Professional Service Industries, Inc.
4960 Vulcan Ave.
Columbus, OH 43228
Phone: (614) 876-8000

February 21, 2018

Mr. Kevin J. Grathwol, P.E.
GPD Group
1801 Watermark Drive, Suite 210
Columbus, Ohio 43215

Re: **Geotechnical Exploration Report**
Scottslawn Road Improvements
Marysville, Union County, Ohio
PSI Project No. 01021257

Dear Mr. Grathwol:

Thank you for choosing Professional Service Industries, Inc. (PSI), an Intertek company, as your consultant for the Scottslawn Road Improvements project in Union County, Ohio. The information you requested is attached.

PSI performed the geotechnical engineering study that you requested in general accordance with our agreement dated November 8, 2017. PSI transmits one (1) copy with this letter.

We thank you for your business and we look forward to finding ways to grow our partnership, expand our services, and continue Building Better Together.

Respectfully submitted,
PROFESSIONAL SERVICE INDUSTRIES, INC.

Miles Mullins
Staff Engineer
EI # 1100019484

John Xu
Senior Project Manager
OH, PE #60483, Exp. 12/31/19

Paul Hundley
Regional Engineer/Principal Consultant
OH, PE #43741, Exp. 12/31/19

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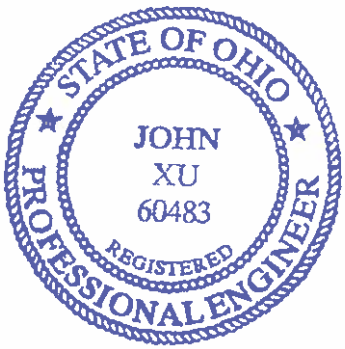

Geotechnical Exploration Report

Scottslawn Road Improvements
Marysville, Union County, Ohio

Prepared for

GPD Group
1801 Watermark Drive, Suite 210
Columbus, Ohio 43215

John Xu, P.E.
Senior Project Manager

Prepared by

Professional Service Industries, Inc.
4960 Vulcan Avenue
Columbus, Ohio 43228

February 21, 2018

PSI Project No. 01021257

Paul S. Hundley, P.E.
Regional Engineer/Principal Consultant

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1 EXECUTIVE SUMMARY

This report has been prepared for GPD Group (GPD) for Scottslawn Road improvements. The project site is located along Scottslawn Road from SR-736 to just north of the grain entrance to Heritage Cooperative near the Marysville Corp. line in Marysville, Union County, Ohio. The project will widen and resurface approximately 1.5 miles of the roadway. An approximate location of the project limits is indicated on the Site Location Map included in the appendix. The roadway improvement will begin near station 10+00 and end near station 87+50.

A total of twenty (20) test borings and eight (8) pavement cores were performed for the project. All test borings were advanced for the purpose of proposed roadway subgrade design.

Soils found from the field exploration are all cohesive soils below pavement, base or surface materials on the shoulder areas.

These cohesive soils include clay (A-7-6), sandy silt (A-4a), silty clay (A-6b), silt and clay (A-6a), and silt (A-4b). In the entire test boring depth of 7.5 feet, the predominant soil type is silty clay (A-6b).

Standard penetration testing (SPT) was performed at each sampling. The consistency of cohesive soils was found to range from “very soft” to “hard,” but was predominantly “very stiff.” Auger refusal materials were not encountered in any test borings drilled for this project.

The Sulfate content test was not conducted due to the local project nature.

According to the results of GB-1 analysis and laboratory test results, an average CBR of 5 (or resilient modulus of 5,842 psi) can be used for the pavement design for the project section. Global subgrade improvement is recommended for the project if roadway widening lanes.

This summary should be used in conjunction with the entire exploration report since this summary sheet cannot include all details of the preliminary exploration findings.

2 INTRODUCTION

2.1 PROJECT DESCRIPTION

This report has been prepared for GPD Group (GPD) for Scottslawn Road improvements. The project site is located along Scottslawn Road from SR-736 to just north of the grain entrance to Heritage Cooperative near the Marysville corp. line in Marysville, Union County, Ohio. Information provided by the client indicated that additional half to one lane width will be added to the existing roadway section. An approximate project length of 1.5 miles will be included in the project limits. Proposed improvements may include: subgrade improvement, base and pavement construction and pavement overlay construction or resurfacing; culvert replacement, adjustments to utility structures; new signage; and incorporation of bike lanes on the paved shoulders. The widening project will add a half-lane wide paved shoulder at most locations and one right turning lane onto Weaver Road along southbound Scottslawn Road near station 48. The roadway improvement will begin near station 10+00 and end near station 87+50. An approximate location of the project site is indicated on the Site Location Map included in the appendix.

Included in this report are geotechnical exploration findings and recommendations for roadway section widening, improvements or reconstruction within the project limits. The report represents the intent of the design engineer, GPD, and project owner, Union County, to secure subsurface information at selected locations which will aid the design engineer in preparation of the design and construction plans and specifications, and potential contractors in development of their bid estimates.

2.2 PROJECT AUTHORIZATION

GPD Group requested a revised proposal for the above-mentioned project, from PSI on July 6, 2017. PSI subsequently submitted a revised proposal on July 10, 2017. The proposal was approved and a written authorization to proceed with the project was given by GPD Group on November 8, 2017.

2.3 SCOPE OF SERVICES

The detailed scope of services for this project was outlined in the PSI's Proposal No. 0102-213809R-1 dated July 10, 2017. PSI's scope of services for this project was limited to the execution of the following phases:

Reconnaissance and Planning:

Perform a reconnaissance of the project site, development of the test boring and sampling program, and notify Ohio Utility Protection Services (OUPS) and area underground utility companies of the location of proposed test borings.

Field Exploration for Roadway and Subgrade:

Advance a total of twenty (20) roadway test borings and eight (8) pavement cores; the number of tests were selected by GPD, and the location determined by PSI, along the project alignments in general accordance with the latest version of ODOT's Specifications for Geotechnical Exploration (SGE). A GPD survey crew surveyed the boring and core locations.

Laboratory Testing:

Collect, test and analyze select subsurface soil and rock samples obtained from the field exploration in general accordance with the ODOT's Specifications for Geotechnical Exploration, and classify the samples using the ODOT Soil Classification System. Laboratory testing included in the exploration are physical property tests for the soil. These tests include Liquid and Plastic limit test, soil particle size distribution, natural moisture content, and visual soil classifications

Roadway Exploration Report:

This technical report includes a brief introduction of the project, investigation findings, suggestions and recommendations regarding the roadway design, construction, and earthwork considerations during construction of the project. Full size geotechnical exploration plans for this project in accordance with the ODOT's SGE are not required for this project.

The scope of services did not include any environmental assessments for the presence or absence of wetlands, or hazardous or toxic materials in the soil, surface water, groundwater or air, on, below or around this site. Any statements in this report regarding odors, colors or unusual or suspicious items or conditions are strictly for the information of the client.

3 GEOLOGY AND OBSERVATION OF THE PROJECT

3.1 SITE RECONNAISSANCE

PSI conducted a preliminary reconnaissance of the site which included discussions with the project design engineer, extensive research on websites, search for historical data and information from the site visit. Top of rock depths were estimated using available information published by the Ohio Department of Natural Resources (ODNR) and PSI's past experience working in the general area

3.2 GENERAL GEOLOGY OF THE SITE

Based on the geologic map published by the Ohio Geological Survey, the site lies within the Central Ohio Clayey Till Plain. Geology consists of clayey, high-lime Wisconsian-age till from a northeastern source (Erie glacial Lobe) and lacustrine materials over Lower Paleozoic-age carbonate rocks and, in the east, shales; loess thin to absent. Surface geology consists of clayey till; well-defined moraines with intervening flay-lying ground moraine and intermorainal lake basins.

Information obtained from the Ohio Department of Natural Resources (ODNR) website indicated that no known abandoned / active mine was recorded in the vicinity of the site area. "Known and Probable Karst in Ohio" map published by ODNR indicates that no Karst (sink hole) is recorded in the vicinity of the project site.

3.3 SITE OBSERVATION

The project roadway is located in a rural area near Marysville, Union County, Ohio. The section of Scottslawn Road is a two-lane road with narrow shoulders. The site area is mainly used for farming.

The existing roadway pavement appeared to be in fair to good condition, depending on the pavement location. Along the project section, some local pavement overlay and pothole repairs can be observed. No major pavement rutting or severe pavement cracking were observed within the project limits. Pavement evaluation is beyond PSI's scope of services for this project. PSI's pavement condition description cannot substitute detailed pavement evaluation performed by the pavement design engineer for this project.

4 FIELD EXPLORATION

4.1 PLANNING

PSI conducted preliminary site reconnaissance prior to field drilling operations. The reconnaissance included discussions with the project design engineer, GPD, reviewing available historical (ODNR and ODOT) records and information from visiting the site.

The client selected the number of test borings and the boring locations were marked/staked in the field by PSI's engineering staff prior to PSI's field exploration. Twenty (20) test borings and eight (8) pavement cores were planned and advanced for the project. The drilled test boring locations are shown on the attached figure - "Boring Location Map" in the appendix of this report. Station, offset and elevations at each test boring location were provided by the client after field exploration.

PSI personnel contacted Ohio Utility Protection Services (OUPS), project owner, and utility companies whose names were made available to us prior to commencing test-boring operations. PSI provided traffic control signs, cones and flagging crew in order to maintain vehicular traffic during field drilling and pavement coring operations. GPD was notified for the field activities prior to mobilization and after de-mobilization. GPD surveyed the boring and coring locations after completion of PSI's field exploration.

4.2 EXPLORATORY TEST BORINGS

The field explorations were performed in accordance with applicable ASTM, AASHTO and ODOT Specifications.

A total of twenty (20) test borings were advanced for the project. All test borings were advanced for the proposed roadway subgrade design purpose. The test boring number and approximate location of each boring are included in a boring location plan, GB 1 analysis sheet and each boring log. Geoprobe 7800 and Geoprobe 7822DT drilling rigs were mobilized to advance the test borings from December 27th to December 29th, 2017. The borings were advanced utilizing 3¼ inch inside diameter, hollow stem auger drilling methods. Soil samples were routinely obtained during the drilling process. Representative disturbed samples of soil were collected at center-to-center intervals of 1.5 feet. The Standard Penetration Test (AASHTO T 206 or ASTM D-1586) was performed at each sampling interval.

The field exploration was conducted in accordance with the ODOT SGE 303.4. The roadway test borings were terminated at a depth of 7.5 feet (Type A borings by ODOT SGE) below estimated roadway grade.

PSI's field crew monitored the water levels in the borehole for the presence of groundwater during drilling operation. Long term groundwater monitoring was not planned for this project. The typed drilling logs, included in the appendix of this report, show the SPT resistance (N_{60}) values for each soil sample obtained in the test boring, and present the classification and description of soil and rock encountered at various depths in the test boring.

Selected soil samples were later tested in the laboratory to obtain soil physical properties for development of the foundation and pavement design recommendations. Drilling, sampling, and laboratory testing was accomplished in general accordance with ASTM procedures.

5 EXPLORATION FINDINGS

5.1 SUBSURFACE CONDITIONS

Borings B-002, B-004, B-005, B-006, B-007, B-008, B-009, B-010, B-014, B-017, B-018, and B-020 were advanced along the roadway soil shoulder areas. The remaining borings were drilled through pavement of varying thicknesses. Soils found on the shoulders typically consisted of topsoil with the exception of B-007 and B-020 which exhibited silty clay and gravel, respectively. Topsoil ranged from 3 to 8 inches in thickness with an average of 4.6 inches. Asphalt thickness according to the pavement cores ranged from 9 to 13 ¼ inches with an approximate average of 11. According to drilling logs, the base was not clearly identified in several locations. We suggest using the pavement core information to estimate the pavement structure. A brief summary of the pavement thickness is outlined in a table on the following page. Each of the pavement cores were photographed and are included in the appendix of this report. Trends indicated that weaker soil was more often found in the off-road borings than in the roadway embankment.

These subgrade soils were all found to be cohesive and include clay (A-7-6), sandy silt (A-4a), silty clay (A-6b), silt and clay (A-6a), and silt (A-4b). In the entire test boring depth of 7.5 feet, the predominant soil type is silty clay (A-6b).

Standard penetration testing (SPT) was performed at each sampling. The consistency of the soils was found to range from "very soft" to "hard," but was predominantly "very stiff." Auger refusal materials were not encountered in any test borings drilled for this project.

Asphalt Thickness from Pavement Core

Boring Number	Station	Offset	Asphalt Thickness (in.)
PC-001	10+37.3	Right 15.2 ft	10
PC-003	18+07.9	Right 2.8	12
PC-011	50+43.4	Right 7.7	13 ¼
PC-012	54+13.0	Left 5.7	10 ¼
PC-013	58+39.9	Right 4.5	10 ½
PC-015	65+74.8	Right 5.8	9
PC-016	70+23.2	Right 5.5	11 ¼
PC-019	81+88.5	Left 5.9	12 ¼
Average			**11.1**

Note: Station and offset are approximate

5.2 LABORATORY ANALYSIS

A geotechnical engineer visually examined all soil samples obtained during the field investigation. The engineer selected representative soil samples to be tested in the laboratory for assistance in soil classification and determination of engineering properties of the soils. The tests consisted of Moisture Content Determination, Particle-Size Analysis, Liquid Limit, Plastic Limit and Plasticity Index Determinations. All tests were performed in accordance with AASHTO, ASTM or other standards listed in a table located in the appendix. The soils were classified in accordance with the ODOT Soil Classification System (OSCS). A description of the classification system and the results of the laboratory tests are included in the appendix.

A total of 20 soil samples (including Atterberg limits and particle size analysis) were selected from split-spoon samples for laboratory tests. A total of 20 Atterberg limits tests were conducted successfully, and none of these soil samples were found to be non-plastic.

5.3 WATER LEVEL MEASUREMENTS

Groundwater was not in any of the borings. The water level readings were taken by PSI's drilling crew during field explorations. Additionally, discontinuous zones of perched water may exist within the overburden materials, especially near the utility trenches.

In fine-grained glacial soils, the depth of the soil color change from brown to gray can be an indicator of the prevailing groundwater level. Above the prevailing groundwater level, fine-grained soils oxidize to a brown color. On this site, the majority of soil borings were terminated relatively shallow, therefore, the soil color change is not clearly identified.

Long term groundwater monitoring was not planned for this project. The typed drilling logs, included in the appendix of this report, show the SPT resistance (N_{60}) values for each soil sample obtained in the test boring, and presents the classification and description of soil and rock encountered at various depths in the test boring.

The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. Test boring logs included in the appendix should be reviewed for specific information at individual boring locations. These records include soil descriptions, stratifications, penetration resistances, and locations of the samples and laboratory test data. The stratifications shown on the boring logs represent the conditions only at the actual boring locations. Variations may occur and should be expected between boring locations. The stratifications represent the approximate boundary between subsurface materials and the actual transition may be gradual. Water level information obtained during field operations is also shown on these boring logs. The samples that were not altered by laboratory testing will be retained for 60 days from the date of this report and then will be discarded.

6 ANALYSES AND RECOMMENDATIONS FOR ROADWAY DESIGN

The geotechnical exploration findings, analyses and recommendations are included in the following sections.

The geotechnical recommendations presented in this report are based on the available project information for the proposed roadway located within the project limits in Marysville, Union County, Ohio and the subsurface materials described in this report. If any of the information noted above is incorrect, please inform PSI in writing so that we may amend the recommendations presented in this report if appropriate and if desired by the client. PSI will not be responsible for the implementation of its recommendations when it is not notified of changes in the project.

6.1 SULFATE CONTENT TEST

Sulfate content test was not planned for this project. According to information provided by the client, the project will involve most likely adding half lane to the existing road. Because of proposed work width is narrower than chemical stabilization vehicle, use of chemical stabilization on this project is impractical during the adding lane subgrade construction for this project.

6.2 GB 1 ANALYSIS

PSI conducted GB 1 analysis using the ODOT spread sheet based on laboratory test results and visual soil classifications from the upper 7.5 feet of the subgrade soils, including only the off-road test borings (where subgrade improvement may be required). The GB 1 analysis was designed for pavement rehabilitation/reconstruction of the existing roadway subgrade.

Comparing the existing moisture content of the soils to the optimum moisture content is an indicator for the need for subgrade stabilization. Moisture contents that exceed the optimum moisture content by more than 3 percent will likely require some form of subgrade stabilization. When the need for stabilization is positively identified; the lowest N (N_L) value in the top 6 feet of the proposed subgrade is used when averaging multiple N values. GPD provided grade elevations at each boring location based on recent survey data. PSI uses the available information in the GB 1 analysis. Please note that the GB 1 analysis was conducted based on no major grade elevation changes. All discussions regarding to the design options are PSI's opinions, and the project design engineer should make final decision based not only on the exploration findings but also on other design requirements.

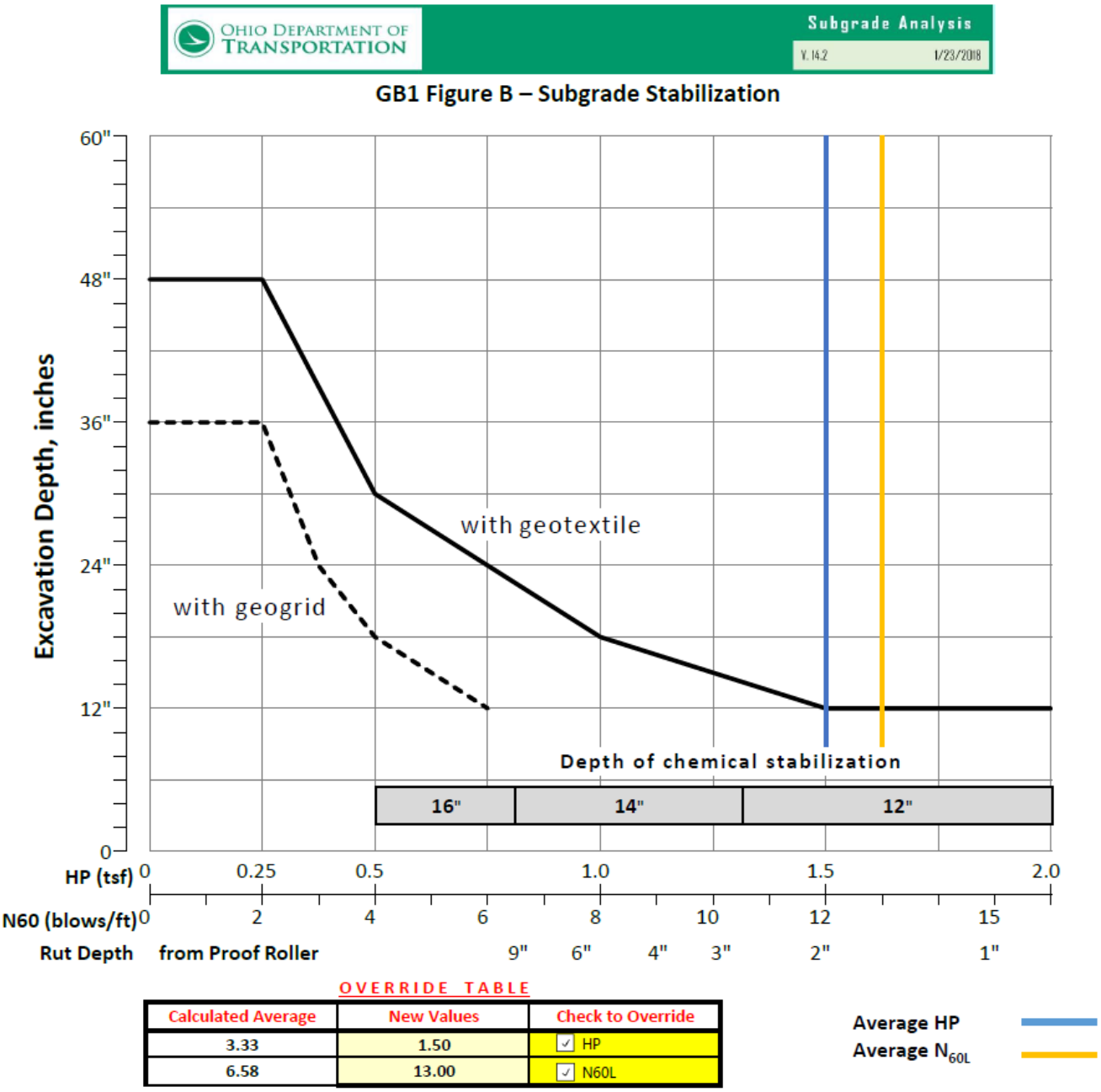
The new ODOT GB-1 form does not seem to agree with the previous form for the non-cohesive and cohesive soils grouping. However, PSI used the new GB-1 form for this project. According to the latest GB 1 analysis, the upper 7.5 feet of the existing subgrade had 32% granular soils and 68% cohesive soils. These soils are clay (A-7-6, approx. 28%), silty clay (A-6b approx. 26%), silt and clay (A-6a approx. 13%), silt (A-4b, approx. 2%), and sandy silt (A-4a approx. 32%).

Natural moisture content of subgrade soils was found to range from 8% to 36% with an average of 20%. According to the GB 1 analysis, the optimum moisture contents of the same group soils should range from 10% to 21%. SPT N_{60} values ranged from 0 to 33 blows per foot (bpf) with an average of 13 bpf. The lowest SPT N_{60} values in the upper 6 feet of the subgrade in each boring ranged from 0 to 18 blows per foot (bpf) with an average of 7 bpf. Plastic Index of soils ranged from 9 to 41 with an average of 21. Silt (A-4b) was only found in test boring B-007 between 1.5 and 3.0 feet. The GB 1 analysis indicated that within 6 feet of subgrade, 43% of soil samples had an SPT N_{60} less than or equal to 12 bpf, and 30% of soil samples had natural moisture contents greater than their optimum values.

The GB-1 analysis was conducted using a uniform depth to the top of subgrade of 1.5 feet or 18 inches from the ground surface for shoulder borings. References to undercut depths are from this depth. The GB-1 analysis indicated that 76% of surface soils need to be undercut and improved (soil re-compaction) or be replaced with suitable engineered fill. As discussed previously, chemical stabilization is not planned for this project. These soils either had high moisture or low density or both. Depth of the undercut is estimated to be between 12 to 33 inches with an average of 22 inches. When geogrid is used, the thickness of the subgrade improvement can be ranged from 12 to 21 inches. According to GB-1, use of geotextile will not reduce the thickness required for the subgrade improvement. Since approximately 76% of the existing subgrade at the upper 6 feet is considered unstable, global subgrade improvement should be considered for this project. Silt (A-4b) found in boring B-007 must be undercut to the minimum depth of 24 inches below the proposed subgrade, according to GB-1. PSI assumes the subgrade below the existing pavement is not going to be reconstructed, the subgrade reconstruction will be needed only for widening lanes. Please refer to attached GB-1 analysis form for locations (near test borings) and thicknesses of the subgrade improvement. Soil test borings for this project was performed during winter seasons, the subgrade conditions may be different during the construction seasons. PSI recommends further visual examination or testing (such as proof rolling) the entire project sections, to finalize the sections where the improvement is needed.

Cut-and-fill or subgrade re-compaction is a common method of subgrade improvement during the pavement reconstruction. The method will require removal of the unsuitable soils, replacing the soil with engineered fill or recompact the on-site cuttings to the required minimum density. However, soil replacement can be more expensive than cement stabilization due to cost of hauling during a large project construction. As an option, GB-1 provided an option of using geogrid to reduce the undercutting depths. According to GB 1 analysis and subgrade condition, it seems to be necessary to perform subgrade stabilization for the entire lane widening areas.

The following Figure B from the ODOT GB1 can be used to select the method of subgrade improvement and calculate the minimum improvement thickness for each option. The following GB 1 Figure C can be utilized to estimate quantity of different chemicals needed for chemical stabilization option.



Each of the above subgrade improvement methods should be suitable for this project. Please note this report was prepared according to subgrade conditions explored in winter, and subgrade conditions may vary by season. PSI recommends further subgrade inspection during the earthwork construction and making necessary construction revision. The decision of choosing one of these methods should be made by the project design engineer or the project owner based on economic analysis and feasibility (such as method of MOT) of each method planned for the project.

6.3 SELECTION OF SUBGRADE STABILIZATION METHOD

Factors that should be considered when selecting which method of subgrade stabilization should be used for the project are:

- Sequence of project construction and Maintenance of Traffic (MOT) limitations of work areas. Smaller sections are best treated using undercutting and replacement with granular materials.
- Restriction of undercut depth due to utilities. Chemical stabilization would not require undercutting and soil replacement.
- Access to business/residences must be maintained during construction.
- Exposure of nearby residences to airborne (lime or cement) dust is a concern.
- Limited project size may not be conducive to cost effectiveness of chemical stabilization.
- Time of year construction is carried out (dry season) and subgrade preparation per item 203 of ODOT CMS and proof rolling requirements to identify areas requiring stabilization (less area) may be more conducive to undercutting and replacement.
- Lowering subgrade to accommodate an aggregate base may reduce the need to stabilize.

6.4 AGGREGATE BASE AND DRAINAGE

Design and installation of proper drainage systems can reduce subgrade moisture contents and minimize potential subgrade saturation, especially in the low-lying subgrade areas and in the silt and clay rich subgrade soils, such as this project area where cohesive subgrade is encountered predominantly**.** Based on PSI's exploration findings, groundwater levels were not encountered in any test borings. The project design engineer should evaluate the site conditions and other historical or maintenance records to ensure that the existing storm water drainage system serves the drainage need.

6.5 RECOMMENDED CBR FOR NEW PAVEMENT DESIGN AND CONSTRUCTION

When the roadway section is reconstructed, aggregate base and pavement will be constructed. We have estimated a CBR value using the tool of GB-1 analysis. According to the results of GB-1 analysis and laboratory test results, an average CBR of 5 (or resilient modulus of 5,842 psi) can be used for the pavement design for the project section.

6.6 CUT-AND-FILL CONSTRUCTION

At the time the report was prepared, the final construction plans were not available to PSI. However, the client had indicated that the finished soil profile will have minimal change from the existing profile. PSI's GB 1 analysis was conducted based on maintaining the same finished grade. Proposed cut-and-fill depths are included in GB-1 analysis forms attached in the appendix.

6.7 OVERLAY CONSTRUCTION

When pavement overlay construction is planned, total pavement thickness should meet the design traffic volume and subgrade conditions. It may be necessary to re-evaluate future pavement thickness based on an average CBR of 5, required pavement structural number and thickness of the current pavement to determine

the thickness of pavement overlay design. According to PSI's observation, minimum overlay thickness (according to the ODOT pavement design manual) is anticipated along this project section

PSI recommends the project design engineer evaluate the conditions of the existing pavement to identify the final design plan. If overlay design is planned, severely damaged pavement area must be removed/replaced or full depth repaired before overlay construction.

7 CONSTRUCTION CONSIDERATIONS

The following geotechnical related recommendations have been developed on the basis of the subsurface conditions encountered and PSI's understanding of the proposed development. This section can be used when pavement reconstruction is planned. Should changes in the project criteria occur, a review must be made by PSI to determine if modifications to our recommendations will be required.

7.1 SITE PREPARATION-IN MINOR REPAIR AREAS

When pavement reconstruction is needed in isolated poor pavement areas, PSI recommends that old pavement, soft organic, frozen, or unsuitable soils in the construction areas be stripped from the site and either wasted or stockpiled for later use in non-structural areas. A representative of the geotechnical engineer should determine and document the depth of removal at the time of construction.

Since any new roadway pavement will be constructed in the same general areas as the existing roadway, the condition of the site should be checked before base and pavement construction. Roadway subgrade should be constructed in accordance with Item 203 of the ODOT CMS.

PSI should be retained to provide observation and testing of construction activities involved in the foundation, earthwork, and related activities of this project. PSI cannot accept responsibility for conditions that deviate from those described in this report, nor for the performance of the foundation system if not engaged to also provide construction observation and testing for this project.

7.2 EARTHWORK CONSTRUCTION

Backfill of the proposed below-grade structure or replacement of unsuitable subgrade soils may consist of low plastic soils or granular material. PSI suggests using granular material to provide improved drainage and to reduce lateral pressures on the walls resulting from water pressure. All earthwork should be constructed in accordance with Items 201, 202, 203, 204, 503 and 518 of the ODOT CMS. PSI advises performing field density tests on the backfill to monitor compliance with the recommendations provided. Care should be exercised during the backfilling operation to prevent overstressing and damaging the constructed structures.

7.3 DRAINAGE AND GROUNDWATER/WATER CONSIDERATIONS

PSI recommends that the contractor determine the method of surface water drainage during the construction activities to assess the impact groundwater may have on construction. According to PSI's past experience, groundwater has little to no impact to the subgrade and pavement constructions on this project site.

7.4 SILTATION CONTROL

The Clean Water Act, implemented in 1990 includes a federal permit program called the National Pollutant Discharge Elimination System (NPDES). This program requires that projects sites in excess of one (1) acre or are part of a development which exceeds one (1) acre be covered under a permit. This typically includes the development of a storm water pollution prevention plan (SWPPP) as well as periodic inspections (typically once a week plus after significant rainfall). PSI is available to assist with these services.

7.5 EXCAVATION SAFETY

In Federal Register, Volume 54, Number 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, part 1926, Subpart P". This document was issued to better enhance the safety of workers entering trenches or excavations. It is mandated by this federal regulation that excavations, whether they be utility trenches, basement excavation or footing excavations, be constructed in accordance with the new OSHA guidelines. It is PSI's understanding that these regulations are being strictly enforced and if they are not closely followed, the owner and the contractor could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor's "responsible person", as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations.

PSI is providing this information solely as a service to our client. PSI does not assume responsibility for construction site safety or the contractor's or other parties' compliance with local, state, and federal safety or other regulations.

8 GEOTECHNICAL RISK

The concept of risk is an important aspect of the geotechnical evaluation. The primary reason for this is that the analytical methods used to develop geotechnical recommendations do not comprise an exact science. The analytical tools which geotechnical engineers use are generally empirical and must be used in conjunction with engineering judgment and experience. Therefore, the solutions and recommendations presented in the geotechnical evaluation should not be considered risk-free and, more importantly, are not a guarantee that the interaction between the soils and the proposed structure will perform as planned. Based on the information generated and referenced during this evaluation, and PSI's experience in working with these conditions, the engineering recommendations presented in the preceding section constitutes PSI's professional estimate of those measures that are necessary for the proposed structure to perform according to the proposed design.

9 REPORT LIMITATIONS

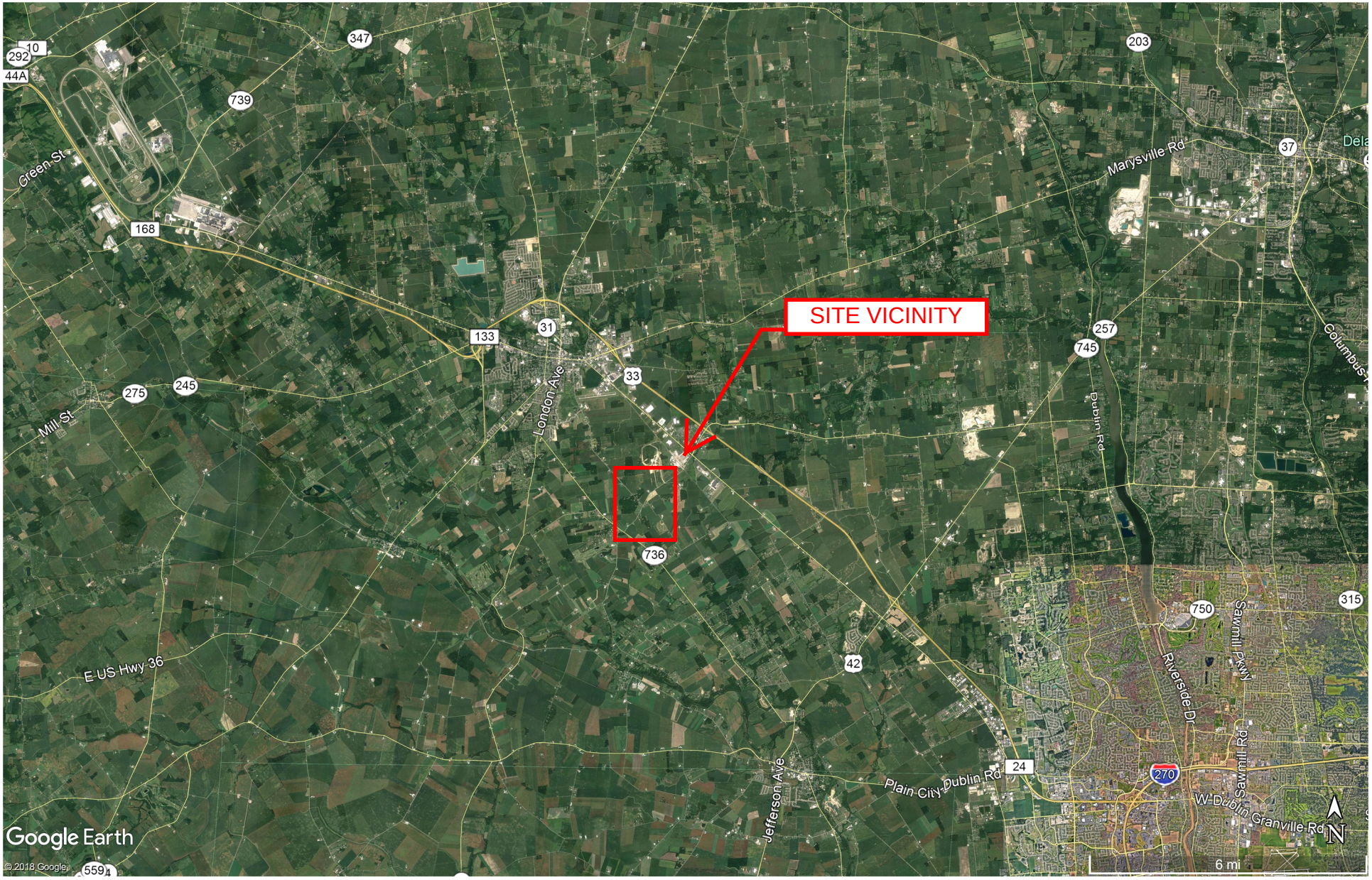
The recommendations submitted are based on the available subsurface information obtained by PSI and design details furnished by GPD. If there are revisions to the plans for this project or if deviations from the subsurface conditions noted in this report are encountered during construction, PSI should be notified immediately to determine if changes in the foundation recommendations are required. If PSI is not retained to perform these functions, PSI will not be responsible for the impact of those conditions on the project.

The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

After the plans and specifications are more complete, the geotechnical engineer should be retained and provided the opportunity to review the final design plans and specifications to check that our engineering recommendations have been properly incorporated into the design documents. At that time, it may be necessary to submit supplementary recommendations. This report has been prepared for the exclusive use of Union County (the project owner) and GPD (the project design engineer) for the specific application to the proposed Scottslawn Road improvements project in Union County, Ohio.

APPENDIX

Site Vicinity Plan
Boring Location Plan
ODNR Mine Map
FEMA 1% Annual Chance Flood Map
Boring Logs
GB1 Analysis
Pavement Core Photos
General Notes
Karst Map
Soil Classification Chart



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Site Vicinity Plan

Scottslawn Road Improvements

Marysville, Union County, Ohio

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4960 Vulcan Ave. Suite C
Columbus, OH 43228
Telephone: (614) 876-8000

Boring Location Plan

Scottslawn Road Improvements

Marysville, Union County, Ohio

PSI Project No.: 01021257

intertek psi
Professional Services Industries, Inc.
4960 Vulcan Ave. Suite C
Columbus, OH 43228
Telephone: (614) 876-8000

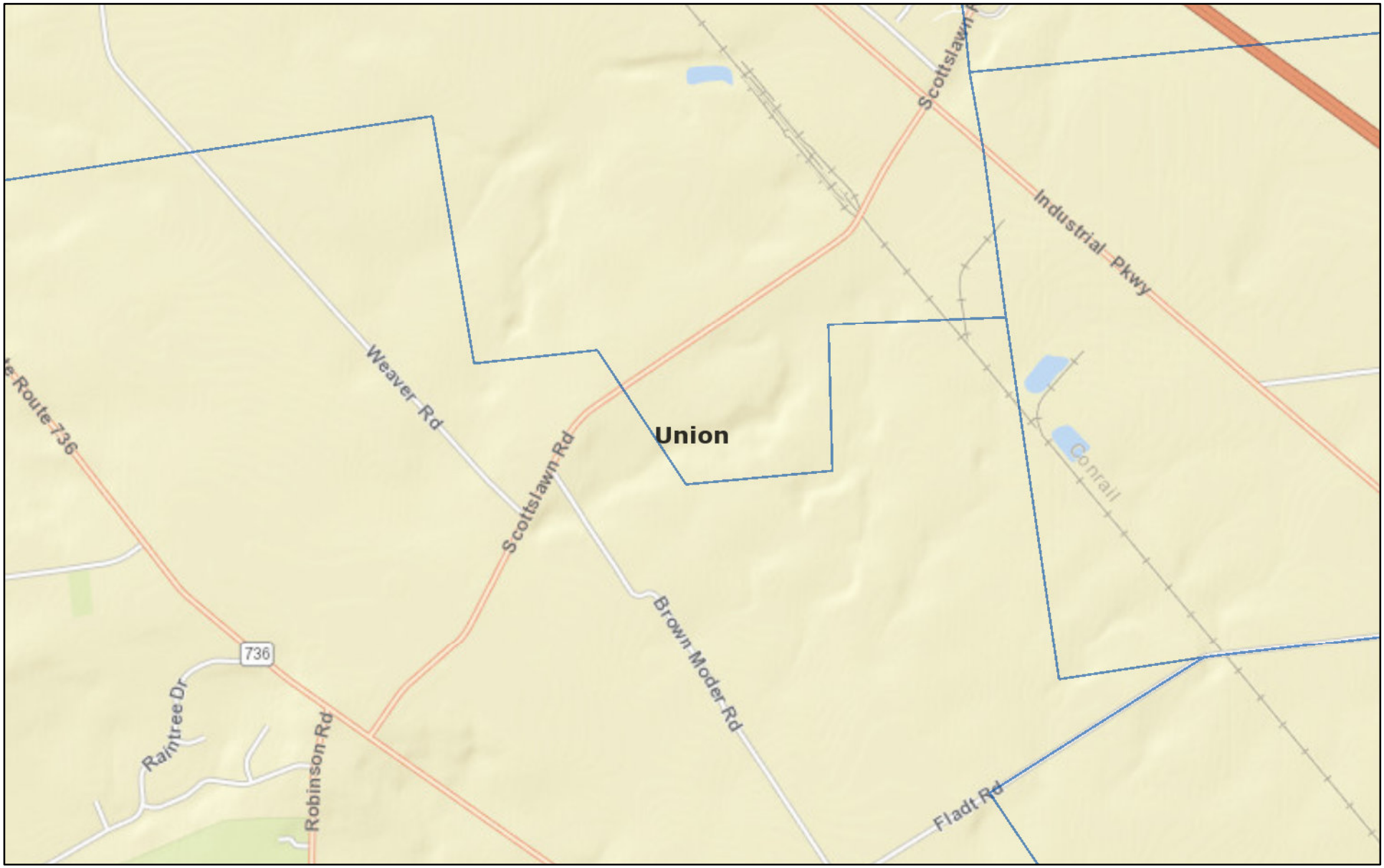
Boring Location Plan

Scottslawn Road Improvements

Marysville, Union County, Ohio

PSI Project No.: 01021257

Mines of Ohio - Scottslawn Road



February 15, 2018

Current

- Air Shaft
- Drift Entry
- Vertical Mine Shaft
- Slope Entry

Past

- Air Shaft
- Drift Entry
- Vertical Mine Shaft
- Slope Entry
- Locations

N

0 0.25 0.5 1 mi

0 0.4 0.8 1.6 km

1:29,661

Ohio Dept. of Natural Resources

FEMA's National Flood Hazard Layer (Official)

Data from Flood Insurance Rate Maps (FIRMs) where available digitally. New NFHL FIRMette Print app available: http://tinyurl.com/j4xwp5e

National Geospatial-Intelligence Agency (NGA); Delta State University; Esri | Print here instead: http://tinyurl.com/j4xwp5e Support: FEMAMapSpecialist@riskmapcds.com | USGS The National Map: Orthoimagery

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / C.S.	DRILL RIG: GEOPROBE 78	STATION / OFFSET: 11+39, 9 RT	EXPLORATION ID B-001-0-17	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105		
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1044.4 (MSL) EOB: 7.5 ft.	PAGE 1 OF 1	
START: 12/27/17 END: 12/27/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 82.36	LAT / LONG: 40.182980000, -83.340510000		

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)	INST.
PAVEMENT AND BASE, 10 IN.	1044.4																	
	1043.6																	
MEDIUM STIFF, BROWN AND GRAY, **SANDY SILT**, LITTLE ROCK FRAG, LITTLE GRAVEL, DAMP		1																
		2	4 3 3	8	89	SS-1	3.00	-	-	-	-	-	-	-	-	17	A-4a (V)	
	1041.4	3																
STIFF TO VERY STIFF, BROWN AND GRAY, **SILT AND CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, DAMP		4	3 5 7	16	100	SS-2	4.50	-	-	-	-	-	-	-	-	19	A-6a (V)	
		5	2 4 7	15	83	SS-3	4.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
		6	3 5 9	19	72	SS-4	4.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
	1036.9	7 EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 6 IN. ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 1 BAG BENTONITE CHIPS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / T.H.	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 14+38, 13 LT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1048.7 (MSL) EOB: 7.5 ft.
START: 12/28/17 END: 12/28/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 84.98	LAT / LONG: 40.183690000, -83.339970000

EXPLORATION ID B-002-0-17

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 1048.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
TOPSOIL, 5 IN.	1048.3																	
MEDIUM STIFF, BROWN AND GRAY, **SILT AND CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, MOIST	1045.7	1	2 2 2	6	22	SS-1	2.25	-	-	-	-	-	-	-	-	25	A-6a (V)	
VERY STIFF, BROWN AND GRAY, **SANDY SILT**, LITTLE ROCK FRAG, LITTLE GRAVEL, DAMP		2 3 4 5 6	2 5 7	17	100	SS-2	2.00	2	3	19	47	29	26	16	10	21	A-4a (8)	
			4 3 9	17	83	SS-3	4.50	-	-	-	-	-	-	-	-	15	A-4a (V)	
	1041.2	7 EOB	4 8 8	23	67	SS-4	4.50	-	-	-	-	-	-	-	-	15	A-4a (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH 6 IN. AUGER CUTTINGS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / C.S.	DRILL RIG: GEOPROBE 78	STATION / OFFSET: 18+37, 6 RT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1051.1 (MSL) EOB: 7.5 ft.
START: 12/27/17 END: 12/27/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 82.36	LAT / LONG: 40.184530000, -83.339050000

EXPLORATION ID B-003-0-17

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 1051.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
PAVEMENT AND BASE, 12 IN.	1050.1																	
MEDIUM STIFF, BROWN AND GRAY, **CLAY**, TRACE GRAVEL, TRACE ROCK FRAG, MOIST	1048.1	1	4 3 3	8	100	SS-1	2.00	1	0	2	36	61	52	20	32	26	A-7-6 (18)	
STIFF, BROWN AND GRAY, **SILTY CLAY**, TRACE GRAVEL, TRACE ROCK FRAG, MOIST	1046.6	2	2 4 5	12	89	SS-2	3.00	2	3	5	40	50	40	18	22	21	A-6b (13)	
VERY STIFF, BROWN AND GRAY, **SANDY SILT**, TRACE GRAVEL, TRACE ROCK FRAG, DAMP	1043.6	3 4 5 6 7 EOB	4 7 9	22	100	SS-3	4.50	-	-	-	-	-	-	-	-	16	A-4a (V)	
			5 10 10	27	78	SS-4	4.50	-	-	-	-	-	-	-	-	16	A-4a (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 6 IN. ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 1 BAG BENTONITE CHIPS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / T.H.	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 22+45, 13 LT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1045.4 (MSL) EOB: 7.5 ft.
START: 12/28/17 END: 12/28/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 84.98	LAT / LONG: 40.185320000, -83.338010000

EXPLORATION ID B-004-0-17

PAGE 1 OF 1

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)	INST.
TOPSOIL, 3 IN.	1045.4																	
MEDIUM STIFF, BROWN AND GRAY, **CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, MOIST	1045.2	1																
		2	2 2 2	6	44	SS-1	2.00	-	-	-	-	-	-	-	-	29	A-7-6 (V)	
		3	2 3 2	7	100	SS-2	2.00	0	0	2	30	68	59	20	39	30	A-7-6 (20)	
	1040.9	4																
VERY SOFT, BROWN AND GRAY, **CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, MOIST		5	WOH WOH 1	1	44	SS-3	1.00	0	0	2	26	72	63	22	41	36	A-7-6 (20)	
		6	WOH WOH WOH	0	0	SS-4	0.00	-	-	-	-	-	-	-	-	-	A-7-6 (V)	
	1037.9	7 EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH 6 IN. AUGER CUTTINGS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / T.H.	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 25+83, 13 RT	EXPLORATION ID B-005-0-17	
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105		
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1048.0 (MSL) EOB: 7.5 ft.		PAGE 1 OF 1
START: 12/28/17 END: 12/28/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 84.98	LAT / LONG: 40.185870000, -83.337030000		

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)	INST.
TOPSOIL, 4 IN.	1048.0 1047.6																	
STIFF, BROWN AND GRAY, **SILTY CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, DAMP		1																
		2	2 2 5	10	100	SS-1	3.25	8	6	9	35	42	34	17	17	16	A-6b (11)	
	1045.0	3																
VERY STIFF, BROWN AND GRAY, **SANDY SILT**, LITTLE ROCK FRAG, LITTLE GRAVEL, DAMP		4	2 5 6	16	78	SS-2	4.00	-	-	-	-	-	-	-	-	15	A-4a (V)	
		5	2 5 7	17	89	SS-3	4.50	-	-	-	-	-	-	-	-	15	A-4a (V)	
		6																
		7	2 4 7	16	56	SS-4	4.50	-	-	-	-	-	-	-	-	16	A-4a (V)	
	1040.5	EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH 6 IN. AUGER CUTTINGS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / T.H.	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 30+62, 16 LT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1045.0 (MSL) EOB: 7.5 ft.
START: 12/28/17 END: 12/28/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 84.98	LAT / LONG: 40.186880000, -83.335970000

EXPLORATION ID B-006-0-17

PAGE 1 OF 1

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)	INST.
TOPSOIL, 4 IN.	1045.0 1044.7																	
STIFF TO VERY STIFF, BROWN AND GRAY, **SILTY CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, DAMP		1																
		2	3 2 5	10	72	SS-1	4.50	-	-	-	-	-	-	-	-	17	A-6b (V)	
		3	3 4 8	17	100	SS-2	2.50	-	-	-	-	-	-	-	-	19	A-6b (V)	
	1040.5	4																
VERY STIFF, BROWN AND GRAY, **SILT AND CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, DAMP		5	3 4 7	16	78	SS-3	4.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
		6																
		7	2 5 9	20	56	SS-4	4.50	-	-	-	-	-	-	-	-	18	A-6a (V)	
	1037.5	EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH 6 IN. AUGER CUTTINGS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / T.H.	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 33+60, 14 RT	EXPLORATION ID B-007-0-17
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105	
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1042.1 (MSL) EOB: 7.5 ft.	PAGE 1 OF 1
START: 12/28/17 END: 12/28/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 84.98	LAT / LONG: 40.187560000, -83.335370000	

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)	INST.
MEDIUM STIFF, BROWN AND GRAY, **SILTY CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, MOIST	1042.1																	
	1039.1	2	3 3 1	6	56	SS-1	2.00	1	4	10	52	33	28	19	9	23	A-4b (8)	
MEDIUM STIFF, BROWN AND GRAY, **CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, MOIST	1037.6	4	4 4 2	8	89	SS-2	2.25	1	3	9	35	52	50	19	31	27	A-7-6 (18)	
VERY STIFF, BROWN AND GRAY, **SANDY SILT**, LITTLE ROCK FRAG, LITTLE GRAVEL, DAMP	1036.1	5	3 6 8	20	100	SS-3	4.50	-	-	-	-	-	-	-	-	15	A-4a (V)	
STIFF, BROWN AND GRAY, **CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, MOIST	1034.6	7	3 4 5	13	0	SS-4	-	-	-	-	-	-	-	-	-	26	A-7-6 (V)	
		EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH 6 IN. AUGER CUTTINGS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / T.H.	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 38+24, 28 LT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1036.4 (MSL) EOB: 7.5 ft.
START: 12/28/17 END: 12/28/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 84.98	LAT / LONG: 40.188740000, -83.334730000

EXPLORATION ID B-008-0-17

PAGE 1 OF 1

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)	INST.
TOPSOIL, 4 IN.	1036.4																	
	1036.0																	
MEDIUM STIFF, BROWN AND GRAY, **SILT AND CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, MOIST		1																
		2	2 2 3	7	83	SS-1	3.25	-	-	-	-	-	-	-	-	21	A-6a (V)	
	1033.4	3																
VERY STIFF, BROWN AND GRAY, **SANDY SILT**, LITTLE ROCK FRAG, LITTLE GRAVEL, DAMP		4	3 6 9	21	100	SS-2	4.50	-	-	-	-	-	-	-	-	15	A-4a (V)	
		5	4 7 9	23	72	SS-3	4.50	-	-	-	-	-	-	-	-	10	A-4a (V)	
		6	3 4 9	18	72	SS-4	4.50	-	-	-	-	-	-	-	-	16	A-4a (V)	
	1028.9	7 EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH 6 IN. AUGER CUTTINGS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / T.H.	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 42+05, 32 RT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1028.3 (MSL) EOB: 7.5 ft.
START: 12/28/17 END: 12/28/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 84.98	LAT / LONG: 40.189600000, -83.333930000

EXPLORATION ID B-009-0-17

PAGE 1 OF 1

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)	INST.
	1028.3																	
TOPSOIL, 3 IN.	1028.0																	
SOFT TO MEDIUM STIFF, BROWN AND GRAY, **SILTY CLAY**, LITTLE ROCK FRAG, MOIST TO DAMP		1																
		2	1 1 1	3	67	SS-1	3.25	3	4	8	37	48	35	19	16	20	A-6b (10)	
		3	2 2 2	6	72	SS-2	4.50	-	-	-	-	-	-	-	-	16	A-6b (V)	
	1023.8	4																
STIFF, BROWN AND GRAY, **SILT AND CLAY**, LITTLE ROCK FRAG, DAMP		5	2 2 7	13	89	SS-3	1.50	4	5	9	39	43	33	19	14	19	A-6a (10)	
	1022.3	6																
VERY STIFF, BROWN AND GRAY, **SILTY CLAY**, LITTLE ROCK FRAG, DAMP		7	2 6 9	21	78	SS-4	4.50	-	-	-	-	-	-	-	-	17	A-6b (V)	
	1020.8	EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH 6 IN. AUGER CUTTINGS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / T.H.	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 47+85, 29 LT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1032.6 (MSL) EOB: 7.5 ft.
START: 12/28/17 END: 12/28/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 84.98	LAT / LONG: 40.191100000, -83.333190000

EXPLORATION ID B-010-0-17

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 1032.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
TOPSOIL, 8 IN.	1031.9																	
MEDIUM STIFF, BROWN AND GRAY, **SILTY CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, MOIST	1029.6	1	3 2 3	7	78	SS-1	2.50	-	-	-	-	-	-	-	-	22	A-6b (V)	
VERY STIFF, BROWN AND GRAY, **SANDY SILT**, LITTLE ROCK FRAG, LITTLE GRAVEL, DAMP		2	5 4 7	16	89	SS-2	4.00	-	-	-	-	-	-	-	-	15	A-4a (V)	
		3	2 6 8	20	100	SS-3	4.00	-	-	-	-	-	-	-	-	16	A-4a (V)	
		4	4 8 13	30	72	SS-4	4.50	-	-	-	-	-	-	-	-	16	A-4a (V)	
	1025.1	EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH 6 IN. AUGER CUTTINGS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / C.S.	DRILL RIG: GEOPROBE 78	STATION / OFFSET: 50+43, 7 RT	EXPLORATION ID B-011-0-17
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105	
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1033.1 (MSL) EOB: 7.5 ft.	PAGE 1 OF 1
START: 12/27/17 END: 12/27/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 82.36	LAT / LONG: 40.191680000, -83.332640000	

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)	INST.
PAVEMENT AND BASE, 13-1/4 IN.	1033.1																	
	1032.0	1																
STIFF TO VERY STIFF, BROWN AND GRAY, **SILTY CLAY**, LITTLE ROCK FRAG, DAMP		2	5 5 3	11	33	SS-1	4.00	4	8	10	40	38	37	18	19	17	A-6b (12)	
		3	3 5 7	16	100	SS-2	4.50	2	3	6	40	49	36	19	17	17	A-6b (11)	
		5	3 6 6	16	100	SS-3	4.50	-	-	-	-	-	-	-	-	16	A-6b (V)	
		6	3 5 9	19	56	SS-4	4.50	-	-	-	-	-	-	-	-	16	A-6b (V)	
	1025.6	7 EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 6 IN. ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 1 BAG BENTONITE CHIPS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / C.S.	DRILL RIG: GEOPROBE 78	STATION / OFFSET: 54+34, 7 LT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1032.3 (MSL) EOB: 7.5 ft.
START: 12/27/17 END: 12/27/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 82.36	LAT / LONG: 40.192650000, -83.332040000

EXPLORATION ID B-012-0-17

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 1032.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
PAVEMENT AND BASE, 10-1/4 IN.	1031.4																	
VERY STIFF, BROWN AND GRAY, **SILT AND CLAY**, LITTLE ROCK FRAG, TRACE GRAVEL, DAMP	1029.3	1	10 15 7	30	0	SS-1	-	-	-	-	-	-	-	-	-	10	A-6a (V)	
STIFF TO VERY STIFF, BROWN AND GRAY, **SILTY CLAY**, LITTLE ROCK FRAG, TRACE GRAVEL, DAMP	1024.8	2	8 5 7	16	83	SS-2	4.00	-	-	-	-	-	-	-	-	16	A-6b (V)	
		3	4 6 10	22	56	SS-3	4.25	-	-	-	-	-	-	-	-	17	A-6b (V)	
		4	2 4 5	12	0	SS-4	-	-	-	-	-	-	-	-	-	15	A-6b (V)	
		EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 6 IN. ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 1 BAG BENTONITE CHIPS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / C.S.	DRILL RIG: GEOPROBE 78	STATION / OFFSET: 58+72, 7 RT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1030.6 (MSL) EOB: 7.5 ft.
START: 12/27/17 END: 12/27/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 82.36	LAT / LONG: 40.193700000, -83.331280000

EXPLORATION ID B-013-0-17

PAGE 1 OF 1

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)	INST.
PAVEMENT AND BASE, 10-1/2 IN.	1030.6																	
	1029.7	1																
HARD, BROWN AND GRAY, **CLAY**, TRACE ROCK FRAG, TRACE GRAVEL, DAMP TO MOIST		2	21 10 5	21	72	SS-1	2.50	-	-	-	-	-	-	-	-	18	A-7-6 (V)	
		3																
	1026.1	4	2 5 7	16	28	SS-2	2.00	1	2	7	34	56	48	20	28	23	A-7-6 (17)	
HARD, BROWN AND GRAY, **SILTY CLAY**, TRACE ROCK FRAG, TRACE GRAVEL, DAMP		5	4 7 9	22	100	SS-3	4.50	-	-	-	-	-	-	-	-	16	A-6b (V)	
		6																
	1023.1	7	4 7 9	22	39	SS-4	4.50	-	-	-	-	-	-	-	-	16	A-6b (V)	
		EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 6 IN. ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 1 BAG BENTONITE CHIPS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / C.S.	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 62+58, 10 LT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1027.0 (MSL) EOB: 7.5 ft.
START: 12/29/17 END: 12/29/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 84.98	LAT / LONG: 40.194610000, -83.330560000

EXPLORATION ID B-014-0-17

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 1027.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
TOPSOIL, 5 IN.	1026.6																	
SOFT, BROWN AND GRAY, **SILT AND CLAY**, TRACE ROCK FRAG, TRACE GRAVEL, MOIST	1024.0		2 (1, 1)	3	67	SS-1	2.25	2	7	11	46	34	33	19	14	23	A-6a (10)	
VERY SOFT TO SOFT, BROWN AND GRAY, **CLAY**, TRACE ROCK FRAG, TRACE GRAVEL, MOIST			1 (1, 2)	4	78	SS-2	2.25	-	-	-	-	-	-	-	-	31	A-7-6 (V)	
			3 (4, 5)	13	100	SS-3	3.00	-	-	-	-	-	-	-	-	33	A-7-6 (V)	
	1019.5	EOB	3 (5, 7)	17	100	SS-4	3.50	-	-	-	-	-	-	-	-	22	A-7-6 (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH 6 IN. AUGER CUTTINGS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / C.S.	DRILL RIG: GEOPROBE 78	STATION / OFFSET: 66+10, 4 RT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1023.9 (MSL) EOB: 7.5 ft.
START: 12/27/17 END: 12/27/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 82.36	LAT / LONG: 40.195190000, -83.329540000

EXPLORATION ID B-015-0-17

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 1023.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
PAVEMENT AND BASE, 9 IN.	1023.1																	
STIFF, BROWN AND GRAY, **SILTY CLAY**, TRACE ROCK FRAG, TRACE GRAVEL, MOIST		1																
		2	5 5 5	14	78	SS-1	1.50	-	-	-	-	-	-	-	-	20	A-6b (V)	
	1019.4	3																
		4	2 2 5	10	100	SS-2	4.00	1	2	4	38	55	40	20	20	21	A-6b (12)	
STIFF TO VERY STIFF, BROWN AND GRAY, **SILT AND CLAY**, TRACE ROCK FRAG, TRACE GRAVEL, DAMP		5	2 5 8	18	100	SS-3	4.00	-	-	-	-	-	-	-	-	17	A-6a (V)	
		6																
	1016.4	7	3 4 7	15	44	SS-4	4.50	-	-	-	-	-	-	-	-	20	A-6a (V)	
		EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 6 IN. ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 1 BAG BENTONITE CHIPS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / C.S.	DRILL RIG: GEOPROBE 78	STATION / OFFSET: 70+43, 7 RT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1023.6 (MSL) EOB: 7.5 ft.
START: 12/27/17 END: 12/27/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 82.36	LAT / LONG: 40.195850000, -83.328250000

EXPLORATION ID B-016-0-17

PAGE 1 OF 1

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)	INST.
PAVEMENT AND BASE, 11-1/4 IN.	1023.6																	
	1022.7	1																
VERY STIFF, GRAY, **SANDY SILT**, LITTLE ROCK FRAG, LITTLE GRAVEL, DAMP		2	15 10 8	25	33	SS-1	4.00	-	-	-	-	-	-	-	-	16	A-4a (V)	
	1020.6	3																
STIFF, BROWN AND GRAY, **CLAY**, TRACE ROCK FRAG, MOIST		4	6 3 4	10	83	SS-2	4.50	1	2	4	27	66	48	22	26	23	A-7-6 (16)	
	1019.1	5																
STIFF, BROWN AND GRAY, **SILT AND CLAY**, TRACE ROCK FRAG, DAMP			1 4 6	14	100	SS-3	2.50	-	-	-	-	-	-	-	-	19	A-6a (V)	
	1017.6	6																
VERY STIFF, BROWN AND GRAY, **SILTY CLAY**, TRACE ROCK FRAG, DAMP			2 5 8	18	56	SS-4	4.50	-	-	-	-	-	-	-	-	16	A-6b (V)	
	1016.1	7 EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 6 IN. ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 1 BAG BENTONITE CHIPS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / C.S.	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 73+73, 16 LT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1020.6 (MSL) EOB: 7.5 ft.
START: 12/29/17 END: 12/29/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 84.98	LAT / LONG: 40.196410000, -83.327320000

EXPLORATION ID B-017-0-17

PAGE 1 OF 1

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)	INST.
TOPSOIL, 5 IN.	1020.6 / 1020.2																	
SOFT TO MEDIUM STIFF, BROWN AND GRAY, **CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, MOIST		1																
		2	2 1 1	3	50	SS-1	2.00	7	8	12	48	25	43	24	19	30	A-7-6 (12)	
		3	2 3 3	8	72	SS-2	2.50	0	2	7	37	54	45	21	24	25	A-7-6 (15)	
	1016.1	4																
SOFT TO MEDIUM STIFF, BROWN AND GRAY, **CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, MOIST		5	2 3 5	11	100	SS-3	3.00	-	-	-	-	-	-	-	-	21	A-7-6 (V)	
	1014.6	6																
VERY STIFF, BROWN AND GRAY, **SANDY SILT**, LITTLE ROCK FRAG, LITTLE GRAVEL, DAMP		7	3 6 7	18	78	SS-4	3.25	-	-	-	-	-	-	-	-	14	A-4a (V)	
	1013.1 EOB																	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH 6 IN. AUGER CUTTINGS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / C.S.	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 78+12, 14 RT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1014.4 (MSL) EOB: 7.5 ft.
START: 12/29/17 END: 12/29/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 84.98	LAT / LONG: 40.197030000, -83.325970000

EXPLORATION ID B-018-0-17

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 1014.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
TOPSOIL, 5 IN.	1014.0																	
MEDIUM STIFF, BROWN AND GRAY, **SILT AND CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, DAMP	1011.4		2 2 2	6	44	SS-1	2.00	-	-	-	-	-	-	-	-	19	A-6a (V)	
VERY STIFF, BROWN AND GRAY, **SILTY CLAY**, LITTLE ROCK FRAG, LITTLE GRAVEL, DAMP			2 5 6	16	89	SS-2	4.25	-	-	-	-	-	-	-	-	17	A-6b (V)	
			3 5 6	16	100	SS-3	4.50	-	-	-	-	-	-	-	-	16	A-6b (V)	
			4 4 8	17	56	SS-4	4.50	-	-	-	-	-	-	-	-	15	A-6b (V)	
	1006.9	EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH 6 IN. AUGER CUTTINGS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / C.S.	DRILL RIG: GEOPROBE 78	STATION / OFFSET: 82+08, 7 LT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1012.5 (MSL) EOB: 7.5 ft.
START: 12/27/17 END: 12/27/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 82.36	LAT / LONG: 40.197690000, -83.324840000

EXPLORATION ID B-019-0-17

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 1012.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
PAVEMENT AND BASE, 12-1/4 IN.	1011.5	1																
VERY STIFF, BROWN AND GRAY, **SILTY CLAY**, LITTLE ROCK FRAG, DAMP		2	10 12 5	23	6	SS-1	-	-	-	-	-	-	-	-	-	12	A-6b (V)	
		3																
	1008.0	4	4 7 10	23	100	SS-2	4.50	2	5	7	35	51	37	19	18	16	A-6b (11)	
VERY STIFF TO HARD, BROWN AND GRAY, **SILTY CLAY**, TRACE ROCK FRAG, DAMP		5	6 8 10	25	89	SS-3	4.50	-	-	-	-	-	-	-	-	14	A-6b (V)	
		6																
	1005.0	7	6 11 13	33	100	SS-4	4.50	-	-	-	-	-	-	-	-	14	A-6b (V)	
		EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 6 IN. ASPHALT PATCH; AUGER CUTTINGS MIXED WITH 1 BAG BENTONITE CHIPS

PROJECT: UNI-CR 105-	DRILLING FIRM / OPERATOR: ENVIROCORE / C.S.	DRILL RIG: GEOPROBE 7822DT	STATION / OFFSET: 85+78, 13 RT
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: PSI / G.W.	HAMMER: GEOPROBE AUTOMATIC	ALIGNMENT: PROPOSED CL CR105
PID: BR ID:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: N/A	ELEVATION: 1009.3 (MSL) EOB: 7.5 ft.
START: 12/29/17 END: 12/29/17	SAMPLING METHOD: SPT	ENERGY RATIO (%): 84.98	LAT / LONG: 40.198200000, -83.323690000

EXPLORATION ID B-020-0-17

MATERIAL DESCRIPTION AND NOTES	ELEV. 1009.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	INST.
GRAVEL, 14 IN.	1008.1																	
MEDIUM STIFF, BROWN AND GRAY, **SANDY SILT**, TRACE ROCK FRAG, TRACE GRAVEL, DAMP	1006.3	1	8 3 3	8	33	SS-1	-	-	-	-	-	-	-	-	-	8	A-4a (V)	
MEDIUM STIFF, BROWN AND GRAY, **CLAY**, TRACE ROCK FRAG, TRACE GRAVEL, MOIST	1004.8	2	2 2 3	7	83	SS-2	3.00	2	4	7	34	53	41	20	21	21	A-7-6 (13)	
STIFF TO VERY STIFF, BROWN AND GRAY, **SILTY CLAY**, TRACE ROCK FRAG, TRACE GRAVEL, DAMP	1001.8	3 4 5 6 7	3 4 6	14	100	SS-3	4.00	-	-	-	-	-	-	-	-	17	A-6b (V)	
	EOB		3 4 7	16	72	SS-4	4.50	-	-	-	-	-	-	-	-	16	A-6b (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH 6 IN. GRAVEL

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES
Geotechnical Bulletin GB1

UNI-CR-105

Scottslawn Road Improvements - Off Road Borings

PSI

Prepared By: Miles Mullins and John Xu
Date prepared: 2/13/2018

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NO. OF BORINGS: 12

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.2 1/23/2018

#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL	Cut Fill
1	B-002-0-17	Centerline	14+37.89	13	LT.	Geo 7822DT	85	1048.7	1047.8	0.8 C
2	B-004-0-17	Centerline	22+44.65	13	LT.	Geo 7822DT	85	1045.4	1044.8	0.6 C
3	B-005-0-17	Centerline	25+82.75	13	RT.	Geo 7822DT	85	1048.0	1046.5	1.4 C
4	B-006-0-17	Centerline	30+61.60	16	LT.	Geo 7822DT	85	1045.0	1043.9	1.1 C
5	B-007-0-17	Centerline	33+59.68	14	RT.	Geo 7822DT	85	1042.1	1041.6	0.5 C
6	B-008-0-17	Centerline	38+23.74	28	LT.	Geo 7822DT	85	1036.4	1033.0	3.4 C
7	B-009-0-17	Centerline	42+04.65	32	RT.	Geo 7822DT	85	1028.3	1027.1	1.2 C
8	B-010-0-17	Centerline	47+85.00	29	LT.	Geo 7822DT	85	1032.6	1031.1	1.5 C
9	B-014-0-17	Centerline	62+57.54	10	LT.	Geo 7822DT	85	1027.0	1026.9	0.1 C
10	B-017-0-17	Centerline	73+72.96	16	LT.	Geo 7822DT	85	1020.6	1019.2	1.4 C
11	B-018-0-17	Centerline	78+11.90	14	RT.	Geo 7822DT	85	1014.4	1013.3	1.1 C
12	B-020-0-17	Centerline	85+78.31	13	RT.	Geo 7822DT	85	1009.3	1008.1	1.2 C

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.2 1/23/2018

#	Boring	Sample	Sample Depth		Subgrade Depth		Standard Penetration		HP (tsf)	Physical Characteristics						Moisture		Ohio DOT		Sulfate Content (ppm)	Problem		Excavate and Replace (Item 204)		Recommendation
			From	To	From	To	N_{60}	N_{60L}		LL	PL	PI	% Silt	% Clay	P200	M_C	M_{OPT}	Class	GI		Unsuitable	Unstable	Unsuitable	Unstable	
1	B	1	1.5	3.0	0.7	2.2	6		2.25							25	14	A-6a	10			N_{60} & Mc		24"	Geotextile Option:
	002-0	2	3.0	4.5	2.2	3.7	17		2	26	16	10	47	29	76	21	11	A-4a	8						24"
	17	3	4.5	6.0	3.7	5.2	17		4.5							15	10	A-4a	8						GEOGRID Option:
		4	6.0	7.5	5.2	6.7	23	6	4.5							15	10	A-4a							12"
2	B	1	1.5	3.0	0.9	2.4	6		2							29	18	A-7-6	16			N_{60} & Mc		24"	Geotextile Option:
	004-0	2	3.0	4.5	2.4	3.9	7		2	59	20	39	30	68	98	30	18	A-7-6	20						24"
	17	3	4.5	6.0	3.9	5.4	1		1	63	22	41	26	72	98	36	19	A-7-6	20						GEOGRID Option:
		4	6.0	7.5	5.4	6.9	0	0	0								18	A-7-6							12"
3	B	1	1.5	3.0	0.1	1.6	10		3.25	34	17	17	35	42	77	16	16	A-6b	11			N_{60}		12"	Geotextile Option:
	005-0	2	3.0	4.5	1.6	3.1	16		4							15	10	A-4a	8			Mc			12"
	17	3	4.5	6.0	3.1	4.6	17		4.5							15	10	A-4a	8						
		4	6.0	7.5	4.6	6.1	16	10	4.5							16	10	A-4a	8						
4	B	1	1.5	3.0	0.4	1.9	10		4.5							17	16	A-6b	16			N_{60}		12"	Geotextile Option:
	006-0	2	3.0	4.5	1.9	3.4	17		2.5							19	16	A-6b	16			Mc			12"
	17	3	4.5	6.0	3.4	4.9	16		4.5							15	14	A-6a	10						
		4	6.0	7.5	4.9	6.4	20	10	4.5							18	14	A-6a	10						
5	B	1	1.5	3.0	1.0	2.5	6		2	28	19	9	52	33	85	23	14	A-4b	8		A-4b	N_{60} & Mc	30"	24"	Geotextile Option:
	007-0	2	3.0	4.5	2.5	4.0	8		2.25	50	19	31	35	52	87	27	18	A-7-6	18						30"
	17	3	4.5	6.0	4.0	5.5	20		4.5							15	10	A-4a	8						
		4	6.0	7.5	5.5	7.0	13	6								26	18	A-7-6							
6	B	1	1.5	3.0	-1.9	-0.4	7		3.25							21	14	A-6a	10						
	008-0	2	3.0	4.5	-0.4	1.1	21		4.5							15	10	A-4a	8			Mc			
	17	3	4.5	6.0	1.1	2.6	23		4.5							10	10	A-4a	8						
		4	6.0	7.5	2.6	4.1	18	18	4.5							16	10	A-4a	8						
7	B	1	1.5	3.0	0.3	1.8	3		3.25	35	19	16	37	48	85	20	16	A-6b	10			N_{60} & Mc		33"	Geotextile Option:
	009-0	2	3.0	4.5	1.8	3.3	6		4.5							16	16	A-6b	16			N_{60}			33"
	17	3	4.5	6.0	3.3	4.8	13		1.5	33	19	14	39	43	82	19	14	A-6a	10						GEOGRID Option:
		4	6.0	7.5	4.8	6.3	21	3	4.5							17	16	A-6b	16						21"
8	B	1	1.5	3.0	0.0	1.5	7		2.5							22	16	A-6b	16			N_{60} & Mc		15"	Geotextile Option:
	010-0	2	3.0	4.5	1.5	3.0	16		4							15	10	A-4a	8			Mc			15"
	17	3	4.5	6.0	3.0	4.5	20		4							16	10	A-4a	8						
		4	6.0	7.5	4.5	6.0	30	7	4.5							16	10	A-4a	8						
9	B	1	1.5	3.0	1.4	2.9	3		2.25	33	19	14	46	34	80	23	14	A-6a	10			N_{60} & Mc			
	014-0	2	3.0	4.5	2.9	4.4	4		2.25							31	18	A-7-6	16						
	17	3	4.5	6.0	4.4	5.9	13		3							33	18	A-7-6	16						
		4	6.0	7.5	5.9	7.4	17	3	3.5							22	18	A-7-6							

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.2 1/23/2018

#	Boring	Sample	Sample Depth		Subgrade Depth		Standard Penetration		HP (tsf)	Physical Characteristics						Moisture		Ohio DOT		Sulfate Content (ppm)	Problem		Excavate and Replace (Item 204)		Recommendation
			From	To	From	To	N_{60}	N_{60L}		LL	PL	PI	% Silt	% Clay	P200	M_C	M_{OPT}	Class	GI		Unsuitable	Unstable	Unsuitable	Unstable	
10	B	1	1.5	3.0	0.1	1.6	3		2	43	24	19	48	25	73	30	21	A-7-6	12			N_{60} & Mc		33"	Geotextile Option:
	017-0	2	3.0	4.5	1.6	3.1	8		2.5	45	21	24	37	54	91	25	18	A-7-6	15			N_{60} & Mc			33"
	17	3	4.5	6.0	3.1	4.6	11		3							21	18	A-7-6	16						GEOGRID Option:
		4	6.0	7.5	4.6	6.1	18	3	3.25							14	10	A-4a	8						21"
11	B	1	1.5	3.0	0.4	1.9	6		2							19	14	A-6a	10			N_{60} & Mc		24"	Geotextile Option:
	018-0	2	3.0	4.5	1.9	3.4	16		4.25							17	16	A-6b	16						24"
	17	3	4.5	6.0	3.4	4.9	16		4.5							16	16	A-6b	16						GEOGRID Option:
		4	6.0	7.5	4.9	6.4	17	6	4.5							15	16	A-6b	16						12"
12	B	1	1.5	3.0	0.3	1.8	8									8	10	A-4a	8			N_{60}		18"	Geotextile Option:
	020-0	2	3.0	4.5	1.8	3.3	7		3	41	20	21	34	53	87	21	18	A-7-6	13			N_{60} & Mc			18"
	17	3	4.5	6.0	3.3	4.8	14		4							17	16	A-6b	16						
		4	6.0	7.5	4.8	6.3	16	7	4.5							16	16	A-6b	16						

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.2 1/23/2018

PID:

County-Route-Section: UNI-CR-105
No. of Borings: 12

Geotechnical Consultant: PSI
Prepared By: Miles Mullins and John Xu
Date prepared: 2/13/2018

Chemical Stabilization Options		
320	Rubblize & Roll	No
206	Cement Stabilization	No
	Lime Stabilization	Option
206	Depth	16''

Excavate and Replace Stabilization Options	
Global Geotextile Override(N60L):	12''
Override(HP):	12''
Global Geogrid Override(N60L):	0''
Override(HP):	0''

Design CBR	5

% Samples within 6 feet of subgrade			
$N_{60} \leq 5$	13%	HP ≤ 0.5	2%
$N_{60} < 12$	43%	0.5 < HP ≤ 1	2%
$12 \leq N_{60} < 15$	9%	1 < HP ≤ 2	15%
$N_{60} \geq 20$	17%	HP > 2	77%
M+	30%		
Rock	0%		
Unsuitable	2%		

Excavate and Replace at Surface	
Average	22''
Maximum	33''
Minimum	12''

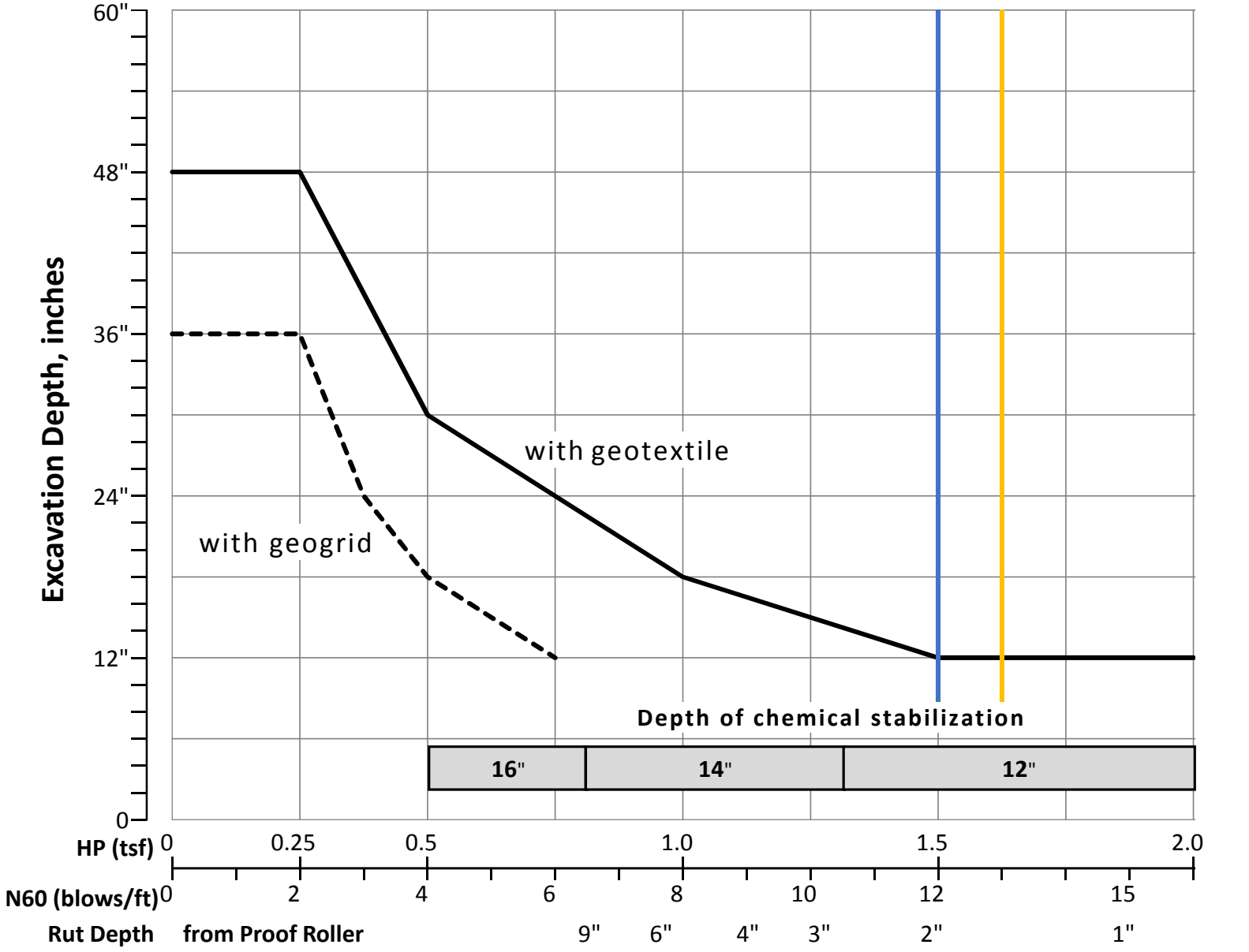
% Proposed Subgrade Surface	
Unstable & Unsuitable	76%
Unstable	72%
Unsuitable	4%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	13	7	3.33	41	20	21	39	46	85	20	14	12
Maximum	30	18	4.50	63	24	41	52	72	98	36	21	20
Minimum	0	0	0.00	26	16	9	26	25	73	8	10	8

Classification Counts by Sample

ODOT Class	Rock	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7	A-3	A-3a	A-4a	A-4b	A-5	A-6a	A-6b	A-7-5	A-7-6	A-8a	A-8b	Totals
Count	0	0	0	0	0	0	0	0	0	15	1	0	6	12	0	13	0	0	47
Percent	0%	0%	0%	0%	0%	0%	0%	0%	0%	32%	2%	0%	13%	26%	0%	28%	0%	0%	100%
% Rock|Cohesive|Granular	0%	32%									68%								100%
Surface Class Count	0	0	0	0	0	0	0	0	0	7	1	0	4	7	0	6	0	0	25
Surface Class Percent	0%	0%	0%	0%	0%	0%	0%	0%	0%	28%	4%	0%	16%	28%	0%	24%	0%	0%	100%

GB1 Figure B – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
3.33	1.50	☑ HP
6.58	13.00	☑ N60L

Average HP

Average N_{60L}

Pavement Core Information

Boring/Core Number	B-001
Date Sampled	12-06-17
Thickness of Asphalt	10.0
Thickness of Wearing Course	- -
Thickness of Base Course	- -
Thickness of Concrete	N/A
Thickness of Aggregate/Granular Base	N/A

Comments

Top of core in good condition

Bottom layers separated during coring

intertek psi

4960 Vulcan Ave
Columbus, Ohio 43228
Telephone: (614) 876-8000
Fax Number: (614) 876-0548

Scottslawn Road Widening

Marysville, Union County, OH

PSI Project Number: 1021257

Pavement Core Information

Boring/Core Number	B-003
Date Sampled	12-06-17
Thickness of Asphalt	12.0
Thickness of Wearing Course	- -
Thickness of Base Course	- -
Thickness of Concrete	N/A
Thickness of Aggregate/Granular Base	N/A

Comments

Core in good condition

intertek psi

4960 Vulcan Ave
Columbus, Ohio 43228
Telephone: (614) 876-8000
Fax Number: (614) 876-0548

Scottslawn Road Widening

Marysville, Union County, OH

PSI Project Number: 1021257

Pavement Core Information

Boring/Core Number	B-011
Date Sampled	12-06-17
Thickness of Asphalt	13.25
Thickness of Wearing Course	- -
Thickness of Base Course	- -
Thickness of Concrete	N/A
Thickness of Aggregate/Granular Base	N/A

Comments

Top of core in good condition

Bottom layers separated during coring

intertek psi

4960 Vulcan Ave
Columbus, Ohio 43228
Telephone: (614) 876-8000
Fax Number: (614) 876-0548

Scottslawn Road Widening

Marysville, Union County, OH

PSI Project Number: 1021257

Pavement Core Information

Boring/Core Number	B-012
Date Sampled	12-06-17
Thickness of Asphalt	10.25
Thickness of Wearing Course	- -
Thickness of Base Course	- -
Thickness of Concrete	N/A
Thickness of Aggregate/Granular Base	N/A

Comments

Core in good condition

intertek psi

4960 Vulcan Ave
Columbus, Ohio 43228
Telephone: (614) 876-8000
Fax Number: (614) 876-0548

Scottslawn Road Widening

Marysville, Union County, OH

PSI Project Number: 1021257

Pavement Core Information

Boring/Core Number	B-013
Date Sampled	12-06-17
Thickness of Asphalt	10.5
Thickness of Wearing Course	- -
Thickness of Base Course	- -
Thickness of Concrete	N/A
Thickness of Aggregate/Granular Base	N/A

Comments

Top of core in good condition

Bottom layers separated during coring

intertek psi

4960 Vulcan Ave
Columbus, Ohio 43228
Telephone: (614) 876-8000
Fax Number: (614) 876-0548

Scottslawn Road Widening

Marysville, Union County, OH

PSI Project Number: 1021257

Pavement Core Information

Boring/Core Number	B-015
Date Sampled	12-06-17
Thickness of Asphalt	9.0
Thickness of Wearing Course	- -
Thickness of Base Course	- -
Thickness of Concrete	N/A
Thickness of Aggregate/Granular Base	N/A

Comments

Top of core in good condition

Bottom layers separated during coring

intertek psi

4960 Vulcan Ave
Columbus, Ohio 43228
Telephone: (614) 876-8000
Fax Number: (614) 876-0548

Scottslawn Road Widening

Marysville, Union County, OH

PSI Project Number: 1021257

Pavement Core Information

Boring/Core Number	B-016
Date Sampled	12-06-17
Thickness of Asphalt	11.25
Thickness of Wearing Course	- -
Thickness of Base Course	- -
Thickness of Concrete	N/A
Thickness of Aggregate/Granular Base	N/A

Comments

Top of core in good condition

Bottom layers separated during coring

intertek psi

4960 Vulcan Ave
Columbus, Ohio 43228
Telephone: (614) 876-8000
Fax Number: (614) 876-0548

Scottslawn Road Widening

Marysville, Union County, OH

PSI Project Number: 1021257

Pavement Core Information

Boring/Core Number	B-019
Date Sampled	12-06-17
Thickness of Asphalt	12.25
Thickness of Wearing Course	- -
Thickness of Base Course	- -
Thickness of Concrete	N/A
Thickness of Aggregate/Granular Base	N/A

Comments

Top of core in good condition

Bottom layers separated during coring

intertek psi

4960 Vulcan Ave
Columbus, Ohio 43228
Telephone: (614) 876-8000
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Scottslawn Road Widening

Marysville, Union County, OH

PSI Project Number: 1021257

GENERAL NOTES

SAMPLE IDENTIFICATION

The Unified Soil Classification System (USCS), AASHTO 1988 and ASTM designations D2487 and D-2488 are used to identify the encountered materials unless otherwise noted. Coarse-grained soils are defined as having more than 50% of their dry weight retained on a #200 sieve (0.075mm); they are described as: boulders, cobbles, gravel or sand. Fine-grained soils have less than 50% of their dry weight retained on a #200 sieve; they are defined as silts or clay depending on their Atterberg Limit attributes. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size.

DRILLING AND SAMPLING SYMBOLS

SFA: Solid Flight Auger - typically 4" diameter flights, except where noted.
HSA: Hollow Stem Auger - typically 3¼" or 4¼ I.D. openings, except where noted.
M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry
R.C.: Diamond Bit Core Sampler
H.A.: Hand Auger
P.A.: Power Auger - Handheld motorized auger

SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
ST: Shelby Tube - 3" O.D., except where noted.
BS: Bulk Sample
PM: Pressuremeter
CPT-U: Cone Penetrometer Testing with Pore-Pressure Readings

SOIL PROPERTY SYMBOLS

N: Standard "N" penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch O.D. Split-Spoon.
N_{60}: A "N" penetration value corrected to an equivalent 60% hammer energy transfer efficiency (ETR)
Q_u: Unconfined compressive strength, TSF
Q_p: Pocket penetrometer value, unconfined compressive strength, TSF
w%: Moisture/water content, %
LL: Liquid Limit, %
PL: Plastic Limit, %
PI: Plasticity Index = (LL-PL),%
DD: Dry unit weight, pcf
▼,▽,▼ Apparent groundwater level at time noted

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Relative Density	N - Blows/foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	50 - 80
Extremely Dense	80+

ANGULARITY OF COARSE-GRAINED PARTICLES

Description	Criteria
Angular:	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular:	Particles are similar to angular description, but have rounded edges
Subrounded:	Particles have nearly plane sides, but have well-rounded corners and edges
Rounded:	Particles have smoothly curved sides and no edges

GRAIN-SIZE TERMINOLOGY

Component	Size Range
Boulders:	Over 300 mm (>12 in.)
Cobbles:	75 mm to 300 mm (3 in. to 12 in.)
Coarse-Grained Gravel:	19 mm to 75 mm (¾ in. to 3 in.)
Fine-Grained Gravel:	4.75 mm to 19 mm (No.4 to ¾ in.)
Coarse-Grained Sand:	2 mm to 4.75 mm (No.10 to No.4)
Medium-Grained Sand:	0.42 mm to 2 mm (No.40 to No.10)
Fine-Grained Sand:	0.075 mm to 0.42 mm (No. 200 to No.40)
Silt:	0.002 mm to 0.075 mm
Clay:	<0.002mm to <0.005 mm depending on agency

PARTICLE SHAPE

Description	Criteria
Flat:	Particles with width/thickness ratio > 3
Elongated:	Particles with length/width ratio > 3
Flat & Elongated:	Particles meet criteria for both flat and elongated

RELATIVE PROPORTIONS OF FINES

Descriptive Term	% Dry Weight
Trace:	< 5%
With:	5% to 12%
Modifier:	>12%

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

Q_U - TSF	N - Blows/foot	Consistency
0 - 0.25	0 - 2	Very Soft
0.25 - 0.50	2 - 4	Soft
0.50 - 1.00	4 - 8	Firm (Medium Stiff)
1.00 - 2.00	8 - 15	Stiff
2.00 - 4.00	15 - 30	Very Stiff
4.00 - 8.00	30 - 50	Hard
8.00+	50+	Very Hard

MOISTURE CONDITION DESCRIPTION

Description	Criteria
Dry:	Absence of moisture, dusty, dry to the touch
Moist:	Damp but no visible water
Wet:	Visible free water, usually soil is below water table

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term	% Dry Weight
Trace:	< 15%
With:	15% to 30%
Modifier:	>30%

STRUCTURE DESCRIPTION

Description	Criteria
Stratified:	Alternating layers of varying material or color with layers at least ¼-inch (6 mm) thick
Laminated:	Alternating layers of varying material or color with layers less than ¼-inch (6 mm) thick
Fissured:	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided:	Fracture planes appear polished or glossy, sometimes striated
Blocky:	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed:	Inclusion of small pockets of different soils
Layer:	Inclusion greater than 3 inches thick (75 mm)
Seam:	Inclusion 1/8-inch to 3 inches (3 to 75 mm) thick extending through the sample
Parting:	Inclusion less than 1/8-inch (3 mm) thick

SCALE OF RELATIVE ROCK HARDNESS

Q_U - TSF	Consistency
2.5 - 10	Extremely Soft
10 - 50	Very Soft
50 - 250	Soft
250 - 525	Medium Hard
525 - 1,050	Moderately Hard
1,050 - 2,600	Hard
>2,600	Very Hard

ROCK BEDDING THICKNESSES

Description	Criteria
Very Thick Bedded	Greater than 3-foot (>1.0 m)
Thick Bedded	1-foot to 3-foot (0.3 m to 1.0 m)
Medium Bedded	4-inch to 1-foot (0.1 m to 0.3 m)
Thin Bedded	1¼-inch to 4-inch (30 mm to 100 mm)
Very Thin Bedded	½-inch to 1¼-inch (10 mm to 30 mm)
Thickly Laminated	1/8-inch to ½-inch (3 mm to 10 mm)
Thinly Laminated	1/8-inch or less "paper thin" (<3 mm)

ROCK VOIDS

Voids	Void Diameter
Pit	<6 mm (<0.25 in)
Vug	6 mm to 50 mm (0.25 in to 2 in)
Cavity	50 mm to 600 mm (2 in to 24 in)
Cave	>600 mm (>24 in)

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

Component	Size Range
Very Coarse Grained	>4.76 mm
Coarse Grained	2.0 mm - 4.76 mm
Medium Grained	0.42 mm - 2.0 mm
Fine Grained	0.075 mm - 0.42 mm
Very Fine Grained	<0.075 mm

ROCK QUALITY DESCRIPTION

Rock Mass Description	RQD Value
Excellent	90 -100
Good	75 - 90
Fair	50 - 75
Poor	25 -50
Very Poor	Less than 25

DEGREE OF WEATHERING

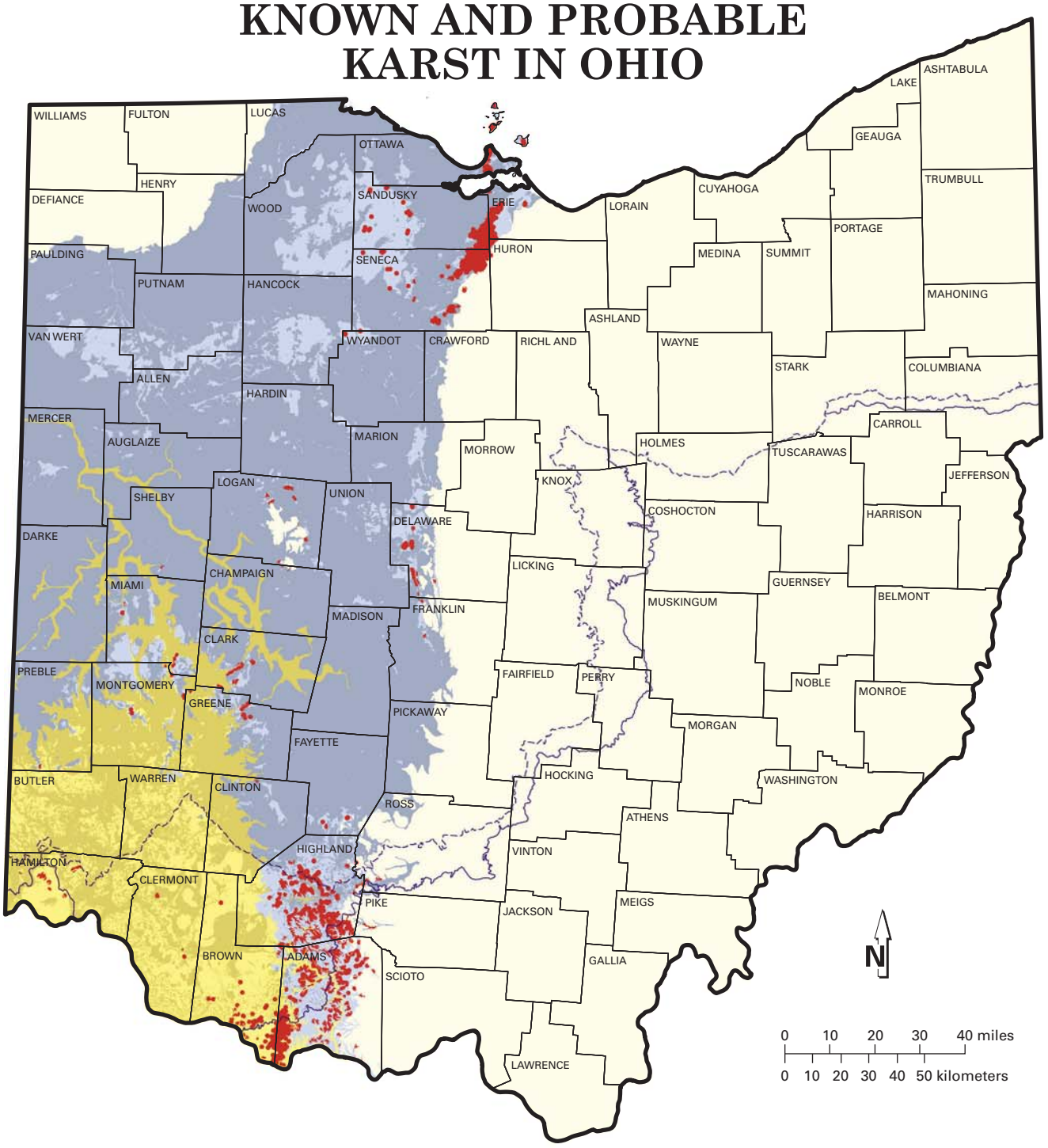
Slightly Weathered:	Rock generally fresh, joints stained and discoloration extends into rock up to 25 mm (1 in), open joints may contain clay, core rings under hammer impact.
Weathered:	Rock mass is decomposed 50% or less, significant portions of the rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.
Highly Weathered:	Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

STATE OF OHIO
Ted Strickland, Governor

DEPARTMENT OF NATURAL RESOURCES
Sean D. Logan, Director

DIVISION OF GEOLOGICAL SURVEY
Larry Wickstrom, Chief

KNOWN AND PROBABLE KARST IN OHIO



EXPLANATION

- Silurian- and Devonian-age carbonate bedrock overlain by less than 20 feet of glacial drift and/or alluvium
- Silurian- and Devonian-age carbonate bedrock overlain by more than 20 feet of glacial drift and/or alluvium
- Interbedded Ordovician-age limestone and shale overlain by less than 20 feet of glacial drift and/or alluvium
- Interbedded Ordovician-age limestone and shale overlain by more than 20 feet of glacial drift and/or alluvium
- Probable karst areas
- Area not known to contain karst features
- Wisconsinan Glacial Margin
- Illinoian Glacial Margin

Recommended citation: Ohio Division of Geological Survey, 1999 (rev. 2002, 2006), Known and probable karst in Ohio: Ohio Department of Natural Resources, Division of Geological Survey Map EG-1, generalized page-size version with text, 2 p., scale 1:2,000,000.

OHIO KARST AREAS

Karst is a landform that develops on or in limestone, dolomite, or gypsum by dissolution and that is characterized by the presence of characteristic features such as sinkholes, underground (or internal) drainage through solution-enlarged fractures (joints), and caves. While karst landforms and features are commonly striking in appearance and host to some of Ohio's rarest fauna, they also can be a significant geologic hazard. Sudden collapse of an underground cavern or opening of a sinkhole can cause surface subsidence that can severely damage or destroy any overlying structure such as a building, bridge, or highway. Improperly backfilled sinkholes are prone to both gradual and sudden subsidence, and similarly threaten overlying structures. Sewage, animal wastes, and agricultural, industrial, and ice-control chemicals entering sinkholes as surface drainage are conducted directly and quickly into the ground-water system, thereby posing a severe threat to potable water supplies. Because of such risks, many of the nation's state geological surveys, and the U.S. Geological Survey, are actively mapping and characterizing the nation's karst regions.

The five most significant Ohio karst regions are described below.

BELLEVUE-CASTALIA KARST PLAIN

The Bellevue-Castalia Karst Plain occupies portions of northeastern Seneca County, northwestern Huron County, southeastern Sandusky County, and western Erie County. Adjacent karst terrain in portions of Ottawa County, including the Marblehead Peninsula, Catawba Island, and the Bass Islands, is related in geologic origin to the Bellevue-Castalia Karst Plain. The area is underlain by up to 175 feet of Devonian carbonates (Delaware Limestone, Columbus Limestone, Lucas Dolomite, and Amherstburg Dolomite) overlying Silurian dolomite, anhydrite, and gypsum of the Bass Islands Dolomite and Salina Group.

The Bellevue-Castalia Karst Plain is believed to contain more sinkholes than any of Ohio's other karst regions. Huge, irregularly shaped, closed depressions up to 270 acres in size and commonly enclosing smaller, circular-closed depressions 5 to 80 feet in diameter pockmark the land between the village of Flat Rock in northeastern Seneca County and Castalia in western Erie County. Surface drainage on the plain is very limited, and many of the streams which are present disappear into sinkholes called swallow holes.

Karst in the Bellevue-Castalia and Lake Erie islands region is due to collapse of overlying carbonate rocks into voids created by the dissolution and removal of underlying gypsum beds. According to Verber and Stansbery (1953, Ohio Journal of Science), ground water is introduced into Salina Group anhydrite ($CaSO_4$) through pores and fractures in the overlying carbonates. The anhydrite chemically reacts with the water to form gypsum ($CaSO_4 \cdot 2H_2O$), undergoing a 33 to 62 percent increase in volume in the process. This swelling lifts overlying strata, thereby opening fractures and creating massive passageways for conduction of greater volumes of ground water through the Silurian Bass Islands Dolomite and into underlying Salina Group strata. Gypsum, being readily soluble in water, is dissolved, creating huge voids. Overlying carbonates then collapse or break down, leaving surface depressions similar to those resulting from roof failure of an underground mine.

DISSECTED NIAGARA ESCARPMENT

The dissected Niagara Escarpment of southwestern Ohio includes the largest single area of karst terrain in the state and the greatest number of surveyed caves. It also is estimated to include the second-largest number of sinkholes in the state. The area is underlain by Silurian rocks of the Peebles Dolomite, Lilley Formation, Bisher Formation, Estill Shale, and Noland Formation in Adams, Highland, and Clinton Counties and the Cedarville Dolomite, Springfield Dolomite, Euphemia Dolomite, Massie Shale, Laurel Dolomite, Osgood Shale, and Dayton Formation in Greene, Clark, Miami, Montgomery, and Preble Counties. The Peebles-Lilley-Bisher sequence and the Cedarville-Springfield-Euphemia sequence constitute the Lockport Group.

Most karst features along the Niagara Escarpment in southwestern Ohio are developed in Lockport Group strata. More than 100 sinkholes and caves developed in the Lockport have been documented in the field, and more than 1,000 probable sinkholes in the Lockport have been identified on aerial photographs, soils maps, and topographic maps. As with most karst terrain, sinkholes developed on the Niagara Escarpment commonly show linear orientations aligned with prevailing joint trends in the area. The greatest concentration of sinkholes on the escarpment is south of the Wisconsinan glacial border in southern Highland and Adams Counties, where highly dissected ridges capped by Silurian carbonate rocks rise 150 to 200 feet above surrounding drainage. Illinoian till in these areas is thin to absent, and soils are completely leached with respect to calcium and calcium-magnesium carbonate. Such geologic settings are ideal for active karst processes, as downward-percolating, naturally acidic rain water is not buffered until it has dissolved some of the underlying carbonate bedrock. Other significant karst features of the Niagara Escarpment include small caves in escarpment re-entrants created by the valleys of the Great Miami and Stillwater Rivers in Miami County.

BELLEFONTAINE OUTLIER

The Bellefontaine Outlier in Logan and northern Champaign Counties is an erosionally resistant "island" of Devonian carbonates capped by Ohio Shale and surrounded by a "sea" of Silurian strata. Though completely glaciated, the outlier was such an impediment to Ice Age glaciers that it repeatedly separated advancing ice sheets into two glacial lobes—the Miami Lobe on the west and the Scioto Lobe on the east. Most Ohioans recognize the outlier as the location of Campbell Hill—the highest point in the state at an elevation of 1,549 feet above mean sea level.

Although it is not known for having an especially well-developed karst terrain, the outlier is the location of Ohio's largest known cave, Ohio Caverns. The greatest sinkhole concentrations are present in McArthur and Rushcreek Townships of Logan County, where the density of sinkholes in some areas approaches 30 per square mile. Sinkholes here typically occur in upland areas of Devonian Lucas Dolomite or Columbus Limestone that are 30 to 50 feet or more above surrounding drainage and are covered by less than 20 feet of glacial drift and/or Ohio Shale.

SCIOTO AND OLENTANGY RIVER GORGES

The uplands adjacent to the gorges of the Scioto and Olentangy Rivers in northern Franklin and southern Delaware Counties include areas of well--developed, active karst terrain. These uplands also are among the most rapidly developing areas of the state, which means karst should be a consideration in site assessments for commercial and residential construction projects.

The Scioto River in this area has been incised to a depth of 50 to 100 feet into underlying bedrock, creating a shallow gorge. The floor, walls, and adjacent uplands of the gorge consist of Devonian Delaware and Columbus Limestones mantled by up to 20 feet of Wisconsinan till. Sinkhole concentrations up to 1 sinkhole per acre are not uncommon in Concord, Scioto, and Radnor Townships of Delaware County. The sinkholes range in diameter from about 10 to 100 feet and commonly are aligned linearly along major joint systems.

The Olentangy River is approximately 5 miles east of the Scioto River in southern Delaware County and occupies a gorge that is narrower and up to 50 feet deeper than the Scioto River gorge. The floor and the lower half of the walls along the Olentangy gorge are composed of Delaware and Columbus Limestones, the upper half of the walls is composed of Devonian Ohio and Olentangy Shales mantled by a thin veneer of glacial drift. Karst terrain has developed along portions of the gorge in a manner similar to karst terrain along the Scioto River.

ORDOVICIAN UPLANDS

The Ordovician uplands of southwestern Ohio are the location of surprisingly well-developed karst terrain despite the large component of shale in local bedrock. Numerous sinkholes are present in Ordovician rocks of Adams, Brown, Clermont, and Hamilton Counties.

The carbonate-rich members of the Grant Lake Formation (Bellevue and Mount Auburn), Grant Lake Limestone (Bellevue and Straight Creek), and the upper portion of the Arnheim formation are the Ordovician units most prone to karstification; however, the shale-rich (70 percent shale, 30 percent limestone) Waynesville Formation also has been subjected to a surprising amount of karst development in southeastern Brown and southwestern Adams Counties, just north of the Ohio River.

ACKNOWLEDGMENT

The Division of Geological Survey gratefully acknowledges the Ohio Low-Level Radioactive-Waste Facility Development Authority for its financial support for mapping Ohio karst terrain.

APPENDIX A.1 - ODOT Quick Reference for Visual Description of Soils

1) STRENGTH OF SOIL:

Non-Cohesive (granular) Soils - Compactness	
Description	**Blows Per Ft.**
Very Loose	≤ 4
Loose	5 – 10
Medium Dense	11 – 30
Dense	31 – 50
Very Dense	> 50

2) COLOR :

If a color is a uniform color throughout, the term is single, modified by an adjective such as light or dark. If the predominate color is shaded by a secondary color, the secondary color procedes the primary color. If two major and distinct colors are swirled throughout the soil, the colors are modified by the term "mottled"

3) PRIMARY COMPONENT

Use **DESCRIPTION** from ODOT Soil Classification Chart on Back

Cohesive (fine grained) Soils - Consistency

Description	Qu (TSF)	Blows Per Ft.	Hand Manipulation
Very Soft	<0.25	<2	Easily penetrates 2" by fist
Soft	0.25-0.5	2 - 4	Easily penetrates 2" by thumb
Medium Stiff	0.5-1.0	5 - 8	Penetrates by thumb with moderate effort
Stiff	1.0-2.0	9 - 15	Readily indents by thumb, but not penetrate
Very Stiff	2.0-4.0	16 - 30	Readily indents by thumbnail
Hard	>4.0	>30	Indent with difficulty by thumbnail

4) COMPONENT MODIFIERS:

Description	Percentage By Weight
Trace	0% - 10%
Little	10% - 20%
Some	20% - 35%
"And"	35% -50%

5) Soil Organic Content

Description	% by Weight
Slightly Organic	2% - 4%
Moderately Organic	4% - 10%
Highly Organic	> 10%

6) Relative Visual Moisture

Description	Criteria	
	Cohesive Soil	**Non-cohesive Soils**
Dry	Powdery; Cannot be rolled; Water content well below the plastic limit	No moisture present
Damp	Leaves very little moisture when pressed between fingers; Crumbles at or before rolled to $^1/_8$"; Water content below plastic limit	Internal moisture, but no to little surface moisture
Moist	Leaves small amounts of moisture when pressed between fingers; Rolled to $^1/_8$" or smaller before crumbling; Water content above plastic limit to -3% of the liquid limit	Free water on surface, moist (shiny) appearance
Wet	Very mushy; Rolled multiple times to $^1/_8$" or smaller before crumbles; Near or above the liquid limit	Voids filled with free water, can be poured from split spoon.

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_0/LL x 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.	$\leq$LL-30	20	
	Clay	A-7-6		76 Min.		36 Min.	41 Min.	>LL-30	20	
	Organic Silt	A-8	A-8a	75 Max.		36 Min.				W/o organics would classify as A-4a or A-4b
	Organic Clay	A-8	A-8b	75 Max.		36 Min.				W/o organics would classify as A-5, A-6a, A-6b, A-7-5 or A-7-6

MATERIAL CLASSIFIED BY VISUAL INSPECTION

- Sod and Topsoil
- Pavement or Base
- Uncontrolled Fill (Describe)
- Bouldery Zone
- Peat, 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.