FINAL REPORT
SUBGRADE EXPLORATION
BUT-CR19-5.88
BUTLER COUNTY, OHIO
PID#: 113725

Prepared For:

EMH&T
5500 New Albany Road
Columbus, Ohio 43054

Prepared by:

NATIONAL ENGINEERING AND ARCHITECTURAL SERVICES INC.
2800 Corporate Exchange Drive, Suite 240
Columbus, Ohio 43231

NEAS PROJECT 20-0097

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National Engineering & Architectural Services Inc.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

1. INTRODUCTION

1.1. General

NEAS presents our Subgrade Exploration Report for the proposed project BUT-CR19-5.88 (PID# 113725) along CR-19 between Hamilton Mason Road and Yankee Road in Liberty Township, Butler County, Ohio. The project objective is to provide safe pedestrian access by the construction of a shared use path including ADA curb ramps, crosswalks, and pedestrian signals at the relevant intersections along the western side of Cincinnati-Dayton Road between Hamilton Mason Road and Yankee Road.

This report presents a summary of the encountered surficial and subsurface conditions and our recommendations for subgrade stabilization and pavement design parameters for the proposed shared use path in accordance with ODOT's January 2021 revision of *Geotechnical Bulletin 1* (GB1) (ODOT [1], 2021) and *Pavement Design Manual* (PDM) (ODOT[2], 2021).

The exploration was conducted in general accordance with NEAS, Inc.'s proposal to EMH&T, dated September 21, 2020 and with the provisions of ODOT's *Specifications for Geotechnical Explorations* (SGE) (ODOT[3], 2021).

The scope of work performed included: 1) a review of published geotechnical information; 2) performing 3 total subgrade soil test borings; 3) laboratory testing of soil samples in accordance with the SGE; 4) performing geotechnical engineering analysis to assess subgrade stabilization requirements and pavement design parameters; 5) soil profile sheets; and, 6) development of this summary report.

2. GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1. Geology and Physiography

The project site is located within the Southern Ohio Loamy Till Plain, which is characterized as end and recessional moraines, commonly associated with boulder belts, between relatively flat-lying ground moraine, cut by steep-valleyed large streams with surface soils consisting of loamy till. Buried valleys are common and are generally filled with outwash and alternate between broad floodplains and narrows. Elevation of the region ranges from 530 to 1,150 ft amsl, with moderate relief (200 ft). The geology within this region is described as loamy, high-lime Wisconsinan-age till, outwash and loess over Lower Paleozoic-age carbonate rocks (i.e. limestone or dolostone) and, in the east, shales (ODNR, 1998).

The geology at the project site is mapped as an average of 10 ft of Wisconsinan-age loam till underlain by Ordovician-age limestone-dominant bedrock south of SR-129 and Shale-dominant bedrock north of SR-129 (ODGS, 2005). The loam till is described as an unsorted mix of clay, silt, sand, gravel, and boulders which is noted as containing silt, sand, and gravel lenses. May be overlain by up to 3 ft of loess which is generally thin to absent on slopes. Average sand/silt/clay percentages of till are 25/45/30 respectively. Till in buried valleys and thicker areas is noted as potentially being older than Wisconsinan.

Based on the Bedrock Geologic Units Map of Ohio (USGS & ODGS, 2006), bedrock within the majority of the project area consists of limestone and shale of the Waynesville and Arnheim formations, undivided. The undivided Waynesville and Arnheim formations are comprised of Ordovician-age limestone and shale, with minor lithologic constituents of mudstone. The interbedded limestone and shale in these formations are described as gray to bluish gray and weathers light gray in color, thin to thick bedded, planar to irregular bedding with wavy to nodular bedding exhibited as well.

A small outcropping of bedrock near Liberty Centre Drive consists of limestone and shale of the Grant Lake and Fairview Formations and Miamitown shale, undivided. The undivided Grant Lake, Fairview and Miamitown Shale formations are comprised of Ordovician-age limestone and shale. The interbedded limestone and shale in these formations are described as gray to bluish gray and weathers light gray to yellowish-gray in color, thin to medium bedded in lower half, thin to thick bedded in upper half, planar to lenticular bedding with wavy to irregular to nodular bedding exhibited as well.

Bedrock is anticipated to generally follow the natural topography of the site, sloping downwards from north to south (ODGS, 2003). Based on the ODNR bedrock topography map of Ohio, bedrock elevations at the project site can be expected to be between elevations of 800 and 850 ft amsl, putting bedrock at a depth of about 10 ft below ground surface (bgs).

The soils at the project site south of SR-129 have been mapped (Web Soil Survey) by the Natural Resources Conservation Service (USDA, 2015) as Wynn silt loam followed by Shoals silt loam, followed by Russell-Miamian silt loam from south to north. The soils at the project site north of SR-129 have been mapped as Wynn silt loam followed by Russell-Miamian silt loam, followed by Wynn silt loam from south to north.

Soils in the Russell-Miamian series are characterized as very deep, well drained soils that are deep or very deep to dense till. The Russell-Miamian soils are formed in loess and in the underlying loamy till on till plains and moraines. The Russell-Miamian series is comprised of primarily fine-grained soils and is classified as A-4, A-6 and A-7 type soils according to the AASHTO method of soil classification.

Soils in the Wynn series are characterized as moderately deep, well drained soils formed in a thin layer of loess, loamy till, and the underlying calcareous clayey shale with thin strata of limestone. The Wynn soils are formed in loess and in the underlying loamy till on till plains and moraines. The Wynn series is comprised of primarily fine-grained soils and is classified as A-4, A-6, and A-7 type soils according to the AASHTO method of soil classification.

Soils in the Shoals series are characterized as very deep, somewhat poorly drained soils that formed in alluvium on flood plains. The Shoals soils are formed in loess and in the underlying loamy till on till plains and moraines. The Shoals series is comprised of both coarse-grained and fine-grained soils and is classified as A-2, A-4, A-6, and A-7 type soils according to the AASHTO method of soil classification.

2.1. Hydrology/Hydrogeology

Groundwater at the project site can be expected at an elevation consistent with that of the tributary of Gregory Creek, as it is the most dominant hydraulic influence in the vicinity of the project boundaries. The tributary of Gregory Creek is at an elevation of approximately 800 ft amsl. This elevation is consistent with the static water level of nearby water wells (ID# 2007179 & 2007183) which were drilled in 2006. It should be noted that perched groundwater systems may be existent in areas due to the presence of fine-grained soils making it difficult for groundwater to permeate to the phreatic surface.

The project site is not located within a regulatory floodway based on available mapping by the Federal Emergency Management Agency's (FEMA) National Flood Hazard mapping program (FEMA, 2019).

2.2. Mining and Oil/Gas Production

No abandoned mines are noted on the ODNR’s Abandoned Underground Mine Locator in the vicinity of the project site (ODNR [1], 2021).

No oil or gas wells are noted on the ODNR's Oil and Gas Well Locator in the vicinity of the project site (ODNR [2], 2021).

2.3. Historical Records and Previous Phases of Project Exploration

The following historic reports/plans were available for review and evaluation, and were used in the analysis for this report:

- Boring logs as part of ODOT project BUT-129-23.25, prepared by PSI Inc., dated February 14, 1997.

All the borings from the previous project were reviewed and nine (9) historic borings were utilized in our analysis and report.

2.4. Field Reconnaissance

A field reconnaissance visit for the overall project area was conducted on February 25, 2021 on Cincinnati Dayton Road (C.R. 19) between Hamilton Mason Road and Yankee Road inside the project limits. Site conditions, including the existing land and pavement conditions, were noted and photographed during the visit. Photographs of notable features and a summary of our observations by road segment are provided below. The land use of most of the project area consists of commercial properties.

In general, the pavement along C.R. 19 was observed to be in fair to good condition, with signs of surface wear. Moderate severity longitudinal and transverse cracking was observed along this section, as well as light severity edge cracking and crack sealing deficiencies (Photograph 1). The roadway in this section is roughly level with the surrounding land, which itself slopes downward from northeast to southwest. The exception to this is the area between SR-129 and the northern access ramps to and from SR-129. C.R. 19 in this section sits between the embankments that bring SR-129 over C.R. 19. The slope of these embankments is roughly 3H:1V (3 Horizontal to 1 Vertical) (Photograph 2). The roadway drains to open ditches on either side of the roadway, which then drain to underdrains near the access road to the Donato's Pizza building (Photograph 3). The area is generally lightly vegetated, and signs of standing water such as cattails were observed in the drainage ditches on both sides of the road. One noted exception was the drainage canal on the eastern side of the roadway, which was observed to be heavily vegetated and showed signs of standing water such as cattails. The overall project area appeared to be stable with no signs of geotechnical instability.

Photograph 1. Overall Pavement Condition of C.R. 19

Photograph 2. Slope of Embankment Between SR-129 and Northern Access Ramps

Photograph 3. Underdrains at end of Drainage Ditches

3. GEOTECHNICAL EXPLORATION

3.1. Exploration Program

The project subsurface exploration was conducted by NEAS on March 8, 2021 included 3 borings drilled to depths of between 10.0 and 15.0 ft bgs. The boring locations were selected by NEAS in general accordance with the guidelines contained in the SGE with the intent to evaluate subsurface soil and groundwater conditions. Borings were typically located within the planned shared use path/subgrade construction areas that were not restricted by underground utilities or dictated by terrain (e.g. steep embankment slopes). Project boring locations were located prior to drilling and surveyed in the field after drilling by NEAS. Each individual project boring log (to be included within Appendix B) will include the recorded boring latitude and longitude location (based on the surveyed Ohio State Plane South, NAD83, location) and the corresponding ground surface elevation. The boring locations will be depicted on the Boring Location Plan provided in Appendix A.

Project borings were drilled using a CME 55 track-mounted drilling rig utilizing 3.25-inch (inner diameter) hollow stem augers. Soil samples for subgrade borings were recovered at 2.5-ft intervals using an 18-inch split spoon sampler (AASHTO T-206 “Standard Method for Penetration Test and Split Barrel Sampling of Soils.”). The soil samples obtained from the exploration program were visually observed in the field by the NEAS field representative and preserved for review by a Geologist for possible laboratory testing. Standard penetration tests (SPT) were conducted using CME auto hammers calibrated to be 79.7% efficient as indicated on the boring logs.

Project field boring logs were prepared by drilling personnel and included pavement description (where present), lithological description, and SPT results recorded as blows per 6-inch increment of penetration. Groundwater level observations were recorded both during and after the completion of drilling. These groundwater level observations are included on the individual boring logs (provided in Appendix B). Pavement thickness was measured in the field after the cores were extracted. After completion, the

borings were backfilled with auger cuttings and patched with asphalt cold patch where necessary and appropriate.

3.2. Laboratory Testing Program

The laboratory testing program consisted of classification testing and moisture content determinations. Data from the laboratory testing program was incorporated onto the boring logs (Appendix B). Soil samples are retained through completion and ODOT approval of Stage 2 plans, after which time they will be discarded.

3.2.1. Classification Testing

Representative soil samples were selected for index property (Atterberg Limits) and gradation testing for classification purposes on approximately 33% of the samples. At each subgrade boring location, a sample representing each distinctive strata obtained below the proposed top of subgrade elevation was generally tested while additional samples were selected for testing with the intent of properly classifying the subsurface soil and groundwater conditions within the planned project limits. Soils not selected for testing were compared to laboratory tested samples/strata and classified visually. Moisture content testing was generally conducted on all samples. The laboratory testing was performed in general accordance with applicable AASHTO specifications and ODOT Supplements.

Final classification of soil strata in accordance with AASHTO M-145 “Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes,” as modified by ODOT “Classification of Soils” was made once laboratory test results became available. The results of the soil classification are presented on the boring logs in Appendix B.

3.2.2. Standard Penetration Test Results

Standard Penetration Tests (SPT) and split-barrel (commonly known as split-spoon) sampling of soils were performed at 2.5-ft intervals in the project borings performed. To account for the high efficiency (automatic) hammers used during SPT sampling, field SPT N-values were converted based on the calibrated efficiency (energy ratio) of the specific drill rig's hammer. Field N-values were converted to an equivalent rod energy of 60% (N_{60}) for use in analysis or for correlation purposes. The resulting N_{60} values are shown on the boring logs provided in Appendix B.

3.2.3. Sulfate Testing

Sulfate testing was performed on one sample for each subgrade boring performed for pavement/subgrade design purposes for the subgrade analyses. The selected samples were tested in accordance with ODOT Supplement 1122, “Determining Sulfate Content in Soils” dated July 20, 2018. In general, sulfate testing was performed on one of the upper two samples (within 3 ft of the anticipated proposed subgrade elevation) of each boring. Sulfate testing results are provided in Appendix B. Testing results with sulfate content greater than 3,000 ppm are summarized in Table 1 below.

Table 1: Sulfate Content Greater than 3,000 ppm

Boring ID	Sample	Depth (ft)	Dilution Ratio	Average Sulfate Content (ppm)
B-002-0-20	SS-1	1.0 - 2.5	100	>8,000
B-003-0-20	SS-1	1.0 - 2.5	100	>8,000

4. GEOTECHNICAL FINDINGS

The subsurface conditions encountered during NEAS's explorations are described in the following subsections and/or on each boring log presented in Appendix B. The boring logs represent NEAS's interpretation of the subsurface conditions encountered at each boring location based on our site observations, field logs, visual review of the soil samples by NEAS's geologist, and laboratory test results. The lines designating the interfaces between various soil strata on the boring logs represent the approximate interface location; the actual transition between strata may be gradual and indistinct. The subsurface soil and groundwater characterizations included herein, including summary test data, are based on the subsurface findings from the geotechnical explorations performed by NEAS as part of the referenced project. It should be noted that for the purposes of this report and our analysis the term 'subgrade' has been assumed to represent soils and/or soil conditions from 1.5 ft below proposed final pavement grades to a depth of 7.5 ft below the proposed pavement grades.

4.1. Existing Pavement

The pavement section thickness in terms of asphalt, concrete, and granular base were measured at a representative subgrade boring. Pavement section thickness was measured during the subsurface exploration and is recorded on the test boring log provided in Appendix B. A summary of these measurements is provided in Table 2 below.

Table 2: Measured Pavement Thicknesses

Boring ID	Proposed Alignment	Drilled Depth (ft)	Asphalt Thickness (in)	Concrete Thickness (in)	Base Thickness (in)	Total Thickness (in)
B-002-0-20	Shared Use Path	13.7	8.0	0.0	5.0	13.0

4.2. Subgrade Conditions

The surficial materials encountered consist of asphalt pavement and granular base, topsoil, or naturally occurring cohesive materials. Below the surficial materials, the subgrade soils encountered within the project limits are relatively consistent and are comprised of fill material and natural cohesive materials. The subgrade soils are generally classified as A-1-a, A-4a, A-4b, A-6a, A-6b and A-7-5. Bedrock was encountered in borings B-002-0-20, B-003-0-20, B-011-0-95, B-012-A-95, B-038-0-95, B-039-0-95 and B-098-0-95 and is comprised of either shale or limestone.

The following section presents a brief summary of the subsurface conditions encountered throughout the project site.

4.2.1. Shared use path

The subgrade soils encountered along the proposed shared use path consisted of 68% cohesive materials, 3% granular materials, and 29% rock. Those cohesive materials are: 1) Silty Clay (A-6b, 23% of

samples); 2) Silt and Clay (A-6a, 19 % of samples); 3) Sandy Silt (A-4a, 13% of samples); 4) Elastic Clay (A-7-5, 10% of samples); and, 5) Silt (A-4b, 3%). Those granular materials are: 1) Gravel (A-1-a, 3% of samples).

With respect to the soil strength, the cohesive soils encountered can be characterized as having a relative consistency of very stiff, correlating to converted SPT-N values (N_{60}) between 4 and 100 blows per foot (bpf). Natural moisture contents of representative samples ranged from 6 to 28 percent. Based on Atterberg Limits tests performed on a representative sample of the subgrade soils obtained along the proposed shared use path, the liquid and plastic limits of the cohesive materials ranged from 26 to 36 percent and from 15 to 18 percent, respectively.

With respect to the soil strength, the granular soils encountered can be characterized as having a relative compactness of loose to medium dense, correlating to converted SPT-N values (N_{60}) between 8 and 20 blows per foot (bpf). Natural moisture content of representative samples ranged from 4 to 7 percent.

4.2.2. Groundwater

Groundwater was observed during drilling within the proposed subgrade depth in one (1) of the borings (B-003-0-20) performed at the site as part of the geotechnical exploration. Based on measurements at this boring location groundwater was encountered at a depth of 8.5 ft bgs (elevation 833.9 ft amsl). It should be noted that groundwater is affected by many hydrologic characteristics in the area and may vary from those measured at the time of the exploration. The specific groundwater readings are included on the individual test boring logs located within Appendix B.

4.2.3. Bedrock

Bedrock was encountered within the proposed subgrade depth in two (2) of the borings (B-002-0-20, B-003-0-20) performed at the site as part of the geotechnical exploration and five (5) of the borings (B-011-0-95, B-012-A-95, B-038-0-95, B-039-0-95, and B-098-0-95) performed in the 1977 exploration. Based on measurements at these boring locations, bedrock was encountered at a depth of 2.3 ft to 14.1 ft bgs (elevation 796.6 ft to 837.9 ft amsl). Bedrock consisted of gray, severely to highly weathered shale.

5. ANALYSES AND RECOMMENDATIONS

We understand that the construction of a shared use path is planned as part of the project (BUT-CR19-5.88, PID 113725). For this purpose, a subgrade exploration and subsequent subgrade analysis was completed for the referenced project. The subgrade analysis was performed in accordance with ODOT's GB1 criteria utilizing the ODOT-provided *GB1: Subgrade Analysis Spreadsheet* (GB1_SubgradeAnalysis.xlsm, Version 14.5 dated January 18, 2019). Input information for the spreadsheet was based on the soil characteristics gathered during NEAS's subgrade exploration (i.e., SPT results, laboratory test results, etc.), the historic project BUT-129-23.25, prepared by PSI Inc., dated February 14, 1997, and our geotechnical experience. The GB1 analysis was performed for the entire length of the project.

Based on our evaluation of the subsurface conditions and our geotechnical engineering analyses of the proposed construction project, it is our opinion that the subgrade conditions encountered are generally satisfactory and pavement can be designed without the need for extreme levels of remediation. In general, the subgrade soils throughout the project can be stabilized by either typical excavate and replace practices or chemical stabilization. The following sections provide further detail about the analysis performed and the recommended remediation.

5.1. Pavement Design Analysis

A GB1 analysis was performed to identify the method, location, and dimensions (including depth) of recommended subgrade stabilization in the referenced project plans. Appropriate stabilization of the subgrade will ensure a constructible pavement buildup, enhance pavement performance over its life, and help reduce costly extra work change orders (ODOT [1], 2021). In addition to identifying stabilization recommendations, pavement design parameters are also determined to aid in pavement section design. The subsections below present the results of our GB1 analysis including pavement design parameters and unsuitable subgrade conditions if any are identified within the project limits. The GB1 analysis spreadsheet is provided in Appendix C.

5.1.1. Pavement Design Recommendations

It is our understanding that pavement analyses and design is to be performed to determine the proposed pavement sections for the shared use path. A GB1 analysis was performed using the subgrade soil data obtained for the proposed shared use path to evaluate the soil characteristics for use in pavement design. The subgrade analysis parameters recommended for use in pavement design for the proposed shared use path are presented in Table 3 below. Provided in the table are the average Plasticity Index (PI) value, maximum, minimum and average N_{60L} values for the indicated alignment, as well as the design CBR value recommended for use in pavement design.

Table 3: Pavement Design Values

Segment	Maximum N_{60L}	Minimum N_{60L}	Average N_{60L}	Average PI Values	Design CBR
Shared Use Path	30	0	18	18	6

5.1.2. Unstable & Unsuitable Subgrade

Per ODOT's GB1, the presence of select subgrade conditions is prohibited within the subgrade zone for new pavement construction. These prohibited subgrade conditions generally include the presence of rock, specific soil types, weak soil conditions, and overly moist soil conditions. With respect to the planned shared use path, these subgrade conditions are further discussed in the following subsections.

5.1.2.1. Rock

As per the GB1, *"When rock, shale, or coal is encountered within 24 inches of the bottom of the asphalt or concrete pavement, it is to be removed according to 204.05 and replaced with Item 204 Embankment."* Bedrock was encountered within 24 inches of the top of the proposed subgrade in three (3) borings performed (B-002-0-20, B-011-0-95, B-012-A-95, B-003-0-20). Therefore, remediation is required with respect to rock. As per the GB1, *"When rock, shale, or coal is encountered within 24 inches of the bottom of the asphalt or concrete pavement, it is to be removed according to 204.05 and replaced with Item 204 Embankment. Remove the rock, shale, or coal to 12 inches beyond the edge of the surface of the pavement, paved shoulders, or paved medians, including under new curbs and gutters"*.

5.1.2.2. Prohibited Soils

Prohibited soil types per the GB1 include A-4b, A-2-5, A-5, A-7-5, A-8a, A-8b, and soils with liquid limits greater than 65. Prohibited soils identified as A-7-5 (Elastic Clay) were encountered within 3 feet of top of proposed subgrade in two (2) of the borings performed (B-008-0-95, B-098-0-95). Therefore, remediation is required with respect to prohibited soils. As per the GB1, *"When excavating and*

replacing, any A-2-5, A-5, and A-7-5 soils should be completely removed or excavated 36 inches, whichever is less".

5.1.2.3. Weak Soils

Soils for which the lowest N_{60} (N_{60L}) at the referenced boring location is less than 12 bpf and in some cases less than 15 bpf (i.e., where moisture content is greater than optimum plus 3 percent), or in which the lowest HP reading at the referenced boring location is less than 1.5 and in some cases less than 1.875 (i.e., where moisture content is greater than optimum plus 3 percent), subgrade stabilization depths are recommended per *Figure B - Subgrade Stabilization* within the GB1.

It should be noted that for the purposes of this report the term "weak soils" has been assumed to represent subgrade soils of these conditions. Weak soils were encountered along the proposed shared use path within 3 ft of proposed finish grade. Therefore, remediation is needed for the weak soils encountered along the alignment.

It should be noted that *Figure B - Subgrade Stabilization* does not apply to soil types A-1-a, A-1-b, A-3, or A-3a, nor to soils with N_{60L} values of 15 or more. Per GB1 guidance *these soils should be reworked to stabilize the subgrade.*

5.1.2.4. High Moisture Content Soils

High moisture content soils are defined by the GB1 as soils that exceed the estimated optimum moisture content (per *Figure A - Optimum Moisture Content* within the GB1) for a given classification by 3 percent or more. Per the GB1, soils determined to be above the identified moisture content levels are a likely indication of the presence of an unstable subgrade and may require some form of subgrade stabilization. High moisture content soils were encountered along the proposed shared use path within 3 ft of proposed finished grade of the alignment in one (1) boring (B-037-0-95). Therefore, remediation is needed for the high moisture content soils encountered at these locations.

5.1.2.5. High Sulfate Content Soils

High sulfate content soils are defined as soils that exceed 5,000 ppm. Where high sulfate content soils are encountered, the GB1 prohibits the use of chemical stabilization without prior consultation with the District Geotechnical Engineer. Two soil samples in borings B-002-0-20 and B-003-0-20 present sulfate contents greater than 5,000 ppm.

5.2. Stabilization Recommendations

5.2.1. Summary of Stabilization

Based on the results of our analysis, subgrade conditions designated by ODOT's GB1 as both "unsuitable" and "unstable" were present at various locations throughout the project. Subgrade conditions designated as "unsuitable" consisted of materials classifying as A-7-5 (Elastic Clay) and Rock and were encountered within subgrade depths that require remediation in five (5) borings (B-008-0-95, B-002-0-20, B-011-0-95, B-012-A-95, B-003-0-20) performed along the proposed shared use path. Subgrade soils designated as "unstable" were encountered in four (4) borings (B-037-0-95, B-038-0-95, B-001-0-20, and B-039-0-95) along the proposed shared use path. Two (2) soil samples in Borings B-002-0-20 and B-003-0-20 present sulfate contents greater than 5,000 ppm.

NEAS recommends stabilization in the form of Excavate and Replace (Item 204 with Geotextile) be performed. Based on: 1) the results of our GB1 analysis; 2) the review of the unsuitable and unstable subgrade conditions as described in Section 5.1.2. of this report; and, 3) the subsequent conclusions regarding recommended stabilization, Table 4 presents our recommendations for subgrade stabilization for the proposed shared use path within the project limits.

Table 4: Summay of Stabilization

Start Station	End Station	Excavate and Replace w/ Item 204 (inches)	Chemical Stabilization (inches)	Unsuitable / Unstable Subgrade Conditions	Borings Considered
By Segment					
Begin Work	109+13	12	N/A	N_{60}, HP, Mc	B-037-0-95, B-038-0-95, B-001-0-20, B-039-0-95
109+13	113+15	36	N/A	A-7-5	B-008-0-95
113+15	119+96	24	N/A	Rock, Sulfate >5,000	B-002-0-95, B-012-A-95, B-011-0-95, B-003-0-20
127+29	End Work	36	N/A	A-7-5	B-098-0-95

Stabilization limits should extend 18-inches beyond the edge of the proposed paved roadway, shoulder or median and it is recommended removing any topsoil, existing pavement materials or abandoned structure foundation materials.

6. QUALIFICATIONS

This investigation was performed in accordance with accepted geotechnical engineering practice for the purpose of characterizing the subgrade conditions along the referenced proposed shared use path. This report has been prepared for EMH&T, ODOT and their design consultants to be used solely in evaluating the proposed shared use path subgrade soils within the project limits and presenting geotechnical engineering recommendations specific to this project. The assessment of general site environmental conditions or the presence of pollutants in the soil, rock and groundwater of the site was beyond the scope of this geotechnical exploration. Our recommendations are based on the results of our field explorations, laboratory test results from representative soil samples, review of historic geotechnical exploration data, and geotechnical engineering analyses. The results of the field explorations and laboratory tests, which form the basis of our recommendations, are presented in the appendices as noted. This report does not reflect any variations that may occur between the borings or elsewhere on the site, or variations whose nature and extent may not become evident until a later stage of construction. In the event that any changes occur in the nature, design or location of the proposed pavement work, the conclusions and recommendations contained in this report should not be considered valid until they are reviewed, and have been modified or verified in writing by a geotechnical engineer.

It has been a pleasure to be of service to EMH&T in performing this geotechnical exploration for the BUT-CR19-5.88 project. Please call if there are any questions, or if we can be of further service.

Respectfully Submitted,

Chunmei (Melinda) He, Ph. D., P.E.
Project Geotechnical Engineer

Matthew Jasiewicz, E.I.
Staff Engineer

REFERENCES

FEMA. (2019). *National Flood Hazard Layer kmz v3.2.* Federal Emergency Management Agency.

ODGS. (2003). Bedrock-topography data for Ohio: Ohio Department of Natural Resources, Division of Geological Survey Map BG-3, 1 CD-ROM, GIS file formats. Revised January 9, 2004.

ODNR [1]. (2021). *Ohio Abandoned Mine Locator Interactive Map*. Retrieved from ODNR Mines of Ohio Viewer: https://gis.ohiodnr.gov/MapViewer/?config= OhioMines

ODNR [2]. (2021). *Ohio Oil & Gas Locator Interactive Map*. Retrieved from ODNR Oil & Gas Well Viewer: https://gis.ohiodnr.gov/MapViewer/?config=OilGasWells

ODNR [3]. (2021). *ODNR Water Wells Viewer*. Retrieved from ODNR GIS Interactive Maps: https://gis.ohiodnr.gov/MapViewer/?config=WaterWells

ODNR. (1998, April). Physiographic Regions of Ohio: Ohio Department of Natural Resources, Division of Geological Survey, page-size map with text, 2 p., scale 1:2,100,000.

ODOT [1]. (2021). *Geotechnical Bulletin 1*. Columbus, Ohio: Ohio Department of Transportation: Office of Geotechnical Engineering. Retrieved from https://www.dot.state.oh.us/Divisions/Engineering /Geotechnical/Geotechnical_Documents/GB1_Plan_Subgrades.pdf

ODOT[2]. (2021). *Pavement Design Manual*. Columbus, Ohio: Ohio Department of Transportation: Office of Pavement Engineering. Retrieved from http://www.dot.state.oh.us/Divisions/Engineering/ Pavement/Pavement%20Design%20%20Rehabilitation%20Manual/Complete_PDM_2015-07-17_version.pdf

ODOT[3]. (2021). *Specifications for Geotechnical Explorations.* Ohio Department of Transportation: Office of Geotechnical Engineering.

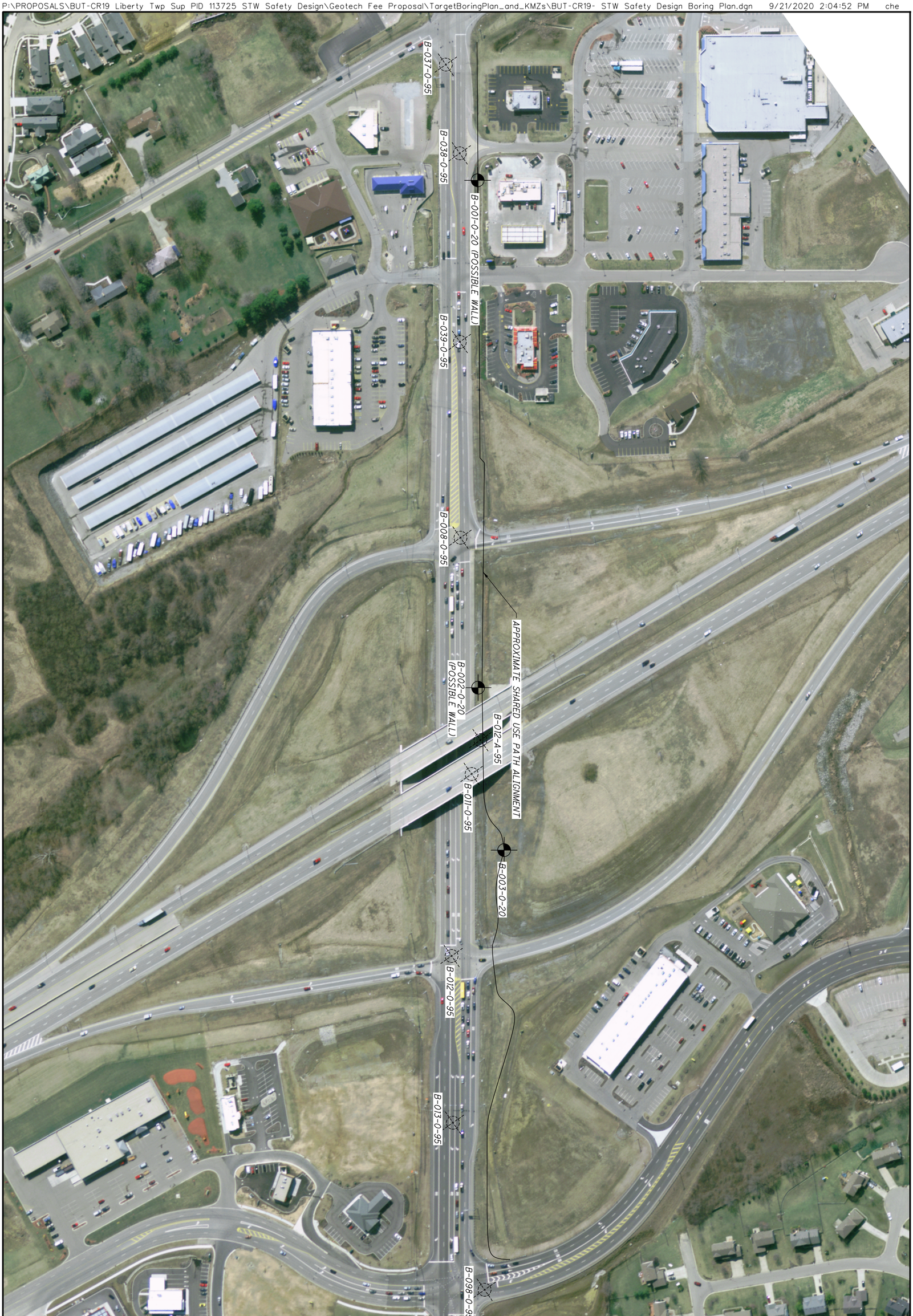
USDA. (2015, September). Web Soil Survey. Retrieved from http://websoilsurvey.nrcs.usda.gov

USGS & ODGS. (2006, June). Geologic Units of Ohio. *ohgeol.kmz*. United States Geologic Survey.

APPENDIX A

BORING LOCATION PLAN

P:\PROPOSALS\BUT-CR19 Liberty Twp Sup PID 113725 STW Safety Design\Geotech Fee Proposal\TargetBoringPlan_and_KMZs\BUT-CR19- STW Safety Design Boring Plan.dgn 9/21/2020 2:04:52 PM che



LIBERTY TOWNSHIP

CINCINNATI-DATON SHARED-USE PATH
TARGET BORING PLAN

DRAWN CH
CHECKED

0 50 100 200
HORIZONTAL SCALE IN FEET

APPENDIX B

BORING LOGS AND SULFATE CONTENT DATA

PROJECT: BUT-CR19-5.88	DRILLING FIRM / OPERATOR: W / BW	DRILL RIG: CME 55X W	STATION / OFFSET: 103+15, 11' RT.	EXPLORATION ID B-001-0-20
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: NEAS / ERICH B.	HAMMER: CME AUTOMATIC	ALIGNMENT: PROP. SHARED USE PATH	
PID: 113725 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 3/12/20	ELEVATION: 806.9 (MSL) EOB: 10.0 ft.	PAGE 1 OF 1
START: 3/8/21 END: 3/8/21	SAMPLING METHOD: SPT	ENERGY RATIO (%): 79.7	LAT / LONG: 39.371098, -84.384434	

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)	SO4 ppm	BACK FILL
6.0" TOPSOIL (DRILLERS DESCRIPTION)	806.4																		
LOOSE, BROWNISH GRAY, **GRAVEL**, LITTLE SAND, TRACE SILT, TRACE CLAY, RESEMBLES PEA GRAVEL, DAMP **(FILL)**	804.9	1	3 3 3	8	61	SS-1A	-	-	-	-	-	-	-	-	-	4	A-1-a (V)	-	
						SS-1B	4.25	-	-	-	-	-	-	-	-	15	A-6b (V)	<100	
VERY STIFF TO HARD, BROWNISH GRAY, **SILTY CLAY**, LITTLE TO SOME SAND, TRACE TO LITTLE GRAVEL, DAMP		2																	
		3																	
		4	7 7 6	17	72	SS-2	4.50	10	9	13	30	38	36	18	18	16	A-6b (10)	-	
		5																	
		6																	
		7	9 9 9	24	61	SS-3	3.00	-	-	-	-	-	-	-	-	15	A-6b (V)	-	
		8																	
	797.4	9	4 4 4	11	67	SS-4A	3.25	-	-	-	-	-	-	-	-	18	A-6b (V)	-	
MEDIUM DENSE, BROWNISH GRAY, **COARSE AND FINE SAND**, TRACE GRAVEL, TRACE SILT, TRACE CLAY, DAMP	796.9	EOB 10				SS-4B	-	-	-	-	-	-	-	-	-	11	A-3a (V)	-	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SHOVELED SOIL CUTTINGS

PROJECT: BUT-CR19-5.88	DRILLING FIRM / OPERATOR: W / BW	DRILL RIG: CME 55X W	STATION / OFFSET: 114+89, 20' RT.	EXPLORATION ID B-002-0-20
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: NEAS / ERICH B.	HAMMER: CME AUTOMATIC	ALIGNMENT: PROP. SHARED USE PATH	
PID: 113725 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 3/12/20	ELEVATION: 821.6 (MSL) EOB: 13.7 ft.	PAGE 1 OF 1
START: 3/8/21 END: 3/8/21	SAMPLING METHOD: SPT	ENERGY RATIO (%): 79.7	LAT / LONG: 39.373783, -84.382153	

MATERIAL DESCRIPTION AND NOTES	ELEV. 821.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
8.0" ASPHALT AND 5.0" GRANULAR BASE (PEA GRAVEL - DRILLERS DESCRIPTION)	820.6																		
MEDIUM DENSE, BROWN, **GRAVEL**, SOME SAND, TRACE SILT, TRACE CLAY, RESEMBLES PEA GRAVEL, CONTAINS SLAG, DAMP **(FILL)**	818.1	TR	15 9 6	20	61	SS-1	-	61	19	12	7	1	NP	NP	NP	7	A-1-a (0)	8000	
SHALE, GRAY, SEVERELY TO HIGHLY WEATHERED, VERY WEAK TO WEAK, FISSILE.			31 50/5"	-	100	SS-2	-	-	-	-	-	-	-	-	-	-	Rock (V)	-	
			7 29 50/5"	-	53	SS-3	-	-	-	-	-	-	-	-	-	-	Rock (V)	-	
			50/1"	-	100	SS-4	-	-	-	-	-	-	-	-	-	-	Rock (V)	-	
			50/3"	-	100	SS-5	-	-	-	-	-	-	-	-	-	-	Rock (V)	-	
	807.9	EOB	50/2"	-	100	SS-6	-	-	-	-	-	-	-	-	-	-	Rock (V)	-	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; SHOVELED SOIL CUTTINGS

PROJECT: BUT-CR19-5.88	DRILLING FIRM / OPERATOR: W / BW	DRILL RIG: CME 55X W	STATION / OFFSET: 118+65, 19' LT.	EXPLORATION ID B-003-0-20
TYPE: CUT SECTION	SAMPLING FIRM / LOGGER: NEAS / ERICH B.	HAMMER: CME AUTOMATIC	ALIGNMENT: PROP. SHARED USE PATH	
PID: 113725 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 3/12/20	ELEVATION: 842.4 (MSL) EOB: 13.8 ft.	PAGE 1 OF 1
START: 3/8/21 END: 3/8/21	SAMPLING METHOD: SPT	ENERGY RATIO (%): 79.7	LAT / LONG: 39.374737, -84.381626	

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)	SO4 ppm	BACK FILL
HARD, GRAY, **SILT AND CLAY**, SOME SAND, SOME GRAVEL AND STONE FRAGMENTS, SS-2 CONTAINS A RELIC ROCK STRUCTURE, DAMP	842.4	1	8 13 32	60	100	SS-1	4.50	24	12	13	22	29	34	19	15	9	A-6a (5)	8000	
		2																	
		3																	
	837.9	4	47 50/5"	-	82	SS-2	4.50	-	-	-	-	-	-	-	-	7	A-6a (V)	-	
SHALE, GRAY, SEVERELY WEATHERED, VERY WEAK.		TR 5																	
		6	50/5"	-	80	SS-3	-	-	-	-	-	-	-	-	-	-	Rock (V)	-	
		W 833.9 7																	
		833.4 8	50/5"	-	100	SS-4	-	-	-	-	-	-	-	-	-	-	Rock (V)	-	
		9																	
		10																	
		11	50/5"	-	100	SS-5	-	-	-	-	-	-	-	-	-	-	Rock (V)	-	
		12																	
	828.6	13 EOB	50/3"	-	100	SS-6	-	-	-	-	-	-	-	-	-	-	Rock (V)	-	

NOTES: GROUNDWATER ENCOUNTERED AT 8.5' DURING DRILLING, 9.0' AT COMPLETION. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SHOVELED SOIL CUTTINGS

LOG OF BORING

Date Started October 24, 1995
Date Completed October 24, 1995
Boring Number B-8 B-008-0-95

Station & Offset 30 + 826.3 3.5mLt***
Water Elevation Dry on completion
Surface Elevation 250.7

***Cincinnati-Dayton Road Station
Hole Advancement & Sampling
82.55mm ID Hollow Stem Auger
50.8mm OD Splitspoon Sampler
Drilled By: PSI, Inc.

Elev.	Depth	Std. Pen. (N)	Description	Sample Number	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Qp#	SHTL Class
		3-4-5	Dark Brown Silty CLAY. trace Sand. Moist. Stiff.	1								20	140	A-6a**
	1	3-4-6	Brown Elastic Clay. Moist. Stiff to Hard.	2								22	170	A-7-5**
	2	6-7-6		3	0	0	0	50	50			22	190	A-7-5*
247.7	3	6-10-33		4								16	430	A-7-5**
			End of Boring 3.0m											
	4													

*No Atterberg Limits. Description is visual with the aid of grain-size analysis.
#Kilopascals
**Description is visual with the aid of previous boring information.
~Samples composited.

Project: Butler County Regional Highway, BUT 129-23.25
Job No.: 123-55042
Client: LJB Engineers and Architects, Inc.

LOG OF BORING

Date Started November 2, 1995
Date Completed November 2, 1995
Boring Number B-11 B-011-0-95

Station & Offset 39 + 558.0 22.4mLt
Water Elevation Dry on completion
Surface Elevation 258.3

Hole Advancement & Sampling
82.55mm ID Hollow Stem Auger
50.8mm OD Splitspoon Sampler
Drilled By: PSI, Inc.

Elev.	Depth	Std. Pen. (N)	Description	Sample Number	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Qp#	SHTL Class
258.1			200 mm of Topsoil											
		5-7-10	Dark Brown Silty CLAY. Moist.	1								25	385	A-6b**
257.3	1													
		6-10-13	Brown Sandy SILT. little Clay. trace Gravel. Moist. Very Stiff to Hard.	2	19	8	14	40	19	27	8	12	430+	A-4a~
	2	10-23-20		3								11	430+	A-4a~
255.8														
		15-36-50	Gray weathered Limestone fragments and Gray Shale with Silty CLAY. Moist. Hard.	4								21	430+	
	3													
		28-48-50/125mm.		5								8	430+	
	4													

*No Atterberg Limits. Description is visual with the aid of grain-size analysis.
#Kilopascals
**Description is visual with the aid of previous boring information.
~Samples composited

Project Butler County Regional Highway, BUT-129-23.25
Job No 123-55042
Client: LJB Engineers and Architects, Inc.

LOG OF BORING

Date Started November 2, 1995
Date Completed November 2, 1995
Boring Number B-11 B-011-0-95

Station & Offset 39 + 558.0 22.4mLt
Water Elevation Dry on completion
Surface Elevation 258.3

Hole Advancement & Sampling
82.55mm ID Hollow Stem Auger
50.8mm OD Splitspoon Sampler
Drilled By: PSI, Inc.

Elev.	Depth	Std. Pen. (N)	Description	Sample Number	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Qp#	SHTL Class
254.0		50/75mm.	Gray weathered Limestone and Gray Shale with Silty CLAY. Moist. Hard.	6								2		
	5		Gray Limestone with seams of Gray Shale. Recovery = 94% RQD = 43%	7										
	6			8										
251.0	7		End of Boring 7.3m.											
	8													

*No Atterberg Limits. Description is visual with the aid of grain-size analysis.
#Kilopascals
**Description is visual with the aid of previous boring information.
~Samples composited

Project: Butler County Regional Highway, BUT-129-23.25
Job No.: 123-55042
Client: LJB Engineers and Architects, Inc.

LOG OF BORING

Date Started December 1, 1995
Date Completed December 1, 1995
Boring Number B-12
B-012-0-95

Station & Offset 31 + 121.6 4.0mRt***
Water Elevation Dry on Completion
Surface Elevation 262.2

***Cincinnati-Dayton Road Station
Hole Advancement & Sampling
82.55mm ID Hollow Stem Auger
50.8mm OD Splitspoon Sampler
Drilled By: PSI, Inc.

Elev.	Depth	Std. Pen. (N)	Description	Sample Number	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Qp#	SHTL Class
262.0			200mm. of Asphalt											
			300mm. of Aggregate Base											
261.7		12-6-7	Brown and Gray Silt and CLAY. trace Sand. Moist. Stiff.	1								13		A-6a**
	1													
260.9		3-5-8		2								23	120	A-6a**
			Brown and Gray Silt and Clay. some Sand. trace Gravel. Moist. Stiff.											
	2	12-10-11		3								18	430+	A-6a**
259.7														
		7-18-18	Brown Sandy SILT. some CLAY. trace Gravel. Moist. Hard.	4								14	430+	A-4a**
	3													
		30-29-25		5								10	430+	A-4a**
258.2	4													

*No Atterberg Limits. Description is visual with the aid of grain-size analysis.
#Kilopascals
**Description is visual with the aid of previous boring information.
~Samples composited.

Project: Butler County Regional Highway, BUT 129-23.25
Job No.: 123-55042
Client: LJB Engineers and Architects, Inc.

LOG OF BORING

Date Started: December 1, 1995
Date Completed: December 1, 1995
Boring Number: B-12 B-012-0-95

Station & Offset: 31 + 121.6 4.0mRt***
Water Elevation: Dry on Completion
Surface Elevation: 262.2

***Cincinnati-Dayton Road Station
Hole Advancement & Sampling
82.55mm ID Hollow Stem Auger
50.8mm OD Splitspoon Sampler
Drilled By: PSI, Inc.

Elev.	Depth	Std. Pen. (N)	Description	Sample Number	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Qp#	SHTL Class
257.7		20-18-30	Gray Silt and Clay. trace Sand and Gravel. Moist. Hard.	6								12		A-6a**
			End of Boring 4.5m.											
	5													
	6													
	7													
	8													

*No Atterberg Limits. Description is visual with the aid of grain-size analysis.
#Kilopascals
**Description is visual with the aid of previous boring information.
~Samples composited.

Project: Butler County Regional Highway, BUT 129-23.25
Job No.: 123-55042
Client: LJB Engineers and Architects, Inc.

LOG OF BORING

Date Started: November 2, 1995
Date Completed: November 2, 1995
Boring Number: B-12A B-012-A-95

Station & Offset: 39 + 543.4 0.2mLt
Water Elevation: Dry on Completion
Surface Elevation: 257.1

Hole Advancement & Sampling
82.55mm ID Hollow Stem Auger
50.8mm OD Splitspoon Sampler
Drilled By: PSI, Inc.

Elev.	Depth	Std. Pen. (N)	Description	Sample Number	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Qp#	SHTL Class
256.9			200mm of Topsoil											
		10-13-30	Brown Silt and Clay. some Sand. trace Gravel. Moist. Hard.	1								17	290	A-6a**
	1													
		40-28-21		2								14		A-6a**
	2													
		10-15-17		3	4	9	24	48	15	26	11	13	430+	A-6a~
		14-17-25		4								11	430+	A-6a~
	3													
253.9														
		50/125mm.	Gray weathered Limestone fragments and Gray Shale with Silty CLAY. Moist. Hard.	5								11		
	4													

*No Atterberg Limits. Description is visual with the aid of grain-size analysis.
#Kilopascals
**Description is visual with the aid of previous boring information.
~Samples composited.

Project: Butler County Regional Highway, BUT 129-23.25
Job No.: 123-55042
Client: LJB Engineers and Architects, Inc.

LOG OF BORING

Date Started November 2, 1995
Date Completed November 2, 1995
Boring Number B-12A B-012-A-95

Station & Offset 39 + 543.4 0.2mLt
Water Elevation Dry on Completion
Surface Elevation 257.1

Hole Advancement & Sampling
82.55mm ID Hollow Stem Auger
50.8mm OD Splitspoon Sampler
Drilled By: PSI, Inc.

Elev.	Depth	Std. Pen. (N)	Description	Sample Number	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Qp#	SHTL Class
252.8		50/75mm	same as above.	6								10		
	5		Gray Limestone with seams of Gray Shale. Recovery = 95% RQD = 64%	7										
	6			8										
	7													
249.8			End of boring 7.3m.											
	8													

*No Atterberg Limits. Description is visual with the aid of grain-size analysis.
#Kilopascals
**Description is visual with the aid of previous boring information.
~Samples composited.

Project: Butler County Regional Highway, BUT 129-23.25
Job No.: 123-55042
Client: LJB Engineers and Architects, Inc.

LOG OF BORING

Date Started December 1, 1995
Date Completed December 1, 1995
Boring Number B-13 B-013-0-95

Station & Offset 31 + 241.7 4.0mRt***
Water Elevation Dry on completion
Surface Elevation 264.7

***Cincinnati-Dayton Road Station
Hole Advancement & Sampling
82.55mm ID Hollow Stem Auger
50.8mm OD Splitspoon Sampler
Drilled By: PSI, Inc.

Elev.	Depth	Std. Pen. (N)	Description	Sample Number	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Qp#	SHTL Class
264.5			150mm of Asphalt											
264.2			300 mm of Aggregate Base											
		14-6-5	Brown Silt and Clay. trace Sand. Moist. Stiff.	1								21	230	A-6a**
263.7	1													
		5-6-13	Brown Sandy SILT. some CLAY. trace Gravel. Moist. Very Stiff.	2								9	430+	A-4a**
	2	24-17-18		3								11	430+	A-4a**
262.3														
		26-22-50/ 25 mm.	Brown Sandy SILT. some Clay. trace Limestone fragments. Moist. Hard.	4								5	430+	A-4a**
261.7	3													
			Auger Refusal 3.0m.											
	4													

*No Atterberg Limits. Description is visual with the aid of grain-size analysis.
#Kilopascals
**Description is visual with the aid of previous boring information.
~Samples composited

Project: Butler County Regional Highway, BUT-129-23.25
Job No.: 123-55042
Client: LJB Engineers and Architects, Inc.

LOG OF BORING

Date Started December 1, 1995
Date Completed December 1, 1995
Boring Number B-37 B-037-0-95

Station & Offset 30 + 493.6 5.9mRt***
Water Elevation Dry on completion
Surface Elevation 246.4

***Hamilton-Mason Road Station
Hole Advancement & Sampling
82.55mm ID Hollow Stem Auger
50.8mm OD Splitspoon Sampler
Drilled By: PSI, Inc.

Elev.	Depth	Std. Pen. (N)	Description	Sample Number	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Qp#	SHTL Class
246.1			150 mm.of Asphalt 150 mm. of Aggregate Base											
245.6		3-3-5	Dark Brown SILT and CLAY. trace Sand. trace Gravel. Moist. Medium.	1								15	235	A-6a**
	1	1-2-2	Brown SILT and CLAY. trace Sand. Moist. Soft to Medium.	2								24	120	A-6a**
	2	1-2-3		3								28	120	A-6a**
	3	4-2-3		4								22	95	A-6a**
243.2														
		6-10-35	Brown Sandy SILT. some Clay. some Gravel. Moist. Hard.	5								13	430+	A-4a**
	4													

*No Atterberg Limits. Description is visual with the aid of grain-size analysis.
#Kilopascals
**Description is visual with the aid of previous boring information.
~Samples composited.

Project: Butler County Regional Highway, BUT 129-23.25
Job No.: 123-55042
Client: LJB Engineers and Architects, Inc.

LOG OF BORING

Date Started December 1, 1995
Date Completed December 1, 1995
Boring Number B-37 B-037-0-95

Station & Offset 30 + 493.6 5.9mRt***
Water Elevation Dry on completion
Surface Elevation 246.4

***Hamilton-Mason Road Station
Hole Advancement & Sampling
82.55mm ID Hollow Stem Auger
50.8mm OD Splitspoon Sampler
Drilled By: PSI, Inc.

Elev.	Depth	Std. Pen. (N)	Description	Sample Number	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Qp#	SHTL Class
241.9		16-19-25	Brown Sandy SILT. some Clay. some Gravel. Moist. Dense.	6								10	430+	A-4a**
	5		End of Boring 4.5m.											
	6													
	7													
	8													

*No Atterberg Limits. Description is visual with the aid of grain-size analysis.
#Kilopascals
**Description is visual with the aid of previous boring information.
~Samples composited

Project: Butler County Regional Highway, BUT 129-23.25
Job No.: 123-55042
Client: LJB Engineers and Architects, Inc.

LOG OF BORING

Page 1 of 1

***Cincinnati-Dayton Road Station

Date Started December 1, 1995
Date Completed December 1, 1995
Boring Number B-38 B-038-0-95

Station & Offset 30 + 555.1 4.2mLt***
Water Elevation Dry on completion
Surface Elevation 245.4

Hole Advancement & Sampling
82.55mm ID Hollow Stem Auger
50.8mm OD Splitspoon Sampler
Drilled By: PSI, Inc.

Elev.	Depth	Std. Pen. (N)	Description	Sample Number	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Qp#	SHTL Class
245.1			100 mm. of Asphalt 150 mm. of Aggregate Base											
	1	8-4-4	Brown Silty CLAY. trace Sand. Moist. Medium.	1								12	190	A-6b**
		2-2-4		2								26	120	A-6b**
243.9														
	2	18-8-9	Brown and Gray Sandy SILT. trace Clay and Limestone fragments. Moist. Medium.	3								6	430+	A-4a**
243.1														
		50/75mm.	Gray weathered Limestone fragments and Gray Shale with Silty CLAY. Moist. Hard.	4								11	430+	
242.4	3													
			End of Boring 3.0m.											
	4													

*No Atterberg Limits. Description is visual with the aid of grain-size analysis.
#Kilopascals
**Description is visual with the aid of previous boring information.
~Samples composited.

Project: Butler County Regional Highway, BUT 129-23.25
Job No.: 123-55042
Client: LJB Engineers and Architects, Inc.

LOG OF BORING

Date Started December 1, 1995
Date Completed December 1, 1995
Boring Number B-39 B-039-0-95

Station & Offset 30 + 688.4 3.4mLt***
Water Elevation Dry on completion
Surface Elevation 246.8

***Cincinnati-Dayton Road Station
Hole Advancement & Sampling
82.55mm ID Hollow Stem Auger
50.8mm OD Splitspoon Sampler
Drilled By: PSI, Inc.

Elev.	Depth	Std. Pen. (N)	Description	Sample Number	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Qp#	SHTL Class
246.6			200 mm. of Asphalt											
	1	6-5-6	Dark Brown Silty CLAY. trace Sand. Moist. Stiff to Soft.	1										A-6b**
		1-1-3		2								28	95	A-6b**
245.2														
	2	3-5-5	Brown and Gray Sandy SILT. some Clay. Moist. Medium.	3								20	170	A-4a**
244.4														
	3	2-5-9	Gray and Brown SILT and CLAY. Moist. Stiff.	4								22	430+	A-6a**
243.6														
		9-18-17	Brown Sandy SILT. some Clay. trace Limestone fragments. Moist. Dense.	5								14	430+	A-4a**
242.8	4													

*No Atterberg Limits. Description is visual with the aid of grain-size analysis.
#Kilopascals
**Description is visual with the aid of previous boring information.
~Samples composited.

Project: Butler County Regional Highway, BUT 129-23.25
Job No.: 123-55042
Client: LJB Engineers and Architects, Inc.

LOG OF BORING

Date Started December 1, 1995
Date Completed December 1, 1995
Boring Number B-39 B-039-0-95

Station & Offset 30 + 688.4 3.4mLt***
Water Elevation Dry on completion
Surface Elevation 246.8

***Cincinnati-Dayton Road Station
Hole Advancement & Sampling
82.55mm ID Hollow Stem Auger
50.8mm OD Splitspoon Sampler
Drilled By: PSI, Inc.

Elev.	Depth	Std. Pen. (N)	Description	Sample Number	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Qp#	SHTL Class
242.3		13-50/ 125mm.	Gray weathered Limestone fragments and Gray Shale with Silty CLAY. Moist. Hard.	6								10	430+	
			End of Boring 4.5m.											

5
6
7
8

*No Atterberg Limits. Description is visual with the aid of grain-size analysis.
#Kilopascals
**Description is visual with the aid of previous boring information.
~Samples composited

Project: Butler County Regional Highway, BUT 129-23.25
Job No.: 123-55042
Client: LJB Engineers and Architects, Inc.

LOG OF BORING

Page 1 of 1

Date Started November 3, 1995
Date Completed November 3, 1995
Boring Number B-98 B-098-0-95

Station & Offset 5 + 880.0 0***
Water Elevation Dry on completion
Surface Elevation 259.8

***Yankee Road Station
Hole Advancement & Sampling
82.55mm ID Hollow Stem Auger
50.8mm OD Splitspoon Sampler
Drilled By: PSI, Inc.

Elev.	Depth	Std. Pen. (N)	Description	Sample Number	% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Qp#	SHTL Class
259.6			200mm of Topsoil											
		4-5-7	Brown Elastic CLAY. some SILT. trace Sand. Moist. Stiff.	1								22	250	A-7-5**
	1													
		6-8-10		2								18	360	A-7-5**
258.3														
	2	14-17-20	Brown SILT and SAND. some Clay. trace Gravel. Moist. Hard.	3								7	430	A-4b**
257.5														
		7-20-22	Gray weathered Limestone fragments and Gray Shale with Silty CLAY. Moist. Hard.	4								13	430	
256.8	3													
			End of Boring 3.0m.											
	4													

*No Atterberg Limits. Description is visual with the aid of grain-size analysis.
#Kilopascals
**Description is visual with the aid of previous boring information.
~Samples composited.

Project: Butler County Regional Highway, BUT 129-23.25
Job No.: 123-55042
Client: LJB Engineers and Architects, Inc.

OHIO DEPARTMENT OF TRANSPORTATION

DETERMINING SULFATE CONTENT IN SOILS

SUPPLEMENT 1122

Project C-R-S:	BUT-CR19-5.88
PID No:	113725
Report Date:	3/17/2021
Consultant:	NEAS Inc.
Technician:	P. Johnson

Boring ID & Sample #	Station	Offset	Latitude & Longitude or State Plane Coordinates	Elevation	Soaking Time (hr)	Replicate Sample Readings						Sulfate Content (ppm)
						1		2		3		
						Dilution	Reading	Dilution	Reading	Dilution	Reading	
B-001-0-20 SS-1B					20.37	20	3	20	2	20	3	**53**
B-002-0-20 SS-1					20.43	100	>80	100	>80	100	>80	**>8000**
B-003-0-20 SS-1					20.4	100	>80	100	>80	100	>80	**>8000**
												0
												0
												0
												0
												0
												0
												0
												0
												0
												0
												0
												0
												0
												0

APPENDIX C

GEOTECHNICAL BULLETIN 1 (GB1) ANALYSIS SPREADSHEETS

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES
Geotechnical Bulletin GB1

BUT-CR19-5.88
113725

Construction of a shared use path along CR-19 in Butler County, Ohio.

NEAS, Inc.

Prepared By: Matthew Jasiewicz
Date prepared: Tuesday, March 23, 2021

Chunmei (Melinda) He, Ph.D, P.E.
2800 Corporate Exchange Drive
Suite 240
Columbus, OH, 43231
614-714-0299
che@neasinc.com

NO. OF BORINGS: 12

#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL	Cut Fill
1	B-037-0-95	Shared use path	100+40	74	Right	Unknown		808.4	806.7	1.7 C
2	B-038-0-95	Shared use path	102+49	41	Right	Unknown		805.1	804.6	0.5 C
3	B-001-0-20	Shared use path	103+15	11	Right	CME 55X	80	806.9	805.0	1.9 C
4	B-039-0-95	Shared use path	106+85	32	Right	Unknown		809.7	809.0	0.7 C
5	B-008-0-95	Shared use path	111+41	44	Right	Unknown		822.5	815.1	7.4 C
6	B-002-0-20	Shared use path	114+89	20	Right	CME 55X	80	821.6	818.2	3.4 C
7	B-012-A-95	Shared use path	116+11	10	Right	Unknown		843.5	823.0	20.5 C
8	B-011-0-95	Shared use path	116+89	30	Right	Unknown		847.4	826.8	20.6 C
9	B-003-0-20	Shared use path	118+65	19	Left	CME 55X	80	842.4	835.6	6.9 C
10	B-012-0-95	Shared use path	121+27	94	Right	Unknown		860.2	847.8	12.4 C
11	B-013-0-95	Shared use path	125+48	94	Right	Unknown		868.4	860.0	8.4 C
12	B-098-0-95	Shared use path	129+11	6	Right	Unknown		852.4	852.4	0.0

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.5 1/18/2019

#	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 (Enter depth in inches)
			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	SS-1	1.0	2.3	-0.7	0.6	8		2.45							15	14	A-6a	10			N_{60}		**12"**	
	037-0	SS-2	3.3	4.6	1.6	2.9	4		1.25							24	14	A-6a	10			HP & Mc			
	95	SS-3	5.9	7.2	4.3	5.6	5		1.25							28	14	A-6a	10						
		SS-4	8.5	9.8	6.9	8.2	5	4	0.99							22	14	A-6a							
2	B	SS-1	1.0	2.3	0.4	1.8	8		1.98							12	16	A-6b	16			N_{60}		**12"**	
	038-0	SS-2	3.3	4.6	2.7	4.1	6		1.25							26	16	A-6b	16						
	95	SS-3	5.9	7.2	5.4	6.7	17		4.49							6	10	A-4a							
		SS-4	8.5	8.9	8.0	8.3	100	6	4.49							11	0	Rock							
3	B	SS-1A	1.0	2.0	-0.9	0.1	8									4	6	A-1-a	0						
	001-0	SS-1B	2.0	2.5	0.1	0.6			4.25							15	16	A-6b	16	53		N_{60}		**0"**	
	20	SS-2	3.5	5.0	1.6	3.1	17		4.5	36	18	18	30	38	68	16	16	A-6b	10						
		SS-3	6.0	7.5	4.1	5.6	24	8	3							15	16	A-6b	16						
4	B	SS-1	1.0	2.3	0.2	1.6	11										16	A-6b	16			N_{60}		**12"**	
	039-0	SS-2	3.3	4.6	2.5	3.8	4		0.99							28	16	A-6b	16						
	95	SS-3	5.9	7.2	5.2	6.5	10		1.78							20	10	A-4a							
		SS-4	8.5	9.8	7.8	9.1	14	4	4.49							22	14	A-6a							
5	B	SS-1	1.0	2.3	-6.5	-5.2	9		1.46							20	14	A-6a	10						
	008-0	SS-2	3.3	4.6	-4.2	-2.9	10		1.78							22		A-7-5	16						
	95	SS-3	5.9	7.2	-1.5	-0.2	13		1.98				50	50	100	22		A-7-5	16						
		SS-4	8.5	9.8	1.1	2.4	43	30	4.49							16		A-7-5	16		A-7-5		**29"**		
6	B	SS-1	1.0	2.5	-2.4	-0.9	20			NP	NP	NP	7	1	8	7	6	A-1-a	0	8000					
	002-0	SS-2	3.5	4.4	0.1	1.0	91										0	Rock	0		Rock		**12"**		
	20	SS-3	6.0	7.4	2.6	4.0	89										0	Rock	0						
		SS-4	8.5	8.6	5.1	5.2	100	30									0	Rock							
7	B	SS-3	5.9	7.2	-14.6	-13.3	32		4.49	26	15	11	48	15	63	13	14	A-6a	6						
	012-A	SS-4	8.5	9.8	-12.0	-10.7	42		4.49							11	14	A-6a	10						
	95	SS-5	11.2	12.5	-9.4	-8.0	100									11	0	Rock	0						
		SS-6	13.5	14.3	-7.1	-6.3	100	30								10	0	Rock	0						
8	B	SS-5	11.2	12.5	-9.4	-8.1	100		4.49							8	0	Rock	0						
	011-0	SS-6	13.5	14.3	-7.2	-6.3	100									2	0	Rock	0						
	95	7	13.8	19.0	-6.8	-1.6											0	Rock	0						
		8	19.0	24.0	-1.6	3.4		0									0	Rock	0		Rock	N_{60}	**40"**	**0"**	
9	B	SS-3	6.0	6.4	-0.9	-0.5	100										0	Rock	0						
	003-0	SS-4	8.5	8.9	1.6	2.1	100										0	Rock	0		Rock				
	20	SS-5	11.0	11.4	4.1	4.6	100										0	Rock	0						
		SS-6	13.5	13.8	6.6	6.9	100	30									0	Rock							

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.5 1/18/2019

#	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 (Enter depth in inches)
			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	SS-3	5.9	7.2	-6.5	-5.2	21		4.49							18	14	A-6a	10						
	012-0	SS-4	8.5	9.8	-3.9	-2.6	36		4.49							14	10	A-4a	8						
	95	SS-5	11.2	12.5	-1.2	0.1	54		4.49							10	10	A-4a	8						
		SS-6	13.5	14.8	1.1	2.4	48	30								12	14	A-6a	10						
11	B	SS-1	1.0	2.3	-7.4	-6.1	11		2.4							21	14	A-6a	10						
	013-0	SS-2	3.3	4.6	-5.1	-3.8	19		4.49							9	10	A-4a	8						
	95	SS-3	5.9	7.2	-2.5	-1.2	35		4.49							11	10	A-4a	8						
		SS-4	8.5	9.8	0.1	1.4	72	30	4.49							5	10	A-4a	8						
12	B	SS-1	1.0	2.3	1.0	2.3	12		2.61							22		A-7-5	16		A-7-5		**28"**		
	098-0	SS-2	3.3	4.6	3.3	4.6	18		3.76							18		A-7-5	16						
	95	SS-3	5.9	7.2	5.9	7.2	37		4.49							7	10	A-4b							
		SS-4	8.5	9.8	8.5	9.8	42	12	4.49							13	0	Rock							

PID: 113725

County-Route-Section: BUT-CR19-5.88
No. of Borings: 12

Geotechnical Consultant: NEAS, Inc.
Prepared By: Matthew Jasiewicz
Date prepared: 3/23/2021

Chemical Stabilization Options		
320	Rubblize & Roll	Option
206	Cement Stabilization	Option
	Lime Stabilization	Option
206	Depth	NA

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

Design CBR	6

% Samples within 6 feet of subgrade			
$N_{60} \leq 5$	12%	HP ≤ 0.5	0%
$N_{60} < 12$	35%	0.5 < HP ≤ 1	4%
$12 \leq N_{60} < 15$	4%	1 < HP ≤ 2	19%
$N_{60} \geq 20$	42%	HP > 2	42%
M+	4%		
Rock	29%		
Unsuitable	42%		

Excavate and Replace at Surface	
Average	0''
Maximum	0''
Minimum	0''

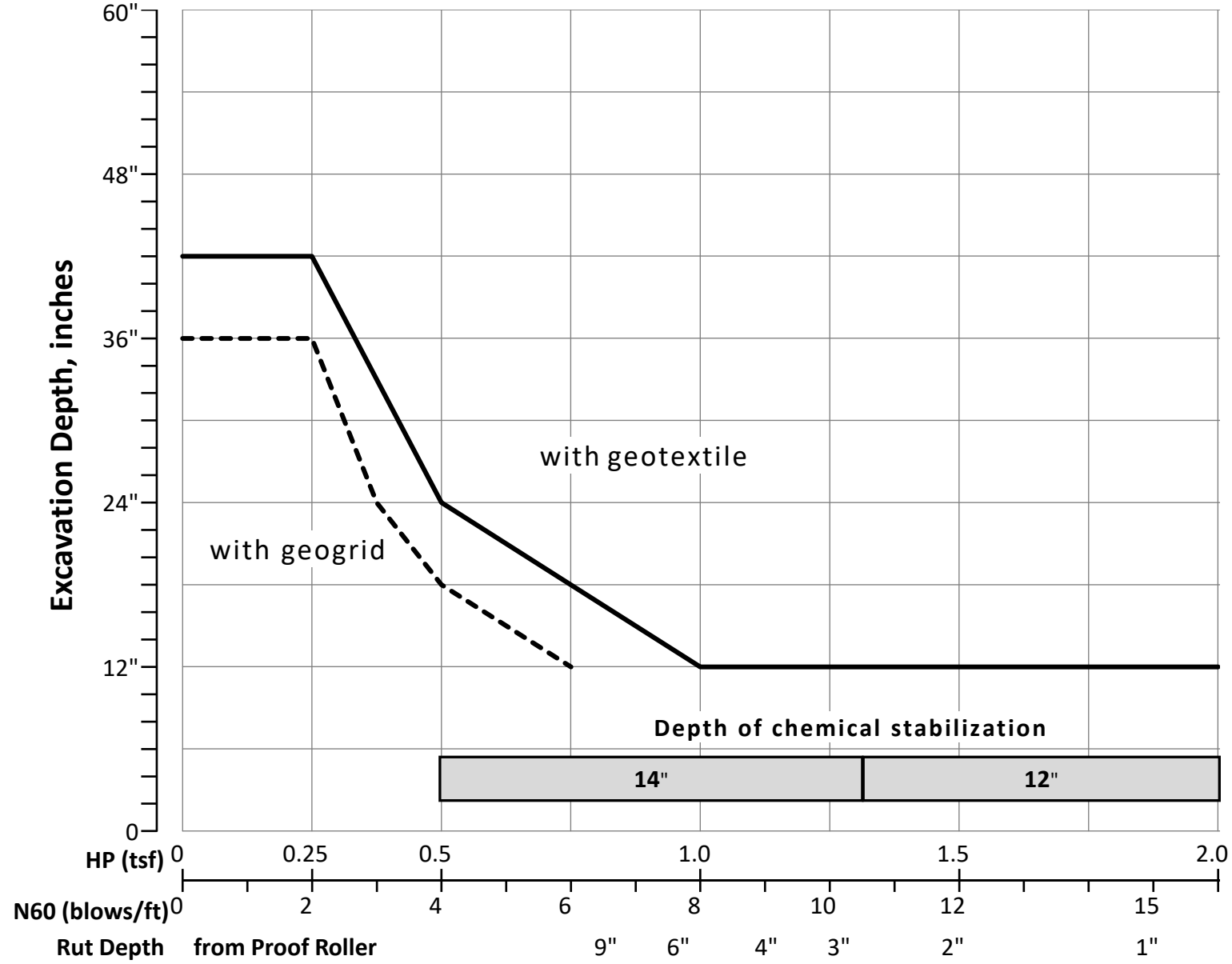
% Proposed Subgrade Surface	
Unstable & Unsuitable	31%
Unstable	17%
Unsuitable	14%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	40	18	3.14	36	18	18	30	38	68	16	9	10
Maximum	100	30	4.50	36	18	18	50	50	100	28	16	16
Minimum	4	0	0.99	26	15	11	7	1	8	2	0	0

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	9	1	0	0	0	0	0	0	0	4	1	0	6	7	3	0	0	0	31
Percent	29%	3%	0%	0%	0%	0%	0%	0%	0%	13%	3%	0%	19%	23%	10%	0%	0%	0%	100%
% Rock|Granular|Cohesive	29%	16%									55%								100%
Surface Class Count	10	2	0	0	0	0	0	0	0	5	0	0	8	6	4	0	0	0	35
Surface Class Percent	29%	6%	0%	0%	0%	0%	0%	0%	0%	14%	0%	0%	23%	17%	11%	0%	0%	0%	100%

GB1 Figure B – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
3.14	0.50	☐ HP
17.83	6.00	☐ N60L

Average HP
Average N_{60L}