Resource International, Inc.

FRA-317-10.63
HAMILTON ROAD CORRIDOR
PID NO. 95570
CITY OF COLUMBUS, OHIO

ROADWAY EXPLORATION REPORT

Prepared For:
ms consultants, inc.
2221 Schrock Road
Columbus, OH 43229-1547

Prepared By:
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Rii Project No. W-13-155

May 2016

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May 26, 2016

Mr. James Villacres, P.E., P.S.
ms consultants, inc.
2221 Schrock Road
Columbus, OH 43229-1547

Re: Roadway Exploration Report
FRA-317-10.63
Hamilton Road Corridor
PID No. 95570
City of Columbus, Ohio
Rii Project No. W-13-155

Mr. Villacres:

Resource International, Inc. (Rii) is pleased to submit this roadway 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 proposed Hamilton Road Corridor (FRA-317-10.63) project in the City of Columbus, Ohio.

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

Sincerely,

RESOURCE INTERNATIONAL, INC.

Peyman P. Majidi, E.I.
Staff Engineer

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

Enclosure: Roadway Exploration Report

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APPENDICES

EXECUTIVE SUMMARY

Resource International, Inc. (Rii) has completed a roadway exploration report for the design and construction of the proposed improvements along the Hamilton Road Corridor from just south of Refugee Road to north of Groves Road as part of the FRA-317-10.63 project in the City of Columbus, Ohio. It is understood that the roadway will be widen to the west along the southbound lane between Kimberly Parkway and Groves Road, and at various other places along the corridor. Access roads will also be constructed within the intersection of Hamilton Road and Groves Road as well as a multiuse path on the west side of Hamilton Road along the entire project length. An existing culvert will be improved along Groves Road, to the west of Hamilton Road. It is understood that the culvert will be extended to the north, including a new headwall.

Exploration and Findings

Between December 15 and 21, 2015, a total of sixteen (16) test borings, designated as B-001-0-15 through B-016-0-15, were drilled to completion depths ranging from 10.0 to 25.0 feet below the existing ground surface at the locations illustrated on the boring plan in Appendix I of the full report. In addition to the aforementioned borings, five (5) pavement cores were also obtained, four (4) within the existing travel lanes of Hamilton Road and one (1) within the existing pavement of Eastland One, to determine the existing pavement thickness and composition.

Borings B-001-0-15, B-002-0-15, B-004-0-15, B-006-0-15, B-010-0-15 and pavement cores C-1, C-3, C-4 and C-5 were performed within the existing pavement along Hamilton road and encountered 4.5 to 9.0 inches of asphalt overlying 6.0 to 12.0 inches of concrete in borings B-001-0-15, B-002-0-15, B-004-0-15 and pavement cores C-4 and C-5. With the exception of borings B-001-0-15 and B-002-0-15, 6.0 to 12.0 inches of aggregate base was encountered below the pavement materials along Hamilton Road. Pavement core C-2 was performed within the existing pavement along Eastland One and encountered 6.5 inches of asphalt overlying 2.0 inches of aggregate base. Borings B-007-0-15 and B-008-0-15 were performed within the existing pavement of Kingsland Avenue and Kimberly Parkway and encountered 6.0 and 4.0 inches of asphalt overlaying 6.0 and 8.0 inches of concrete, respectively. Borings B-011-0-15 and B-016-0-15 were performed within the existing pavement along Groves Road and encountered 6.0 inches of asphalt in each boring overlaying 6.0 inches of concrete in boring B-011-0-15 and 12.0 inches of aggregate base in boring B-016-0-15. Borings B-003-0-15, B-005-0-15, B-009-0-15, B-014-0-15 and B-015-0-15 were performed in the grass adjacent to Hamilton Road and Groves Road and encountered 1.0 to 3.0 inches of topsoil at the ground surface.

Underlying the surficial materials, natural cohesive soils were encountered with intermittent seams and layers of granular material. The cohesive soils were generally described as brown and gray sandy silt, silt and clay, silty clay, and clay (ODOT A-4a, A-6a, A-6b, A-7-6). The granular soils were generally described as brown, gray and

black gravel and sand, gravel with sand and silt, and gravel with sand, silt and clay (ODOT A-1-b, A-2-4, A-2-6).

Bedrock was not encountered in any of the borings performed for this exploration.

Analysis and Recommendations

Pavement Subgrade Recommendations

The subgrade soils along the various alignments, within the project corridor, are anticipated to consist of predominantly cohesive materials comprised of medium stiff to hard sandy silt, silt and clay, silty clay and clay (ODOT A-4a, A-6a, A-6a, A-7-6). Based on the results of the GB1 analysis, the overall average site parameters based on all sixteen (16) soil borings performed as part of this exploration are as follows:

Overall Average Site Parameters

Average N_{60L}	Average PI	Average Moisture	Average Optimum Moisture	Average Group Index	Design CBR
10	14	15	13	6.5	7

California Bearing Ratio (CBR) values for the entire project ranged from 4 to 12 with an average of 7. Based on the conditions encountered across the subject site, **it is recommended that pavement design be based on a CBR value of 7** with a corresponding resilient modulus, M_R, of 8,400 psi. Correlation charts indicate a modulus of subgrade reaction (K) of 165 pci and a soil support value (SSV) of 5.0. Station by station and global stabilization options are provided in Section 5.1.1 and 5.1.2 of the full report, respectively.

Foundation Recommendations (Culvert under Groves Road)

It is understood that the existing 54-inch by 96-inch box culvert that crosses under Groves Road at approximately Sta. 103+35 will be extended to the north and a new headwall constructed in order to support the new configuration in this area. It is recommended that the proposed culvert structure and associated headwall be supported on a conventional shallow foundation system bearing on competent natural soils and/or engineered fill. Based on the soil conditions encountered in the borings performed at this site, it is recommended that the shallow spread foundation system bear on the very stiff to hard sandy silt (ODOT A-4a) encountered in boring B-015-0-15 at or below elevation 753.0 feet msl. Footings bearing at or below this elevation may be proportioned for a nominal bearing resistance as follows:

- Nominal bearing resistance of q_n = 13.0 ksf at the strength limit state
- LRFD Bearing Resistance Factor of φ = 0.5 at the strength limit state

For service limit state design, the settlement analysis indicates that a service limit bearing pressure of 2.8 ksf results in a total settlement of approximately 1.0 inch. Please note that the settlement analysis considers a net increase in applied pressure based on an initial overburden stress of 0.69 ksf at the service limit state.

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

1.0 INTRODUCTION

This report is a presentation of the roadway exploration performed for the design and construction of the proposed improvements along the Hamilton Road Corridor from just south of Refugee Road to north of Groves Road as part of the FRA-317-10.63 project in the City of Columbus, Ohio. It is understood that the roadway will be widen to the west along the southbound lane between Kimberly Parkway and Groves Road, and at various other places along the corridor. Access roads will also be constructed within the intersection of Hamilton Road and Groves Road as well as a multiuse path on the west side of Hamilton Road along the entire project length. An existing culvert will be improved along Groves Road, to the west of Hamilton Road. It is understood that the culvert will be extended to the north, including a new headwall. The project area is shown on the vicinity map presented in Appendix I.

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. 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 Big Walnut Creek, Blacklick Creek, and their 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 is comprised of the Upper Devonian-aged Ohio Shale Formation. The Ohio Shale Formation, which can be further subdivided into three (3) primary members, generally consists of brownish black to greenish gray, laminated to thinly bedded, carbonaceous shale with carbonate/siderite concretions, and ranges from 250 to more than 500 feet thick. Regionally, the bedrock surface forms a broad valley that is roughly aligned southwest-to-northeast beneath Lockbourne, Groveport and Canal Winchester, which branches off into narrower valleys that extend north and east near the Refugee Road

and Hamilton Road interchange. The bedrock surface underlying the project alignment slopes up to the northeast to a small bedrock plateau. The bedrock surface is at an approximate elevation of 650 feet mean sea level (msl) near the I-70 and Hamilton Road interchange and slopes down to an approximate elevation of 550 feet msl near the intersection of Refugee Road and Hamilton Road. According to the bedrock topography mapping, the depth to bedrock ranges from approximately 110 feet below the existing ground surface grade at the north end of the project alignment to 210 feet below the existing ground surface grade at the south end of the project alignment.

2.2 Existing Site Conditions

The project site is located within the southeastern limits of the City of Columbus, Ohio. Within the project corridor, Hamilton Road is aligned in a primarily north-to-south orientation, while Refugee Road and Groves Road are oriented in a primarily east-to-west alignment. The existing Hamilton Road is a composite asphalt and concrete paved roadway that currently maintains two (2) through lanes in both the northbound and southbound direction, with a dedicated central turn lane along the entire project alignment. There are currently six (6) signalized intersections along the project alignment at Refugee Road, two at the entrances to Eastland Mall (Eastland One and Two), Macsway Avenue, Kimberly Parkway and Groves Road. Additional turn lanes are present along Hamilton Road at each of these intersections. The existing pavement along Hamilton Road is in fair condition, with a significant amount of crack sealing evident along the majority of the alignment. Auxiliary lanes that run parallel to Hamilton Road are present along both the east and west sides of the roadway north of Groves Road, and along just the west side of the roadway between Groves Road and Macsway Avenue.

The existing Groves Road is an asphalt paved roadway that currently maintains one (1) lane of traffic in both the eastbound and westbound lanes, with dedicated turn lanes at the intersection with Hamilton Road. The pavement appears to be in fair condition. There is an existing concrete culvert that crosses under Groves Road approximately 365 feet west of Hamilton Road.

Underground utilities are present along the majority of the alignment of Hamilton Road and overhead electric runs along the east side of the roadway. Traffic volume is very high throughout the project corridor. Land use along the project corridor consists primarily of commercially developed properties with parking lots in both side of the street. The existing terrain across the subject site was observed to be relatively flat, with a slight dip in elevation where Hamilton Road crosses under I-270. Surface drainage is directed to grass ditches within that both sides of Hamilton Road.

3.0 EXPLORATION

Between December 15 and 21, 2015, a total of sixteen (16) test borings, designated as B-001-0-15 through B-016-0-15, were drilled to completion depths ranging from 10.0 to 25.0 feet below the existing ground surface. The boring locations are illustrated on the boring plan presented in Appendix I of this report and summarized in Table 1.

Table 1. Test Boring Summary

Reference Alignment	Boring Number	Station	Offset	Latitude	Longitude	Ground Elevation [1] (feet msl)	Boring Depth (feet)
Ex. CL Hamilton Road	B-001-0-15	11+75	25' Rt.	39.916017242	-82.880491784	754.0	10.0
	B-002-0-15	17+73	33' Lt.	39.917666823	-82.880543863	745.5	10.0
	B-003-0-15	25+20	53' Lt.	39.919716112	-82.880423368	756.6	12.5
	B-004-0-15	31+79	49' Lt.	39.921517969	-82.880240405	760.5	10.0
	B-005-0-15	40+07	44' Lt.	39.923785264	-82.880008962	761.4	10.0
	B-006-0-15	44+54	30' Rt.	39.924992915	-82.879632540	762.1	10.0
	B-009-0-15	52+04	52' Lt.	39.927063353	-82.879729793	760.5	10.0
	B-010-0-15	56+22	27' Lt.	39.928203253	-82.879533483	756.1	10.0
	B-014-0-15	65+89	66' Lt.	39.930859056	-82.879423929	763.1	10.0
Ex. CL Kingsland Avenue	B-007-0-15	86+06	14' Lt.	39.925874798	-82.879276726	760.5	10.0
Ex. CL Kimberly Parkway	B-008-0-15	82+05	33' Lt.	39.925999966	-82.880699856	760.7	10.0
Ex. CL Groves Road	B-011-0-15	114+02	14 ' Lt.	39.930095678	-82.876749784	765.7	10.0
	B-012-0-15	110+55	58' Lt.	39.930284929	-82.877971440	764.2	10.0
	B-013-0-15	107+97	237' Lt.	39.930827050	-82.878842016	762.5	10.0
	B-015-0-15	103+63	57' Lt.	39.930422221	-82.880433336	759.0	25.0
	B-016-0-15	100+57	12' Lt.	39.930362203	-82.881535164	760.0	10.0

1. Ground surface elevations at the boring locations determined from available topographic mapping provided by ms consultants.

The boring locations were determined and located in the field by Rii representatives prior to the drilling operations. Geographic latitude and longitude coordinates were collected using a handheld GPS device, and ground surface elevations at the boring locations were interpolated using available topographic information provided by ms consultants.

In addition to the aforementioned borings, five (5) pavement cores were also obtained, four (4) within the existing travel lanes of Hamilton Road, and one (1) within the existing pavement of Eastland One. The cores were retained with a portable, 4.0-inch diameter thin-walled, pavement core machine to determine the existing pavement thickness and composition. Photographs of the pavement cores are presented in Appendix IV.

The borings were drilled with a truck-mounted rotary drilling machine, utilizing a 4.5-inch outside diameter, continuous solid flight auger to advance the holes. In general, standard penetration test (SPT) and split spoon sampling were performed at 2.5-foot intervals to the boring termination depth within each of the borings, with the exception of boring B-015-0-15, which was performed at 2.5-foot intervals to a depth of 20.0 feet and at 5.0-foot intervals to the boring termination depth. 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 blows 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 pavement and 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 Mobile B-53 truck-mounted drill rig used for this project was calibrated on May 13, 2015 and has a drill rod energy ratio of 77.1 percent.

Upon completion of drilling, the borings were backfilled with either soil cuttings generated during the drilling process or a mixture of soil cuttings and bentonite hole plug. Where borings and pavement cores penetrated the existing roadway, the pavement surface was patched with an equivalent thickness of quickset concrete

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 D 2216	75
Plastic and Liquid Limits	AASHTO T89, T90	33
Gradation – Sieve/Hydrometer	AASHTO T88	33
Sulfate Content – Colorimetric Method	TEX-145-E	16

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 for pavement and 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.

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.

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 current version of the ODOT Specifications for Geotechnical Explorations (SGE). 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

A summary of the surficial materials encountered at each boring location is provided in Table 3.

Table 3. Summary of Surface Material Profile

Reference Alignment	Boring Number	Station	Offset	Topsoil (in)	Asphalt Thickness (in)	Concrete Thickness (in)	Aggregate Base Thickness (in)
Ex. CL Hamilton Road	C-5	105+98 [1]	33' Rt.	-	4.75	9.0	9.0
	B-001-0-15	11+75	25' Rt.	-	6.0	12.0	-
	B-002-0-15	17+73	33' Lt.	-	6.0	12.0	-
	C-1	25+00	23' Rt.	-	8.75	-	6.0
	B-003-0-15	25+20	53' Lt.	3.0	-	-	-
	B-004-0-15	31+79	49' Lt.	-	6.0	6.0	6.0
	B-005-0-15	40+07	44' Lt.	2.0	-	-	-
	C-3	42+50	11' Lt.	-	9.0	-	7.0
	B-006-0-15	44+54	30' Rt.	-	6.0	-	12.0
	B-009-0-15	52+04	52' Lt.	1.0	-	-	-
	B-010-0-15	56+22	27' Lt.	-	6.0	-	12.0
	B-014-0-15	65+89	66' Lt.	3.0	-	-	-
	C-4	69+00	33' Lt.	-	4.5	9.5	6.5
EX. CL Eastland One	C-2	44+00	7' Lt.	-	6.5	-	2.0
Ex. CL Kingsland Avenue	B-007-0-15	86+06	14' Lt.	-	6.0	6.0	-
Ex. CL Kimberly Parkway	B-008-0-15	82+05	33' Lt.	-	4.0	8.0	-
Ex. CL Groves Road	B-011-0-15	114+02	14 ' Lt.	-	6.0	6.0	-
	B-012-0-15	110+55	58' Lt.	-	2.5	9.5	12.0
	B-013-0-15	107+97	237' Lt.	-	2.0	6.0	-
	B-015-0-15	103+63	57' Lt.	3.0	-	-	-
	B-016-0-15	100+57	12' Lt.	-	6.0	-	12.0

1. *Station equation indicates Sta. 110+00 back equals Sta. 10+00 ahead along the centerline of Hamilton Road.*

Borings B-001-0-15, B-002-0-15, B-004-0-15, B-006-0-15, B-010-0-15 and pavement cores C-1, C-3, C-4 and C-5 were performed within the existing pavement along Hamilton road and encountered 4.5 to 9.0 inches of asphalt overlying 6.0 to 12.0 inches of concrete in borings B-001-0-15, B-002-0-15, B-004-0-15 and pavement cores C-4 and C-5. With the exception of borings B-001-0-15 and B-002-0-15, 6.0 to 12.0 inches of aggregate base was encountered below the pavement materials along Hamilton

Road. Pavement core C-2 was performed within the existing pavement along Eastland One and encountered 6.5 inches of asphalt overlying 2.0 inches of aggregate base. Borings B-007-0-15 and B-008-0-15 were performed within the existing pavement of Kingsland Avenue and Kimberly Parkway and encountered 6.0 and 4.0 inches of asphalt overlaying 6.0 and 8.0 inches of concrete, respectively. Borings B-011-0-15 and B-016-0-15 were performed within the existing pavement along Groves Road and encountered 6.0 inches of asphalt in each boring overlaying 6.0 inches of concrete in boring B-011-0-15 and 12.0 inches of aggregate base in boring B-016-0-15. Borings B-003-0-15, B-005-0-15, B-009-0-15, B-014-0-15 and B-015-0-15 were performed in the grass adjacent to Hamilton Road and Groves Road and encountered 1.0 to 3.0 inches of topsoil at the ground surface.

4.2 Subsurface Soils

Underlying the surficial materials, natural cohesive soils were encountered with intermittent seams and layers of granular material. The cohesive soils were generally described as brown and gray sandy silt, silt and clay, silty clay, and clay (ODOT A-4a, A-6a, A-6b, A-7-6). The granular soils were generally described as brown, gray and black gravel and sand, gravel with sand and silt, and gravel with sand, silt and clay (ODOT A-1-b, A-2-4, A-2-6).

The shear strength and consistency of the cohesive soils are primarily derived from the hand penetrometer values (HP). The cohesive soils encountered across the site ranged from soft ($0.25 < HP \leq 0.5$ tsf) to hard ($HP \geq 4.0$ tsf). The unconfined compressive strength of the cohesive soil samples tested, obtained from the hand penetrometer, ranged from 0.5 tsf to over 4.5 tsf (limit of the instrument). The relative density of the granular soils is primarily derived from SPT blow counts (N_{60}). Based on the SPT blow counts obtained, the granular soils encountered ranged from very loose ($N_{60} < 5$ blows per foot [bpf]) to dense ($31 \leq N_{60} \leq 50$ bpf). Overall blow counts recorded from the SPT sampling ranged from 4 to 45 blows per foot.

Natural moisture contents of the soil samples tested ranged from 5 to 27 percent. The natural moisture contents of the cohesive soil samples tested for plasticity index ranged from 8 percent below to 10 percent above their corresponding plastic limits. In general, the soils exhibited natural moisture contents estimated to be significantly below to significantly above optimum moisture levels.

Sulfate testing was performed in all of the borings in accordance with the Texas Department of Transportation test method TEX-145-E in the upper soils of the existing subgrade along the proposed alignments, as outlined in the current ODOT SGE and Geotechnical Bulletin GB1: Plan Subgrades (GB1). Based on the results of the testing, the sulfate contents of the subgrade soils range from 60 to 1,200 parts per million (ppm or mg/kg of material). Results of the sulfate testing at each boring location tested are provided on the respective boring log in Appendix III.

4.3 Bedrock

Bedrock was not encountered in any of the borings performed for this exploration.

4.4 Groundwater

Groundwater was encountered initially during drilling in borings B-002-0-15 and B-015-0-15 at a depth of 8.5 and 10.0 feet below the existing ground surface, respectively. At the completion of drilling in borings B-002-0-15 and B-015-0-15, groundwater accumulated in the boreholes to a depth of 7.0 and 9.0 feet below the ground surface, respectively. The remaining borings were observed to be dry, meaning that no measurable amount of water accumulated in the boreholes during or at the completion of drilling prior to backfilling the boreholes. 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.

5.0 ANALYSES AND RECOMMENDATIONS

Data obtained from the drilling and testing program have been used to determine pavement foundation and support capabilities for the soils encountered at the site. These parameters have been used to provide guidelines for the design of the pavement and foundation systems, as well as the construction specifications related to the placement of the pavement and general earthwork recommendations, which are discussed in the following paragraphs.

5.1 Pavement Subgrade Recommendations

The subgrade soils along the various alignments, within the project corridor, are anticipated to consist of predominantly cohesive materials comprised of medium stiff to hard sandy silt, silt and clay, silty clay and clay (ODOT A-4a, A-6a, A-6a, A-7-6). Based on the soil conditions encountered during the drilling phase, it is estimated that the subgrade soils within the upper portions of the proposed subgrade will require some level of stabilization under ODOT GB1. Profile information was not available at the time of this report; however, it is anticipated that the proposed subgrade will match relatively closely with the existing subgrade, and that minor amounts of earthwork cut or fill will be required to achieve the proposed subgrade elevations.

The moisture content of cohesive soil has a significant effect on the physical properties of the material. It must be noted that the moisture contents illustrated on the boring logs and utilized in this analysis represent the conditions during the drilling phase of the

project. The referenced borings for subgrade analysis were drilled between December 15 and 21, 2015. These soil conditions, especially in the surficial soils, may not coincide with the soil conditions that will be encountered during construction. Consequently, the extent/need for subgrade improvement is entirely dependent on the subgrade conditions (i.e., moisture contents) encountered at the time of construction.

5.1.1 Station-By-Station Stabilization Recommendations

It is understood that specific, "station-by-station" recommendations for subgrade stabilization under GB1 are required for anticipated stabilization quantities. Therefore, a summary of recommended undercut and replacement quantities, as well as chemical stabilization quantities, in reference to boring locations are presented in Table 4. A complete GB1 analysis of each soil boring, looking at the proposed subgrade soils at each location, is presented in Appendix V. Please note that the undercut and replacement depths provided in Table 4 are measured from the proposed roadway subgrade, which is anticipated to approximately match the existing roadway subgrade elevation in the existing and widened lanes, as applicable. This elevation was used in the GB1 spreadsheet analysis. If the final design subgrade elevation differs significantly, adjustments to the subgrade analysis will be required to determine the subgrade treatment depth.

Table 4. Station-By-Station Subgrade Treatment Summary

Reference Alignment	From Station [1]	To Station [1]	Length (ft)	Representative Boring(s)	GB1 Subgrade Stabilization
Ex. CL Hamilton Road	11+00 (Est. Project Start)	21+50	1,050	B-001-0-15 and B-002-0-15	No stabilization is anticipated. Subgrade should be proof rolled per ODOT Item 204 to verify that the subgrade will not require stabilization.
	21+50	42+30	2,080	B-003-0-15, B-004-0-15 and B-005-0-15	Proof roll and perform cement stabilization to depth of 14 inches or excavate 18 inches and replace with ODOT Item 703.16C granular material Type B or C, with 712.09 Geotextile Fabric Type D
	42+30	72+50 (Est. Project End)	3,020	B-006-0-15, B-009-0-15, B-010-0-15 and B-014-0-15	No stabilization is anticipated. Subgrade should be proof rolled per ODOT Item 204 to verify that the subgrade will not require stabilization.
Ex. CL Kingsland Avenue	85+00	88+50	350	B-007-0-15	Proof roll and perform cement stabilization to depth of 12 inches or excavate 12 inches and replace with ODOT Item 703.16C granular material Type B or C, with 712.09 Geotextile Fabric Type D

Reference Alignment	From Station [1]	To Station [1]	Length (ft)	Representative Boring(s)	GB1 Subgrade Stabilization
Ex. CL Kimberly Parkway	79+20	85+00	580	B-008-0-15	Proof roll and perform cement stabilization to depth of 14 inches or excavate 18 inches and replace with ODOT Item 703.16C granular material Type B or C, with 712.09 Geotextile Fabric Type D
Ex. CL Groves Road	100+80	107+00	620	B-015-0-15 and B-016-0-15	No stabilization is anticipated. Subgrade should be proof rolled per ODOT Item 204 to verify that the subgrade will not require stabilization.
	107+00	114+05	705	B-011-0-15 and B-012-0-15	Proof roll and perform cement stabilization to depth of 14 inches or excavate 18 inches and replace with ODOT Item 703.16C granular material Type B or C, with 712.09 Geotextile Fabric Type D
Relocated Service Road	Est. Start	Est. End	500	B-012-0-15 and B-013-0-15	Proof roll and perform cement stabilization to depth of 14 inches or excavate 18 inches and replace with ODOT Item 703.16C granular material Type B or C, with 712.09 Geotextile Fabric Type D

1. *Station limits estimated based on soil conditions encountered in the borings. Actual limits of stabilization may vary based on the conditions encountered during construction.*

Note that the limits of the treatment areas are based upon the "Limitation of the Study", defined in Section 6.0 of this subgrade exploration report.

Please note that the limits and depth of stabilization provided in the table above are estimated based on the soil conditions encountered in the borings performed during the field exploration. Actual limits and depth of stabilization may differ from the recommendations provided. Per ODOT GB1 requirements, if it is elected to perform station by station stabilization, the entire subgrade should be proof rolled to identify the actual limits of unstable subgrade and depth of stabilization required. Upon completion of the stabilization, areas that required stabilization should be proof rolled to verify that stability has been achieved.

5.1.2 Global Stabilization

Based on the ODOT GB1, when approximately 30 percent or more of the subgrade requires stabilization, consideration should be given to utilizing a global stabilization option. For this project, approximately 50 percent of the subgrade is anticipated to require stabilization based on the soil borings performed (8 of 16 borings). Per ODOT GB1, global stabilization recommendations are based upon the overall average site parameters, as noted in Table 5.

Table 5. Average Site Parameters

Average N_{60L}	Average PI	Average Moisture	Average Optimum Moisture	Average Group Index	Average CBR
10	14	15	13	6.5	7

Applying the averages in Table 5, GB1 recommends the following global stabilization options within the project limits:

Option 1. Chemically stabilize the entire subgrade with 14-inches of cement, as per ODOT Item 206. For estimating purposes, utilize a cement content of 6.0 percent by weight of soil. Actual application rates shall be verified by the contractor under Item 206.06 Mixture Design for Chemically Stabilized Soils.

Option 2. Stone stabilize the entire subgrade via an 18-inch undercut and replacement with ODOT Item 703.16C granular material, Type B, C or D installed over ODOT Item 712.09 Geotextile Fabric, Type D as detailed in accordance with ODOT Item 204.

Per ODOT GB1 requirements, if it is elected to perform global stabilization, the entire subgrade should be stabilized using one of the global stabilization options provided above. Upon completion of the stabilization, the entire subgrade should be proof rolled to verify that stability has been achieved.

5.1.3 Subgrade Design Considerations

California Bearing Ratio (CBR) values for the entire project ranged from 4 to 12 with an average of 7. Based on the conditions encountered across the subject site, **it is recommended that pavement design be based on a CBR value of 7** with a corresponding resilient modulus, M_R, of 8,400 psi. Correlation charts indicate a modulus of subgrade reaction (K) of 165 pci and a soil support value (SSV) of 5.0.

Per ODOT GB1, soils with sulfate content in excess of 3,000 ppm cannot be chemically stabilized due to the potential for sulfate heave in the soil. Based on the results of the testing, the sulfate contents of the subgrade soils range from 60 to 1,200 ppm. Therefore, soil with a sulfate content greater than 3,000 ppm was not encountered in any boring.

Please note that the recommended CBR values assume that the materials utilized for the roadway subgrade in fill areas are equivalent to, or better than materials at the existing subgrade elevation. Sources of borrow material should be designated in advance of construction. The material should be tested in the laboratory to verify the soil exhibits a minimum design CBR value of 7.

Pavement design is dependent on the inclusion of adequate surface and subsurface drainage in order to maintain the compacted subgrade near optimum moisture conditions throughout the lifetime of the pavement. If underdrain systems are considered, they should be installed in accordance to the specifications presented in Item 204 of the ODOT Construction and Materials Specifications (CMS).

5.2 Foundation Recommendations (Culvert under Groves Road)

It is understood that the existing 54-inch by 96-inch box culvert that crosses under Groves Road at approximately Sta. 103+35 will be extended to the north and a new headwall constructed in order to support the new configuration in this area. It is recommended that the proposed culvert structure and associated headwall be supported on a conventional shallow foundation system bearing on competent natural soils and/or engineered fill. Based on the soil conditions encountered in the borings performed at this site, it is recommended that the shallow spread foundation system bear on the very stiff to hard sandy silt (ODOT A-4a) encountered in boring B-015-0-15 at or below elevation 753.0 feet msl. Footings bearing at or below this elevation may be proportioned for a nominal bearing resistance as follows:

- Nominal bearing resistance of q_n = 13.0 ksf at the strength limit state
- LRFD Bearing Resistance Factor of φ = 0.5 at the strength limit state

For service limit state design, the settlement analysis indicates that a service limit bearing pressure of 2.8 ksf results in a total settlement of approximately 1.0 inch. Please note that the settlement analysis considers a net increase in applied pressure based on an initial overburden stress of 0.69 ksf at the service limit state. Calculations for bearing resistance and settlement are provided in Appendix VI.

Pursuant to the ODOT "Location and Design Manual, Volume 2 – Drainage Design" manual (Rev. April 2010), arch or flat slab topped culverts supported on spread footings should be founded at a minimum of 4.0 feet below the flowline on competent scour resistant native soils. The requirements in this manual should govern the design of this project.

The footings should be carefully inspected to verify the bearing strata. Footing concrete should be placed as soon as possible following excavation, preferably the same day, in order to avoid degradation of the bearing surface. All bearing surfaces should be free of loose or disturbed material and water prior to placing footing concrete.

5.2.1 Sliding Resistance (Headwalls)

The resistance of the footings for the headwalls to sliding will be dependent on the friction between the concrete footing and bearing surface. For concrete footings bearing on cohesive soil, the sliding resistance is taken as one-half of the normal stress on the

interface between the footing and soil, limited by the undrained shear strength of the bearing soil, multiplied by the width of the footing, as outlined in Section 10.6.3.4 of the 2014 AASHTO LRFD BDS. The undrained shear strength of the cohesive bearing soils is estimated to be 2.5 ksf. A geotechnical resistance factor of φ_τ = 1.0 should be considered when calculating the factored shear resistance between the soil and foundation for sliding.

5.3 Lateral Earth Pressure Parameters

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 6 and Table 7.

Table 6. Estimated Undrained Soil Parameters for Design

Soil Type	γ (pcf) [1]	c (psf)	φ	k_a	k_o	k_p
Soft to Medium Stiff Cohesive Soil	110	750	0°	1.0	1.0	1.0
Stiff Cohesive Soil	115	1,500	0°	1.0	1.0	1.0
Very Stiff to Hard Cohesive Soil	120	3,000	0°	1.0	1.0	1.0
Very Loose to Loose Granular Soil	120	0	28°	0.36	0.53	2.77
Medium Dense Granular Soil	125	0	30°	0.33	0.50	3.00
Dense Granular Soil	130	0	34°	0.28	0.44	3.54
Compacted Cohesive Engineered Fill	120	1,500	0°	1.0	1.0	1.0
Compacted Granular Engineered Fill	130	0	33°	0.30	0.46	3.39

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

Table 7. Estimated Drained Soil Parameters for Design

Soil Type	γ (pcf) [1]	c (psf)	φ'	k_a	k_o	k_p
Natural Cohesive Soil	120	0	26°	0.39	0.56	2.56
Very Loose to Loose Granular Soil	120	0	28°	0.36	0.53	2.77
Medium Dense Granular Soil	125	0	30°	0.33	0.50	3.00
Dense Granular Soil	130	0	34°	0.28	0.44	3.54
Compacted Cohesive Engineered Fill	120	0	28°	0.36	0.53	2.77
Compacted Granular Engineered Fill	130	0	33°	0.30	0.46	3.39

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 any temporary retaining structures (where the top of the structure is allowed to move), earth pressure distributions should be based on active conditions (k_a) and passive pressure (k_p). 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 assumed). Earth pressures on excavation support systems will be dependent on the type of sheeting and method of bracing or anchorage.

Temporary retaining structures should be designed using the undrained soil parameters provided in Table 6, and the design should follow all applicable guidelines for the type of retaining structure utilized. Permanent retaining structures should be designed using the drained soil parameters provided in Table 7. Regardless of whether the retaining structure is temporary or permanent, the effective unit weight ($\gamma' = \gamma$ - 62.4 pcf) plus the hydrostatic water pressure ($\gamma_w * h_w$, where h_w is the height of water behind the wall above the base of the wall) should be utilized below the design groundwater level. The lateral earth pressure coefficients should only be applied to the horizontal pressure resulting from the effective overburden pressure, and should not be applied to the hydrostatic water pressure.

5.4 Construction Considerations

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

Prior to beginning excavation, grading and/or embankment operations across the site, all necessary clearing and grubbing shall be completed, including the complete removal of all topsoil and unsuitable fill materials (as determined by a geotechnical engineer or an experienced soil technician), vegetation, debris, saturated and/or soft/loose soils and/or existing pavement sections (where applicable) within the footprint of the proposed improvements.

Cohesive soil, primarily those containing silt (ODOT A-4b), tend to become unstable (i.e., soft and flexing) under repeated loading from heavy rubber-tired vehicles. Therefore, heavy vehicle traffic on subgrades should be limited as much as possible during construction. The subgrade should be closely observed to determine if unstable conditions do develop which will require stabilization as determined by the geotechnical engineer.

The proposed subgrade surfaces should be proof rolled with sufficient proof rolling apparatus (preferably a fully-loaded tandem-axle dump truck), prior to placing engineered fill. A geotechnical engineer or an experienced soil technician should be present during proof rolling to determine if soft soil with inadequate stability exists. Subgrade instability encountered during a proof roll is indicated by deflection, cracking or rutting of the surface. Soft soil is generally a result of the presence of very moist to wet cohesive soil. Deflecting subgrades may also be due to the presence of subsurface lenses of silt or fine sand, which typically contain water because the soil exhibits a higher porosity than the overlying and/or underlying cohesive soil. Based on the borings drilled, the moisture contents of the cohesive samples tested are considered to be slightly below to significantly above the corresponding optimum moisture contents. Soil in excess of the optimum moisture content creates the possibility of soft or unstable subgrades. It is likely that cohesive subgrade soil exhibiting natural moisture content in excess of its corresponding plastic limit will require some level of stabilization.

The extent/need for subgrade stabilization is entirely dependent on the subgrade conditions (i.e., moisture contents) encountered at the time of construction. If required, the method of stabilization employed is a function of the type of instability encountered the location (i.e., depth) of the instability and the resources available.

Fine-grained soils, such as silt (ODOT A-4b), have the potential to create a frost-susceptible subgrade. During construction, it is recommended that this type of material, where encountered, be over excavated and completely removed from within 3.0 feet of the proposed finished subgrade elevation. The over-excavation should be backfilled with engineered fill in accordance to the following paragraphs. Based on the soil conditions encountered in the borings performed for this project, fine-grained, frost-susceptible soils are not anticipated to be encountered during construction of the proposed improvements.

Other stabilization options include 1) scarifying, drying and recompacting, 2) mixing wet soil with dry soil, 3) undercutting unsuitable surficial soil and replacing it with controlled density fill, and 4) a geogrid subgrade reinforcement system. Additional methods of subgrade stabilization are available and certainly may be effective (both physically and economically) in stabilizing the soil. The adequacy of any stabilization method should be verified through the construction of a test section. All proposed subgrade surfaces should be shaped to promote positive drainage, with a minimum slope of 2.0 percent or 0.25 inches per foot. Adequate drainage is necessary for maintaining the stability of the subgrade. Care should be taken during final grading so that no areas of potential ponding or standing water remain at the subgrade surface.

Generally, materials utilized for engineered fill should be free of waste construction debris and other deleterious materials and meet the following requirements:

- Maximum Dry Density per ASTM D698 > 110 pcf
- Liquid Limit < 40
- Plasticity Index < 15
- Organic Matter < 3 percent
- Maximum Particle Size < 3 inches
- Silt Content (between 0.075 and 0.005 mm) < 45 percent

Compacted granular fill shall meet the above specification and additionally shall have a maximum 35 percent passing the No. 200 sieve.

It is anticipated that portions of the existing aggregate base material will be able to be reused as new aggregate base. In addition, most of the natural soils encountered on the site are considered suitable for reuse as structural fill for pavement support when compacted at its optimum moisture content. Fill soil placed for pavement support should be placed in loose lifts not to exceed 8.0 inches. **All embankment fill should be placed and compacted in general accordance to Item 203 of the ODOT CMS**. Fill soil containing excess moisture shall be required to dry prior to or during compaction to a moisture content not greater than 3.0 percent above or below optimum. However, for material that displays pronounced elasticity or deformation under the action of loaded rubber tire construction equipment, the moisture content shall be reduced to optimum if necessary to secure stability. Drying wet soil can be expedited by the use of plows, discs, or by other approved methods. The final determination of whether a material is suitable for reuse as fill should be made by the project geotechnical engineer or a field representative thereof. Fill soil should not be placed in a frozen condition or on a frozen subgrade.

5.4.1 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 8. 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

5.5 Groundwater Considerations

Based on the groundwater observations made during drilling, seepage and/or groundwater is not anticipated to be encountered during construction at the site. Where/if groundwater is encountered, proper groundwater control measures should be implemented to prevent disturbance to excavation bottoms consisting of cohesive soil, and to prevent the possible development of a quick or “boiling” condition if soft/loose silts and/or fine sands are encountered. It is preferable that the groundwater level, if encountered, be maintained at least 24.0 inches below the deepest excavation. 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.

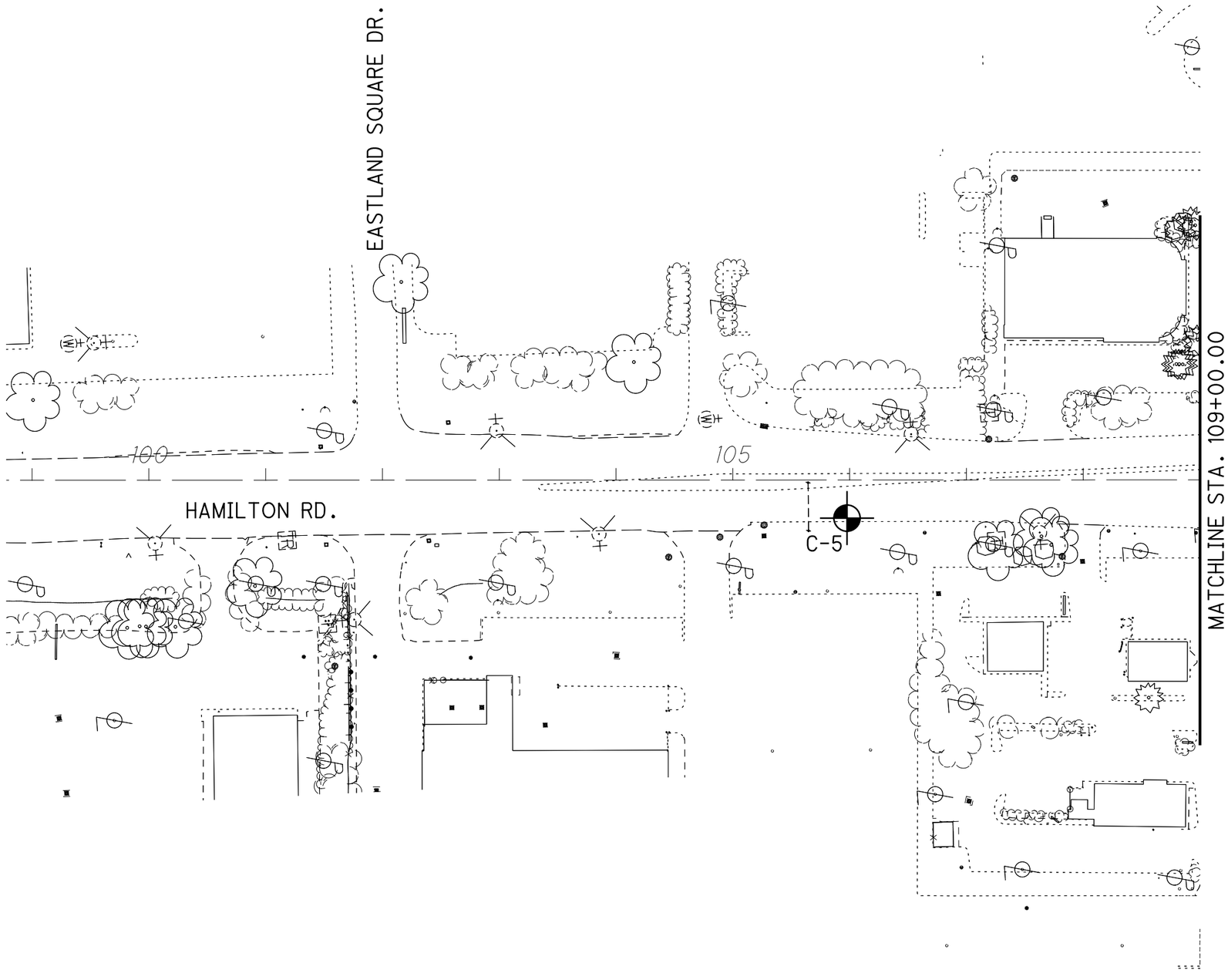
The conclusions and recommendations herein have been based upon the available soil and bedrock information and the design details furnished by a representative of the owner of the proposed project. Any revision in the plans for the proposed construction from those anticipated in this report should be 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



BORING PLAN

HAMILTON ROAD CORRIDOR
FRANKLIN COUNTY, OHIO

RII PROJECT NO. W-13-155		DRAWN RRM
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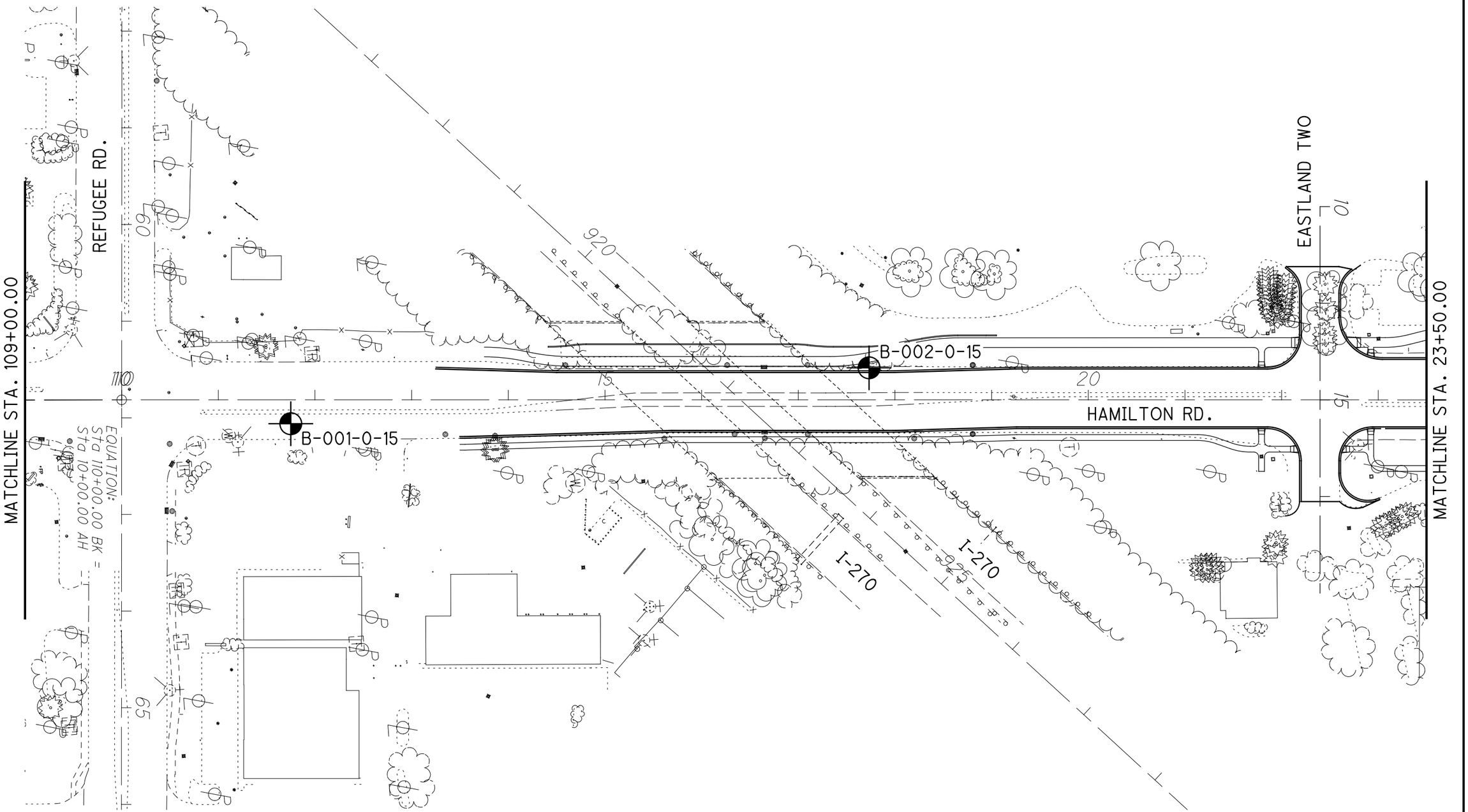
		DATE 5-25-16

RESOURCE INTERNATIONAL Rii



BORING PLAN

HAMILTON ROAD CORRIDOR
FRANKLIN COUNTY, OHIO

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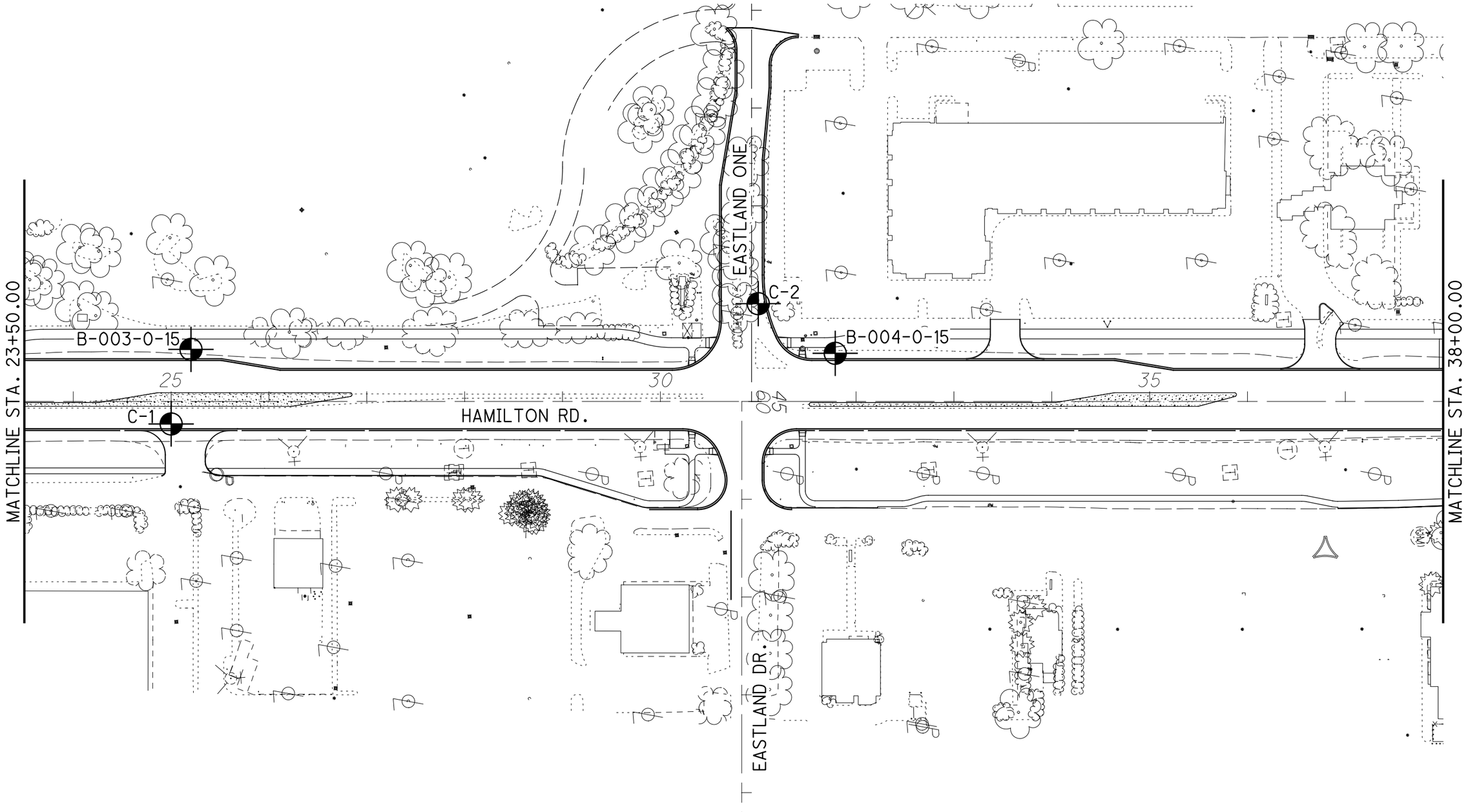
	DATE 5-25-16

RESOURCE INTERNATIONAL



BORING PLAN

HAMILTON ROAD CORRIDOR
FRANKLIN COUNTY, OHIO

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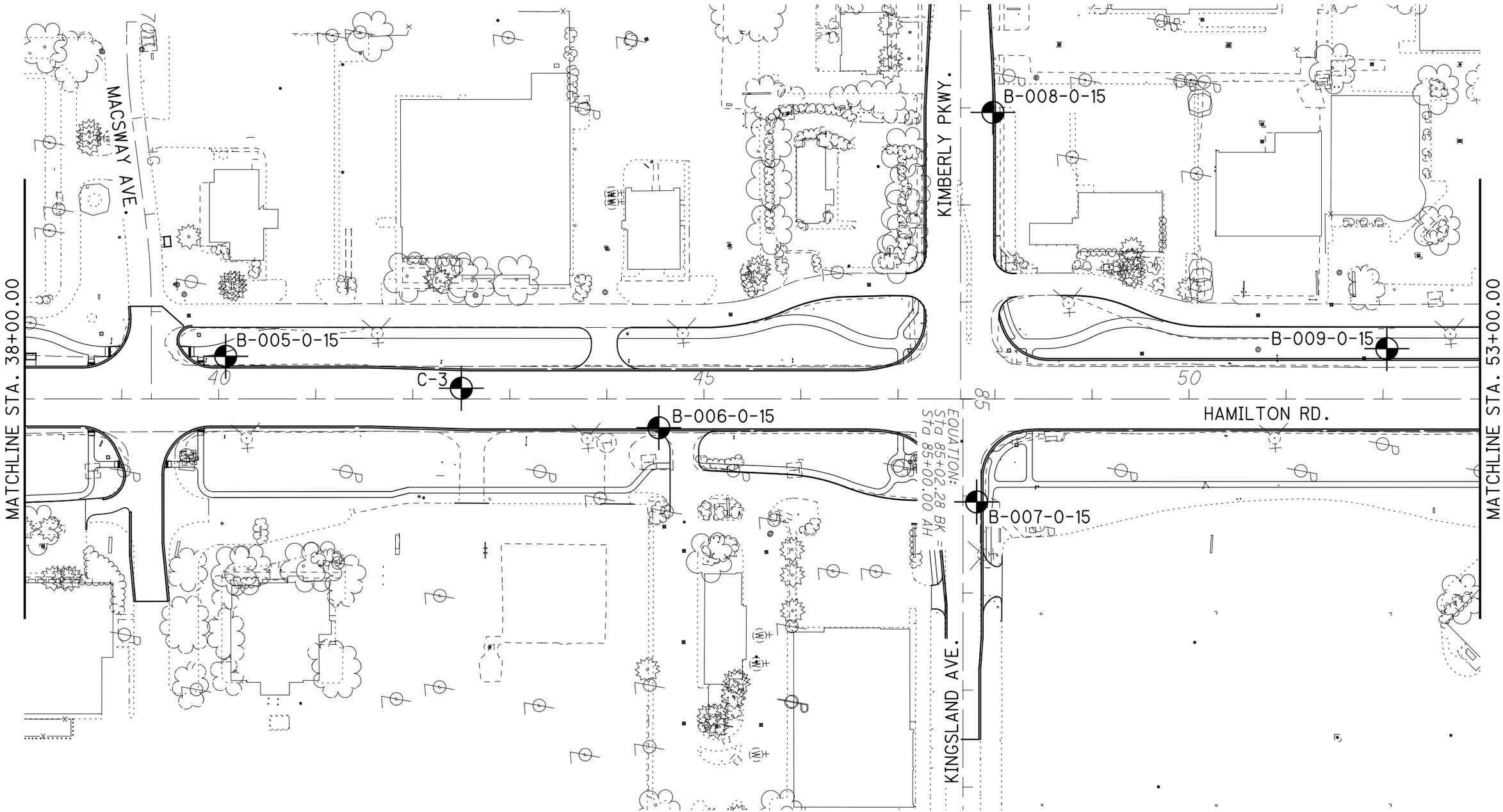
SCALE: 1"=100' 0 50 100	N	REVIEWED BRT
		DATE 5-25-16

RESOURCE INTERNATIONAL Rii



BORING PLAN

HAMILTON ROAD CORRIDOR
FRANKLIN COUNTY, OHIO

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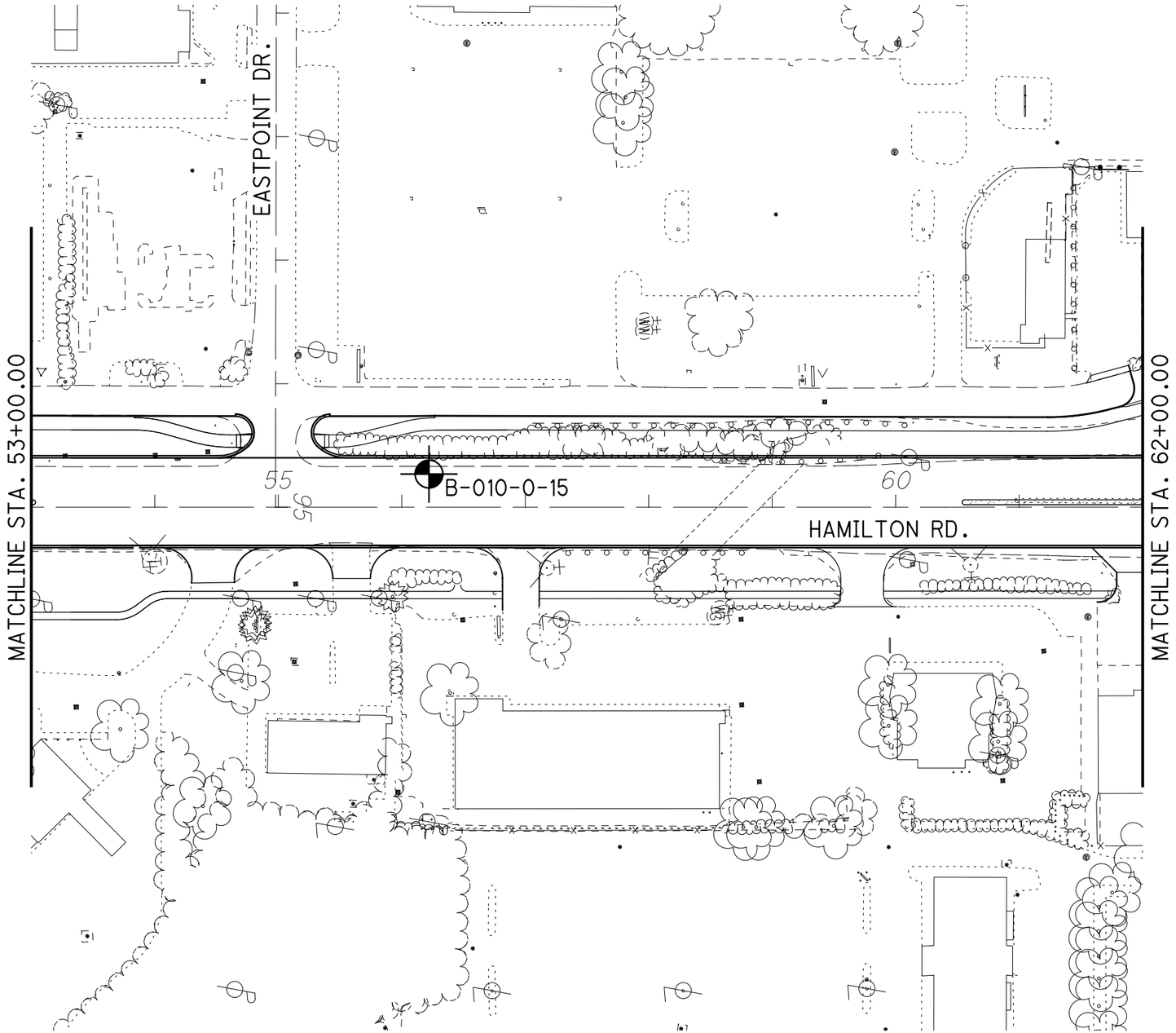
		DATE 5-25-16

RESOURCE INTERNATIONAL Rii



BORING PLAN

HAMILTON ROAD CORRIDOR
FRANKLIN COUNTY, OHIO

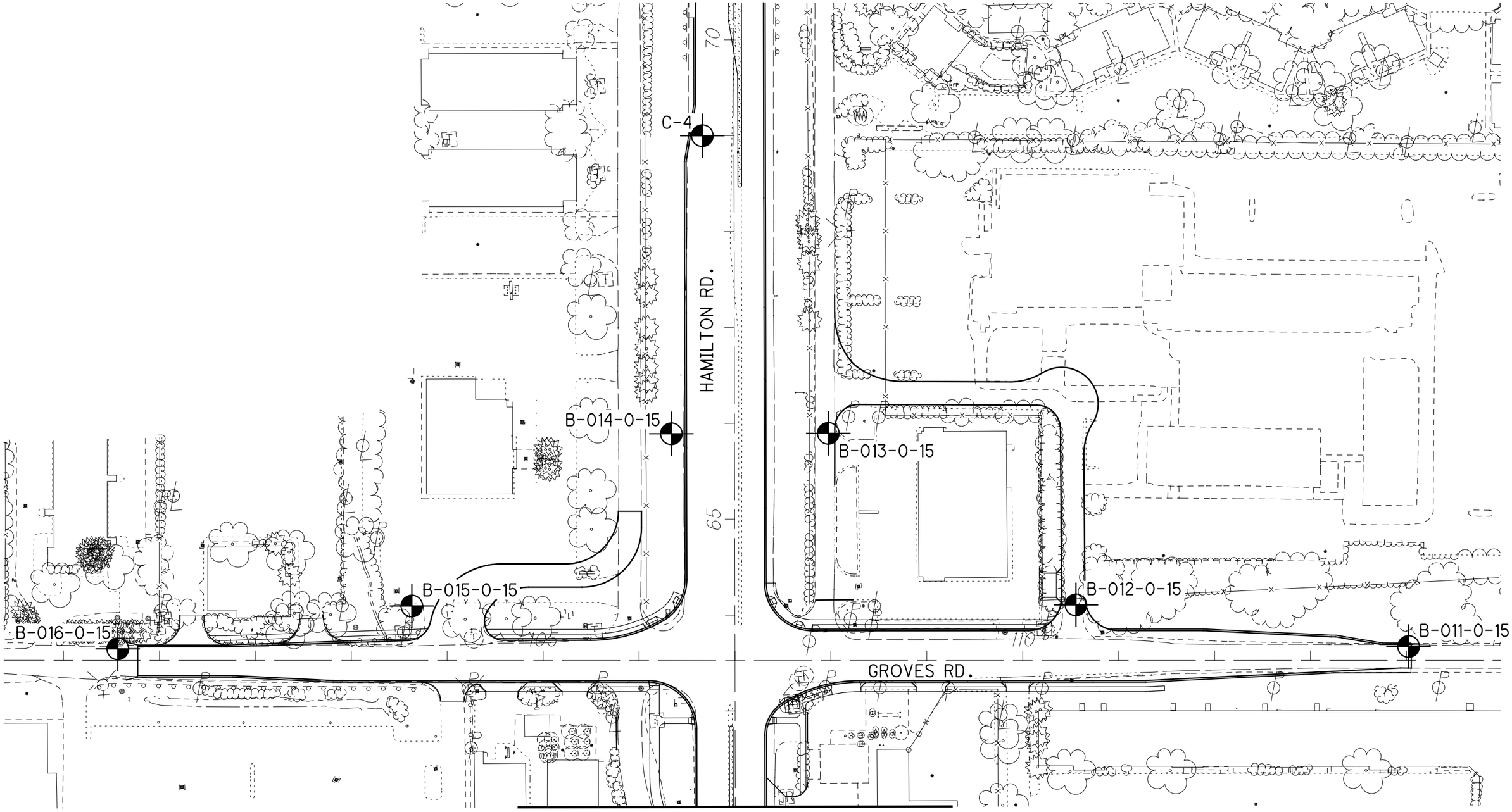
RII PROJECT NO.
W-13-155

SCALE: 1"=100'
0 50 100

DRAWN
RRM

REVIEWED
BRT

DATE
5-25-16



MATCHLINE STA. 62+00.00

BORING PLAN

HAMILTON ROAD CORRIDOR
FRANKLIN COUNTY, OHIO

RII PROJECT NO. W-13-155		DRAWN RRM
SCALE: 1"=100' 0 50 100	N	REVIEWED BRT
		DATE 5-25-16

RESOURCE INTERNATIONAL Rii

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 - The relative compactness of granular soils is described as:
ODOT A-1, A-2, A-3, A-4 (non-plastic) or USCS GW, GP, GM, GC, SW, SP, SM, SC, ML (non-plastic)

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 - The relative consistency of cohesive soils is described as:
ODOT A-4, A-5, A-6, A-7, A-8 or USCS ML, CL, OL, MH, CH, OH, PT

Description	Blows per foot – SPT (N_{60})			Unconfined Compression (tsf)
Very Soft	Below		2	UCS ≤ 0.25
Soft	2	-	4	0.25 < UCS ≤ 0.5
Medium Stiff	5	-	8	0.5 < UCS ≤ 1.0
Stiff	9	-	15	1.0 < UCS ≤ 2.0
Very Stiff	16	-	30	2.0 < UCS ≤ 4.0
Hard	Over		30	UCS > 4.0

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

Soil Fraction		USCS Size	ODOT Size
Boulders		Larger than 12”	Larger than 12”
Cobbles		12” to 3”	12” to 3”
Gravel	coarse	3” to ¾”	3” to ¾“
	fine	¾” to 4.75 mm (¾” to #4 Sieve)	¾” to 2.0 mm (¾” to #10 Sieve)
Sand	coarse	4.75 mm to 2.0 mm (#4 to #10 Sieve)	2.0 mm to 0.42 mm (#10 to #40 Sieve)
	medium	2.0 mm to 0.42 mm (#10 to #40 Sieve)	-
	fine	0.42 mm to 0.074 mm (#40 to #200 Sieve)	0.42 mm to 0.074 mm (#40 to #200 Sieve)
Silt		0.074 mm to 0.005 mm (#200 to 0.005 mm)	0.074 mm to 0.005 mm (#200 to 0.005 mm)
Clay		Smaller than 0.005 mm	Smaller than 0.005 mm

Modifiers of Components - Modifiers of components are as follows:

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 - USCS	Range - ODOT
Dry	0% to 10%	Well below Plastic Limit
Damp	>2% below Plastic Limit	Below Plastic Limit
Moist	2% below to 2% above Plastic Limit	Above PL to 3% below LL
Very Moist	>2% above Plastic Limit	
Wet	[3] Liquid Limit	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 bedrock hardness:

Term		Blows per foot – SPT (N)		
Very Soft		Below		50
Soft		50/5”	–	50/6”
Medium Hard		50/3”	–	50/4”
Hard		50/1”	–	50/2”
Very Hard	50/0”			

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		$LL_0/LL \times 100$*	% 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	
F S	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.	≦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, S-Sedimentary W-Woody F-Fibrous L-Loamy & etc

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

APPENDIX III

BORING LOGS:

B-001-0-15 through B-016-0-15

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-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 11+75 / 25' RT	**EXPLORATION ID B-001-0-15**
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL HAMILTON RD	
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 754.0 (MSL) EOB: 10.0 ft.	PAGE 1 OF 1
START: 12/16/15 END: 12/16/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.916017242, -82.880491784	

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
0.5' - ASPHALT (6.0")	754.0																	
1.0' - CONCRETE (12.0")	753.5																	
	752.5	1																
HARD, BROWN **SILTY CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-1: SULFATE CONTENT = 247 PPM		2	4 5 7	15	67	SS-1	4.5+	5	9	18	31	37	39	18	21	18	A-6b (11)	
	751.0	3																
VERY STIFF TO HARD, BROWN **SANDY SILT**, SOME CLAY, TRACE FINE GRAVEL, DAMP TO MOIST.		4	2 6 7	17	100	SS-2	4.00	10	9	22	37	22	24	15	9	14	A-4a (5)	
		5																
		6																
		7	3 7 18	32	100	SS-3	4.5+	-	-	-	-	-	-	-	-	15	A-4a (V)	
		8																
		9	4 7 10	22	100	SS-4	3.50	-	-	-	-	-	-	-	-	11	A-4a (V)	
	744.0	EOB 10																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 17+73 / 33' LT	**EXPLORATION ID B-002-0-15**	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL HAMILTON RD		
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 745.5 (MSL) EOB: 10.0 ft.		PAGE 1 OF 1
START: 12/15/15 END: 12/15/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.917666823, -82.880543863		

MATERIAL DESCRIPTION AND NOTES	ELEV. 745.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
0.5' - ASPHALT (6.0")	745.0																	
1.0' - CONCRETE (12.0")	744.0																	
HARD, BROWN **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, DAMP. -SS-1A: SULFATE CONTENT = 240 PPM	743.0		4 7 14	27	100	SS-1	4.5+	32	14	14	23	17	26	16	10	11	A-4a (1)	
							-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
MEDIUM DENSE TO DENSE, BROWN **GRAVEL AND SAND**, LITTLE SILT, TRACE CLAY, DAMP TO MOIST.			10 13 21	44	100	SS-2	-	40	30	12	13	5	23	17	6	7	A-1-b (0)	
			8 9 6	19	100	SS-3	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
	735.5	EOB	5 6 7	17	67	SS-4	-	-	-	-	-	-	-	-	-	11	A-1-b (V)	

NOTES: SEEPAGE ENCOUNTERED @ 7.0'; GROUNDWATER ENCOUNTERED INITIALLY @ 8.5' AND AT COMPLETION @ 7.0'; CAVE-IN DEPTH @ 7.5'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER SOIL CUTTINGS

2015-ODOT BORING LOG-BRIDGE ID - OH DOT.GDT - 2/5/16 18:07 - U:\GI8\PROJECTS\2013\W-13-155.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 25+20 / 53' LT	**EXPLORATION ID B-003-0-15**	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL HAMILTON RD		
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 756.6 (MSL) EOB: 12.5 ft.		PAGE 1 OF 1
START: 12/17/15 END: 12/17/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.919716112, -82.880423368		

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
0.3' - TOPSOIL (3.0")	756.6																	
	756.3																	
SOFT TO STIFF, LIGHT BROWN **SILTY CLAY**, LITTLE TO SOME COARSE TO FINE SAND, TRACE TO LITTLE FINE GRAVEL, MOIST.		1																
-SS-1: SULFATE CONTENT = 100 PPM		2	2 3 4	9	100	SS-1	2.00	4	6	13	39	38	39	19	20	21	A-6b (12)	
		3																
		4	1 1 2	4	56	SS-2	0.50	12	10	22	29	27	34	16	18	23	A-6b (7)	
		5																
		6																
		7	1 3 4	9	100	SS-3	2.00	-	-	-	-	-	-	-	-	19	A-6b (V)	
	748.6	8																
VERY LOOSE TO MEDIUM DENSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, MOIST.		9	1 1 2	4	100	SS-4	-	-	-	-	-	-	-	-	-	22	A-2-6 (V)	
		10																
		11																
		12	5 5 10	19	100	SS-5	-	-	-	-	-	-	-	-	-	13	A-2-6 (V)	
	744.1	EOB																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER SOIL CUTTINGS

2015-ODOT BORING LOG-BRIDGE ID - OH DOT.GDT - 2/5/16 18:07 - U:\GI\8\PROJECTS\2013\W-13-155.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 31+79 / 49' LT	**EXPLORATION ID B-004-0-15**	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL HAMILTON RD		
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 760.5 (MSL) EOB: 10.0 ft.	PAGE 1 OF 1	
START: 12/17/15 END: 12/17/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.921517969, -82.880240405		

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
0.5' - ASPHALT (6.0")	760.5																	
0.5' - AGGREGATE BASE (6.0")	760.0																	
STIFF, DARK BROWN **SANDY SILT**, SOME CLAY, SOME FINE GRAVEL, MOIST. -SS-1A: SULFATE CONTENT = 420 PPM	759.5	1	2 5 5	13	67	SS-1	1.50	30	7	10	31	22	26	16	10	16	A-4a (4)	
MEDIUM DENSE, BROWN **GRAVEL AND SAND**, TRACE SILT, TRACE CLAY, DAMP.	758.5	2					-	-	-	-	-	-	-	-	-	5	A-1-b (V)	
VERY STIFF, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.	757.5	3																
		4	3 4 5	12	78	SS-2	2.25	7	13	17	36	27	33	19	14	19	A-6a (7)	
	755.0	5																
MEDIUM STIFF, BROWN **SILTY CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.		6																
		7	WOH 2 2	5	89	SS-3	0.75	-	-	-	-	-	-	-	-	23	A-6b (V)	
		8																
		9	1 2 2	5	33	SS-4	1.00	-	-	-	-	-	-	-	-	23	A-6b (V)	
	750.5	EOB 10																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 40+07 / 44' LT	**EXPLORATION ID B-005-0-15**	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL HAMILTON RD		
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 761.4 (MSL) EOB: 10.0 ft.		PAGE 1 OF 1
START: 12/16/15 END: 12/16/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.923785264, -82.880008962		

MATERIAL DESCRIPTION AND NOTES	ELEV. 761.4	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
0.2' - TOPSOIL (2.0")	761.2																	
MEDIUM STIFF TO STIFF, BROWN **SILTY CLAY**, LITTLE TO SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-1: SULFATE CONTENT = 460 PPM		1																
		2	2 1 2	4	100	SS-1	1.00	4	5	12	47	32	33	17	16	27	A-6b (10)	
		3																
		4	2 3 3	8	100	SS-2	1.50	8	5	16	35	36	38	17	21	23	A-6b (12)	
	755.9	5																
VERY STIFF, BROWN **SILT AND CLAY**, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.		6																
		7	2 5 10	19	100	SS-3	2.50	-	-	-	-	-	-	-	-	14	A-6a (V)	
		8																
		9	4 4 5	12	100	SS-4	3.00	-	-	-	-	-	-	-	-	16	A-6a (V)	
	751.4	EOB 10																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER SOIL CUTTINGS

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RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 44+54 / 30' RT	**EXPLORATION ID B-006-0-15**	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL HAMILTON RD		
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 762.1 (MSL) EOB: 10.0 ft.		PAGE 1 OF 1
START: 12/16/15 END: 12/16/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.924992915, -82.879632540		

MATERIAL DESCRIPTION AND NOTES	ELEV. 762.1	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
0.5' - ASPHALT (6.0")	761.6																	
1.0' - AGGREGATE BASE (12.0")	760.6																	
VERY STIFF TO HARD, BROWN **SILTY CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-1: SULFATE CONTENT = 1,200 PPM		1 2 3 4 5 6 7	5 5 6 7 7 8	14 19	100 100	SS-1 SS-2	4.25 3.75	9 7	11 9	18 21	31 32	31 31	39 38	18 17	21 21	18 18	A-6b (10) A-6b (10)	
	754.1	8	2 3 3	8	100	SS-3	2.50	-	-	-	-	-	-	-	-	19	A-6b (V)	
VERY STIFF, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.	752.1	9 EOB 10	2 5 7	15	100	SS-4	3.75	-	-	-	-	-	-	-	-	15	A-6a (V)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 86+06 / 14' LT	**EXPLORATION ID B-007-0-15**	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL KINGSLAND AVE		
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 760.5 (MSL) EOB: 10.0 ft.		PAGE 1 OF 1
START: 12/15/15 END: 12/15/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.925874798, -82.879276726		

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
0.5' - ASPHALT (6.0")	760.5																	
0.5' - CONCRETE (6.0")	760.0																	
STIFF, BROWN **SANDY SILT**, SOME CLAY, LITTLE FINE GRAVEL, DAMP. -SS-1: SULFATE CONTENT = 247 PPM	759.5	1	1 3 7	13	100	SS-1	1.75	15	10	14	33	28	28	21	7	20	A-4a (5)	
	757.5	2																
VERY STIFF TO HARD, BROWN TO DARK GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.		3																
		4	1 4 6	13	100	SS-2	4.25	8	9	17	36	30	27	16	11	15	A-6a (7)	
		5																
		6	5 6 10	21	100	SS-3	2.50	-	-	-	-	-	-	-	-	11	A-6a (V)	
	752.5	7																
DENSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, MOIST.		8																
		W 9	9 14 10	31	100	SS-4	-	-	-	-	-	-	-	-	-	13	A-2-6 (V)	
	750.5 EOB	10																

NOTES: SEEPAGE ENCOUNTERED @ 9.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER SOIL CUTTINGS

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RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 82+05 / 33' LT	**EXPLORATION ID B-008-0-15**	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL KIMBERLY PKWY		
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 760.7 (MSL) EOB: 10.0 ft.		PAGE 1 OF 1
START: 12/16/15 END: 12/16/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.925999966, -82.880699856		

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
0.3' - ASPHALT (4.0")	760.7																	
0.7' - CONCRETE (8.0")	760.4																	
	759.7																	
STIFF TO VERY STIFF, BROWN **SILTY CLAY**, SOME TO "AND" COARSE TO FINE SAND, TRACE TO LITTLE FINE GRAVEL, MOIST. -SS-1: SULFATE CONTENT = 907 PPM		1	1 4 4	10	56	SS-1	2.75	11	9	18	29	33	35	17	18	21	A-6b (9)	
		2																
		3																
		W 4	1 2 4	8	100	SS-2	1.75	9	11	37	18	25	32	14	18	19	A-6b (4)	
		5																
	755.2	6																
HARD, BROWN **SANDY SILT**, LITTLE CLAY, LITTLE FINE GRAVEL, DAMP.		7	3 6 8	18	100	SS-3	4.50	-	-	-	-	-	-	-	-	10	A-4a (V)	
		8																
		9	4 10 18	36	100	SS-4	4.50	-	-	-	-	-	-	-	-	7	A-4a (V)	
	750.7	EOB 10																

NOTES: SEEPAGE ENCOUNTERED @ 4.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2015-ODOT BORING LOG-BRIDGE ID - OH DOT.GDT - 2/5/16 18:08 - U:\GI8\PROJECTS\2013\W-13-155.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 52+04 / 52' LT	**EXPLORATION ID B-009-0-15**	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL HAMILTON RD		
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 760.5 (MSL) EOB: 10.0 ft.		PAGE 1 OF 1
START: 12/16/15 END: 12/16/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.927063353, -82.879729793		

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
760.5																		
0.1' - TOPSOIL (1.0")	760.4																	
HARD, BROWN **SILTY CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.		1	9 6 6	15	50	SS-1	4.50	9	10	25	29	27	32	16	16	14	A-6b (7)	
-SS-1: SULFATE CONTENT = 233 PPM		2																
	757.5	3																
VERY STIFF TO HARD, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP.		4	3 5 7	15	100	SS-2	2.75	11	8	15	36	30	31	17	14	16	A-6a (8)	
		5																
		6	4 8 9	22	100	SS-3	3.50	-	-	-	-	-	-	-	-	14	A-6a (V)	
		7																
		8																
		9	3 9 13	28	100	SS-4	4.5+	-	-	-	-	-	-	-	-	11	A-6a (V)	
	750.5	EOB 10																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 56+22 / 27' LT	**EXPLORATION ID B-010-0-15**	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL HAMILTON RD		
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 756.1 (MSL) EOB: 10.0 ft.		PAGE 1 OF 1
START: 12/16/15 END: 12/16/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.928203253, -82.879533483		

MATERIAL DESCRIPTION AND NOTES	ELEV. 756.1	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
0.5' - ASPHALT (6.0")	755.6																	
1.0' - AGGREGATE BASE (12.0")	754.6																	
HARD, LIGHT BROWN **SANDY SILT**, SOME CLAY, LITTLE FINE GRAVEL, DAMP. -SS-1: SULFATE CONTENT = 100 PPM	753.1		3 6 5	14	100	SS-1	4.25	18	10	15	32	25	26	17	9	13	A-4a (4)	
STIFF, BROWN **SILTY CLAY**, TRACE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.	752.1		2 5 12	22	100	SS-2	1.75	-	-	-	-	-	-	-	-	22	A-6b (V)	
							4.5+	32	12	16	25	15	22	17	5	14	A-4a (1)	
HARD, BROWN TO DARK GRAY **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, DAMP.	748.1		4 5 6	14	0	SS-3	-	-	-	-	-	-	-	-	-	-		
			12	-	100	3S-3A	4.5+	-	-	-	-	-	-	-	-	10	A-4a (V)	
MEDIUM DENSE, BROWN **GRAVEL WITH SAND, SILT, AND CLAY**, MOIST.	747.1	W	7 12 9	27	100	SS-4	-	-	-	-	-	-	-	-	-	8	A-2-6 (V)	
HARD, GRAY **SILT AND CLAY**, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, DRY.	746.1						4.5+	-	-	-	-	-	-	-	-	9	A-6a (V)	
		EOB																

NOTES: SEEPAGE ENCOUNTERED @ 8.7'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER SOIL CUTTINGS

2015-ODOT BORING LOG-BRIDGE ID - OH DOT.GDT - 2/5/16 18:08 - U:\GI8\PROJECTS\2013\W-13-155.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 114+02 / 14' LT	**EXPLORATION ID B-011-0-15**	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL GROVES RD		
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 765.7 (MSL) EOB: 10.0 ft.		PAGE 1 OF 1
START: 12/17/15 END: 12/17/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.930095678, -82.876749784		

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
0.5' - ASPHALT (6.0")	765.7																	
0.5' - CONCRETE (6.0")	765.2																	
VERY STIFF, MOTTLED GRAY & BROWN **CLAY**, SOME SILT, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-1: SULFATE CONTENT = 600 PPM	764.7	1	2 3 3	8	50	SS-1	3.50	6	7	16	33	38	43	18	25	23	A-7-6 (14)	
	762.7	2																
VERY STIFF TO HARD, MOTTLED GRAY & BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP TO MOIST.		3																
		4	2 9 7	21	67	SS-2	2.75	15	10	21	31	23	28	15	13	15	A-6a (5)	
		5																
		6																
		7	2 7 5	15	89	SS-3	4.25	-	-	-	-	-	-	-	-	14	A-6a (V)	
		8																
		9																
	755.7	EOB 10	6 8 10	23	100	SS-4	4.5+	-	-	-	-	-	-	-	-	10	A-6a (V)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 110+55 / 58' LT	**EXPLORATION ID B-012-0-15**	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL GROVES RD		
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 764.2 (MSL) EOB: 10.0 ft.		PAGE 1 OF 1
START: 12/17/15 END: 12/17/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.930284929, -82.877971440		

MATERIAL DESCRIPTION AND NOTES	ELEV. 764.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
0.2' - ASPHALT (2.5")	764.0																	
0.8' - CONCRETE (9.5")	763.2																	
1.0' - AGGREGATE BASE (12.0")	762.2																	
HARD, BROWN **SANDY SILT**, LITTLE CLAY, LITTLE FINE GRAVEL, DAMP TO MOIST. -SS-1: SULFATE CONTENT = 820 PPM			2 3 5	10	78	SS-1	4.5+	15	12	18	35	20	25	17	8	16	A-4a (4)	
			3 3 5	10	100	SS-2	4.5+	13	11	24	36	16	23	17	6	13	A-4a (3)	
	759.7						1.00	-	-	-	-	-	-	-	-	23	A-4a (V)	
MEDIUM STIFF, BROWN **SANDY SILT**, TRACE CLAY, TRACE FINE GRAVEL, WET.	758.7																	
VERY STIFF, DARK GRAY **SILT AND CLAY**, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.			2 3 4	9	100	SS-3	4.00	-	-	-	-	-	-	-	-	11	A-6a (V)	
	756.2																	
MEDIUM DENSE, DARK GRAY **GRAVEL WITH SAND, SILT, AND CLAY**, DAMP.			3 5 6	14	100	SS-4	-	-	-	-	-	-	-	-	-	10	A-2-6 (V)	
	754.2	EOB																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER SOIL CUTTINGS

2015-ODOT BORING LOG-BRIDGE ID - OH DOT.GDT - 2/5/16 18:08 - U:\GI8\PROJECTS\2013\W-13-155.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 107+97 / 237' LT	**EXPLORATION ID B-013-0-15**
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL GROVES RD	
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 762.5 (MSL) EOB: 10.0 ft.	PAGE 1 OF 1
START: 12/21/15 END: 12/21/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.930827050, -82.878842016	

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
0.2' - ASPHALT (2.0")	762.5																	
0.5' - CONCRETE (6.0")	762.3																	
STIFF, BROWN **SILTY CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -SS-1: SULFATE CONTENT = 60 PPM	761.8	1	3 4 4	10	100	SS-1	1.75	9	10	20	27	34	37	17	20	22	A-6b (9)	
	759.5	2																
VERY STIFF, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP.		3																
		4	3 5 6	14	100	SS-2	3.25	19	22	13	27	19	33	19	14	16	A-6a (3)	
	757.0	5																
MEDIUM DENSE TO DENSE, BROWN AND BLACK **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP TO MOIST.		6																
		7	6 9 12	27	100	SS-3	-	-	-	-	-	-	-	-	-	10	A-2-4 (V)	
		8																
		9	9 12 14	33	100	SS-4	-	-	-	-	-	-	-	-	-	8	A-2-4 (V)	
	752.5	10																
		EOB																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 65+89 / 66' LT	**EXPLORATION ID B-014-0-15**	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL HAMILTON RD		
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 763.1 (MSL) EOB: 10.0 ft.		PAGE 1 OF 1
START: 12/17/15 END: 12/17/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.930859056, -82.879423929		

MATERIAL DESCRIPTION AND NOTES	ELEV. 763.1	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
3.0" - TOPSOIL (3.0")	762.9																	
VERY STIFF TO HARD, BROWN TO DARK GRAY **SANDY SILT**, LITTLE TO SOME CLAY, LITTLE TO SOME FINE GRAVEL, DAMP.		1																
-SS-1: SULFATE CONTENT = 320 PPM		2	4 6 9	19	100	SS-1	3.75	13	12	19	31	25	25	15	10	14	A-4a (4)	
		3																
		4	16 15 11	33	39	SS-2	4.50	-	-	-	-	-	-	-	-	12	A-4a (V)	
		5																
		6																
		7	3 4 5	12	100	SS-3	2.50	24	14	18	34	10	22	15	7	7	A-4a (2)	
		8																
		9	4 7 7	18	100	SS-4	4.5+	-	-	-	-	-	-	-	-	9	A-4a (V)	
	753.1 EOB	10																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 25 LBS BENTONITE CHIPS AND SOIL CUTTINGS

2015-ODOT BORING LOG-BRIDGE ID - OH DOT.GDT - 2/5/16 18:08 - U:\GI8\PROJECTS\2013\W-13-155.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 103+63 / 57' LT	**EXPLORATION ID B-015-0-15**
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL GROVES RD	
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 759.0 (MSL) EOB: 25.0 ft.	PAGE 1 OF 1
START: 12/21/15 END: 12/21/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.930422221, -82.880433336	

MATERIAL DESCRIPTION AND NOTES	ELEV. 759.0	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
0.3' - TOPSOIL (3.0")	758.7																	
STIFF TO VERY STIFF, BROWN **SILT AND CLAY**, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP. -SS-1: SULFATE CONTENT = 420 PPM	753.5		3 4 6	13	44	SS-1	3.75	14	10	15	32	29	34	19	15	18	A-6a (7)	
VERY STIFF, BROWN **SANDY SILT**, SOME FINE GRAVEL, LITTLE CLAY, DAMP.	751.0		2 3 4	9	100	SS-2	1.50	-	-	-	-	-	-	-	-	16	A-6a (V)	
MEDIUM DENSE, BLACK, BROWN AND GRAY **GRAVEL WITH SAND AND SILT**, TRACE CLAY, MOIST.	748.5	W	4 6 9	19	100	SS-3	3.00	25	14	15	33	13	21	15	6	11	A-4a (2)	
HARD, GRAY **SANDY SILT**, SOME CLAY, LITTLE FINE GRAVEL, DAMP.	737.3		9 8 9	22	100	SS-4	-	-	-	-	-	-	-	-	-	12	A-2-4 (V)	
			10 10 11	27	100	SS-5	4.5+	-	-	-	-	-	-	-	-	10	A-4a (V)	
			8 14 21	45	100	SS-6	4.5+	-	-	-	-	-	-	-	-	10	A-4a (V)	
			8 12 14	33	100	SS-7	4.5+	11	11	16	40	22	24	14	10	12	A-4a (5)	
			6 9 11	26	67	SS-8	4.5+	-	-	-	-	-	-	-	-	13	A-4a (V)	
MEDIUM DENSE, GRAY **GRAVEL WITH SAND AND SILT**, TRACE CLAY, MOIST.	734.0	EOB	5 8 13	27	56	SS-9	-	-	-	-	-	-	-	-	-	15	A-2-4 (V)	

NOTES: GROUNDWATER ENCOUNTERED INITIALLY @ 10.0' AND AT COMPLETION @ 9.0'; CAVE-IN DEPTH @ 11.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 100 LB. BENTONITE CHIPS AND SOIL CUTTINGS BENTONITE CHIPS AND SOIL CUTTINGS

2015-ODOT BORING LOG-BRIDGE ID - OH DOT.GDT - 2/5/16 18:08 - U:\GI8\PROJECTS\2013\W-13-155.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: FRA-317-10.63	DRILLING FIRM / OPERATOR: RII / S.B.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 100+57 / 12' LT	**EXPLORATION ID B-016-0-15**	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / C.D.	HAMMER: AUTOMATIC	ALIGNMENT: EX CL GROVES RD		
PID: 95570 BR ID: N/A	DRILLING METHOD: 4.5" SFA	CALIBRATION DATE: 5/13/15	ELEVATION: 760.0 (MSL) EOB: 10.0 ft.		PAGE 1 OF 1
START: 12/17/15 END: 12/17/15	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.930362203, -82.881535164		

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
0.5' - ASPHALT (6.0")	760.0																	
1.0' - AGGREGATE BASE (12.0")	759.5																	
STIFF TO VERY STIFF, BROWN TO MOTTLED BROWN AND GRAY **SILT AND CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP TO MOIST. -SS-1: SULFATE CONTENT = 713 PPM	758.5	1																
		2	5 5 4	12	72	SS-1	3.75	3	7	19	38	33	31	17	14	17	A-6a (9)	
		3																
		4	1 2 2	5	100	SS-2	1.25	6	8	18	37	31	35	20	15	27	A-6a (9)	
		5																
		6	2 3 4	9	94	SS-3	3.00	-	-	-	-	-	-	-	-	21	A-6a (V)	
		7																
		8																
		9	3 6 9	19	44	SS-4	3.50	-	-	-	-	-	-	-	-	14	A-6a (V)	
	750.0	EOB 10																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER SOIL CUTTINGS

APPENDIX IV

PAVEMENT CORE DATA SHEETS

6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT	Hamilton Road Corridor
LOCATION	Columbus, Ohio
JOB No.	W-13-155
BORING/CORE No.	C-1
DATE CORE OBTAINED	1/29/2016
CORE OBTAINED BY	C.D./N.A.

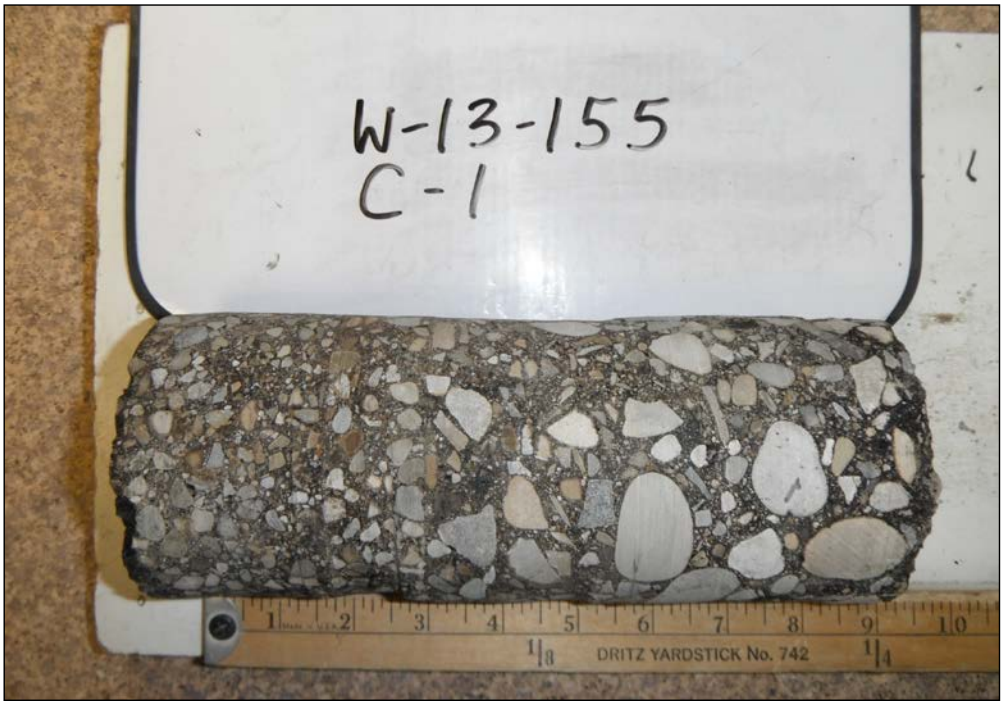
Core Composition

Core Number	Lift Thickness (in.)	Asphalt: 404	Asphalt: 402	Asphalt: 301	Concrete	Aggregate/Granular Base	Other			
C-1	2.25	✓								
	1.00	✓								
	2.00		✓							
	3.50			✓						
	6.00					✓				

Comments/Remarks

- Air voids evident in the top lift of 404 ashalt
- Bottom lift of 404 asphalt appears to be in good condition with only trace air voids evident
- Slight deterioration present along the bottom inch of 301 asphalt
- Difficult to distinguish layer separation between 402 and 301 lifts of asphalt
- Overall condition of asphalt and core is good

Total Pavement Thickness =	8.75	in.	Total Asphalt Thickness =	8.75	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	6.00	in.



6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT	Hamilton Road Corridor
LOCATION	Columbus, Ohio
JOB No.	W-13-155
BORING/CORE No.	C-2
DATE CORE OBTAINED	1/29/2016
CORE OBTAINED BY	C.D./N.A.

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: 404	Asphalt: 402	Asphalt: 301	Concrete	Aggregate/Granular Base	Other			
C-2	2.00	✓								
	1.00	✓								
	3.50	✓								
	2.00					✓				

Comments/Remarks

- Core appears to consist of three (3) lifts of 404 asphalt
- Trace air voids present in each lift, with slightly more evident at the base of the top lift
- Some base material still adhered to bottom of core
- Overall condition of asphalt and core is good

Total Pavement Thickness =	6.50	in.	Total Asphalt Thickness =	6.50	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	2.00	in.

6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT	Hamilton Road Corridor
LOCATION	Columbus, Ohio
JOB No.	W-13-155
BORING/CORE No.	C-3
DATE CORE OBTAINED	1/29/2016
CORE OBTAINED BY	C.D./N.A.

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: 404	Asphalt: 402	Asphalt: 301	Concrete	Aggregate/Granular Base	Other			
C-3	2.00	✓								
	1.75		✓							
	5.25			✓						
	7.00					✓				

Comments/Remarks

- Tack coat evident between the 402 and 404 lifts of asphalt
- A vertical crack extends 6.0 inches from top of the core down through the 404 and 402 lifts of asphalt and into the 301 lift of asphalt
- Slight weathering evident within the vertical crack
- Slight deterioration evident along the bottom of 301 asphalt
- Difficult to distinguish layer separation between 402 and 301 lifts of asphalt
- Overall condition of asphalt and core is fair to good

Total Pavement Thickness =	9.00 in.	Total Asphalt Thickness =	9.00 in.	Total Concrete Thickness =	0.00 in.	Total Base Thickness =	7.00 in.

6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT	Hamilton Road Corridor
LOCATION	Columbus, Ohio
JOB No.	W-13-155
BORING/CORE No.	C-4
DATE CORE OBTAINED	1/29/2016
CORE OBTAINED BY	C.D./N.A.

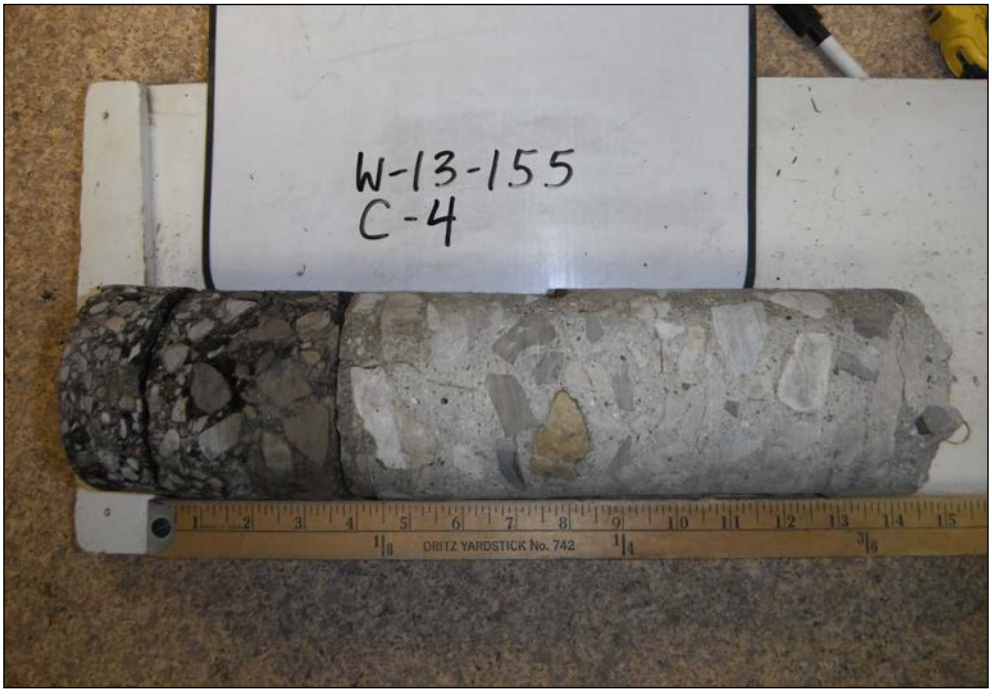
Core Composition

Core Number	Lift Thickness (in.)	Asphalt: 404	Asphalt: 402	Asphalt: 301	Concrete	Aggregate/Granular Base	Other			
C-4	1.25	✓								
	3.25		✓							
	9.50				✓					
	6.50					✓				

Comments/Remarks

- Core is separated between the 404 and 402 lifts of asphalt and also between the asphalt and concrete sections of the core
- Both lifts of asphalt are significantly deteriorated and slightly friable
- Air voids evident throughout asphalt
- Concrete is in fair condition, but has very small vertical and horizontal cracks throughout
- Rebar or wire mesh at 3.5 inches below the top of the concrete section of the core, which appears to be highly corroded and degraded

Total Pavement Thickness =	14.00 in.	Total Asphalt Thickness =	4.50 in.	Total Concrete Thickness =	9.50 in.	Total Base Thickness =	6.50 in.



6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT: Hamilton Road Corridor
LOCATION: Columbus, Ohio
JOB No.: W-13-155

BORING/CORE No.: C-5
DATE CORE OBTAINED: 5/12/2016
CORE OBTAINED BY: C.D./S.B.

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: 404	Asphalt: 402	Asphalt: 301	Concrete	Aggregate/Granular Base	Other			
C-5	0.75	✓								
	1.00	✓								
	1.00	✓								
	2.00		✓							
	9.00				✓					
	9.00					✓				

Comments/Remarks

- Core has separated between the lower 404 and 402 lifts of asphalt and between the lower and middle lifts of 404 asphalt, as well as between the asphalt and concrete sections of the core
- The upper two lifts of 404 asphalt have broken apart vertically and the lower lift of 404 asphalt has broken into three pieces
- Some deterioration is evident along the surfaces of the asphalt at all of the breaks
- Concrete has broken into four pieces with deterioration evident at the breaks
- Air voids and stress fractures are evident throughout the concrete
- Base material visually identified as 304 aggregate

Total Pavement Thickness =	13.75 in.	Total Asphalt Thickness =	4.75 in.	Total Concrete Thickness =	9.00 in.	Total Base Thickness =	9.00 in.

APPENDIX V

GB1 SUBGRADE STABILIZATION SUMMARY

Subgrade Analysis

V. 12.00 12/30/11

Design CBR 7

Global Options		
320	R&R	No
206	CS	Option
	LS	No
	LKD	Option
206	Depth	14

Classification Counts by Sample																	
R	1a	1b	3	3a	2-4	2-5	2-6	2-7	4a	4b	5	6a	6b	7-5	7-6	8a	8b
0	0	3	0	0	3	0	3	0	18	0	0	20	16	0	1	0	0
		5%			5%		5%		28%			31%	25%		2%		
0%	14%								86%								

Surface Class		
2-5	0	
4b	0	
5	0	
7-5	0	
7-6	1	6%
8a	0	
8b	0	
R	0	

% Borings	
N_{60L}<= 5	25%
<=10	63%
>=20	0%
M+	81%
R	0%

% Surface	
56%	
0%	56%

Rig	ER
A	77
B	
C	
D	
E	
F	
G	
H	

UC @ Surface
16.1
30
12

Total Borings	16
PID	95570
Location	FRA-317-10.63

	N_{60}	N_{60L}	PI	Clay	M	M_{OPT}	GI
Average	16.3	9.8	13.7	25.9	15.2	12.9	6.48
Maximum	44	17	25	38	27	18	14
Minimum	4	4	5	5	7	6	0

	Boring					Subgrade		Standard Penetration						Physical Characteristics						Moisture		Class		Comments	Problem		Undercuts		Analysis
#	B #	Boring Location	Depth	To	Cut Fill	Depth	To	n_2	n_3	N	Rig	N_{60}	N_{60L}	LL	PL	PI	% Silt	% Clay	P 200	M	M_{OPT}	Ohio DOT	GI		w/ Class	w/ MN	UC Class	UC MN	
1	B-001-0-15	11+75, 25' Rt.	1.0	2.5	0.0	1.0	2.5	5	7	12	A	15		39	18	21	31	37	68	18	16	6b	11						
		Ex. CL Hamilton Rd.	2.5	4.0		2.5	4.0	6	7	13		17		24	15	9	37	22	59	14	10	4a	5	Sulfate Content					No Stabilization
		Surface El. = 754.0	4.0	5.5		4.0	5.5	7	18	25		32								15	10	4a	5	= 247 ppm					Anticipated
			5.5	7.0		5.5	7.0	7	10	17		22	15							11	10	4a							
2	B-002-0-15	17+73, 33' Lt.	1.0	2.5	0.0	1.0	2.5	7	14	21	A	27		26	16	10	23	17	40	11	11	4a	1						
		Ex. CL Hamilton Rd.	2.5	4.0		2.5	4.0	13	21	34		44		23	17	6	13	5	18	7	6	1b	0	Sulfate Content					No Stabilization
		Surface El. = 745.5	4.0	5.5		4.0	5.5	9	6	15		19								8	6	1b	0	= 240 ppm					Anticipated
			5.5	7.0		5.5	7.0	6	7	13		17	17							11	6	1b							
3	B-003-015	25+20, 53' Lt.	1.0	2.5	0.0	1.0	2.5	3	4	7	A	9		39	19	20	39	38	77	21	16	6b	12			N		16	
		Ex. CL Hamilton Rd.	2.5	4.0		2.5	4.0	1	2	3		4		34	16	18	29	27	56	23	16	6b	7	Sulfate Content		N		30	14 in Cement
		Surface El. = 756.6	4.0	5.5		4.0	5.5	3	4	7		9								19	16	6b	10	= 100 ppm		N		16	18 in Undercut
			5.5	7.0		5.5	7.0	1	2	3		4	4							22	10	2-6				N		30	
4	B-004-0-15	31+79, 49' Lt.	1.0	2.5	0.0	1.0	2.5	5	5	10	A	13		26	16	10	31	22	53	16	11	4a	4			MN		12	
		Ex. CL Hamilton Rd.	2.5	4.0		2.5	4.0	4	5	9		12		33	19	14	36	27	63	19	14	6a	7	Sulfate Content		MN		12	14 in Cement
		Surface El. = 760.5	4.0	5.5		4.0	5.5	2	2	4		5								23	16	6b	10	= 420 ppm		N		27	18 in Undercut
			5.5	7.0		5.5	7.0	2	2	4		5	5							23	16	6b				N		27	
5	B-005-0-015	40+07, 44' Lt.	1.0	2.5	0.0	1.0	2.5	1	2	3	A	4		33	17	16	47	32	79	27	16	6b	10			N		30	
		Ex. CL Hamilton Rd.	2.5	4.0		2.5	4.0	3	3	6		8		38	17	21	35	36	71	23	16	6b	12	Sulfate Content		N		18	14 in Cement
		Surface El. = 761.4	4.0	5.5		4.0	5.5	5	10	15		19								14	14	6a	8	= 460 ppm					18 in Undercut
			5.5	7.0		5.5	7.0	4	5	9		12	4							16	14	6a							
6	B-006-0-15	44+54, 30' Rt.	1.0	2.5	0.0	1.0	2.5	5	6	11	A	14		39	18	21	31	31	62	18	16	6b	10						
		Ex. CL Hamilton Rd.	2.5	4.0		2.5	4.0	7	8	15		19		38	17	21	32	31	63	18	16	6b	10	Sulfate Content					No Stabilization
		Surface EL. 762.1	4.0	5.5		4.0	5.5	3	3	6		8								19	16	6b	10	= 1,200 ppm		N		18	Anticipated
			5.5	7.0		5.5	7.0	5	7	12		15	8							15	14	6a							
7	B-007-0-15	86+06, 14' Lt.	1.0	2.5	0.0	1.0	2.5	3	7	10	A	13		28	21	7	33	28	61	20	16	4a	5			MN		12	
		Ex. CL Kingsland Ave.	2.5	4.0		2.5	4.0	4	6	10		13		27	16	11	36	30	66	15	14	6a	7	Sulfate Content					12 in Cement
		Surface El. 760.5	4.0	5.5		4.0	5.5	6	10	16		21								11	14	6a	8	= 247 ppm					12 in Undercut
			5.5	7.0		5.5	7.0	14	10	24		31	13							13	10	2-6							
8	B-008-0-15	82+05, 33' Lt.	1.0	2.5	0.0	1.0	2.5	4	4	8	A	10		35	17	18	29	33	62	21	16	6b	9			N		15	
		Ex. CL Kimberly Pkwy.	2.5	4.0		2.5	4.0	2	4	6		8		32	14	18	18	25	43	19	16	6b	4	Sulfate Content		N		18	14 in Cement
		Surface El. 760.7	4.0	5.5		4.0	5.5	6	8	14		18								10	10	4a	5	= 907 ppm					18 in Undercut
			5.5	7.0		5.5	7.0	10	18	28		36	8							7	10	4a							
9	B-009-0-15	52+04, 52' Lt.	1.0	2.5	0.0	1.0	2.5	6	6	12	A	15		32	16	16	29	27	56	14	16	6b	7						
		Ex. CL Hamilton Rd.	2.5	4.0		2.5	4.0	5	7	12		15		31	17	14	36	30	66	16	14	6a	8	Sulfate Content					No Stabilization
		Surface El. 760.5	4.0	5.5		4.0	5.5	8	9	17		22								14	14	6a	8	= 233 ppm					Anticipated
			5.5	7.0		5.5	7.0	9	13	22		28	15							11	14	6a							
10	B-010-0-15	56+22, 27' Lt.	1.0	2.5	0.0	1.0	2.5	6	5	11	A	14		26	17	9	32	25	57	13	12	4a	4						
		Ex. CL Hamilton Rd.	2.5	4.0		2.5	4.0	5	12	17		22		22	17	5	25	15	40	14	16	6b	1	Sulfate Content					No Stabilization
		Surface El. 756.1	4.0	5.5		4.0	5.5	5	6	11		14								10	10	4a	5	= 100 ppm					Anticipated
			5.5	7.0		5.5	7.0	12	9	21		27	14							8	10	4a							
11	B-011-0-15	114+02, 14' Lt.	1.0	2.5	0.0	1.0	2.5	3	3	6	A	8		43	18	25	33	38	71	23	18	7-6	14			N		18	
		Ex. CL Groves Rd.	2.5	4.0		2.5	4.0	9	7	16		21		28	15	13	31	23	54	15	14	6a	5	Sulfate Content					14 in Cement
		Surface El. 765.7	4.0	5.5		4.0	5.5	7	5	12		15								14	14	6a	8	= 600 ppm					18 in Undercut
			5.5	7.0		5.5	7.0	8	10	18		23	8							10	14	6a							
12	B-012-0-15	110+55, 58' Lt.	1.0	2.5	0.0	1.0	2.5	3	5	8	A	10		25	17	8	35	20	55	16	12	4a	4			N		15	
		Ex. CL Groves Rd.	2.5	4.0		2.5	4.0	3	5	8		10		23	17	6	36	16	52	13	12	4a	3	Sulfate Content		N		15	14 in Cement
		Surface El. 764.2	4.0	5.5		4.0	5.5	3	4	7		9								11	14	6a	8	= 820 ppm		N		16	18 in Undercut
			5.5	7.0		5.5	7.0	5	6	11		14	9							10	10	2-6							

	Boring					Subgrade		Standard Penetration						Physical Characteristics						Moisture		Class		Comments	Problem		Undercuts		Analysis
#	B #	Boring Location	Depth	To	Cut Fill	Depth	To	n_2	n_3	N	Rig	N_{60}	N_{60L}	LL	PL	PI	% Silt	% Clay	P 200	M	M_{OPT}	Ohio DOT	GI		w/ Class	w/ MN	UC Class	UC MN	
13	B-013-0-15	107+97, 237' Lt.	1.0	2.5	0.0	1.0	2.5	4	4	8	A	10		37	17	20	27	34	61	22	16	6b	9			N		15	
		Ex. CL Groves Rd.	2.5	4.0		2.5	4.0	5	6	11		14		33	19	14	27	19	46	16	14	6a	3	Sulfate Content					14 in Cement
		Surface El. 762.5	4.0	5.5		4.0	5.5	9	12	21		27								10	10	2-4	0	= 60 ppm					18 in Undercut
			5.5	7.0		5.5	7.0	12	14	26		33	10							8	10	2-4							
14	B-014-0-15	65+89, 66' Lt.	1.0	2.5	0.0	1.0	2.5	6	9	15	A	19		25	15	10	31	25	56	14	10	4a	4						
		Ex. CL Hamilton Rd.	2.5	4.0		2.5	4.0	15	11	26		33								12	10	4a	5	Sulfate Content					No Stabilization
		Surface El. 763.1	4.0	5.5		4.0	5.5	4	5	9		12		22	15	7	34	10	44	7	10	4a	2	=320 ppm					Anticipated
			5.5	7.0		5.5	7.0	7	7	14		18	12							9	10	4a							
15	B-015-0-15	103+63, 57' Lt.	1.0	2.5	0.0	1.0	2.5	4	6	10	A	13		34	19	15	32	29	61	18	14	6a	7			MN		12	
		Ex. CL Groves Rd.	2.5	4.0		2.5	4.0	3	4	7		9								16	14	6a	8	Sulfate Content		N		16	No Stabilization
		Surface El. 759.0	4.0	5.5		4.0	5.5	6	9	15		19		21	15	6	33	13	46	11	10	4a	2	=420 ppm					Anticipated
			5.5	7.0		5.5	7.0	8	9	17		22	9							12	10	2-4							
16	B-016-0-15	100+57, 12' Lt.	1.0	2.5	0.0	1.0	2.5	5	4	9	A	12		31	17	14	38	33	71	17	14	6a	9						
		Ex. CL Groves Rd.	2.5	4.0		2.5	4.0	2	2	4		5		35	20	15	37	31	68	27	15	6a	9	Sulfate Content		N		27	No Stabilization
		Surface El. 760.0	4.0	5.5		4.0	5.5	3	4	7		9								21	14	6a	8	=713 ppm		N		16	Anticipated
			5.5	7.0		5.5	7.0	6	9	15		19	5							11	14	6a							

APPENDIX VI

SHALLOW FOUNDATION CALCULATIONS

W-13-155 FRA-317-10.63 - Hamilton Road Corridor

Shallow Foundation Bearing Resistance - 9.0 ft. x 4.5 ft. Concrete Box Culvert

B =	9.0	ft	
L =	70	ft	
c =	2,500	psf	
γ =	120	pcf	
D_f =	0.0	ft	
φ =	0	deg	
D_w =	0.0	ft	Below ground surface

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + \tfrac{1}{2}\gamma B N_{\gamma m} C_{w\gamma} = 13.17 \text{ ksf}$$

$N_{cm} = N_c s_c i_c$ = 5.27 $N_{qm} = N_q s_q d_q i_q$ = 1.00 $N_{\gamma m} = N_\gamma s_\gamma i_\gamma$ = 0.00

N_c =	5.14	s_c =	1.025	i_c =	1.000	d_q =	1.000
N_q =	1.00	s_q =	1.000	i_q =	1.000	C_{wq} =	1.000
N_γ =	0.00	s_γ =	0.949	i_γ =	1.000	$C_{w\gamma}$ =	0.500

$$q_R = q_n \cdot \phi_b = 6.59 \text{ ksf}$$

φ_b = 0.5

W-13-155 FRA-317-10.63 - Hamilton Road Corridor

Shallow Foundation Settlement - 9.0 ft. x 4.5 ft. Concrete Box Culvert

Calculated By: PM Date: 2/4/2016

Checked By: BRT Date: 2/4/2016

Boring B-015-0-15

B =	9.0	ft	
D_w =	0.0	ft	
q =	2,775	psf	Applied loading from structure
q_{net} =	2,085	psf	Net loading from structure (considers initial overburden stress of 690 psf)

Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' (psf) [1]	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)
1	A-4a	C	0.0	2.0	2.0	1.0	120	240	120	58	2,058	21	0.099	0.010	0.436				0.11	0.996	2,076	2,133	0.024	0.283
2	A-2-4	G	2.0	4.5	2.5	3.3	125	553	396	193	2,193					22	39	128	0.36	0.904	1,885	2,078	0.020	0.242
3	A-4a	C	4.5	6.0	1.5	5.3	125	740	646	319	2,319	24	0.126	0.009	0.460				0.58	0.766	1,596	1,915	0.008	0.091
	A-4a	C	6.0	8.5	2.5	7.3	125	1,053	896	444	2,444	24	0.126	0.009	0.460				0.81	0.639	1,332	1,776	0.010	0.117
	A-4a	C	8.5	11.0	2.5	9.8	125	1,365	1,209	600	2,600	24	0.126	0.009	0.460				1.08	0.518	1,079	1,679	0.007	0.087
	A-4a	C	11.0	13.5	2.5	12.3	125	1,678	1,521	757	2,757	24	0.126	0.009	0.460				1.36	0.430	897	1,654	0.005	0.066
	A-4a	C	13.5	16.0	2.5	14.8	125	1,990	1,834	913	2,913	24	0.126	0.009	0.460				1.64	0.366	764	1,677	0.004	0.051
4	A-2-4	G	16.0	19.0	3.0	17.5	130	2,380	2,185	1,093	3,093					27	33	106	1.94	0.314	654	1,747	0.006	0.069
																						Total Settlement:		1.006 in

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 2,000 psf for slightly to moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 26, FHWA GEC 5
3. $C_r = 0.15(C_c)$ for medium stiff to stiff natural soil deposits and existing fill material, 0.075 to $0.10(C_c)$ for very stiff to hard natural soil deposits, and 0.05(Cc) for new embankment fill; Ref. Section 5.4.2.5 of FHWA GEC 5
4. $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing
8. $\Delta\sigma_v = q_{ei}(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)