Resource International, Inc.

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MOT – ELBEE ROAD BRIDGE REPLACEMENT
ODOT PID NO. 120483
MONTGOMERY COUNTY, OHIO

STRUCTURE FOUNDATION EXPLORATION REPORT

Prepared For:
Fishbeck
10856 Reed Hartman Highway, Suite 175
Cincinnati, Ohio 45242

Prepared By:
Resource International, Inc.
6350 Presidential Gateway
Columbus, OH 43231

Rii Project No. W-24-111

January 2026

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Planning
Engineering
Construction Management
Technology

January 14, 2026

Mr. Jonathan P. Carroll, P.E.
Vice President/Senior Bridge Engineer
Fishbeck
10856 Reed Hartman Highway, Suite 175
Cincinnati, Ohio 45242

Re: Structure Foundation Exploration Report
MOT – Elbee Road Bridge Replacement
ODOT PID No. 120483
Montgomery County, Ohio
Rii Project No. W-24-111

Mr. Carroll:

Resource International, Inc. (Rii) is pleased to submit this structure foundation exploration report for the above-referenced project. Engineering logs have been prepared and are attached to this report along with results of laboratory testing. This report includes geotechnical recommendations for the proposed Elbee road bridge over an unnamed stream in Montgomery County, Ohio.

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

Sincerely,

RESOURCE INTERNATIONAL, INC.

Ashok Gaire, P.E.
Project Manager

Daniel E. Karch, P.E.
Director – Geotechnical Services

Enclosure: Structure Foundation Exploration Report

ISO 9001: 2015 QMS
Committed to providing a high quality, accurate service in a timely manner

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APPENDICES

EXECUTIVE SUMMARY

Resource International, Inc. (Rii) has completed a structure foundation exploration performed for the design and construction of the proposed Elbee Road bridge replacement over an unnamed stream in Montgomery County, Ohio.

As per the available information, the existing structure will be completely removed and replaced with a four-sided precast reinforced concrete box (RCB) structure measuring 20 feet in span and 4 feet in rise. It is understood that headwalls and wingwalls will also be constructed for the proposed structure.

Exploration and Findings

On October 28 and 29, 2024, two (2) structure borings, designated as B-001-0-24 and B-002-0-24, were performed for this project and were advanced to a depth of 70.0 feet each below the existing roadway grade.

At the ground surface, borings B-001-0-24 and B-002-0-24 encountered asphalt pavement consisting of 17.0 and 16.0 inches of asphalt, respectively overlying 3.0 and 3.5 inches of aggregate base, respectively.

Below the surficial material, boring B-002-0-24 encountered natural cohesive soils extended to a depth of 4.3 feet below the existing grade underlain by natural granular soils to the termination depth. Beneath the surficial materials, boring B-001-0-24 encountered natural granular soils to the termination depth. The natural cohesive soils were described as brown silty clay (ODOT A-6b). The natural granular soils were described as gravel, gravel with sand, gravel with sand and silt, coarse and fine sand (ODOT A-1-a, A-1-b, A-2-4, A-3a).

Bedrock was not encountered in the soil borings performed for this investigation.

During drilling, groundwater was not encountered above the depths where the water was added into the boreholes. The water was added at the depths of 45.0 and 20.0 feet in borings B-001-0-24 and B-002-0-24, respectively. Upon the completion of drilling, groundwater was not recorded due to the influence of water added during the drilling process.

Conclusions and Recommendations

4-Sided Precast Reinforced Box Culvert Support

Rii understands that the invert elevations of the proposed RCB culvert will be 749.36 and 748.76 feet at inlet and outlet, respectively. The structure borings encountered medium dense to very dense gravel with sand (ODOT A-1-b) at and near the invert elevations of the proposed structure. These soils, in their present condition, are considered suitable to support the proposed structure.

Headwall / Wingwall Foundation Support

Rii has considered that the bearing elevation of the proposed headwalls and wingwalls will be 746.5 feet. The structure borings encountered dense to very dense gravel with sand (ODOT A-1-b) at and near the bearing elevations of the proposed structure. These soils, in their present condition, are considered suitable to support the proposed structure.

Provided that the recommendations of this report are implemented, the spread footings may be proportioned for the maximum nominal bearing resistance values not exceeding those provided below:

- Nominal bearing resistance of q_n = 12.3 ksf at the strength limit state.
- Nominal bearing resistance of q_n = 9.0 ksf at the service limit state.
- LRFD Bearing Resistance Factor of φ = 0.55 at the strength limit state.
- LRFD Bearing Resistance Factor of φ = 1.0 at the service limit state.

For the purposes of bearing capacity calculations, Rii has considered foundation width of 5.5 feet. If foundation width is different than what Rii has considered in this report, the information should be provided to Rii for review and the recommendations revised, if necessary.

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

1.0 INTRODUCTION

This report is a presentation of the structure foundation exploration performed for the design and construction of the proposed Elbee Road bridge replacement over an unnamed stream in Montgomery County, Ohio.

As per the available information, the existing structure will be completely removed and replaced with a four-sided precast reinforced concrete box (RCB) structure measuring 20 feet in span and 4 feet in rise. Detailed information of the proposed structure including site grading and foundation bearing elevations were not available at the time of this report. However, based on the preliminary information provided by Fishbeck, the invert elevations of the proposed RCB culvert will be 749.36 and 748.76 feet at inlet and outlet, respectively. Additionally, the bearing elevation of the proposed headwalls and/ or wingwalls will be approximately 9 feet below the existing roadway grade corresponding to an approximate elevation of 746.5 feet. Rii has considered that minimal site grading (less than 3.0 feet of cut or fill) will be required to bring the site to the proposed grade.

The exploration was performed within general accordance of the Ohio Department of Transportation's (ODOT) Specifications for Geotechnical Explorations (SGE), dated July 2024. The project site and general location of the proposed structure are as shown on the vicinity map and boring plan presented in Appendix I.

2.0 GEOLOGY AND OBESERVATIONS OF THE PROJECT

2.1 Site Geology

Physiographically, this site lies within the Southern Ohio Loamy Till Plain Region. This region is characterized by relatively flat-lying silty loam till ground moraine, interspersed with end and recessional moraines, outwash and alluvial deposits. Ground moraines are deposited during the retreat of a glacier, resulting in an undifferentiated mixture of clay, silt, sand and gravel. End moraines are normally associated with ice melting that is neither advancing nor retreating for a period of time. Recessional moraines are deposited when the ice sheet is retreating. Both end and recessional moraines are commonly associated with boulder belts. 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 from silty clay to cobble sized deposits, usually deposited in present and former floodplain areas. Based on the Ohio Department of Natural Resources (ODNR) maps, the project site is underlain by late Wisconsinan age outwash deposits.

Based on the ODNR bedrock geology maps, the bedrock at the project site consists of the Ordovician-aged Miamitown shale-Fairview formation undivided. The Miamitown shale consist of shale (90%) with limestone (10%) interbeds with gray to bluish gray in color, planer to nodular and thin to medium bedding. The Fairview formation shale consist of interbedded shale (50%) with limestone (50%) with gray to bluish gray in color, planer to lenticular and thin to medium bedding. According to ODNR bedrock topography mapping, the bedrock surface in the vicinity of the site is at an approximate elevation between 475 to 500 feet, which is approximately 250 to 275 feet below the existing surface grade.

2.2 Existing Site Conditions

The existing structure carrying Elbee Road over an unnamed Stream is located approximately 320 feet northeast of Southtown Boulevard in the City of Moraine, Montgomery County, Ohio. As per the available information, the existing structure is a three-cell cast-in-place reinforced concrete culvert measuring 27 feet in length. The existing roadway within the project limits is a two-lane, undivided, bi-directional, asphalt surfaced roadway, running northeast and southwest. Land use immediately surrounding the project area consists of commercial properties.

Overhead electric and cable lines aligned north-south are present along the eastern perimeter of roadway, and overhead electric and cable lines aligned east-west are also present above the existing structure footprint. The general topography of the roadway, in the vicinity of project site, appears to be relatively flat. Within the project site, surface runoff appears to drain through sheet flow to catch basin located on either side of the roadway.

3.0 EXPLORATION

On October 28 and 29, 2024, two (2) structure borings, designated as B-001-0-24 and B-002-0-24, were performed for this project and were advanced to a depth of 70.0 feet each below the existing roadway grade. The borings were performed at the locations illustrated on the boring plan presented in Appendix I of this report, and a summary of boring information is provided in Table 1.

Table 1. Summary of Soil Borings

Boring Number	Station [1]	Offset [1]	Latitude	Longitude	Ground Elevation [1] (feet)	Boring Depth (feet)
B-001-0-24	27+96	13' Lt	39.704898	-84.207684	755.5	70.0
B-002-0-24	28+53	13' Rt	39.704958	-84.20753	755.8	70.0

1. *Station, offsets and ground surface elevations were interpolated from basemaps provided by Fishbeck. Elevations are considered to be referenced to the North American Vertical Datum of 1988 (NAVD 88).*

The boring locations were determined and located in the field by Rii personnel based on available project information. Rii utilized a GPS unit to obtain latitude and longitude coordinates of the boring locations. Station, offsets and ground surface elevations at the boring locations were interpolated from basemaps provided by Fishbeck. Elevations are considered to be referenced to the North American Vertical Datum of 1988 (NAVD 88).

The borings were drilled and sampled with a CME 55 truck mounted drill rig utilizing 3.25-inch inside diameter hollow stem augers to advance the boreholes. Standard penetration test (SPT) and split spoon sampling were performed at 2.5-foot intervals to a depth of 35.0 feet below existing grade followed by 5.0-foot intervals to the termination depths for structure borings.

The SPT, per the American Society for Testing and Materials (ASTM) designation D1586, is conducted using a 140-pound hammer free 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). SPT blow counts aid in determining soil properties applicable in foundation system design and settlement calculation of foundation soil. Measured blow count (N_m) values are corrected to an equivalent (60 percent) 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 utilized in CME 55 rig used for this project was calibrated on March 22, 2024 and has a drill rod energy ratio of 85.1 percent.

In general, for instances of no recovery from standard split spoon sampling, a 2.5-inch outside diameter split spoon sampler was driven the full length of the standard split spoon interval plus an additional 6.0 inches to obtain a representative sample. These samples are designated with a “2S” preceding the sample number on the boring logs. Only the final 6.0 inches of sample were retained for classification.

Upon completion of drilling, the borings were backfilled with a mixture of soil cuttings and bentonite chips in accordance with ODOT standards. The pavement was patched with an equivalent thickness of quick set concrete.

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

During drilling, field personnel prepared field logs showing the encountered subsurface conditions. Soil samples obtained from the drilling operation were preserved in sealed glass jars and were 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	AASHTO T265	44
Plastic and Liquid Limits	AASHTO T89, T90	1
Gradation Analysis – Sieve/Hydrometer	AASHTO T88	10

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

4.0 FINDINGS

Interpreted engineering logs have been prepared from field logs, visual examination of samples and laboratory testing. Classification follows the current version of the ODOT Specifications of Geotechnical Exploration (SGE). The following is a generalization of what was found in the test borings and what is represented on the boring logs.

4.1 Surface Materials

At the ground surface, borings B-001-0-24 and B-002-0-24 encountered asphalt pavement consisting of 17.0 and 16.0 inches of asphalt, respectively overlying 3.0 and 3.5 inches of aggregate base, respectively.

4.2 Subsurface Soils

Below the surficial material, boring B-002-0-24 encountered natural cohesive soils extending to a depth of 4.3 feet below the existing grade underlain by natural granular soils to the termination depth. Beneath the surficial materials, boring B-001-0-24 encountered natural granular soils to the termination depth. The natural cohesive soils were described as brown silty clay (ODOT A-6b). The natural granular soils were described as gravel, gravel with sand, gravel with sand and silt, coarse and fine sand (ODOT A-1-a, A-1-b, A-2-4, A-3a).

The shear strength and consistency of the cohesive soils are primarily derived from the hand penetrometer values (HP). The consistency of the cohesive soils was very stiff (2.0 tsf ≤ HP ≤ 4.0 tsf). The unconfined compressive strength of the cohesive soil samples tested, obtained from the hand penetrometer, was 2.0 tsf.

The relative density of granular soils is primarily derived from SPT blow counts (N_{60}), measured in blows per foot (bpf). Based on the SPT blow counts (N_{60}) obtained, the relative density of granular soils ranged from medium dense (10 bpf ≤ N_{60} ≤ 30 bpf [blows per foot]) to very dense (N_{60} ≥ 50 bpf). The N_{60} values within the granular soils ranged from 13 bpf to split spoon refusal. Split spoon refusal is defined as the hammer blows of more than 50 for less than 6 inches of sampler penetration.

Moisture contents of the soil samples tested ranged from 1 to 25 percent. The natural moisture contents of the cohesive soil samples tested for plasticity ranged from 1 to 12 percent above its corresponding plastic limits value, considered to be slightly to significantly above the corresponding optimum moisture levels.

4.3 Bedrock

Bedrock was not encountered in the soil borings performed for this investigation.

4.4 Groundwater

During drilling, groundwater was not encountered above the depths where the water was added into the boreholes. Water was added at the depths of 45.0 and 20.0 feet in borings B-001-0-24 and B-002-0-24, respectively. Upon the completion of drilling, groundwater was not recorded due to the influence of water added during the drilling process.

Please note that short-term water level readings are not necessarily an accurate indication of the actual groundwater level. In addition, groundwater levels and the presence of groundwater is considered to be dependent on seasonal fluctuations in precipitation and groundwater levels in nearby bodies of water at the time of the investigation.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Data obtained from the drilling and testing program have been used to determine the foundation support capabilities and the settlement potential for the subsurface conditions encountered at the site. These parameters have been used to provide guidelines for the design of foundation systems for the subject structure and construction specifications and general earthwork recommendations, all of which are discussed in the following paragraphs.

5.1 Foundation Recommendations

Based on the Stage 2 Plans provided by Fishbeck, the invert elevations of the proposed RCB culvert will be 749.36 and 748.76 feet at inlet and outlet, respectively. Additionally, the bearing elevation of the proposed headwalls and/ or wingwalls will be at elevation 746.5 feet or lower. Rii has considered that minimal site grading (less than 3.0 feet of cut or fill) will be required to bring the site to the proposed grade.

If the proposed site grading and/or foundation loading information differs from what is described in this report, Rii should be provided this information for our review and our report revised and/or amended, if necessary.

5.1.1 Four-Sided Precast Reinforced Box Culvert Support

As stated, Rii has considered that the invert elevations of the proposed RCB culvert will be 749.36 and 748.76 feet at inlet and outlet, respectively. The structure borings encountered medium dense to very dense gravel with sand (ODOT A-1-b) at and near the invert elevations of the proposed structure. These soils, in their present condition, are considered suitable to support the proposed structure.

5.1.2 Headwall / Wingwall Foundation Support

Rii has considered that the bearing elevation of the proposed headwalls and wingwalls will be 746.5 feet. The structure borings encountered dense to very dense gravel with sand (ODOT A-1-b) at and near the bearing elevations of the proposed structure. These soils, in their present condition, are considered suitable to support the proposed structure.

Provided that the recommendations of this report are implemented, the spread footings may be proportioned for the maximum nominal bearing resistance values not exceeding those provided below:

- Nominal bearing resistance of q_n = 12.3 ksf at the strength limit state.
- Nominal bearing resistance of q_n = 9.0 ksf at the service limit state.
- LRFD Bearing Resistance Factor of φ = 0.55 at the strength limit state.
- LRFD Bearing Resistance Factor of φ = 1.0 at the service limit state.

For the purposes of bearing capacity calculations, Rii has considered foundation width of 5.5 feet. If foundation width is different than what Rii has considered in this report, the information should be provided to Rii for review and the recommendations revised, if necessary.

If soft, loose, wet and/or highly plastic soils are encountered at the foundation bearing elevations, these soils should be undercut and removed, and replaced with ODOT CMS Item 304 crushed aggregate up to the foundation bearing elevation. All bearing surfaces should be observed and approved by a geotechnical engineer or his/or representative.

In order to protect against frost, footings should be placed at a minimum frost depth of 36.0 inches below the adjacent exterior grade. Additionally, all foundations should be protected against scour.

Footing concrete should be placed as soon as possible following excavation, preferably the same day.

Protect foundation support materials exposed in an open excavation from freezing weather, severe drying, and water accumulations.

Foundation concrete should completely fill the open excavation. Forming the foundations and then backfilling the space behind the forms tends to allow moisture to penetrate and softened bearing materials resulting in poor foundation bearing capacity.

5.2 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 3 and Table 4.

Table 3. Estimated Undrained Soil Parameters for Design

Soil Type	γ (pcf) [1]	c (psf)	φ	k_a	k_o	k_p
Very Stiff Cohesive Soils	125	2,000	0°	N/A	N/A	N/A
Medium Dense Granular Soil	125	0	32°	0.31	0.47	3.25
Dense to Very Dense Granular Soil	130	0	33°	0.29	0.46	3.39
Compacted Cohesive Engineered Fill	125	2,000	0°	N/A	N/A	N/A
Compacted Granular Engineered Fill	130	0	33°	0.29	0.46	3.39

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

Table 4. Estimated Drained Soil Parameters for Design

Soil Type	γ (pcf) [1]	c' (psf)	φ'	k_a	k_o	k_p
Very Stiff Cohesive Soils	125	0	26°	0.39	0.56	2.56
Medium Dense Granular Soil	125	0	32°	0.31	0.47	3.25
Dense to Very Dense Granular Soil	130	0	33°	0.29	0.46	3.39
Compacted Cohesive Engineered Fill	125	0	28°	0.36	0.53	2.76
Compacted Granular Engineered Fill	130	0	33°	0.29	0.46	3.39

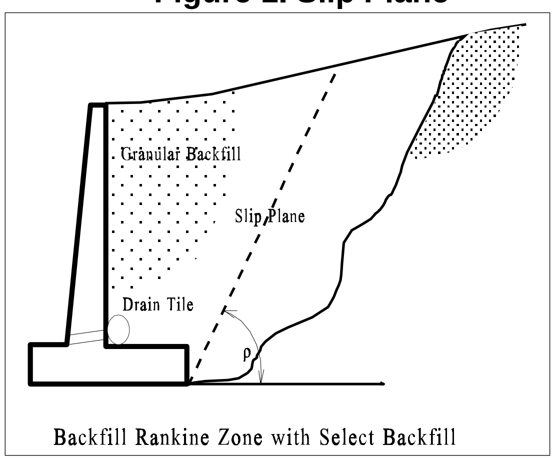
1. *When below groundwater table, use effective unit weight, $\gamma' = \gamma$ - 62.4 pcf and add hydrostatic water pressure.*

These parameters are considered appropriate for the design of subsurface walls, wing walls, headwalls and excavation support systems. Subsurface structures (where the top of the structure is restrained from movement) should be designed based on at-rest conditions. For proposed wing walls or 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 tables above 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.

In order to alleviate the build-up of hydrostatic pressure above the flow line of the stream behind the walls, a minimum of 2.0 feet of clean free-draining granular fill (i.e., No. 57 gravel) should be placed full depth behind the walls. If granular fill other than No. 57 gravel is used, it should not have more than 8 percent (by weight) passing the No. 200 screen, and should be compacted to 95 percent of the maximum dry density as determined by the Standard Proctor Test (ASTM D698). A perforated, corrugated drain tile, wrapped with filter fabric, should be placed along the perimeter at the base of the walls or at the design flow line/flood line for drainage purposes. A clay cap (minimum 1.0-foot thick) should be placed overtop the granular backfill to deter inflow of the surface water. The drainage system should properly outlet to creek/river or to a properly sized sump pump system.

The 2.0 feet of free draining material placed behind the wall prevents the formation of hydrostatic pressures as noted above. However, unless the free draining granular backfill is placed beyond the slip plane, it has no influence on the equivalent fluid weight of the soil. If free draining granular fill (meeting the requirements listed above) is to be placed beyond the slip plane (ρ=45° for at-rest conditions; ρ=45°+φ/2 for active conditions), the values presented for the compacted granular engineered fill can be employed, consequently lowering the pressures on the wall.

Figure 1. Slip Plane



5.3 Groundwater Considerations

As stated, groundwater was not encountered above the depths where water was added into the boreholes. Please note, groundwater is considered to be dependent on seasonal fluctuations in precipitation and groundwater levels in nearby bodies of water at the time of the investigation. As such, groundwater should be anticipated at or near the water level elevation of the existing stream.

Where 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 36.0 inches below the deepest excavation. Note that determining and maintaining actual groundwater levels during construction is the responsibility of the contractor.

5.4 Construction Considerations

All site work shall conform to local codes and to the latest ODOT Construction and Material Specifications (CMS).

5.5 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.

6.0 LIMITATIONS OF STUDY

The recommendations presented in this report 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.

The recommendations for this project were developed utilizing soil and bedrock information obtained from the test borings that were made at the proposed 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.

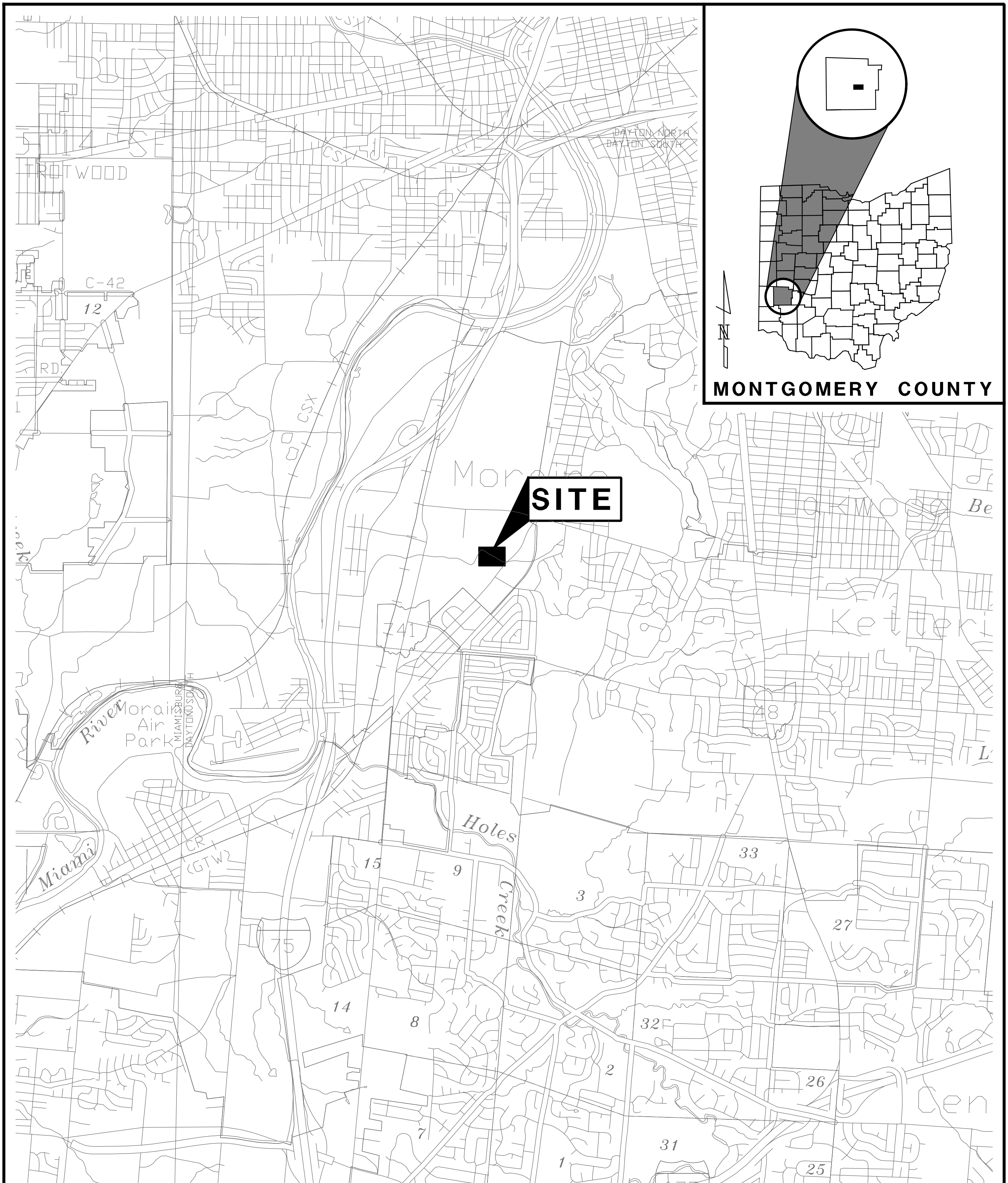
The conclusions and recommendations herein have been based upon the available soil information and the preliminary design details furnished by a representative of the owner of the proposed project. Any revision in the plans for the proposed construction from those anticipated in this report should be 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 or hazardous or toxic materials in the soil, groundwater or surface water within or beyond the site studied. Any statements in this report or on the test boring logs regarding odors, staining of soils or other unusual conditions observed are strictly for the information of our client.

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

APPENDIX I

VICINITY MAP AND BORING PLAN



VICINITY MAP
MOT - ELBEE ROAD
BRIDGE REPLACEMENT
MONTGOMERY COUNTY, OHIO

RII PROJECT NO. W-24-111	DRAWN ALF
	REVIEWED DEK
SCALE: 1"=5000' (0 2500 5000)	DATE 12/31/2024

RESOURCE INTERNATIONAL

BORING PLAN

MOT - ELBEE ROAD BRIDGE REPLACEMENT

MONTGOMERY COUNY, OHIO

RII PROJECT NO. W-24-111

SCALE: 1"=20'

0 10 20

N

DRAWN ALF

REVIEWED DEK

DATE 12/31/2024

RESOURCE INTERNATIONAL Rii

APPENDIX II

DESCRIPTION OF SOIL TERMS

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 AASHTO	Classifcation OHIO	$LL_O/LL \times 100$*	% Pass #40	% Pass #200	Liquid Limit (LL)	Plastic Index (PI)	Group Index Max.	REMARKS
	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
- P Peat

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

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

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

Soil Fraction		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	≥ 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 the relative strength of bedrock:

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

APPENDIX III

BORING LOGS:

B-001-0-24 and B-002-0-24

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: MOT-ELBEE RD. BRIDGE REPL.	DRILLING FIRM / OPERATOR: RII / LH	DRILL RIG: CME 55 (386345)	STATION / OFFSET: 27+96 / 13' LT	EXPLORATION ID **B-001-0-24**
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / KC/NH	HAMMER: AUTOMATIC	ALIGNMENT: ELBEE RD.	
PID: 120483 SFN: 5766700	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 3/22/24	ELEVATION: 755.5 (FEET) EOB: 70.0 ft.	PAGE 1 OF 3
START: 10/28/24 END: 10/28/24	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.1	LAT / LONG: 39.704898, -84.207684	

MATERIAL DESCRIPTION AND NOTES	ELEV. 755.5	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
1.4' - ASPHALT (17.0")	754.1																
0.3' - AGGREGATE BASE (3.0")	753.8																
MEDIUM DENSE TO VERY DENSE, BROWN AND LIGHT GRAY **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP.		8 7 6	18	89	SS-1	-	-	-	-	-	-	-	-	-	5	A-1-b (V)	
		10 8 6	20	78	SS-2	-	41	11	28	14	6	NP	NP	NP	6	A-1-b (0)	
		15 11 9	28	67	SS-3	-	-	-	-	-	-	-	-	-	3	A-1-b (V)	
		25 15 10	35	94	SS-4	-	-	-	-	-	-	-	-	-	5	A-1-b (V)	
		20 16 20	51	83	SS-5	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	
-COBBLES @ 14.0'		48 29 36	92	94	SS-6	-	59	17	8	12	4	NP	NP	NP	4	A-1-b (0)	
	737.5	35 26 20	65	100	SS-7	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	
VERY DENSE, BROWN AND LIGHT GRAY **GRAVEL**, SOME SAND, TRACE SILT, TRACE CLAY, DAMP TO WET.		50/3"	-	33	SS-8	-	-	-	-	-	-	-	-	-	3	A-1-a (V)	
-COBBLES @ 22.0'		21 20 26	65	0	SS-9	-	-	-	-	-	-	-	-	-	-		
		50/5"	-	100	SS-9A	-	-	-	-	-	-	-	-	-	4	A-1-a (V)	
		50/3"	-	100	SS-10	-	-	-	-	-	-	-	-	-	1	A-1-a (V)	
		50/5"	-	90	SS-11	-	-	-	-	-	-	-	-	-	3	A-1-a (V)	
		21 38 38	108	69	SS-12	-	-	-	-	-	-	-	-	-	4	A-1-a (V)	

000-23 RII STA ODOT BORING LOG (8.5X11) - OH DOT.GDT - 6/12/25 13:33 - U:\GI8\PROJECTS\2024\W-24-111.GPJ

PID: 120483	SFN: 5766700	PROJECT: MOT-ELBEE RD. BRIDGE REPL.	STATION / OFFSET: 2796, 13' LT.	START: 10/28/24	END: 10/28/24	PG 2 OF 3	B-001-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV. 725.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
VERY DENSE, BROWN AND LIGHT GRAY **GRAVEL**, SOME SAND, TRACE SILT, TRACE CLAY, DAMP TO WET. *(continued)*																		
		31 – 32	36 22 17	55	75	SS-13	-	49	26	13	8	4	NP	NP	NP	5	A-1-a (0)	
		34 – 35	39 36 24	85	93	SS-14	-	-	-	-	-	-	-	-	-	8	A-1-a (V)	
		38 – 39	50/4"	-	100	SS-15	-	-	-	-	-	-	-	-	-	4	A-1-a (V)	
		43 – 44	50/5"	-	100	SS-16	-	-	-	-	-	-	-	-	-	5	A-1-a (V)	
-WATER ADDED TO BOREHOLE @ 45.0'	709.5																	
DENSE TO VERY DENSE, BROWN AND LIGHT GRAY **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, WET.																		
		49 – 50	17 21 18	55	97	SS-17	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
		54 – 55	17 14 18	45	100	SS-18	-	39	28	17	12	4	NP	NP	NP	11	A-1-b (0)	
		59 – 60	14 15 15	43	86	SS-19	-	-	-	-	-	-	-	-	-	13	A-1-b (V)	
	693.8	61																

PID: 120483	SFN: 5766700	PROJECT: MOT-ELBEE RD. BRIDGE REPL.	STATION / OFFSET: 2796, 13' LT.	START: 10/28/24	END: 10/28/24	PG 3 OF 3	B-001-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV. 693.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
VERY DENSE, BROWN **COARSE AND FINE SAND**, LITTLE FINE GRAVEL, TRACE SILT, TRACE CLAY, WET. *(continued)*		63																
		64	50/6"	-	100	SS-20	-	13	36	39	9	3	NP	NP	NP	13	A-3a (0)	
-WATER ADDED TO BOREHOLE @ 65.0'		65																
		66																
		67																
		68																
		69	50/4"	-	100	SS-21	-	-	-	-	-	-	-	-	-	12	A-3a (V)	
	685.5	EOB 70																

NOTES: GROUNDWATER COULD NOT BE DETERMINED DUE TO THE ADDITION OF WASH WATER DURING DRILLING. CAVE-IN DEPTH @ 22.0'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH BENTONITE CHIPS AND SOIL CUTTINGS. PAVEMENT PATCHED WITH CONCRETE. .

000-23 RII STA ODOT BORING LOG (8.5X11) - OH DOT.GDT - 6/12/25 13:33 - U:\GI8\PROJECTS\2024\W-24-111.GPJ

RESOURCE INTERNATIONAL, INC.

PROJECT: MOT-ELBEE RD. BRIDGE REPL.	DRILLING FIRM / OPERATOR: RII / LH	DRILL RIG: CME 55 (386345)	STATION / OFFSET: 28+53 / 13' RT	EXPLORATION ID **B-002-0-24**
TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / NH	HAMMER: AUTOMATIC	ALIGNMENT: ELBEE RD.	
PID: 120483 SFN: 5766700	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 3/22/24	ELEVATION: 755.8 (FEET) EOB: 70.0 ft.	PAGE
START: 10/28/24 END: 10/29/24	SAMPLING METHOD: SPT	ENERGY RATIO (%): 85.1	LAT / LONG: 39.704958, -84.207530	1 OF 3

MATERIAL DESCRIPTION AND NOTES	ELEV. 755.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
1.3' - ASPHALT (16.0")	754.5																	
0.3' - AGGREGATE BASE (3.5")	754.2																	
VERY STIFF, BROWN **SILTY CLAY**, "AND" SAND, TRACE FINE GRAVEL, DAMP.			14 5 4	13	83	SS-1	2.00	10	14	27	28	21	31	13	18	14	A-6b (6)	
	751.5		8 4 5	13	40	SS-2A	2.00	-	-	-	-	-	-	-	-	25	A-6b (V)	
MEDIUM DENSE TO VERY DENSE, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP.						SS-2B	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
			10 17 17	48	72	SS-3	-	-	-	-	-	-	-	-	-	3	A-1-b (V)	
-COBBLES @ 9.0'			35 20 34	77	100	SS-4	-	-	-	-	-	-	-	-	-	3	A-1-b (V)	
			16 16 13	41	56	SS-5	-	52	21	9	13	5	NP	NP	NP	4	A-1-b (0)	
			26 15 14	41	72	SS-6	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	
			32 16 14	43	83	SS-7	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	
			50/5"	-	95	SS-8	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	
-WATER ADDED TO BOREHOLE @ 20.0'	735.3																	
DENSE TO VERY DENSE, LIGHT BROWN **GRAVEL**, SOME SAND, TRACE SILT, TRACE CLAY, WET.			21 45 50/5"	-	38	SS-9	-	-	-	-	-	-	-	-	-	10	A-1-a (V)	
			10 10 20	43	83	SS-10A	-	56	22	10	8	4	NP	NP	NP	9	A-1-a (0)	
			19 50/5"	-	52	SS-11	-	-	-	-	-	-	-	-	-	9	A-1-a (V)	
	727.8																	
MEDIUM DENSE TO VERY DENSE, LIGHT BROWN **GRAVEL WITH SAND AND SILT**, TRACE CLAY, WET.			50/6"	-	91	SS-12	-	-	-	-	-	-	-	-	-	7	A-2-4 (V)	

000-23 RII STA ODOT BORING LOG (8.5X11) - OH DOT.GDT - 6/12/25 13:33 - U:\GI8\PROJECTS\2024\W-24-111.GPJ

PID: 120483	SFN: 5766700	PROJECT: MOT-ELBEE RD. BRIDGE REPL.	STATION / OFFSET: 2853, 13' RT.	START: 10/28/24	END: 10/29/24	PG 2 OF 3	B-002-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV. 725.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE TO VERY DENSE, LIGHT BROWN **GRAVEL WITH SAND AND SILT**, TRACE CLAY, WET. *(continued)*		31	50/5"	-	100	SS-13	-	-	-	-	-	-	-	-	-	6	A-2-4 (V)	
		32 – 33																
		34	50/5"	-	100	SS-14	-	-	-	-	-	-	-	-	-	6	A-2-4 (V)	
-WATER ADDED TO BOREHOLE @ 35.0'		35 – 38																
		39	31 50/3"	-	100	SS-15	-	17	22	26	22	13	NP	NP	NP	10	A-2-4 (0)	
		40 – 43																
		44	50/5"	-	100	SS-16	-	-	-	-	-	-	-	-	-	9	A-2-4 (V)	
-COBBLES @ 45.0' -WATER ADDED TO BOREHOLE @ 45.0'		45 – 48																
		49 – 50	12 9 6	21	83	SS-17	-	-	-	-	-	-	-	-	-	9	A-2-4 (V)	
	704.1	51																
DENSE TO VERY DENSE, BROWN **GRAVEL**, SOME SAND, TRACE SILT, TRACE CLAY, WET.		52 – 53																
		54 – 55	12 17 11	40	58	SS-18	-	-	-	-	-	-	-	-	-	19	A-1-a (V)	
		56 – 58																
		59 – 60	9 11 19	43	90	SS-19	-	66	24	6	2	2	NP	NP	NP	11	A-1-a (0)	
		61																

000-23 RII STA ODOT BORING LOG (8.5X11) - OH DOT.GDT - 6/12/25 13:33 - U:\GI8\PROJECTS\2024\W-24-111.GPJ

PID: 120483	SFN: 5766700	PROJECT: MOT-ELBEE RD. BRIDGE REPL.	STATION / OFFSET: 2853, 13' RT.	START: 10/28/24	END: 10/29/24	PG 3 OF 3	B-002-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV. 693.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
DENSE TO VERY DENSE, BROWN **GRAVEL**, SOME SAND, TRACE SILT, TRACE CLAY, WET. *(continued)*		63																
		64	50/3"	-	100	SS-20	-	-	-	-	-	-	-	-	-	11	A-1-a (V)	
	689.1	65–66																
VERY DENSE, LIGHT BROWN **COARSE AND FINE SAND**, LITTLE FINE GRAVEL, TRACE SILT, TRACE CLAY, WET.		67–68																
		69	50/4"	-	100	SS-21	-	-	-	-	-	-	-	-	-	13	A-3a (V)	
	685.8	EOB 70																

NOTES: GROUNDWATER COULD NOT BE DETERMINED DUE TO THE ADDITION OF WASH WATER DURING DRILLING. CAVE-IN DEPTH @ 30.5'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH BENTONITE CHIPS AND SOIL CUTTINGS. PAVEMENT PATCHED WITH CONCRETE. .

000-23 RII STA ODOT BORING LOG (8.5X11) - OH DOT.GDT - 6/12/25 13:33 - U:\GI8\PROJECTS\2024\W-24-111.GPJ

APPENDIX IV

ANALYSIS CALCULATIONS

Project :	***MOT- Elbee Road Bridge Replacement***
Location:	***Montgomery County, Ohio County, Ohio.***
Rii Project Number:	***W-24-111***

Wingwall/Headwall -Shallow Foundation Bearing Resistance Analysis

Borings: *B-001-0-24 and B-002-0-24*

Bearing Elevation: *746.5 feet*

Foundation Bearing Materials: *Dense to very dense A-1-b.*

B =	5.5	ft	(Foundation Width - Assumed)
L =	28.0	ft	(Foundation Length - Assumed)
c'=	0	psf	(Drained cohesion of foundation soil/rock)
γ =	130	pcf	(Unit weight of soil)
D_f =	3.0	ft	(Minimum foundation embedment depth)
φ' =	33	deg	(Drained friction angle of foundation soil/rock)
D_w =	0.0	ft	

Nominal Bearing Resistance (q_n)

$$q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + \tfrac{1}{2}\gamma B N_{\gamma m} C_{w\gamma} = 12.30 \text{ ksf}$$

$N_{cm} = N_c s_c i_c$ = 43.76

$N_{qm} = N_q s_q d_q i_q$ = 33.37

$N_{\gamma m} = N_\gamma s_\gamma i_\gamma$ = 32.43

N_c =	38.64
N_q =	26.09
N_γ =	35.19

s_c =	1.133
s_q =	1.128
s_γ =	0.921

i_c =	1.000
i_q =	1.000
i_γ =	1.000

d_q =	1.134
C_{wq} =	0.500
$C_{w\gamma}$ =	0.500

Factored Bearing Resistance (q_R)

$$q_R = q_n \cdot \phi_b = 6.8 \text{ ksf}$$

φ_b = 0.55

Project: MOT Elbee Road Bridge Replacement

ODOT PID: 120483

Rii Project No.: W-24-111

Settlement - CONTINUOUS SPREAD FOOTINGS

Calculated By: AG Date: 1.6.2025

Checked By: DEK Date: 1.6.2025

Boring: B-001-0-24

Existing groundsurface elevation at proposed wall= 755 feet

Approximate bearing elevation= 746.5 feet

Overburden Pressure 510 psf (only half of overbuden taken into considereation)

B = 5.5 ft (Footing Width for Continuous Footing)

D_w = 0.0 ft (Depth to Groundwater below the footing) (Assumed at or near creek bed)

q = 9,000 psf (Foundation Pressure)

Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Elevation (ft. msl)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' (1) (psf)	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-1-b	G	0.0	1.5	746.5	745.0	1.5	0.8	130	705	608	561						35	50	169	0.14	0.99	8,929	9,490	0.011	0.131
	A-1-b	G	1.5	9.5	745.0	737.0	8.0	5.5	130	1,745	1,225	882						60	77	306	1.00	0.550	4,948	5,830	0.021	0.257
2	A-1-a	G	9.5	16.5	737.0	730.0	7.0	13.0	130	2,655	2,200	1,389						60	67	254	2.36	0.262	2,355	3,743	0.012	0.143
	A-1-a	G	16.5	21.5	730.0	725.0	5.0	19.0	130	3,305	2,980	1,794						60	62	227	3.45	0.182	1,636	3,430	0.006	0.075
	A-1-a	G	21.5	26.5	725.0	720.0	5.0	24.0	130	3,955	3,630	2,132						60	59	209	4.36	0.145	1,302	3,434	0.005	0.059
	A-1-a	G	26.5	36.5	720.0	710.0	10.0	31.5	130	5,255	4,605	2,639						60	55	189	5.73	0.111	995	3,635	0.007	0.088
	A-1-a	G	36.5	46.5	710.0	700.0	10.0	41.5	130	6,555	5,905	3,315						60	50	169	7.55	0.084	757	4,073	0.005	0.063
																								Total Settlement:		***0.816 in***

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 4,000 psf for 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 continuous footing
8. $\Delta\sigma_v = q_e(I)$
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)