15 minutes to failure)	Stress:	12,584 psi

Unconfined Compression Test



Before Testing

After Failure

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Unconfined Compressive Strength
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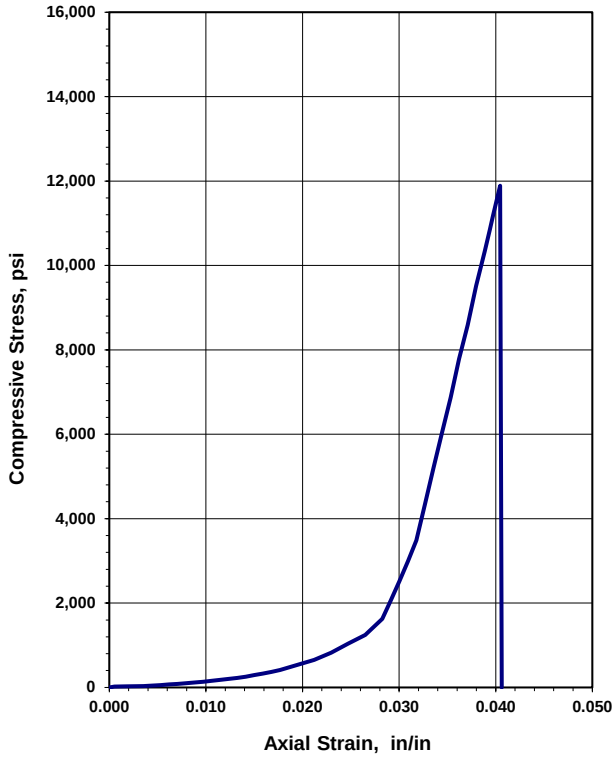
Project: FRA-70-12.68 - Project 4A
Project No.: W-13-045
Date of Testing: 6/19/2014
Test Performed by: CS/TK

Rock Description: LIMESTONE: Gray, unweathered, very strong, dolomitic.

Boring No.:	B-016-3-13	Average Length:	5.662 in
Sample No:	RC-3	Average Diameter:	2.489 in
Depth (ft):	48.6	Length to diameter ratio:	2.275
Moisture condition:	Dry	Cross Sectional Area:	4.863 in^2
Rate of Loading:	93.9 lbs/sec	Failure Load:	57,840 lbs
Testing Time:	616 sec	Axial Strain at Failure:	0.0404 in/in
	(Rate 2-15 minutes to failure)	Stress:	11,889 psi

Unconfined Compression Test



Before Testing

After Failure

REMARKS: Depths shown in photos are measured from the top of the barge and have not been adjusted to the river bottom depth.

RESOURCE INTERNATIONAL, INC.
Engineering Consultants

6350 Presidential Gatew.
Columbus, OH 43231
Phone (614) 823-4949

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Cleveland, OH 44125
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4480 Lake Forest Drive
Cincinnati, Ohio 45242
Phone (513) 769-6998

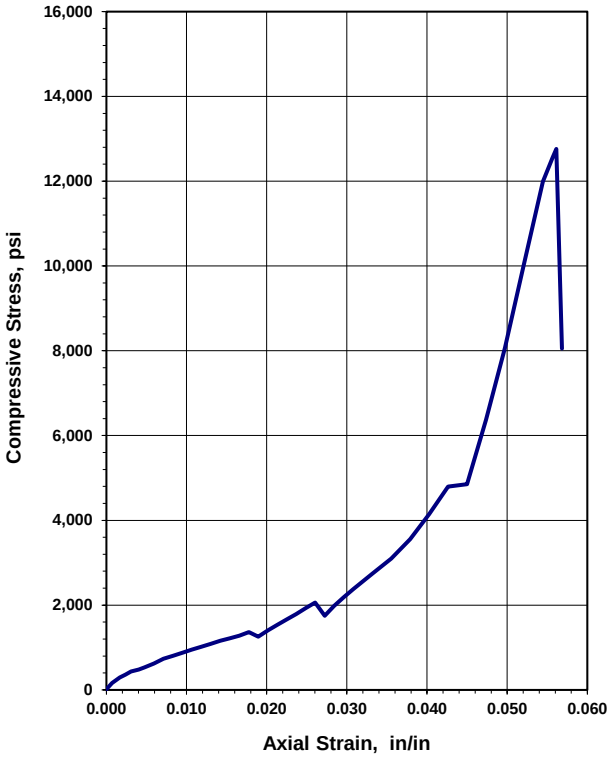
Unconfined Compressive Strength
of Intact Rock Core Specimens (ASTM D 7012-04)

Project: FRA-70-12.68 - Project 4A
Project No.: W-13-045
Date of Testing: 8/29/2013
Test Performed by: KR/TK

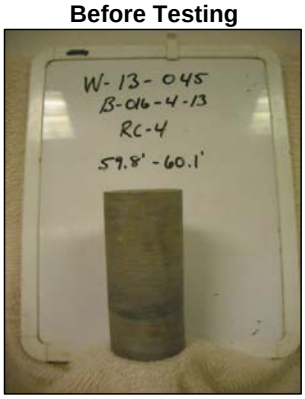
Rock Description: LIMESTONE: Gray, slightly weathered, strong.

Boring No.:	B-016-4-13	Average Length:	4.223 in
Sample No:	RC-4	Average Diameter:	1.869 in
Depth (ft):	59.8	Length to diameter ratio:	2.259
Moisture condition:	As received	Cross Sectional Area:	2.742 in^2
Rate of Loading:	61.9 lbs/sec	Failure Load:	35,010 lbs
Testing Time:	566 sec	Axial Strain at Failure:	0.0561 in/in
	(Rate 2-15 minutes to failure)	Stress:	12,760 psi

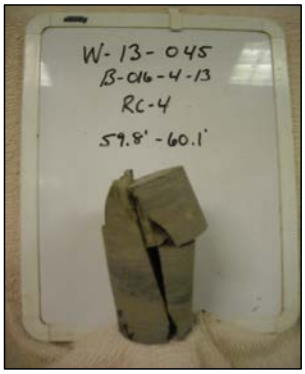
Unconfined Compression Test



Before Testing



After Failure



REMARKS:

APPENDIX VI

DRILLED SHAFT CALCULATIONS

End Bearing Resistance in Bedrock:

Intact Rock (Minimum Embedment ≥ 1.5B):

$q_p = 2.5q_u$ Equation 10.8.3.5.4c-1

q_u =	1080	ksf
q_p =	2701	ksf

Jointed Rock (or Shafts with Embedment Depth < 1.5B):

$q_p = A + q_u\left[m_b\left(\frac{A}{q_u}\right) + s\right]^a$ Equation 10.8.3.5.4c-2:

$A = \sigma'_{vb} + q_u\left[m_b\frac{\sigma'_{vb}}{q_u} + s\right]^a$ Equation 10.8.3.5.4c-3

q_u =	1080	ksf
GSI =	70	Per Figure 10.4.6.4-1
D =	0.0	Per Section 10.4.6.4 for undisturbed foundation excavation
m_i =	9	Per Table 10.4.6.4-1
s =	0.036	Per Equation 10.4.6.4-2
a =	0.50	Per Equation 10.4.6.4-3
m_b =	3.08	Per Equation 10.4.6.4-4

σ'_{vb} =	2.59	ksf	Considering overburden depth of 45 feet and bouyant unit weight of overburden of 57.6 psf
A =	225.8	ksf	Per Equation 10.8.3.5.4c-3
q_p =	1116	ksf	

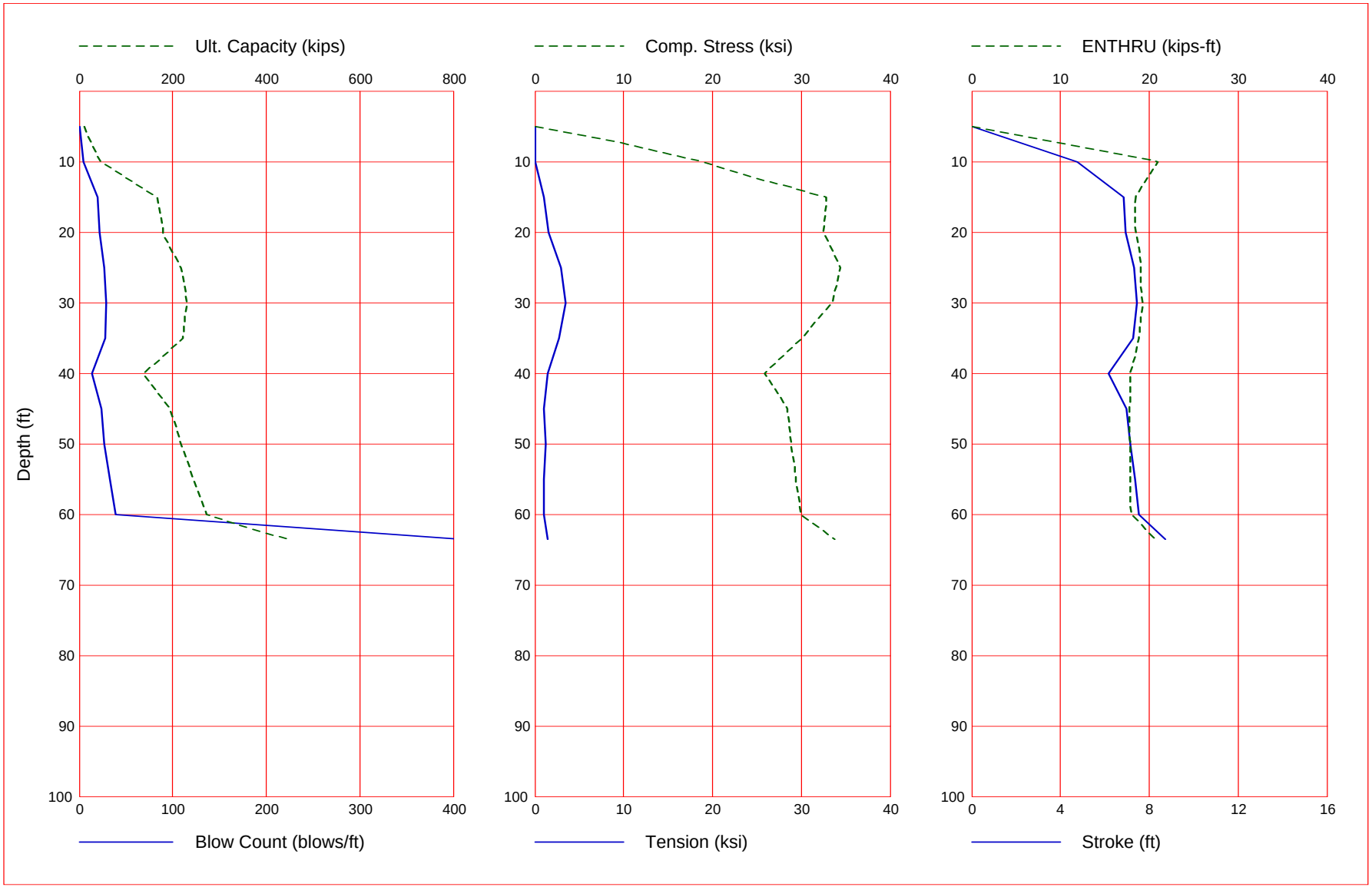
APPENDIX VII

GRLWEAP DRIVEABILITY ANALYSIS OUTPUTS

Resource International Inc
FRA-70-1321R - RA - B-015-7-13 - HP10x42

Apr 02 2015
GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 0.667 / 1.000



Gain/Loss 1 at Shaft and Toe 0.667 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	11.3	1.4	9.9	-1.0	0.000	0.000	0.00	0.0
10.0	45.8	6.1	39.7	4.4	18.931	0.000	4.74	21.0
15.0	166.1	15.8	150.2	20.0	32.788	-1.034	6.83	18.4
20.0	180.1	29.8	150.2	21.6	32.526	-1.553	6.94	18.5
25.0	217.3	47.2	170.1	27.0	34.413	-2.948	7.30	19.0
30.0	230.6	60.5	170.1	29.1	33.429	-3.509	7.43	19.3
35.0	222.6	75.2	147.4	27.6	29.991	-2.758	7.26	18.8
40.0	136.9	91.0	45.9	13.9	25.867	-1.470	6.16	17.9
45.0	193.8	108.8	85.0	23.3	28.394	-1.001	6.96	17.8
50.0	217.9	132.9	85.0	27.2	28.856	-1.203	7.16	17.9
55.0	243.9	158.9	85.0	32.5	29.395	-1.059	7.37	17.9
60.0	271.8	186.7	85.0	39.1	29.888	-0.980	7.55	18.0
63.5	447.6	210.0	237.5	408.6	33.793	-1.415	8.72	20.7

Total Continuous Driving Time 47.00 minutes; Total Number of Blows 2010

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

♀

Input File: J:\GEOTECH\PROJECTS\2013\W-13-045 FRA-70-13.54 PROJECT 4A\ANALYSIS\FRA-70-1321A AND R\DRIVEABILITY\B-015-7-13\B-015-7-13.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2003.GW
Hammer File Version: 2003 (2/22/2013)

Input File Contents
FRA-70-1321R - RA - B-015-7-13 - HP10x42

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
-100	0	41	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.170	32.170	97.720	10.070	H Pile

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
1.900	227.000	530.0	2.000	0.800	0.010	0.0

A Cu	E Cu	T Cu	CoR	ROut	StCu
0.000	0.0	0.000	0.000	0.000	0.0

LPle	APle	EPle	WPle	Peri	CI	CoR	ROut
65.000	12.40	30000.0	492.000	3.295	0	0.850	0.010

Manufac	Hmr Name	HmrType	No Seg-s
DELMAG	D 19-42	1	5

Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy
4.00	129.10	12.60	11.86	10.81	0.80

IB. Wt	IB. L	IB.Dia	IB CoR	IB RO
0.75	25.30	12.60	0.900	0.010

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
16.65	124.70	157.70	0.002	0.002	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1520.00	1368.00	1231.00	1108.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
10.8100	0.8000	1520.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.100	0.100	0.069	0.150	0.000	0.000	0.000	0.000

Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000	0.000	0.000	0.000

Research Soil Model: RD-skn: m, d, toe: m, d

0.000	0.000	0.000	0.000

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimD	SU T
0.00	0.00	9.95	0.10	0.17	0.20	0.15	1.50	6.56	168.0
5.50	0.28	9.95	0.10	0.17	0.20	0.15	1.50	6.56	168.0
5.50	0.25	39.68	0.10	0.17	0.05	0.15	1.20	6.56	1.0
10.50	0.49	39.68	0.10	0.17	0.05	0.15	1.20	6.56	1.0
10.50	0.50	150.23	0.10	0.10	0.05	0.15	1.00	6.56	1.0
24.50	1.20	150.23	0.10	0.10	0.05	0.15	1.00	6.56	1.0
24.50	0.75	170.08	0.10	0.10	0.05	0.15	1.00	6.56	1.0
34.50	0.93	170.08	0.10	0.10	0.05	0.15	1.00	6.56	1.0
34.50	0.90	147.40	0.10	0.10	0.05	0.15	1.00	6.56	1.0
39.50	0.99	147.40	0.10	0.10	0.05	0.15	1.00	6.56	1.0
39.50	1.57	45.92	0.10	0.10	0.20	0.15	1.50	6.56	168.0
44.50	1.57	45.92	0.10	0.10	0.20	0.15	1.50	6.56	168.0
44.50	1.39	85.04	0.10	0.10	0.05	0.15	1.00	6.56	1.0
63.40	1.83	85.04	0.10	0.10	0.05	0.15	1.00	6.56	1.0
63.40	10.00	237.51	0.10	0.10	0.05	0.15	0.00	6.56	0.0
65.00	10.00	237.51	0.10	0.10	0.05	0.15	0.00	6.56	0.0

Gain/Loss factors: shaft and toe

0.66700	0.00000	0.00000	0.00000	0.00000
1.00000	0.00000	0.00000	0.00000	0.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR

5.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
15.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
25.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
30.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
35.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
40.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
45.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
50.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
55.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
60.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
63.50	0.00	0.00	0.000	0.000	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000

1 0 10.81000 11.86000

♀ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

FRA-70-1321R - RA - B-015-7-13 - HP10x42

Hammer Model: D 19-42 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.800				
2	0.800	140046.7	1.000	0.0100	
3	0.800	140046.7	1.000	0.0100	
4	0.800	140046.7	1.000	0.0100	
5	0.800	140046.7	1.000	0.0100	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	5.8
Combined Pile Top		9538.5			

HAMMER OPTIONS:

Hammer File ID No.	41	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	4.00	Ram Length (inch)		129.10
Maximum Stroke	(ft)	11.86			
Rated Stroke	(ft)	10.81	Efficiency		0.800
Maximum Pressure	(psi)	1520.00	Actual Pressure	(psi)	1520.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	12.60			
Combustion Delay	(s)	0.00200	Ignition Duration	(s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

♀

FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth	(ft)	5.0			
Shaft Gain/Loss Factor		0.667	Toe Gain/Loss Factor		1.000

PILE PROFILE:

Toe Area	(in2)	97.720	Pile Type		H Pile
Pile Size	(inch)	10.070			

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	30000.	492.0	3.3	0	16807.	22.1
65.0	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model Total Capacity Rut (kips) 11.3

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9538	0.010	0.000	0.85	0.0	0.000	0.100	3.25	3.3	12.4
2	0.138	9538	0.000	0.000	1.00	0.0	0.000	0.100	6.50	3.3	12.4
19	0.138	9538	0.000	0.000	1.00	0.2	0.200	0.100	61.75	3.3	12.4
20	0.138	9538	0.000	0.000	1.00	1.2	0.200	0.100	65.00	3.3	12.4
Toe						9.9	0.150	0.167			

2.754 kips total unreduced pile weight (g= 32.17 ft/s2)
2.754 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	0.443
Driveability Analysis			
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Normal			
Gravity Mass, Pile, Hammer:	32.170	32.170 32.170	

Output Segment Generation: Automatic

Depth ft	Stroke ft	Pressure Ratio	Efficy
5.00	10.81	1.00	0.800

♀

FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
11.3	Hammer did not run								
	1	0	10.81000	11.86000					

♀

FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth (ft) 10.0
Shaft Gain/Loss Factor 0.667 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	30000.	492.0	3.3	0	16807.	22.1
65.0	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model Total Capacity Rut (kips) 45.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9538	0.010	0.000	0.85	0.0	0.000	0.100	3.25	3.3	12.4
2	0.138	9538	0.000	0.000	1.00	0.0	0.000	0.100	6.50	3.3	12.4
17	0.138	9538	0.000	0.000	1.00	0.0	0.200	0.100	55.25	3.3	12.4
18	0.138	9538	0.000	0.000	1.00	0.7	0.200	0.100	58.50	3.3	12.4
19	0.138	9538	0.000	0.000	1.00	1.9	0.135	0.100	61.75	3.3	12.4
20	0.138	9538	0.000	0.000	1.00	3.5	0.050	0.100	65.00	3.3	12.4
Toe						39.7	0.150	0.167			

2.754 kips total unreduced pile weight (g= 32.17 ft/s2)
2.754 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
10.00	10.81	1.00	0.800

♀

FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
45.8	4.4	4.74	4.72	0.00	1	0 18.93	15	5 21.0	54.3
	1	0	10.81000	11.86000					

♀

FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth (ft) 15.0
Shaft Gain/Loss Factor 0.667 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	30000.	492.0	3.3	0	16807.	22.1
65.0	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model Total Capacity Rut (kips) 166.1

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9538	0.010	0.000	0.85	0.0	0.000	0.100	3.25	3.3	12.4
2	0.138	9538	0.000	0.000	1.00	0.0	0.000	0.100	6.50	3.3	12.4
16	0.138	9538	0.000	0.000	1.00	0.2	0.200	0.100	52.00	3.3	12.4
17	0.138	9538	0.000	0.000	1.00	1.3	0.200	0.100	55.25	3.3	12.4
18	0.138	9538	0.000	0.000	1.00	2.8	0.060	0.100	58.50	3.3	12.4
19	0.138	9538	0.000	0.000	1.00	4.6	0.050	0.100	61.75	3.3	12.4
20	0.138	9538	0.000	0.000	1.00	6.9	0.050	0.100	65.00	3.3	12.4
Toe						150.2	0.150	0.100			

2.754 kips total unreduced pile weight (g= 32.17 ft/s2)
2.754 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
15.00	10.81	1.00	0.800

♀

FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
166.1	20.0	6.83	6.79	-1.03	13	29 32.79	20	6 18.4	45.1
	1	0	10.81000	11.86000					

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Depth (ft) 20.0
Shaft Gain/Loss Factor 0.667 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	12.40	30000.	492.0	3.3	0	16807.	22.1
	65.0	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model Total Capacity Rut (kips) 180.1

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9538	0.010	0.000	0.85	0.0	0.000	0.100	3.25	3.3	12.4
2	0.138	9538	0.000	0.000	1.00	0.0	0.000	0.100	6.50	3.3	12.4
14	0.138	9538	0.000	0.000	1.00	0.0	0.200	0.100	45.50	3.3	12.4
15	0.138	9538	0.000	0.000	1.00	0.8	0.200	0.100	48.75	3.3	12.4
16	0.138	9538	0.000	0.000	1.00	2.1	0.123	0.100	52.00	3.3	12.4
17	0.138	9538	0.000	0.000	1.00	3.6	0.050	0.100	55.25	3.3	12.4
18	0.138	9538	0.000	0.000	1.00	6.0	0.050	0.100	58.50	3.3	12.4
19	0.138	9538	0.000	0.000	1.00	7.8	0.050	0.100	61.75	3.3	12.4
20	0.138	9538	0.000	0.000	1.00	9.6	0.050	0.100	65.00	3.3	12.4
Toe						150.2	0.150	0.100			

2.754 kips total unreduced pile weight (g= 32.17 ft/s2)
2.754 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
20.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
180.1	21.6	6.94	6.91	-1.55	13 28	32.53	20 6	18.5	44.7
	1	0	10.81000		11.86000				

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FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth (ft) 25.0
Shaft Gain/Loss Factor 0.667 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	12.40	30000.	492.0	3.3	0	16807.	22.1
	65.0	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model Total Capacity Rut (kips) 217.3

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9538	0.010	0.000	0.85	0.0	0.000	0.100	3.25	3.3	12.4
2	0.138	9538	0.000	0.000	1.00	0.0	0.000	0.100	6.50	3.3	12.4
13	0.138	9538	0.000	0.000	1.00	0.3	0.200	0.100	42.25	3.3	12.4
14	0.138	9538	0.000	0.000	1.00	1.4	0.200	0.100	45.50	3.3	12.4
15	0.138	9538	0.000	0.000	1.00	2.9	0.050	0.100	48.75	3.3	12.4
16	0.138	9538	0.000	0.000	1.00	4.8	0.050	0.100	52.00	3.3	12.4
17	0.138	9538	0.000	0.000	1.00	7.0	0.050	0.100	55.25	3.3	12.4
18	0.138	9538	0.000	0.000	1.00	8.8	0.050	0.100	58.50	3.3	12.4
19	0.138	9538	0.000	0.000	1.00	10.5	0.050	0.100	61.75	3.3	12.4
20	0.138	9538	0.000	0.000	1.00	11.5	0.050	0.100	65.00	3.3	12.4
Toe						170.1	0.150	0.100			

2.754 kips total unreduced pile weight (g= 32.17 ft/s2)
2.754 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
25.00	10.81	1.00	0.800

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Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
217.3	27.0	7.30	7.29	-2.95	13 25	34.41	20 6	19.0	43.6
	1	0	10.81000		11.86000				

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FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth (ft) 30.0
Shaft Gain/Loss Factor 0.667 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile

Pile Size (inch) 10.070

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	30000.	492.0	3.3	0	16807.	22.1
65.0	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model — Total Capacity Rut (kips) 230.6

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9538	0.010	0.000	0.85	0.0	0.000	0.100	3.25	3.3	12.4
2	0.138	9538	0.000	0.000	1.00	0.0	0.000	0.100	6.50	3.3	12.4
11	0.138	9538	0.000	0.000	1.00	0.0	0.200	0.100	35.75	3.3	12.4
12	0.138	9538	0.000	0.000	1.00	0.8	0.200	0.100	39.00	3.3	12.4
13	0.138	9538	0.000	0.000	1.00	2.2	0.112	0.100	42.25	3.3	12.4
14	0.138	9538	0.000	0.000	1.00	3.7	0.050	0.100	45.50	3.3	12.4
15	0.138	9538	0.000	0.000	1.00	6.2	0.050	0.100	48.75	3.3	12.4
16	0.138	9538	0.000	0.000	1.00	8.0	0.050	0.100	52.00	3.3	12.4
17	0.138	9538	0.000	0.000	1.00	9.7	0.050	0.100	55.25	3.3	12.4
18	0.138	9538	0.000	0.000	1.00	11.5	0.050	0.100	58.50	3.3	12.4
19	0.138	9538	0.000	0.000	1.00	9.6	0.050	0.100	61.75	3.3	12.4
20	0.138	9538	0.000	0.000	1.00	8.8	0.050	0.100	65.00	3.3	12.4
Toe						170.1	0.150	0.100			

2.754 kips total unreduced pile weight (g= 32.17 ft/s2)
2.754 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
30.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
230.6	29.1	7.43	7.40	-3.51	13	25	33.43	20	6	19.3	43.2
	1		0	10.81000			11.86000				

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FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth (ft) 35.0
Shaft Gain/Loss Factor 0.667 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	30000.	492.0	3.3	0	16807.	22.1
65.0	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model — Total Capacity Rut (kips) 222.6

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9538	0.010	0.000	0.85	0.0	0.000	0.100	3.25	3.3	12.4
2	0.138	9538	0.000	0.000	1.00	0.0	0.000	0.100	6.50	3.3	12.4
10	0.138	9538	0.000	0.000	1.00	0.3	0.200	0.100	32.50	3.3	12.4
11	0.138	9538	0.000	0.000	1.00	1.5	0.186	0.100	35.75	3.3	12.4
12	0.138	9538	0.000	0.000	1.00	3.0	0.050	0.100	39.00	3.3	12.4
13	0.138	9538	0.000	0.000	1.00	5.0	0.050	0.100	42.25	3.3	12.4
14	0.138	9538	0.000	0.000	1.00	7.2	0.050	0.100	45.50	3.3	12.4
15	0.138	9538	0.000	0.000	1.00	8.9	0.050	0.100	48.75	3.3	12.4
16	0.138	9538	0.000	0.000	1.00	10.6	0.050	0.100	52.00	3.3	12.4
17	0.138	9538	0.000	0.000	1.00	11.2	0.050	0.100	55.25	3.3	12.4
18	0.138	9538	0.000	0.000	1.00	8.5	0.050	0.100	58.50	3.3	12.4
19	0.138	9538	0.000	0.000	1.00	9.1	0.050	0.100	61.75	3.3	12.4
20	0.138	9538	0.000	0.000	1.00	9.7	0.050	0.100	65.00	3.3	12.4
Toe						147.4	0.150	0.100			

2.754 kips total unreduced pile weight (g= 32.17 ft/s2)
2.754 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
35.00	10.81	1.00	0.800

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FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
222.6	27.6	7.26	7.25	-2.76	12	26	29.99	20	6	18.8	43.7
	1		0	10.81000			11.86000				

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FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth (ft) 40.0
Shaft Gain/Loss Factor 0.667 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	30000.	492.0	3.3	0	16807.	22.1
65.0	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model — Total Capacity Rut (kips) 136.9

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9538	0.010	0.000	0.85	0.0	0.000	0.100	3.25	3.3	12.4
2	0.138	9538	0.000	0.000	1.00	0.0	0.000	0.100	6.50	3.3	12.4
8	0.138	9538	0.000	0.000	1.00	0.1	0.200	0.100	26.00	3.3	12.4
9	0.138	9538	0.000	0.000	1.00	0.9	0.200	0.100	29.25	3.3	12.4
10	0.138	9538	0.000	0.000	1.00	2.3	0.101	0.100	32.50	3.3	12.4
11	0.138	9538	0.000	0.000	1.00	3.9	0.050	0.100	35.75	3.3	12.4
12	0.138	9538	0.000	0.000	1.00	6.4	0.050	0.100	39.00	3.3	12.4
13	0.138	9538	0.000	0.000	1.00	8.1	0.050	0.100	42.25	3.3	12.4
14	0.138	9538	0.000	0.000	1.00	9.8	0.050	0.100	45.50	3.3	12.4
15	0.138	9538	0.000	0.000	1.00	11.6	0.050	0.100	48.75	3.3	12.4
16	0.138	9538	0.000	0.000	1.00	9.3	0.050	0.100	52.00	3.3	12.4
17	0.138	9538	0.000	0.000	1.00	8.8	0.050	0.100	55.25	3.3	12.4
18	0.138	9538	0.000	0.000	1.00	9.5	0.050	0.100	58.50	3.3	12.4
19	0.138	9538	0.000	0.000	1.00	9.9	0.050	0.100	61.75	3.3	12.4
20	0.138	9538	0.000	0.000	1.00	10.5	0.084	0.100	65.00	3.3	12.4
Toe						45.9	0.150	0.100			

2.754 kips total unreduced pile weight (g= 32.17 ft/s2)
2.754 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
40.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
136.9	13.9	6.16	6.19	-1.47	10	34 25.87	10	4 17.9	47.4
	1	0	10.81000		11.86000				

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Depth (ft) 45.0
Shaft Gain/Loss Factor 0.667 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	30000.	492.0	3.3	0	16807.	22.1
65.0	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model — Total Capacity Rut (kips) 193.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9538	0.010	0.000	0.85	0.0	0.000	0.100	3.25	3.3	12.4
2	0.138	9538	0.000	0.000	1.00	0.0	0.000	0.100	6.50	3.3	12.4
7	0.138	9538	0.000	0.000	1.00	0.4	0.200	0.100	22.75	3.3	12.4
8	0.138	9538	0.000	0.000	1.00	1.6	0.172	0.100	26.00	3.3	12.4
9	0.138	9538	0.000	0.000	1.00	3.1	0.050	0.100	29.25	3.3	12.4
10	0.138	9538	0.000	0.000	1.00	5.2	0.050	0.100	32.50	3.3	12.4
11	0.138	9538	0.000	0.000	1.00	7.3	0.050	0.100	35.75	3.3	12.4
12	0.138	9538	0.000	0.000	1.00	9.0	0.050	0.100	39.00	3.3	12.4
13	0.138	9538	0.000	0.000	1.00	10.8	0.050	0.100	42.25	3.3	12.4
14	0.138	9538	0.000	0.000	1.00	11.0	0.050	0.100	45.50	3.3	12.4
15	0.138	9538	0.000	0.000	1.00	8.5	0.050	0.100	48.75	3.3	12.4
16	0.138	9538	0.000	0.000	1.00	9.2	0.050	0.100	52.00	3.3	12.4
17	0.138	9538	0.000	0.000	1.00	9.7	0.050	0.100	55.25	3.3	12.4
18	0.138	9538	0.000	0.000	1.00	10.1	0.050	0.100	58.50	3.3	12.4
19	0.138	9538	0.000	0.000	1.00	11.0	0.167	0.100	61.75	3.3	12.4
20	0.138	9538	0.000	0.000	1.00	11.8	0.179	0.100	65.00	3.3	12.4
Toe						85.0	0.150	0.100			

2.754 kips total unreduced pile weight (g= 32.17 ft/s2)
2.754 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
45.00	10.81	1.00	0.800

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Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
193.8	23.3	6.96	6.94	-1.00	8	27 28.39	8	3 17.8	44.6
	1	0	10.81000		11.86000				

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FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth (ft) 50.0
Shaft Gain/Loss Factor 0.667 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	12.40	30000.	492.0	3.3	0	16807.	22.1
	65.0	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model — Total Capacity Rut (kips) 217.9

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9538	0.010	0.000	0.85	0.0	0.000	0.100	3.25	3.3	12.4
2	0.138	9538	0.000	0.000	1.00	0.0	0.000	0.100	6.50	3.3	12.4
5	0.138	9538	0.000	0.000	1.00	0.1	0.200	0.100	16.25	3.3	12.4
6	0.138	9538	0.000	0.000	1.00	1.0	0.200	0.100	19.50	3.3	12.4
7	0.138	9538	0.000	0.000	1.00	2.4	0.090	0.100	22.75	3.3	12.4
8	0.138	9538	0.000	0.000	1.00	4.1	0.050	0.100	26.00	3.3	12.4
9	0.138	9538	0.000	0.000	1.00	6.5	0.050	0.100	29.25	3.3	12.4
10	0.138	9538	0.000	0.000	1.00	8.2	0.050	0.100	32.50	3.3	12.4
11	0.138	9538	0.000	0.000	1.00	10.0	0.050	0.100	35.75	3.3	12.4
12	0.138	9538	0.000	0.000	1.00	11.7	0.050	0.100	39.00	3.3	12.4
13	0.138	9538	0.000	0.000	1.00	9.0	0.050	0.100	42.25	3.3	12.4
14	0.138	9538	0.000	0.000	1.00	8.9	0.050	0.100	45.50	3.3	12.4
15	0.138	9538	0.000	0.000	1.00	9.5	0.050	0.100	48.75	3.3	12.4
16	0.138	9538	0.000	0.000	1.00	9.9	0.050	0.100	52.00	3.3	12.4
17	0.138	9538	0.000	0.000	1.00	10.6	0.099	0.100	55.25	3.3	12.4
18	0.138	9538	0.000	0.000	1.00	11.2	0.200	0.100	58.50	3.3	12.4
19	0.138	9538	0.000	0.000	1.00	14.0	0.099	0.100	61.75	3.3	12.4
20	0.138	9538	0.000	0.000	1.00	15.9	0.050	0.100	65.00	3.3	12.4
Toe						85.0	0.150	0.100			

2.754 kips total unreduced pile weight (g= 32.17 ft/s2)
2.754 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
50.00	10.81	1.00	0.800

♀
FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
217.9	27.2	7.16	7.14	-1.20	8	50 28.86	7	3 17.9	44.1
	1	0	10.81000		11.86000				

♀
FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth (ft) 55.0
Shaft Gain/Loss Factor 0.667 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	12.40	30000.	492.0	3.3	0	16807.	22.1
	65.0	12.40	30000.	492.0	3.3	0	16807.	22.1

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model — Total Capacity Rut (kips) 243.9

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9538	0.010	0.000	0.85	0.0	0.000	0.100	3.25	3.3	12.4
2	0.138	9538	0.000	0.000	1.00	0.0	0.000	0.100	6.50	3.3	12.4
4	0.138	9538	0.000	0.000	1.00	0.5	0.200	0.100	13.00	3.3	12.4
5	0.138	9538	0.000	0.000	1.00	1.7	0.159	0.100	16.25	3.3	12.4
6	0.138	9538	0.000	0.000	1.00	3.3	0.050	0.100	19.50	3.3	12.4
7	0.138	9538	0.000	0.000	1.00	5.4	0.050	0.100	22.75	3.3	12.4
8	0.138	9538	0.000	0.000	1.00	7.4	0.050	0.100	26.00	3.3	12.4
9	0.138	9538	0.000	0.000	1.00	9.2	0.050	0.100	29.25	3.3	12.4
10	0.138	9538	0.000	0.000	1.00	10.9	0.050	0.100	32.50	3.3	12.4
11	0.138	9538	0.000	0.000	1.00	10.7	0.050	0.100	35.75	3.3	12.4
12	0.138	9538	0.000	0.000	1.00	8.6	0.050	0.100	39.00	3.3	12.4
13	0.138	9538	0.000	0.000	1.00	9.2	0.050	0.100	42.25	3.3	12.4
14	0.138	9538	0.000	0.000	1.00	9.8	0.050	0.100	45.50	3.3	12.4
15	0.138	9538	0.000	0.000	1.00	10.2	0.050	0.100	48.75	3.3	12.4
16	0.138	9538	0.000	0.000	1.00	11.0	0.176	0.100	52.00	3.3	12.4
17	0.138	9538	0.000	0.000	1.00	12.1	0.168	0.100	55.25	3.3	12.4
18	0.138	9538	0.000	0.000	1.00	15.5	0.050	0.100	58.50	3.3	12.4
19	0.138	9538	0.000	0.000	1.00	16.3	0.050	0.100	61.75	3.3	12.4
20	0.138	9538	0.000	0.000	1.00	17.1	0.050	0.100	65.00	3.3	12.4
Toe						85.0	0.150	0.100			

2.754 kips total unreduced pile weight (g= 32.17 ft/s2)
2.754 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
55.00	10.81	1.00	0.800

♀
FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Rut Bl Ct Stroke (ft) Ten Str i t Comp Str i t ENTHRU Bl Rt

kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
243.9	32.5	7.37	7.35	-1.06	6 23	29.40	5	3	17.9	43.4
1		0	10.81000		11.86000					

♀

FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth (ft) 60.0
Shaft Gain/Loss Factor 0.667 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L ft	b Top in2	Area ksi	E-Mod lb/ft3	Spec Wt ft	Perim	C Index ft/s	Wave Sp k/ft/s	EA/c
0.0	12.40	30000.	492.0	3.3	0	16807.	22.1	
65.0	12.40	30000.	492.0	3.3	0	16807.	22.1	

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model Total Capacity Rut (kips) 271.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9538	0.010	0.000	0.85	0.0	0.000	0.100	3.25	3.3	12.4
2	0.138	9538	0.000	0.000	1.00	0.1	0.200	0.100	6.50	3.3	12.4
3	0.138	9538	0.000	0.000	1.00	1.1	0.200	0.100	9.75	3.3	12.4
4	0.138	9538	0.000	0.000	1.00	2.5	0.080	0.100	13.00	3.3	12.4
5	0.138	9538	0.000	0.000	1.00	4.2	0.050	0.100	16.25	3.3	12.4
6	0.138	9538	0.000	0.000	1.00	6.6	0.050	0.100	19.50	3.3	12.4
7	0.138	9538	0.000	0.000	1.00	8.4	0.050	0.100	22.75	3.3	12.4
8	0.138	9538	0.000	0.000	1.00	10.1	0.050	0.100	26.00	3.3	12.4
9	0.138	9538	0.000	0.000	1.00	11.9	0.050	0.100	29.25	3.3	12.4
10	0.138	9538	0.000	0.000	1.00	8.7	0.050	0.100	32.50	3.3	12.4
11	0.138	9538	0.000	0.000	1.00	8.9	0.050	0.100	35.75	3.3	12.4
12	0.138	9538	0.000	0.000	1.00	9.5	0.050	0.100	39.00	3.3	12.4
13	0.138	9538	0.000	0.000	1.00	9.9	0.050	0.100	42.25	3.3	12.4
14	0.138	9538	0.000	0.000	1.00	10.6	0.113	0.100	45.50	3.3	12.4
15	0.138	9538	0.000	0.000	1.00	11.2	0.200	0.100	48.75	3.3	12.4
16	0.138	9538	0.000	0.000	1.00	14.3	0.087	0.100	52.00	3.3	12.4
17	0.138	9538	0.000	0.000	1.00	15.9	0.050	0.100	55.25	3.3	12.4
18	0.138	9538	0.000	0.000	1.00	16.7	0.050	0.100	58.50	3.3	12.4
19	0.138	9538	0.000	0.000	1.00	17.5	0.050	0.100	61.75	3.3	12.4
20	0.138	9538	0.000	0.000	1.00	18.3	0.050	0.100	65.00	3.3	12.4
Toe						85.0	0.150	0.100			

2.754 kips total unreduced pile weight (g= 32.17 ft/s2)
2.754 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
60.00	10.81	1.00	0.800

♀

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Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
271.8	39.1	7.55	7.54	-0.98	5 22	29.89	3	2 18.0	42.9
1		0	10.81000		11.86000				

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FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth (ft) 63.5
Shaft Gain/Loss Factor 0.667 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 97.720 Pile Type H Pile
Pile Size (inch) 10.070

L ft	b Top in2	Area ksi	E-Mod lb/ft3	Spec Wt ft	Perim	C Index ft/s	Wave Sp k/ft/s	EA/c
0.0	12.40	30000.	492.0	3.3	0	16807.	22.1	
65.0	12.40	30000.	492.0	3.3	0	16807.	22.1	

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model Total Capacity Rut (kips) 447.6

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9538	0.010	0.000	0.85	0.2	0.200	0.100	3.25	3.3	12.4
2	0.138	9538	0.000	0.000	1.00	1.2	0.200	0.100	6.50	3.3	12.4
3	0.138	9538	0.000	0.000	1.00	2.7	0.070	0.100	9.75	3.3	12.4
4	0.138	9538	0.000	0.000	1.00	4.4	0.050	0.100	13.00	3.3	12.4
5	0.138	9538	0.000	0.000	1.00	6.8	0.050	0.100	16.25	3.3	12.4
6	0.138	9538	0.000	0.000	1.00	8.5	0.050	0.100	19.50	3.3	12.4
7	0.138	9538	0.000	0.000	1.00	10.2	0.050	0.100	22.75	3.3	12.4
8	0.138	9538	0.000	0.000	1.00	12.0	0.050	0.100	26.00	3.3	12.4
9	0.138	9538	0.000	0.000	1.00	8.3	0.050	0.100	29.25	3.3	12.4
10	0.138	9538	0.000	0.000	1.00	9.0	0.050	0.100	32.50	3.3	12.4
11	0.138	9538	0.000	0.000	1.00	9.6	0.050	0.100	35.75	3.3	12.4
12	0.138	9538	0.000	0.000	1.00	10.0	0.050	0.100	39.00	3.3	12.4
13	0.138	9538	0.000	0.000	1.00	10.7	0.125	0.100	42.25	3.3	12.4
14	0.138	9538	0.000	0.000	1.00	11.2	0.200	0.100	45.50	3.3	12.4
15	0.138	9538	0.000	0.000	1.00	14.6	0.075	0.100	48.75	3.3	12.4
16	0.138	9538	0.000	0.000	1.00	16.0	0.050	0.100	52.00	3.3	12.4
17	0.138	9538	0.000	0.000	1.00	16.8	0.050	0.100	55.25	3.3	12.4
18	0.138	9538	0.000	0.000	1.00	17.6	0.050	0.100	58.50	3.3	12.4
19	0.138	9538	0.000	0.000	1.00	18.4	0.050	0.100	61.75	3.3	12.4
20	0.138	9538	0.000	0.000	1.00	21.9	0.050	0.100	65.00	3.3	12.4
Toe						237.5	0.150	0.100			

2.754 kips total unreduced pile weight (g= 32.17 ft/s2)
2.754 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
63.50	10.81	1.00	0.800

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
447.6	408.6	8.72	8.70	-1.41	5	20	33.79	1	10	20.7	40.0

FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.667 1.000

Depth ft	Rut kips	Frictn kips	End Bg kips	Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft
5.0	11.3	1.4	9.9	Hammer did not run				
10.0	45.8	6.1	39.7	4.4	18.931	0.000	4.74	21.0
15.0	166.1	15.8	150.2	20.0	32.788	-1.034	6.83	18.4
20.0	180.1	29.8	150.2	21.6	32.526	-1.553	6.94	18.5
25.0	217.3	47.2	170.1	27.0	34.413	-2.948	7.30	19.0
30.0	230.6	60.5	170.1	29.1	33.429	-3.509	7.43	19.3
35.0	222.6	75.2	147.4	27.6	29.991	-2.758	7.26	18.8
40.0	136.9	91.0	45.9	13.9	25.867	-1.470	6.16	17.9
45.0	193.8	108.8	85.0	23.3	28.394	-1.001	6.96	17.8
50.0	217.9	132.9	85.0	27.2	28.856	-1.203	7.16	17.9
55.0	243.9	158.9	85.0	32.5	29.395	-1.059	7.37	17.9
60.0	271.8	186.7	85.0	39.1	29.888	-0.980	7.55	18.0
63.5	447.6	210.0	237.5	408.6	33.793	-1.415	8.72	20.7

Total Driving Time 47 minutes; Total No. of Blows 2010

FRA-70-1321R - RA - B-015-7-13 - HP10x42 04/02/2015
Resource International Inc GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth ft	Temp. Length ft	Wait Time hr	Equivalent Stroke ft	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
5.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
10.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
15.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
20.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
25.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
30.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
35.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
40.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
45.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
50.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
55.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
60.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
63.50	65.00	0.00	10.81	1.00	0.80	1.00	1.00

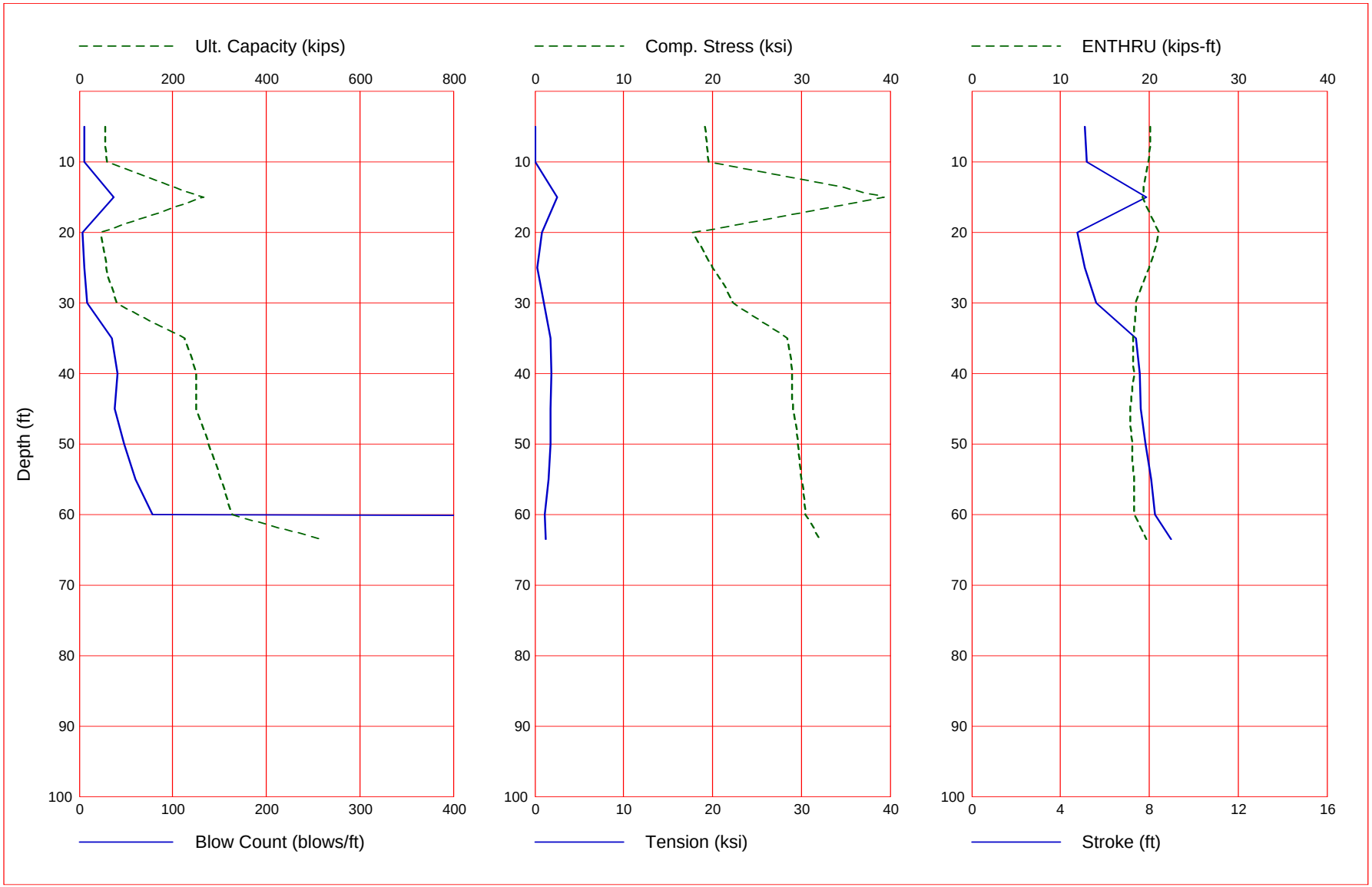
Soil Layer Resistance Values

Depth ft	Shaft Res. k/ft2	End Bearing kips	Shaft Quake inch	Toe Quake inch	Shaft Damping s/ft	Toe Damping s/ft	Soil Setup Normlzd	Limit Distance ft	Setup Time hrs
0.00	0.00	9.95	0.100	0.167	0.200	0.150	1.000	6.560	168.000
5.50	0.28	9.95	0.100	0.167	0.200	0.150	1.000	6.560	168.000
5.50	0.25	39.68	0.100	0.167	0.050	0.150	0.500	6.560	1.000
10.50	0.49	39.68	0.100	0.167	0.050	0.150	0.500	6.560	1.000
10.50	0.50	150.23	0.100	0.100	0.050	0.150	0.000	6.560	1.000
24.50	1.20	150.23	0.100	0.100	0.050	0.150	0.000	6.560	1.000
24.50	0.75	170.08	0.100	0.100	0.050	0.150	0.000	6.560	1.000
34.50	0.93	170.08	0.100	0.100	0.050	0.150	0.000	6.560	1.000
34.50	0.90	147.40	0.100	0.100	0.050	0.150	0.000	6.560	1.000
39.50	0.99	147.40	0.100	0.100	0.050	0.150	0.000	6.560	1.000
39.50	1.57	45.92	0.100	0.100	0.200	0.150	1.000	6.560	168.000
44.50	1.57	45.92	0.100	0.100	0.200	0.150	1.000	6.560	168.000
44.50	1.39	85.04	0.100	0.100	0.050	0.150	0.000	6.560	1.000
63.40	1.83	85.04	0.100	0.100	0.050	0.150	0.000	6.560	1.000
63.40	10.00	237.51	0.100	0.100	0.050	0.150	0.000	6.560	1.000
65.00	10.00	237.51	0.100	0.100	0.050	0.150	0.000	6.560	1.000

Resource International Inc
FRA-70-1321A/R-FA - B-016-5-13 - HP12x53

Apr 02 2015
GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 0.500 / 1.000



Gain/Loss 1 at Shaft and Toe 0.500 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	55.1	1.6	53.5	5.5	19.159	0.000	5.09	20.1
10.0	59.8	6.3	53.5	5.9	19.566	0.000	5.17	19.9
15.0	265.5	18.6	246.9	37.3	39.300	-2.495	7.86	19.2
20.0	45.7	29.1	16.7	3.8	17.796	-0.817	4.75	21.1
25.0	56.9	40.2	16.7	5.4	19.953	-0.261	5.11	20.0
30.0	79.8	57.5	22.2	8.8	22.375	-1.066	5.63	18.5
35.0	226.5	78.3	148.2	34.9	28.418	-1.717	7.40	18.2
40.0	249.2	101.1	148.2	40.7	28.973	-1.886	7.58	18.3
45.0	250.0	126.6	123.5	38.1	29.033	-1.726	7.63	17.9
50.0	275.9	152.5	123.5	47.7	29.608	-1.773	7.84	18.1
55.0	301.8	178.4	123.5	59.9	30.052	-1.578	8.08	18.3
60.0	327.7	204.3	123.5	78.8	30.487	-1.151	8.27	18.3
63.5	519.1	223.5	295.6	9999.0	32.101	-1.229	8.97	19.7

Refusal occurred; no driving time output possible

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

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Input File: J:\GEOTECH\PROJECTS\2013\W-13-045 FRA-70-13.54 PROJECT 4A\ANALYSIS\FRA-70-1321A AND R\DRIVEABILITY\B-016-5-13\B-016-5-13.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2003.GW
Hammer File Version: 2003 (2/22/2013)

Input File Contents
FRA-70-1321A/R-FA - B-016-5-13 - HP12x53

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
-100	0	41	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.170	32.170	141.890	12.040	H Pile

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
1.900	227.000	530.0	2.000	0.800	0.010	0.0

A Cu	E Cu	T Cu	CoR	ROut	StCu
0.000	0.0	0.000	0.000	0.000	0.0

LPle	APle	EPle	WPle	Peri	CI	CoR	ROut
65.000	15.50	30000.0	492.000	3.970	0	0.850	0.010

Manufac	Hmr Name	HmrType	No Seg-s
DELMAG	D 19-42	1	5

Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy
4.00	129.10	12.60	11.86	10.81	0.80

IB. Wt	IB. L	IB.Dia	IB CoR	IB RO
0.75	25.30	12.60	0.900	0.010

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
16.65	124.70	157.70	0.002	0.002	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1520.00	1368.00	1231.00	1108.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
10.8100	0.8000	1520.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.100	0.100	0.162	0.150	0.000	0.000	0.000	0.000

Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000	0.000	0.000	0.000

Research Soil Model: RD-skn: m, d, toe: m, d

0.000	0.000	0.000	0.000

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimD	SU T
0.00	0.00	53.51	0.10	0.20	0.05	0.15	1.20	6.56	1.0
11.00	0.42	53.51	0.10	0.20	0.05	0.15	1.20	6.56	1.0
11.00	0.69	246.95	0.10	0.10	0.05	0.15	1.20	6.56	1.0
16.00	1.03	246.95	0.10	0.10	0.05	0.15	1.20	6.56	1.0
16.00	0.81	16.67	0.10	0.20	0.20	0.15	2.00	6.56	168.0
26.00	1.29	16.67	0.10	0.20	0.20	0.15	2.00	6.56	168.0
26.00	1.34	22.23	0.10	0.20	0.20	0.15	1.50	6.56	168.0
31.00	1.50	22.23	0.10	0.20	0.20	0.15	1.50	6.56	168.0
31.00	1.02	148.17	0.10	0.20	0.05	0.15	1.00	6.56	1.0
41.00	1.21	148.17	0.10	0.20	0.05	0.15	1.00	6.56	1.0
41.00	1.57	123.48	0.10	0.10	0.20	0.15	1.20	6.56	84.0
63.40	1.57	123.48	0.10	0.10	0.20	0.15	1.20	6.56	84.0
63.40	5.00	295.60	0.10	0.10	0.20	0.15	0.00	6.56	0.0
65.00	5.00	295.60	0.10	0.10	0.20	0.15	0.00	6.56	0.0

Gain/Loss factors: shaft and toe

0.50000	0.00000	0.00000	0.00000	0.00000
1.00000	0.00000	0.00000	0.00000	0.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
5.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000

15.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
25.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
30.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
35.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
40.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
45.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
50.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
55.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
60.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000
63.50	0.00	0.00	0.000	0.000	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000

1 0 10.81000 11.86000

♀ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

FRA-70-1321A/R-FA - B-016-5-13 - HP12x53

Hammer Model: D 19-42 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.800				
2	0.800	140046.7	1.000	0.0100	
3	0.800	140046.7	1.000	0.0100	
4	0.800	140046.7	1.000	0.0100	
5	0.800	140046.7	1.000	0.0100	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	5.8
Combined Pile Top		11923.1			

HAMMER OPTIONS:

Hammer File ID No.	41	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	4.00	Ram Length	(inch)	129.10
Maximum Stroke	(ft)	11.86			
Rated Stroke	(ft)	10.81	Efficiency		0.800
Maximum Pressure	(psi)	1520.00	Actual Pressure	(psi)	1520.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	12.60			
Combustion Delay	(s)	0.00200	Ignition Duration	(s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

Depth	(ft)	5.0	
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	141.890	Pile Type	H Pile
Pile Size	(inch)	12.040		

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	15.50	30000.	492.0	4.0	0	16807.	27.7
65.0	15.50	30000.	492.0	4.0	0	16807.	27.7

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model Total Capacity Rut (kips) 55.1

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.172	11923	0.010	0.000	0.85	0.0	0.000	0.100	3.25	4.0	15.5
2	0.172	11923	0.000	0.000	1.00	0.0	0.000	0.100	6.50	4.0	15.5
19	0.172	11923	0.000	0.000	1.00	0.2	0.050	0.100	61.75	4.0	15.5
20	0.172	11923	0.000	0.000	1.00	1.4	0.050	0.100	65.00	4.0	15.5
Toe						53.5	0.150	0.200			

3.442 kips total unreduced pile weight (g= 32.17 ft/s2)
3.442 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	0.553
Driveability Analysis			
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Normal			
Gravity Mass, Pile, Hammer:	32.170	32.170 32.170	
Output Segment Generation: Automatic			

Depth ft	Stroke ft	Pressure Ratio	Efficy
5.00	10.81	1.00	0.800

♀

FRA-70-1321A/R-FA - B-016-5-13 - HP12x53 04/02/2015
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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
55.1	5.5	5.09	5.07	0.00	1	0	19.16	16	5	20.1	52.3
1		0	10.81000		11.86000						

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FRA-70-1321A/R-FA - B-016-5-13 - HP12x53 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth (ft) 10.0
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 141.890 Pile Type H Pile
Pile Size (inch) 12.040

L ft	b Top in2	Area ksi	E-Mod lb/ft3	Spec Wt ft	Perim	C Index ft/s	Wave Sp k/ft/s	EA/c
0.0	15.50	30000.	492.0	4.0	0	16807.	27.7	
65.0	15.50	30000.	492.0	4.0	0	16807.	27.7	

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model Total Capacity Rut (kips) 59.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.172	11923	0.010	0.000	0.85	0.0	0.000	0.100	3.25	4.0	15.5
2	0.172	11923	0.000	0.000	1.00	0.0	0.000	0.100	6.50	4.0	15.5
17	0.172	11923	0.000	0.000	1.00	0.0	0.050	0.100	55.25	4.0	15.5
18	0.172	11923	0.000	0.000	1.00	0.8	0.050	0.100	58.50	4.0	15.5
19	0.172	11923	0.000	0.000	1.00	2.1	0.050	0.100	61.75	4.0	15.5
20	0.172	11923	0.000	0.000	1.00	3.4	0.050	0.100	65.00	4.0	15.5
Toe						53.5	0.150	0.200			

3.442 kips total unreduced pile weight (g= 32.17 ft/s2)
3.442 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
10.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
59.8	5.9	5.17	5.14	0.00	1	0	19.57	16	5	19.9	51.9
1		0	10.81000		11.86000						

♀

FRA-70-1321A/R-FA - B-016-5-13 - HP12x53 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth (ft) 15.0
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 141.890 Pile Type H Pile
Pile Size (inch) 12.040

L ft	b Top in2	Area ksi	E-Mod lb/ft3	Spec Wt ft	Perim	C Index ft/s	Wave Sp k/ft/s	EA/c
0.0	15.50	30000.	492.0	4.0	0	16807.	27.7	
65.0	15.50	30000.	492.0	4.0	0	16807.	27.7	

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model Total Capacity Rut (kips) 265.5

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.172	11923	0.010	0.000	0.85	0.0	0.000	0.100	3.25	4.0	15.5
2	0.172	11923	0.000	0.000	1.00	0.0	0.000	0.100	6.50	4.0	15.5
16	0.172	11923	0.000	0.000	1.00	0.3	0.050	0.100	52.00	4.0	15.5
17	0.172	11923	0.000	0.000	1.00	1.5	0.050	0.100	55.25	4.0	15.5
18	0.172	11923	0.000	0.000	1.00	2.8	0.050	0.100	58.50	4.0	15.5
19	0.172	11923	0.000	0.000	1.00	4.9	0.050	0.100	61.75	4.0	15.5
20	0.172	11923	0.000	0.000	1.00	9.1	0.050	0.100	65.00	4.0	15.5
Toe						246.9	0.150	0.100			

3.442 kips total unreduced pile weight (g= 32.17 ft/s2)
3.442 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
15.00	10.81	1.00	0.800

♀

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
265.5	37.3	7.86	7.93	-2.50	13	23	39.30	20	6	19.2	42.0
1		0	10.81000		11.86000						

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FRA-70-1321A/R-FA - B-016-5-13 - HP12x53 04/02/2015
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Depth (ft) 20.0
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 141.890 Pile Type H Pile
Pile Size (inch) 12.040

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	15.50	30000.	492.0	4.0	0	16807.	27.7
65.0	15.50	30000.	492.0	4.0	0	16807.	27.7

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model — Total Capacity Rut (kips) 45.7

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.172	11923	0.010	0.000	0.85	0.0	0.000	0.100	3.25	4.0	15.5
2	0.172	11923	0.000	0.000	1.00	0.0	0.000	0.100	6.50	4.0	15.5
14	0.172	11923	0.000	0.000	1.00	0.0	0.050	0.100	45.50	4.0	15.5
15	0.172	11923	0.000	0.000	1.00	0.9	0.050	0.100	48.75	4.0	15.5
16	0.172	11923	0.000	0.000	1.00	2.2	0.050	0.100	52.00	4.0	15.5
17	0.172	11923	0.000	0.000	1.00	3.5	0.050	0.100	55.25	4.0	15.5
18	0.172	11923	0.000	0.000	1.00	7.4	0.050	0.100	58.50	4.0	15.5
19	0.172	11923	0.000	0.000	1.00	9.0	0.081	0.100	61.75	4.0	15.5
20	0.172	11923	0.000	0.000	1.00	6.0	0.200	0.100	65.00	4.0	15.5
Toe						16.7	0.150	0.201			

3.442 kips total unreduced pile weight (g= 32.17 ft/s2)
3.442 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
20.00	10.81	1.00	0.800

♀
FRA-70-1321A/R-FA - B-016-5-13 - HP12x53 04/02/2015
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
45.7	3.8	4.75	4.73	-0.82	2	10 17.80	7	3 21.1	54.3
1		0	10.81000		11.86000				

♀
FRA-70-1321A/R-FA - B-016-5-13 - HP12x53 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth (ft) 25.0
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 141.890 Pile Type H Pile
Pile Size (inch) 12.040

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	15.50	30000.	492.0	4.0	0	16807.	27.7
65.0	15.50	30000.	492.0	4.0	0	16807.	27.7

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model — Total Capacity Rut (kips) 56.9

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.172	11923	0.010	0.000	0.85	0.0	0.000	0.100	3.25	4.0	15.5
2	0.172	11923	0.000	0.000	1.00	0.0	0.000	0.100	6.50	4.0	15.5
13	0.172	11923	0.000	0.000	1.00	0.3	0.050	0.100	42.25	4.0	15.5
14	0.172	11923	0.000	0.000	1.00	1.6	0.050	0.100	45.50	4.0	15.5
15	0.172	11923	0.000	0.000	1.00	2.9	0.050	0.100	48.75	4.0	15.5
16	0.172	11923	0.000	0.000	1.00	5.2	0.050	0.100	52.00	4.0	15.5
17	0.172	11923	0.000	0.000	1.00	9.3	0.050	0.100	55.25	4.0	15.5
18	0.172	11923	0.000	0.000	1.00	6.8	0.162	0.100	58.50	4.0	15.5
19	0.172	11923	0.000	0.000	1.00	6.5	0.200	0.100	61.75	4.0	15.5
20	0.172	11923	0.000	0.000	1.00	7.5	0.200	0.100	65.00	4.0	15.5
Toe						16.7	0.150	0.201			

3.442 kips total unreduced pile weight (g= 32.17 ft/s2)
3.442 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
25.00	10.81	1.00	0.800

♀
FRA-70-1321A/R-FA - B-016-5-13 - HP12x53 04/02/2015
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
56.9	5.4	5.11	5.09	-0.26	2	10 19.95	14	4 20.0	52.3
1		0	10.81000		11.86000				

♀
FRA-70-1321A/R-FA - B-016-5-13 - HP12x53 04/02/2015
Resource International Inc GRLWEAP Version 2010

Depth (ft) 30.0
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 141.890 Pile Type H Pile
Pile Size (inch) 12.040

L	b	Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
		0.0	15.50	30000.	492.0	4.0	0	16807.	27.7
		65.0	15.50	30000.	492.0	4.0	0	16807.	27.7

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model — Total Capacity Rut (kips) 79.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.172	11923	0.010	0.000	0.85	0.0	0.000	0.100	3.25	4.0	15.5
2	0.172	11923	0.000	0.000	1.00	0.0	0.000	0.100	6.50	4.0	15.5
11	0.172	11923	0.000	0.000	1.00	0.0	0.050	0.100	35.75	4.0	15.5
12	0.172	11923	0.000	0.000	1.00	1.0	0.050	0.100	39.00	4.0	15.5
13	0.172	11923	0.000	0.000	1.00	2.3	0.050	0.100	42.25	4.0	15.5
14	0.172	11923	0.000	0.000	1.00	3.7	0.050	0.100	45.50	4.0	15.5
15	0.172	11923	0.000	0.000	1.00	7.8	0.050	0.100	48.75	4.0	15.5
16	0.172	11923	0.000	0.000	1.00	8.7	0.092	0.100	52.00	4.0	15.5
17	0.172	11923	0.000	0.000	1.00	6.1	0.200	0.100	55.25	4.0	15.5
18	0.172	11923	0.000	0.000	1.00	7.1	0.200	0.100	58.50	4.0	15.5
19	0.172	11923	0.000	0.000	1.00	8.8	0.200	0.100	61.75	4.0	15.5
20	0.172	11923	0.000	0.000	1.00	12.2	0.200	0.100	65.00	4.0	15.5
Toe						22.2	0.150	0.201			

3.442 kips total unreduced pile weight (g= 32.17 ft/s2)
3.442 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
30.00	10.81	1.00	0.800

♀
FRA-70-1321A/R-FA - B-016-5-13 - HP12x53 04/02/2015
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
79.8	8.8	5.63	5.68	-1.07	13 48	22.37	13	4 18.5	49.5
	1	0	10.81000		11.86000				

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FRA-70-1321A/R-FA - B-016-5-13 - HP12x53 04/02/2015
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Depth (ft) 35.0
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 141.890 Pile Type H Pile
Pile Size (inch) 12.040

L	b	Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
		0.0	15.50	30000.	492.0	4.0	0	16807.	27.7
		65.0	15.50	30000.	492.0	4.0	0	16807.	27.7

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model — Total Capacity Rut (kips) 226.5

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.172	11923	0.010	0.000	0.85	0.0	0.000	0.100	3.25	4.0	15.5
2	0.172	11923	0.000	0.000	1.00	0.0	0.000	0.100	6.50	4.0	15.5
10	0.172	11923	0.000	0.000	1.00	0.4	0.050	0.100	32.50	4.0	15.5
11	0.172	11923	0.000	0.000	1.00	1.7	0.050	0.100	35.75	4.0	15.5
12	0.172	11923	0.000	0.000	1.00	3.0	0.050	0.100	39.00	4.0	15.5
13	0.172	11923	0.000	0.000	1.00	5.6	0.050	0.100	42.25	4.0	15.5
14	0.172	11923	0.000	0.000	1.00	9.5	0.050	0.100	45.50	4.0	15.5
15	0.172	11923	0.000	0.000	1.00	6.5	0.174	0.100	48.75	4.0	15.5
16	0.172	11923	0.000	0.000	1.00	6.6	0.200	0.100	52.00	4.0	15.5
17	0.172	11923	0.000	0.000	1.00	7.6	0.200	0.100	55.25	4.0	15.5
18	0.172	11923	0.000	0.000	1.00	11.0	0.200	0.100	58.50	4.0	15.5
19	0.172	11923	0.000	0.000	1.00	12.7	0.174	0.100	61.75	4.0	15.5
20	0.172	11923	0.000	0.000	1.00	13.8	0.050	0.100	65.00	4.0	15.5
Toe						148.2	0.150	0.201			

3.442 kips total unreduced pile weight (g= 32.17 ft/s2)
3.442 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
35.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
226.5	34.9	7.40	7.39	-1.72	12 26	28.42	13	4 18.2	43.3
	1	0	10.81000		11.86000				

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Depth (ft) 40.0
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 141.890 Pile Type H Pile
Pile Size (inch) 12.040

L	b	Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s

0.0	15.50	30000.	492.0	4.0	0	16807.	27.7
65.0	15.50	30000.	492.0	4.0	0	16807.	27.7

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model — Total Capacity Rut (kips) 249.2

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.172	11923	0.010	0.000	0.85	0.0	0.000	0.100	3.25	4.0	15.5
2	0.172	11923	0.000	0.000	1.00	0.0	0.000	0.100	6.50	4.0	15.5
8	0.172	11923	0.000	0.000	1.00	0.1	0.050	0.100	26.00	4.0	15.5
9	0.172	11923	0.000	0.000	1.00	1.1	0.050	0.100	29.25	4.0	15.5
10	0.172	11923	0.000	0.000	1.00	2.4	0.050	0.100	32.50	4.0	15.5
11	0.172	11923	0.000	0.000	1.00	3.8	0.050	0.100	35.75	4.0	15.5
12	0.172	11923	0.000	0.000	1.00	8.2	0.050	0.100	39.00	4.0	15.5
13	0.172	11923	0.000	0.000	1.00	8.4	0.103	0.100	42.25	4.0	15.5
14	0.172	11923	0.000	0.000	1.00	6.1	0.200	0.100	45.50	4.0	15.5
15	0.172	11923	0.000	0.000	1.00	7.1	0.200	0.100	48.75	4.0	15.5
16	0.172	11923	0.000	0.000	1.00	9.1	0.200	0.100	52.00	4.0	15.5
17	0.172	11923	0.000	0.000	1.00	12.2	0.200	0.100	55.25	4.0	15.5
18	0.172	11923	0.000	0.000	1.00	13.3	0.095	0.100	58.50	4.0	15.5
19	0.172	11923	0.000	0.000	1.00	14.2	0.050	0.100	61.75	4.0	15.5
20	0.172	11923	0.000	0.000	1.00	15.0	0.050	0.100	65.00	4.0	15.5
Toe						148.2	0.150	0.201			

3.442 kips total unreduced pile weight (g= 32.17 ft/s2)
3.442 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
40.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
249.2	40.7	7.58	7.56	-1.89	10	25	28.97	12	4	18.3	42.8
	1		0	10.81000			11.86000				

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Depth (ft) 45.0
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 141.890 Pile Type H Pile
Pile Size (inch) 12.040

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	15.50	30000.	492.0	4.0	0	16807.	27.7
65.0	15.50	30000.	492.0	4.0	0	16807.	27.7

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model — Total Capacity Rut (kips) 250.0

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.172	11923	0.010	0.000	0.85	0.0	0.000	0.100	3.25	4.0	15.5
2	0.172	11923	0.000	0.000	1.00	0.0	0.000	0.100	6.50	4.0	15.5
7	0.172	11923	0.000	0.000	1.00	0.5	0.050	0.100	22.75	4.0	15.5
8	0.172	11923	0.000	0.000	1.00	1.8	0.050	0.100	26.00	4.0	15.5
9	0.172	11923	0.000	0.000	1.00	3.1	0.050	0.100	29.25	4.0	15.5
10	0.172	11923	0.000	0.000	1.00	5.9	0.050	0.100	32.50	4.0	15.5
11	0.172	11923	0.000	0.000	1.00	9.7	0.050	0.100	35.75	4.0	15.5
12	0.172	11923	0.000	0.000	1.00	6.1	0.187	0.100	39.00	4.0	15.5
13	0.172	11923	0.000	0.000	1.00	6.7	0.200	0.100	42.25	4.0	15.5
14	0.172	11923	0.000	0.000	1.00	7.7	0.200	0.100	45.50	4.0	15.5
15	0.172	11923	0.000	0.000	1.00	11.3	0.200	0.100	48.75	4.0	15.5
16	0.172	11923	0.000	0.000	1.00	12.8	0.164	0.100	52.00	4.0	15.5
17	0.172	11923	0.000	0.000	1.00	13.8	0.050	0.100	55.25	4.0	15.5
18	0.172	11923	0.000	0.000	1.00	14.6	0.050	0.100	58.50	4.0	15.5
19	0.172	11923	0.000	0.000	1.00	15.7	0.092	0.100	61.75	4.0	15.5
20	0.172	11923	0.000	0.000	1.00	16.8	0.200	0.100	65.00	4.0	15.5
Toe						123.5	0.150	0.100			

3.442 kips total unreduced pile weight (g= 32.17 ft/s2)
3.442 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
45.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
250.0	38.1	7.63	7.63	-1.73	9	23	29.03	10	4	17.9	42.7
	1		0	10.81000			11.86000				

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Depth (ft) 50.0
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 141.890 Pile Type H Pile

Pile Size (inch) 12.040

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	15.50	30000.	492.0	4.0	0	16807.	27.7
	65.0	15.50	30000.	492.0	4.0	0	16807.	27.7

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model — Total Capacity Rut (kips) 275.9

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.172	11923	0.010	0.000	0.85	0.0	0.000	0.100	3.25	4.0	15.5
2	0.172	11923	0.000	0.000	1.00	0.0	0.000	0.100	6.50	4.0	15.5
5	0.172	11923	0.000	0.000	1.00	0.1	0.050	0.100	16.25	4.0	15.5
6	0.172	11923	0.000	0.000	1.00	1.2	0.050	0.100	19.50	4.0	15.5
7	0.172	11923	0.000	0.000	1.00	2.5	0.050	0.100	22.75	4.0	15.5
8	0.172	11923	0.000	0.000	1.00	3.9	0.050	0.100	26.00	4.0	15.5
9	0.172	11923	0.000	0.000	1.00	8.6	0.050	0.100	29.25	4.0	15.5
10	0.172	11923	0.000	0.000	1.00	8.1	0.114	0.100	32.50	4.0	15.5
11	0.172	11923	0.000	0.000	1.00	6.2	0.200	0.100	35.75	4.0	15.5
12	0.172	11923	0.000	0.000	1.00	7.2	0.200	0.100	39.00	4.0	15.5
13	0.172	11923	0.000	0.000	1.00	9.4	0.200	0.100	42.25	4.0	15.5
14	0.172	11923	0.000	0.000	1.00	12.3	0.200	0.100	45.50	4.0	15.5
15	0.172	11923	0.000	0.000	1.00	13.4	0.081	0.100	48.75	4.0	15.5
16	0.172	11923	0.000	0.000	1.00	14.3	0.050	0.100	52.00	4.0	15.5
17	0.172	11923	0.000	0.000	1.00	15.1	0.050	0.100	55.25	4.0	15.5
18	0.172	11923	0.000	0.000	1.00	16.5	0.172	0.100	58.50	4.0	15.5
19	0.172	11923	0.000	0.000	1.00	16.8	0.200	0.100	61.75	4.0	15.5
20	0.172	11923	0.000	0.000	1.00	16.8	0.200	0.100	65.00	4.0	15.5
Toe						123.5	0.150	0.100			

3.442 kips total unreduced pile weight (g= 32.17 ft/s2)
3.442 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
50.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
275.9	47.7	7.84	7.87	-1.77	7	22 29.61	9	3 18.1	42.1
	1	0	10.81000		11.86000				

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Depth (ft) 55.0
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 141.890 Pile Type H Pile
Pile Size (inch) 12.040

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	15.50	30000.	492.0	4.0	0	16807.	27.7
	65.0	15.50	30000.	492.0	4.0	0	16807.	27.7

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model — Total Capacity Rut (kips) 301.8

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.172	11923	0.010	0.000	0.85	0.0	0.000	0.100	3.25	4.0	15.5
2	0.172	11923	0.000	0.000	1.00	0.0	0.000	0.100	6.50	4.0	15.5
4	0.172	11923	0.000	0.000	1.00	0.6	0.050	0.100	13.00	4.0	15.5
5	0.172	11923	0.000	0.000	1.00	1.9	0.050	0.100	16.25	4.0	15.5
6	0.172	11923	0.000	0.000	1.00	3.2	0.050	0.100	19.50	4.0	15.5
7	0.172	11923	0.000	0.000	1.00	6.3	0.050	0.100	22.75	4.0	15.5
8	0.172	11923	0.000	0.000	1.00	9.9	0.050	0.100	26.00	4.0	15.5
9	0.172	11923	0.000	0.000	1.00	5.8	0.200	0.100	29.25	4.0	15.5
10	0.172	11923	0.000	0.000	1.00	6.7	0.200	0.100	32.50	4.0	15.5
11	0.172	11923	0.000	0.000	1.00	7.7	0.200	0.100	35.75	4.0	15.5
12	0.172	11923	0.000	0.000	1.00	11.6	0.200	0.100	39.00	4.0	15.5
13	0.172	11923	0.000	0.000	1.00	12.9	0.154	0.100	42.25	4.0	15.5
14	0.172	11923	0.000	0.000	1.00	13.9	0.050	0.100	45.50	4.0	15.5
15	0.172	11923	0.000	0.000	1.00	14.7	0.050	0.100	48.75	4.0	15.5
16	0.172	11923	0.000	0.000	1.00	15.8	0.105	0.100	52.00	4.0	15.5
17	0.172	11923	0.000	0.000	1.00	16.8	0.200	0.100	55.25	4.0	15.5
20	0.172	11923	0.000	0.000	1.00	16.8	0.200	0.100	65.00	4.0	15.5
Toe						123.5	0.150	0.100			

3.442 kips total unreduced pile weight (g= 32.17 ft/s2)
3.442 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
55.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
301.8	59.9	8.08	8.07	-1.58	7	21 30.05	7	3 18.3	41.5
	1	0	10.81000		11.86000				

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Depth (ft) 60.0
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 141.890 Pile Type H Pile
Pile Size (inch) 12.040

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	15.50	30000.	492.0	4.0	0	16807.	27.7
	65.0	15.50	30000.	492.0	4.0	0	16807.	27.7

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model Total Capacity Rut (kips) 327.7

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.172	11923	0.010	0.000	0.85	0.0	0.000	0.100	3.25	4.0	15.5
2	0.172	11923	0.000	0.000	1.00	0.1	0.050	0.100	6.50	4.0	15.5
3	0.172	11923	0.000	0.000	1.00	1.3	0.050	0.100	9.75	4.0	15.5
4	0.172	11923	0.000	0.000	1.00	2.6	0.050	0.100	13.00	4.0	15.5
5	0.172	11923	0.000	0.000	1.00	4.2	0.050	0.100	16.25	4.0	15.5
6	0.172	11923	0.000	0.000	1.00	8.8	0.050	0.100	19.50	4.0	15.5
7	0.172	11923	0.000	0.000	1.00	7.8	0.126	0.100	22.75	4.0	15.5
8	0.172	11923	0.000	0.000	1.00	6.3	0.200	0.100	26.00	4.0	15.5
9	0.172	11923	0.000	0.000	1.00	7.3	0.200	0.100	29.25	4.0	15.5
10	0.172	11923	0.000	0.000	1.00	9.7	0.200	0.100	32.50	4.0	15.5
11	0.172	11923	0.000	0.000	1.00	12.4	0.200	0.100	35.75	4.0	15.5
12	0.172	11923	0.000	0.000	1.00	13.5	0.066	0.100	39.00	4.0	15.5
13	0.172	11923	0.000	0.000	1.00	14.3	0.050	0.100	42.25	4.0	15.5
14	0.172	11923	0.000	0.000	1.00	15.1	0.050	0.100	45.50	4.0	15.5
15	0.172	11923	0.000	0.000	1.00	16.6	0.182	0.100	48.75	4.0	15.5
16	0.172	11923	0.000	0.000	1.00	16.8	0.200	0.100	52.00	4.0	15.5
20	0.172	11923	0.000	0.000	1.00	16.8	0.200	0.100	65.00	4.0	15.5
Toe						123.5	0.150	0.100			

3.442 kips total unreduced pile weight (g= 32.17 ft/s2)
3.442 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
60.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t Comp Str ksi	i	t ENTHRU kip-ft	Bl Rt b/min
327.7	78.8	8.27	8.22	-1.15	6	39 30.49	6	3 18.3	41.1
	1	0	10.81000		11.86000				

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Depth (ft) 63.5
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 141.890 Pile Type H Pile
Pile Size (inch) 12.040

L	b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
	0.0	15.50	30000.	492.0	4.0	0	16807.	27.7
	65.0	15.50	30000.	492.0	4.0	0	16807.	27.7

Wave Travel Time 2L/c (ms) 7.735

Pile and Soil Model Total Capacity Rut (kips) 519.1

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.172	11923	0.010	0.000	0.85	0.2	0.050	0.100	3.25	4.0	15.5
2	0.172	11923	0.000	0.000	1.00	1.4	0.050	0.100	6.50	4.0	15.5
3	0.172	11923	0.000	0.000	1.00	2.7	0.050	0.100	9.75	4.0	15.5
4	0.172	11923	0.000	0.000	1.00	4.5	0.050	0.100	13.00	4.0	15.5
5	0.172	11923	0.000	0.000	1.00	8.9	0.050	0.100	16.25	4.0	15.5
6	0.172	11923	0.000	0.000	1.00	7.5	0.138	0.100	19.50	4.0	15.5
7	0.172	11923	0.000	0.000	1.00	6.4	0.200	0.100	22.75	4.0	15.5
8	0.172	11923	0.000	0.000	1.00	7.4	0.200	0.100	26.00	4.0	15.5
9	0.172	11923	0.000	0.000	1.00	10.1	0.200	0.100	29.25	4.0	15.5
10	0.172	11923	0.000	0.000	1.00	12.4	0.200	0.100	32.50	4.0	15.5
11	0.172	11923	0.000	0.000	1.00	13.6	0.050	0.100	35.75	4.0	15.5
12	0.172	11923	0.000	0.000	1.00	14.4	0.050	0.100	39.00	4.0	15.5
13	0.172	11923	0.000	0.000	1.00	15.2	0.050	0.100	42.25	4.0	15.5
14	0.172	11923	0.000	0.000	1.00	16.7	0.191	0.100	45.50	4.0	15.5
15	0.172	11923	0.000	0.000	1.00	16.8	0.200	0.100	48.75	4.0	15.5
20	0.172	11923	0.000	0.000	1.00	18.0	0.200	0.100	65.00	4.0	15.5
Toe						295.6	0.150	0.100			

3.442 kips total unreduced pile weight (g= 32.17 ft/s2)
3.442 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
63.50	10.81	1.00	0.800

♀

FRA-70-1321A/R-FA - B-016-5-13 - HP12x53 04/02/2015
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
519.1	9999.0	8.97	8.95	-1.23	5	37	32.10	5	3	19.7	39.5

♀

FRA-70-1321A/R-FA - B-016-5-13 - HP12x53 04/02/2015
Resource International Inc GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.500 1.000

Depth ft	Rut kips	Frictn kips	End Bg kips	Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft
5.0	55.1	1.6	53.5	5.5	19.159	0.000	5.09	20.1
10.0	59.8	6.3	53.5	5.9	19.566	0.000	5.17	19.9
15.0	265.5	18.6	246.9	37.3	39.300	-2.495	7.86	19.2
20.0	45.7	29.1	16.7	3.8	17.796	-0.817	4.75	21.1
25.0	56.9	40.2	16.7	5.4	19.953	-0.261	5.11	20.0
30.0	79.8	57.5	22.2	8.8	22.375	-1.066	5.63	18.5
35.0	226.5	78.3	148.2	34.9	28.418	-1.717	7.40	18.2
40.0	249.2	101.1	148.2	40.7	28.973	-1.886	7.58	18.3
45.0	250.0	126.6	123.5	38.1	29.033	-1.726	7.63	17.9
50.0	275.9	152.5	123.5	47.7	29.608	-1.773	7.84	18.1
55.0	301.8	178.4	123.5	59.9	30.052	-1.578	8.08	18.3
60.0	327.7	204.3	123.5	78.8	30.487	-1.151	8.27	18.3
63.5	519.1	223.5	295.6	9999.0	32.101	-1.229	8.97	19.7

Refusal occurred; no driving time output possible

♀

FRA-70-1321A/R-FA - B-016-5-13 - HP12x53 04/02/2015
Resource International Inc GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth ft	Temp. Length ft	Wait Time hr	Equivalent Pressure Stroke ft	Ratio	Efficy.	Stiffn. Factor	Cushion CoR
5.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
10.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
15.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
20.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
25.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
30.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
35.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
40.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
45.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
50.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
55.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
60.00	65.00	0.00	10.81	1.00	0.80	1.00	1.00
63.50	65.00	0.00	10.81	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth ft	Shaft Res. k/ft2	End Bearing kips	Shaft Quake inch	Toe Quake inch	Shaft Damping s/ft	Toe Damping s/ft	Soil Setup Normlzd	Limit Distance ft	Setup Time hrs
0.00	0.00	53.51	0.100	0.200	0.050	0.150	0.333	6.560	1.000
11.00	0.42	53.51	0.100	0.200	0.050	0.150	0.333	6.560	1.000
11.00	0.69	246.95	0.100	0.100	0.050	0.150	0.333	6.560	1.000
16.00	1.03	246.95	0.100	0.100	0.050	0.150	0.333	6.560	1.000
16.00	0.81	16.67	0.100	0.201	0.200	0.150	1.000	6.560	168.000
26.00	1.29	16.67	0.100	0.201	0.200	0.150	1.000	6.560	168.000
26.00	1.34	22.23	0.100	0.201	0.200	0.150	0.667	6.560	168.000
31.00	1.50	22.23	0.100	0.201	0.200	0.150	0.667	6.560	168.000
31.00	1.02	148.17	0.100	0.201	0.050	0.150	0.000	6.560	1.000
41.00	1.21	148.17	0.100	0.201	0.050	0.150	0.000	6.560	1.000
41.00	1.57	123.48	0.100	0.100	0.200	0.150	0.333	6.560	84.000
63.40	1.57	123.48	0.100	0.100	0.200	0.150	0.333	6.560	84.000
63.40	5.00	295.60	0.100	0.100	0.200	0.150	0.333	6.560	84.000
65.00	5.00	295.60	0.100	0.100	0.200	0.150	0.333	6.560	84.000

APPENDIX VIII

LATERAL DESIGN PARAMETERS

Substructure Reference (Boring No.)	Elevation (feet msl)	Soil Class.	Soil Type	Strata	N_{60}	$N1_{60}$	γ (pcf)	γ' (pcf)	Strength Parameter	k (soil) k_{rm} (rock)	ε_{50} (soil) E_r (rock)	RQD (rock)
Rear Abutment (B-001-S-57 / B-015-7-13)	723.4 to 705.4	A-1-a	G	4	32	38	130 psf	130 psf	φ = 41°	315 pci	-	-
	705.4 to 700.4	A-6a	C	3	30	30	125 psf	125 psf	Su = 3,750 psf	1,250 pci	0.0048	-
	700.4 to 695.4	A-1-b	G	4	70	58	135 psf	135 psf	φ = 42°	355 pci	-	-
	695.4 to 685.4	A-1-a	G	4	45	34	130 psf	130 psf	φ = 41°	315 pci	-	-
	685.4 to 675.4	A-1-a	G	4	82	57	135 psf	72.6 psf	φ = 43°	215 pci	-	-
	675.4 to 670.4	A-6a	C	2	100	100	130 psf	67.6 psf	Su = 8,000 psf	2,665 pci	0.0033	-
	670.4 to 660.0	Boulders	G	4	100	63	140 psf	77.6 psf	φ = 45°	255 pci	-	-
	660.0 to 651.3	A-1-a	G	4	100	59	135 psf	72.6 psf	φ = 43°	215 pci	-	-
	651.3 to 641.3	Limestone	R	9	-	-	165 psf	102.6 psf	Qu = 10,000 psi	0.00005	1,000,000 psi	85
Pier 1 (B-005-S-57)	681.1 to 673.1	A-1-a	G	4	24	41	125 psf	62.6 psf	φ = 42°	195 pci	-	-
	673.1 to 668.1	A-3a	G	4	73	99	135 psf	72.6 psf	φ = 40°	155 pci	-	-
	668.1 to 658.1	A-1-a	G	4	100	117	135 psf	72.6 psf	φ = 43°	215 pci	-	-
	658.1 to 654.1	A-2-4	G	4	20	21	125 psf	62.6 psf	φ = 37°	110 pci	-	-
	654.1 to 652.1	A-1-a	G	4	100	102	135 psf	72.6 psf	φ = 43°	215 pci	-	-
	652.1 to 651.5	Shale	R	9	-	-	150 psf	87.6 psf	Qu = 200 psi	0.0005	20,000 psi	15
	651.5 to 645.1	Limestone	R	9	-	-	165 psf	102.6 psf	Qu = 10,000 psi	0.00005	1,000,000 psi	85
Pier 2 (B-009-S-57)	685.5 to 667.5	A-1-b	G	4	39	55	130 psf	67.6 psf	φ = 42°	195 pci	-	-
	667.5 to 650.8	A-1-a	G	4	100	103	135 psf	72.6 psf	φ = 43°	215 pci	-	-
	650.8 to 648.1	Shale	R	9	-	-	150 psf	87.6 psf	Qu = 360 psi	0.0005	32,000 psi	25
	648.1 to 645.4	Limestone	R	9	-	-	165 psf	102.6 psf	Qu = 10,000 psi	0.00005	1,000,000 psi	85
Pier 3 (B-013-S-57 / B-016-3-13)	690.8 to 683.8	A-1-a	G	4	15	26	125 psf	62.6 psf	φ = 39°	140 pci	-	-
	683.8 to 678.8	A-1-a	G	4	90	125	135 psf	72.6 psf	φ = 43°	215 pci	-	-
	678.8 to 673.8	A-3a	G	4	27	34	125 psf	62.6 psf	φ = 38°	125 pci	-	-
	673.8 to 668.8	A-1-a	G	4	30	35	130 psf	67.6 psf	φ = 41°	175 pci	-	-
	668.8 to 660.8	A-1-a	G	4	100	105	135 psf	72.6 psf	φ = 43°	215 pci	-	-
	660.8 to 643.8	Shale	R	9	-	-	150 psf	87.6 psf	Qu = 200 psi	0.0005	20,000 psi	15
	643.8 to 626.4	Limestone	R	9	-	-	165 psf	102.6 psf	Qu = 10,000 psi	0.00005	1,000,000 psi	85
Pier 4 (B-013-S-57 / B-020-S-57 / B-016-4-13)	725.4 to 711.4	A-1-b	G	4	10	13	120 psf	120 psf	φ = 36°	160 pci	-	-
	711.4 to 701.4	A-4a	C	3	21	21	120 psf	120 psf	Su = 2,625 psf	875 pci	0.0055	-
	701.4 to 696.4	A-6a	C	3	15	15	120 psf	120 psf	Su = 1,875 psf	625 pci	0.0065	-
	696.4 to 691.4	A-2-4	G	4	23	18	125 psf	125 psf	φ = 36°	160 pci	-	-
	691.4 to 683.8	A-1-a	G	4	25	18	125 psf	62.6 psf	φ = 38°	125 pci	-	-
	683.8 to 678.8	A-1-a	G	4	90	64	135 psf	72.6 psf	φ = 43°	215 pci	-	-
	678.8 to 673.8	A-3a	G	4	27	18	125 psf	62.6 psf	φ = 35°	85 pci	-	-
	673.8 to 668.8	A-1-a	G	4	30	20	130 psf	67.6 psf	φ = 38°	125 pci	-	-
	668.8 to 657.9	A-1-a	G	4	100	63	135 psf	72.6 psf	φ = 43°	215 pci	-	-
	657.9 to 645.3	Shale	R	9	-	-	150 psf	87.6 psf	Qu = 200 psi	0.0005	20,000 psi	15
	645.3 to 643.5	Limestone	R	9	-	-	165 psf	102.6 psf	Qu = 10,000 psi	0.00005	1,000,000 psi	85
Forward Abutment (B-020-S-57 / B-016-5-13)	725.4 to 711.4	A-1-b	G	4	10	13	120 psf	120 psf	φ = 36°	160 pci	-	-
	711.4 to 701.4	A-4a	C	3	21	21	120 psf	120 psf	Su = 2,625 psf	875 pci	0.0055	-
	701.4 to 696.4	A-6a	C	3	15	15	120 psf	120 psf	Su = 1,875 psf	625 pci	0.0065	-
	696.4 to 691.4	A-2-4	G	4	23	18	125 psf	125 psf	φ = 36°	160 pci	-	-
	691.4 to 684.4	A-1-a	G	4	25	18	125 psf	62.6 psf	φ = 38°	125 pci	-	-
	684.4 to 655.2	A-4a	C	2	55	55	130 psf	67.6 psf	Su = 6,875 psf	2,290 pci	0.0037	-
	655.2 to 645.2	Shale	R	9	-	-	150 psf	87.6 psf	Qu = 200 psi	0.0005	20,000 psi	15