Resource International, Inc.

MOT-49-5.46 CULVERT EXTENSION
PID NO. 117202
MONTGOMERY COUNTY, OHIO

DRAFT STRUCTURE FOUNDATION EXPLORATION REPORT

Prepared For:
Crawford, Murphy, & Tilly
84 Remick Boulevard
Springboro, Ohio 45066

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

Rii Project No. W-23-150

January 2025

RESOURCE INTERNATIONAL, INC.
6350 Presidential Gateway
Columbus, Ohio 43231
Ph: 614.823.4949

Planning
Engineering
Construction Management
Technology

May 2, 2024 (Revised January 21, 2025)

Ms. Shelby Ingle, P.E.
Project Manager
Crawford, Murphy, & Tilly
84 Remick Boulevard
Springboro, Ohio 45066

Re: DRAFT Structure Foundation Exploration Report
MOT-49-5.46 Culvert Extension
Montgomery County, Ohio
PID No. 117202
Rii Project No. W-23-150

Ms. Ingle:

Resource International, Inc. (Rii) is pleased to submit this revise draft 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 recommendations for the extension of the existing MOT-49-5.46 culvert structure in Montgomery County.

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.

Daniel K. Hayes, E.I.
Project Manager – Geotechnical Services

Daniel E. Karch, P.E.
Project Manager – Geotechnical Services

Enclosure: DRAFT Structure Foundation Exploration Report

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

TABLE OF CONTENTS

APPENDICES

EXECUTIVE SUMMARY

Resource International. Inc. (Rii) has completed a structure foundation exploration for the proposed extension of the existing culvert structure, MOT-49-5.46, in Montgomery County, Ohio. In addition to the culvert extension, the proposed improvements also include resurfacing the pavement at the intersection of Olive Road and Salem Avenue in Trotwood, Montgomery County, Ohio.

The exploration was performed within general accordance of the Ohio Department of Transportation's (ODOT) Specifications for Geotechnical Explorations (SGE), dated January 2021.

Exploration and Findings

On October 10, 2023, one (1) structure boring, designated as B-001-0-23 was drilled at the proposed culvert extension location illustrated on the boring plans presented in Appendix I of this report and summarized in Table 2. The boring locations and depths are summarized in Table 2 below.

One (1) pavement core was obtained, X-001-0-22, to determine the existing pavement composition and condition of the paved section. The pavement core was obtained with a 4.0-inch diameter thin-walled pavement core bit.

Table 1. Test Boring Summary

Boring Number	Station[1]	Offset[1]	Latitude	Longitude	Ground Elevation (feet msl)[1]	Boring Depth (feet)
B-001-0-23	18+2.3	19.42' Lt.	39.826162	-84.292578	869.2	27.0
X-001-0-22	18+03.03	9.25' Lt.	39.826141	-84.292554	-	-

1. Station, offset and ground elevation were interpolated from basemaps provided by CMT.

The boring locations were determined and located in the field by Rii representatives. Rii utilized a GPS unit to obtain northing and easting coordinates of the boring location. Ground surface elevations at boring locations were interpolated from topographic information provided by Crawford, Murphy, & Tilly (CMT) and are provided on the boring logs in Appendix III.

The boring was performed along the shoulder of Olive Road adjacent to the proposed culvert extension and encountered 10.0-inches of asphalt overlying 2.5 inches of aggregate base at the existing ground surface.

Beneath the surficial pavement materials, layers of natural cohesive and cohesionless soils were encountered. The cohesive soils were described as silty clay, and silt and clay (ODOT A-6a, A-6b). The cohesionless soils were described as gravel with sand and silt (ODOT A-2-4).

Shale bedrock was encountered below the natural soils at a depth of 21.4 feet below the existing ground surface to the boring termination depth. The shale bedrock was described as gray, moderately weathered, weak and blocky.

Groundwater was not encountered in the boring performed for this exploration.

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 soil conditions encountered at the site. These parameters have been used to provide guidelines for the design of foundation system for the subject culvert extension, as well as the construction specifications related to the placement of foundation systems and general earthwork recommendations, all of which are discussed in the following paragraphs.

Foundation Recommendation

Based on design information available to Rii, it is understood that the existing inlet headwall has a foundation bearing elevation of approximately 851.0 feet. Therefore, Rii has considered that the proposed inlet headwall and wingwalls will, in kind, have a foundation bearing elevation of around 851.0 feet. The soils at the anticipated bearing elevation of the headwall and wingwalls consist of hard silty clay (ODOT A-6b). Footings bearing at or below this elevation can be proportioned to meet the following bearing capacity requirements:

- Nominal bearing resistance of q_n = 3.3 ksf at the service limit state.
- Nominal bearing resistance of q_n = 23.7 ksf at the strength limit state.
- LRFD Bearing Resistance Factor of φ = 1.0 at the service limit state.
- LRFD Bearing Resistance Factor of φ = 0.50 at the strength limit state.

The bearing resistance at service limit state is the bearing pressure that results in a maximum total settlement of 1 inch. It should be noted that this value represents the gross bearing pressure.

The resistance of the footings to sliding will be dependent on the friction between the concrete footing and bearing surface. For concrete footings that rest on cohesive soils, the sliding resistance is a function of the coefficient of friction multiplied by the weight applied to the footing from the structure. For the cohesive soils encountered at the bearing depth a coefficient of 0.53 (tangent of 28 deg) may be utilized for analysis.

A geotechnical resistance factor of φ_T=0.85 should be considered when calculating the factored shear resistance between the soil and foundation for sliding for cast-in-place concrete.

In order to protect against frost, footings should be placed at a minimum frost depth of 36.0 inches below the adjacent exterior grade or should follow local codes.

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 proposed extension of the existing culvert structure, MOT-49-5.46, in Montgomery County, Ohio. In addition to the culvert extension, the proposed improvements also include resurfacing the pavement at the intersection of Olive Road and Salem Avenue in the City of Trotwood, Montgomery County, Ohio.

Based on information provided to Rii, it is understood that the existing culvert is a 15-foot 6-inch by 9-foot 5-inch, corrugated metal pipe (CMP) arch, with a length of 92 feet. The culvert includes half-height headwalls, with inlet and outlet elevations of 854.50 and 853.90 feet, respectively. Design details of the proposed culvert extension were not available at the time of this report. For the purpose of this investigation, Rii considers that the proposed structure will generally match the existing structure in dimension and type. It is understood that a full-height headwall and wingwalls will be constructed for the new culvert extension.

The exploration was performed within general accordance of the Ohio Department of Transportation (ODOT) Specifications for Geotechnical Explorations (SGE), dated July 2023. The project site and general location of the proposed culvert are as shown on the vicinity map and boring plan presented in Appendix I.

2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 Site Geology

Physiographically, the 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 bedrock geology and topography maps of the area from the Ohio Department of Natural Resources (ODNR), the underlying bedrock beneath the site is undivided Ordovician bedrock. This unit is comprised of various shades of grey shale with interbedded dolomite and limestone. The undivided formation displays deposition of multiple sedimentary cycles of shale and limestone displaying planar to irregular bedding, and limestone and shale exhibiting wavy to nodular bedding, and is greater than 140 feet in thickness. The bedrock surface in the vicinity of the site is at an approximate elevation of 850 feet, which is approximately 20 feet below the existing surface grade.

2.2 Existing Site Conditions

The existing MOT-49-5.46 culvert structure is located along Olive Road approximately 100 feet southwest of the intersection with Salem Avenue in Trotwood, Montgomery County, Ohio. Land use surrounding the project area is a combination of residential and commercial. Surface topography of the area generally follows a gentle downslope from north to south with elevations within the vicinity of the project to be approximately 869 feet.

3.0 EXPLORATION

On October 10, 2023, one (1) structure boring, designated as B-001-0-22 was drilled at the proposed culvert extension location illustrated on the boring plan presented in Appendix I of this report and summarized below in Table 2.

In addition to the boring, one (1) pavement core, designated as X-001-0-23, was obtained to determine the existing pavement composition and condition of the paved section of Olive Road near the culvert location. The pavement core was obtained with a 4.0-inch diameter thin-walled pavement core bit. A data sheet, including photographs of the retained pavement cores and base samples are presented in Appendix III.

Table 2. Test Boring Summary

Boring Number	Station[1]	Offset[1]	Latitude	Longitude	Ground Elevation (feet msl)[1,2]	Boring Depth (feet)
B-001-0-23	18+02	19' Lt.	39.826162	-84.292578	869.2	27.0
X-001-0-22	18+03	9' Lt.	39.826141	-84.292554	-	-

1. *Station, offset and ground elevation were interpolated from basemaps provided by CMT.*
2. *Elevations are understood to reference NAVD88.*

The boring and core locations were determined and located in the field by Rii representatives. Rii utilized a GPS unit to obtain northing and easting coordinates of the boring and core location. Ground surface elevations at boring location were interpolated from topographic information provided by Crawford, Murphy, & Tilly (CMT) and are provided on the boring logs in Appendix III.

The boring was drilled with a Diedrich D-50 track-mounted rotary drilling machine, utilizing a 3.25-inch inside diameter hollow stem auger. Standard penetration test (SPT) and split spoon sampling were performed at 2.5-foot intervals to termination depth in both borings. Continuous sampling was performed at the bottom of the creek level to approximately 6 feet below the bottom of the creek. 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. 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 for the Diedrich D-50 drill rig used for this project was calibrated on March 21, 2022, and has a drill rod energy ratio of 86.4 percent.

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 delivered to the soil laboratory. In the laboratory, the soil samples were visually classified and select samples were tested, as noted in Table 3.

Table 3. Laboratory Test Schedule

Laboratory Test	Test Designation	Number of Tests Performed
Natural Moisture Content	AASHTO T265	11
Plastic and Liquid Limits	AASHTO T89, T90	4
Sieve/Hydrometers	AASHTO T88	6

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

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.

Upon completion of drilling, the borings were backfilled with a mixture of bentonite chips and soil cuttings generated during the drilling process in accordance with ODOT standards. The pavement surface was repaired with an equivalent thickness of asphalt cold patch.

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

The boring was performed along the shoulder of Olive Road adjacent to the proposed culvert extension and encountered 10.0 inches of asphalt overlying 2.5 inches of aggregate base at the existing ground surface. The core was performed in the southbound drive lane of Olive Road and also encountered 10.0 inches of asphalt overlying 2.5 inches of aggregate base at the existing ground surface.

4.2 Subsurface Soils

Beneath the surficial pavement materials, the boring encountered layers of natural cohesive and cohesionless soils to the top of bedrock. The cohesive soils were described as silt and clay and silty clay (ODOT A-6a, A-6b), while the granular soils were described as gravel with sand and silt (ODOT A-2-4).

The shear strength and consistency of the cohesive soils are primarily derived from the hand penetrometer values (HP). The cohesive soils encountered ranged from stiff ($1.0 < HP \leq 2.0$ tsf) to very hard ($HP > 4.0$ tsf). The unconfined compressive strength of the cohesive soil samples tested, obtained from the hand penetrometer, ranged from 1.25 to 4.5 tsf. The relative density of cohesionless soils is primarily derived from SPT blow counts (N_{60}). Based on the SPT blow counts obtained, the cohesionless material encountered ranged from medium dense ($11 < N_{60} < 30$ blows per foot [bpf]) to dense ($31 < N_{60} < 50$ bpf). Overall blow counts recorded from the SPT sampling ranged from 26 to 35 bpf.

Moisture contents of the cohesive soil samples tested ranged from 9 to 14 percent. The moisture contents of the cohesive soil samples tested for plasticity index ranged from 10 percent below to equaling their corresponding plastic limits. In general, the soils exhibited natural moisture contents estimated to be significantly below to significantly above their optimum moisture levels.

4.3 Bedrock

Shale bedrock was encountered below the natural soils at a depth of 21.4 feet below the existing ground surface to the boring termination depth. The shale bedrock was described as gray, moderately weathered, weak and blocky.

4.4 Groundwater

Groundwater was not encountered in the boring performed for this exploration.

Please note that short-term water level readings, especially in cohesive materials, are not necessarily an accurate indication of the actual groundwater level. In addition, groundwater levels and the presence of groundwater are 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 RECOMMEDATIONS

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

Based on the information provided by CMT it is understood that the existing 15-foot 6-inch by 9-foot 5-inch CMP arch culvert will be extended by approximately 5.0 feet. It is understood that a full-height headwall is planned for the new culvert extension.

5.1 Foundation Recommendations

Based on design information available to Rii, it is understood that the existing inlet headwall has a foundation bearing elevation of approximately 851.0 feet. Therefore, Rii has considered that the proposed inlet headwall and wingwalls will, in kind, have a foundation bearing elevation of around 851.0 feet. The soils at the anticipated bearing elevation of the headwall and wingwalls consist of hard silty clay (ODOT A-6b). Footings bearing at or below this elevation can be proportioned to meet the following bearing capacity requirements:

- Nominal bearing resistance of q_n = 3.3 ksf at the service limit state.
- Nominal bearing resistance of q_n = 23.7 ksf at the strength limit state.
- LRFD Bearing Resistance Factor of φ = 1.0 at the service limit state.
- LRFD Bearing Resistance Factor of φ = 0.50 at the strength limit state.

The bearing resistance at service limit state is the bearing pressure that results in a maximum total settlement of 1.0 inch. It should be noted that this value represents the gross bearing pressure.

The resistance of the footings to sliding will be dependent on the friction between the concrete footing and bearing surface. For concrete footings that rest on cohesive soils, the sliding resistance is a function of the coefficient of friction multiplied by the weight applied to the footing from the structure. For the cohesive soils encountered at the bearing depth a coefficient of 0.53 (tangent of 28 deg) may be utilized for analysis.

A geotechnical resistance factor of φ_T=0.85 should be considered when calculating the factored shear resistance between the soil and foundation for sliding for cast-in-place concrete.

In order to protect against frost, footings should be placed at a minimum frost depth of 36.0 inches below the adjacent exterior grade or should follow local codes.

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 4 and Table 5.

Table 4. Estimated Undrained Soil Parameters for Design

Soil Type	γ (pcf) [1]	c (psf)	φ	k_a	k_o	k_p
Stiff to Very Stiff Cohesive Soils	120	1,500	0°	N/A	N/A	N/A
Hard Cohesive Soil	130	3,000	0°	N/A	N/A	N/A
Medium Dense to Dense Granular Soil	130	0	32°	0.31	0.47	3.25
Compacted Cohesive Engineered Fill	125	2,000	0°	N/A	N/A	N/A
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 5. Estimated Drained Soil Parameters for Design

Soil Type	γ (pcf) [1]	c' (psf)	φ'	k_a	k_o	k_p
Stiff to Very Stiff Cohesive Soil	120	0	27°	0.38	0.55	2.66
Hard Cohesive Soil	130	0	28°	0.36	0.53	2.77
Medium Dense to Dense Granular Soil	130	0	32°	0.31	0.47	3.25
Compacted Cohesive Engineered Fill	125	0	28°	0.36	0.53	2.77
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 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 (k_a) and passive (k_p) conditions. The values in this table have been estimated from correlation charts based on minimum standards specified for compacted engineered fill materials. These recommendations do not take into consideration the effect of any surcharge loading or a sloped ground surface (a flat surface is assumed). Earth pressures on excavation support systems will be dependent on the type of wall and method of bracing or anchorage, if any.

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

5.3 Construction Considerations

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

5.3.1 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 6 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 6. 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

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 and are part of our recommendations.

The recommendations for this project were developed utilizing subsurface 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, bedrock and groundwater 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.

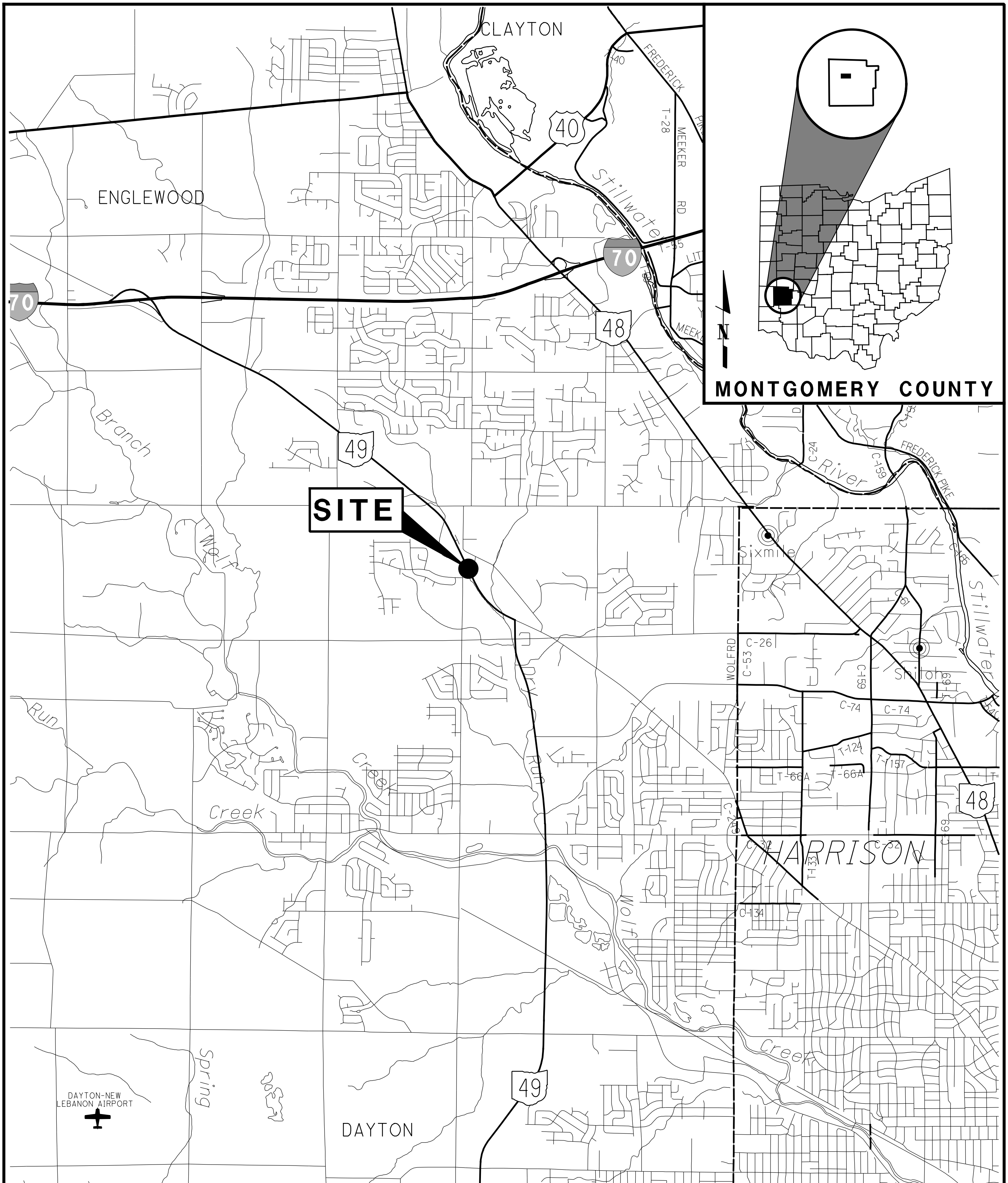
The conclusions and recommendations herein have been based upon the available soil information and the preliminary design details furnished by a representative of the owner of the proposed project. Any revision in the plans for the proposed construction from those anticipated in this report should be 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- 49-5.46 CULVERT EXTENSION

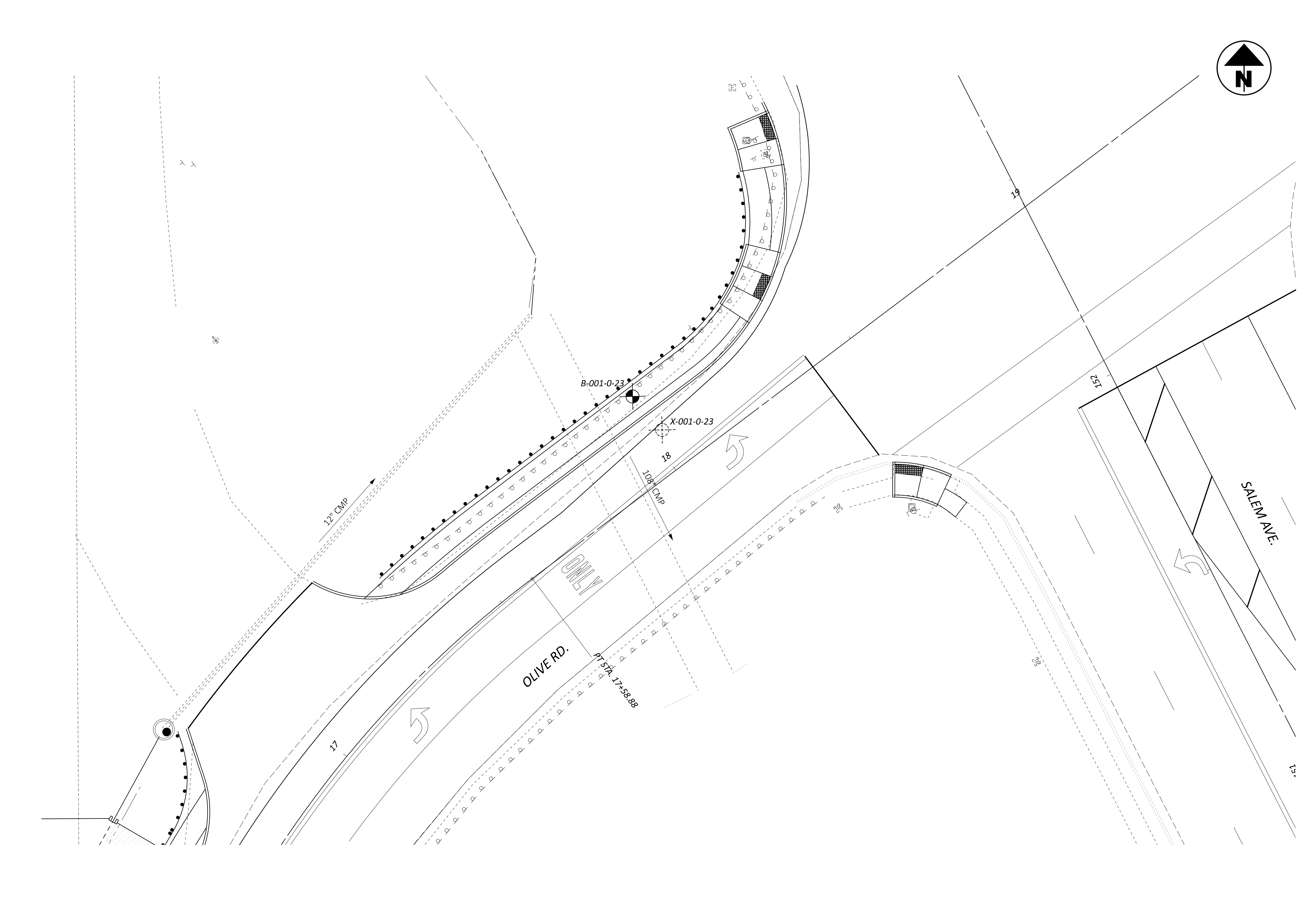
MONTGOMERY COUNTY, OHIO

RII PROJECT NO. W-23-150	DRAWN JAS
SCALE: 1"=5000' (0 – 2500 – 5000)	REVIEWED DEK
	DATE 11/27/2023

RESOURCE INTERNATIONAL Rii

MOT-49-5.46 CULVERT EXTENSION

MODEL: PLAN PAPERSIZE: 17x11 (in.) DATE: 2/28/2024 TIME: 10:43:20 AM USER: juans
J:\GEOTECH\Geotech Connect Projects\2023\W-23-150 MOT TROTWOOD OLIVE RD SIDEWALKS\117202\400-Engineering\Geotechnical\Sheets\117202_IP001-.dgn



HORIZONTAL SCALE IN FEET
0 5 10 20

BORING PLAN
MOT-49-5.46 CULVERT EXTENSION

DESIGN AGENCY

RESOURCE INTERNATIONAL

6350 PRESIDENTIAL GATEWAY
COLUMBUS, OHIO 43231
(614) 823-4949

DESIGNER	JAS
REVIEWER	XXX MM-DD-YY
PROJECT ID	117202
SUBSET / TOTAL	0 / 0
SHEET / TOTAL	P.0 / 0

APPENDIX II

DESCRIPTION OF SOIL AND ROCK TERMS

DESCRIPTION OF SOIL TERMS

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

Granular Soils – USCS GW, GP, GM, GC, SW, SP, SM, SC, ML (non-plastic)
The relative compactness of granular soils is described as:

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

Cohesive Soils – USCS ML, CL, OL, MH, CH, OH, PT
The relative consistency of cohesive soils is described as:

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

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

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

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

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

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

Term	Range
Dry	0% to 10%
Damp	>2% below Plastic Limit
Moist	2% below to 2% above Plastic Limit
Very Moist	>2% above Plastic Limit
Wet	≥ Liquid Limit

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	Parameter
Very Weak	Can be carved with knife and scratched by fingernail.
Weak	Can be grooved or gouged with knife readily.
Slightly Strong	Can be grooved or gouged 0.05 in deep with knife.
Moderately Strong	Can be scratched with knife or pick.
Strong	Can be scratched with knife or pick with difficulty.
Very Strong	Cannot be scratched by knife or pick. Hard repeated blows of hammer to detach specimen.
Extremely Strong	Cannot be scratched by knife or pick. Hard repeated blows of hammer to chip hand specimen.

DESCRIPTION OF ROCK TERMS

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

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

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

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

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

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

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

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

Degree of Fracturing

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

Aperture Width

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

Surface Roughness

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

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

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

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.

APPENDIX III

BORING LOG:

B-001-0-22

ROCK CORE PHOTO LOG

RESOURCE INTERNATIONAL, INC.

PROJECT: MOT-49-5.46 CULVERT EXT.	DRILLING FIRM / OPERATOR: RII / TG/SB	DRILL RIG: DIEDRICH D-50 (# 313)	STATION / OFFSET: 18+02.3 / 19' LT.
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: RII / IS	HAMMER: AUTOMATIC	ALIGNMENT: CLP - OLIVE RD
PID: 117202 SFN: NA	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/21/22	ELEVATION: 869.2 (MSL) EOB: 27.0 ft.
START: 10/10/23 END: 10/10/23	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 86.4	LAT / LONG: 39.826162, -84.292578

EXPLORATION ID **B-001-0-22**

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 869.2
0.8' - ASPHALT (10.0")	868.4
0.2' - AGGREGATE BASE (2.5")	868.2
STIFF, BROWNISH GRAY **SILTY CLAY**, SOME COARSE TO FINE SAND, SOME FINE GRAVEL, MOIST.	866.2
STIFF TO VERY STIFF, BROWN **SILT AND CLAY**, "AND" COARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP TO MOIST. -LIMESTONE FRAGMENTS IN SS-3 -TRACE ROOT FIBERS IN SS-5A	857.7
MEDIUM DENSE TO DENSE, BROWN **GRAVEL WITH SAND AND SILT**, MOIST.	851.7
HARD, LIGHT BROWN TO BROWNISH GRAY **SILTY CLAY**, TRACE COARSE AND FINE SAND, TRACE FINE GRAVEL, DAMP. -SOIL BECOMING HIGHLY WEATHERED SHALE WITH DEPTH	847.8
SHALE : GRAY, MODERATELY WEATHERED, WEAK, LAMINATED, MODERATELY FRACTURED, NARROW APERTURES, SLIGHTLY ROUGH SURFACES, BLOCKY/DISTURBED/SEAMY, POOR SURFACE CONDITION.	842.2

DEPTHS: 1–27 (EOB at 27)

SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
4 6 10	23	61	SS-1	2.00	25	11	17	24	23	29	13	16	13	A-6b (4)	
8 6 8	20	75	SS-2	2.00	19	14	23	27	17	28	13	15	12	A-6a (3)	
5 3 5	12	83	SS-3	1.25	-	-	-	-	-	-	-	-	12	A-6a (V)	
3 5 5	14	56	SS-4	3.75	-	-	-	-	-	-	-	-	14	A-6a (V)	
6 8 10	26	83	SS-5A	2.25	-	-	-	-	-	-	-	-	13	A-6a (V)	
			SS-5B	-	-	-	-	-	-	-	-	-	7	A-2-4 (V)	
17 10 14	35	44	SS-6	-	-	-	-	-	-	-	-	-	7	A-2-4 (V)	
13 11 12	33	33	SS-7	-	45	13	11	- 31 -		NP	NP	NP	6	A-2-4 (0)	
11 13 16	42	33	SS-8	-	10	5	4	26	55	-	-	-	11	A-6b (V)	
7 17 33	72	78	SS-9	4.50	5	2	2	34	57	39	20	19	12	A-6b (12)	
22 50/5"	-	91	SS-10	4.50	0	1	1	43	55	37	19	18	9	A-6b (11)	
63		93	RC-1											CORE	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING; CAVE-IN DPETH @ 21.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS. PAVEMENT PATCHED WITH ASPHALT COLD PATCH. .

Project Name: MOT-Trotwood Olive Road Sidewalks	**Location:** Trotwood Ohio	**Project No.:** W-23-150

Photo No. **1**	
Boring: B-001	
RC-1: 22.0'-27.0" REC (%): 93 REC (%): 43	

APPENDIX IV

PAVEMENT CORE DATA SHEET

Pavement Core Data Summary

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

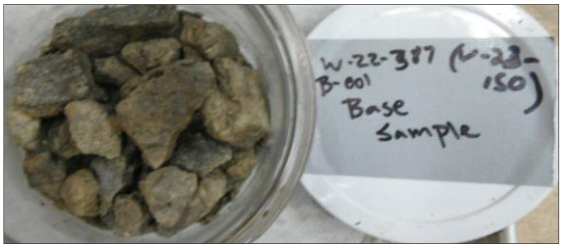
PROJECT	MOT 49-5.46 Culvert Extension
LOCATION	Trotwood, Ohio
JOB No.	W-23-150
BORING/CORE No.	B-001
DATE CORE OBTAINED	10/10/2023
CORE OBTAINED BY	TG, SD, IS

Core Composition

Core Number	Layer Thickness (in.)	Pavement Layer Number	Asphalt: Surface Binder	Asphalt: Intermediate Binder	Asphalt: Base Binder	Concrete	Aggregate/Granular Base	Other		
B-001	2.25	3	✓							
	3.50	2		✓						
	4.25	1		✓						
	2.50						✓			

Comments/Remarks

- Core is separated between layers 1 and 2
- Layer 1 is slightly deteriorated



Total Pavement Thickness = 10.00 in. Total Asphalt Thickness = 10.00 in. Total Concrete Thickness = 0.00 in. Total Base Thickness = 2.50 in.