FINAL REPORT
SUBGRADE EXPLORATION REPORT
ROS-CR550-17.12/18.04
ROSS COUNTY, OHIO
PID#: 114624

Prepared For:

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NEAS PROJECT 22-0037

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1. INTRODUCTION

1.1. General

National Engineering & Architectural Services, Inc. (NEAS) presents our Subgrade Exploration Report for the ROS-CR550-17.12/18.04 project (PID 114624) along portions of County Road 550 (CR-550) / Pleasant Valley Road (Rd) and Clinton Rd in the city of Chillicothe, Ross County, Ohio. The project objective is to improve the overall intersection via: 1) widening the Clinton Rd northbound (NB) approach to three lanes including the addition of a shared use path; and, 2) the addition of right and left turn lanes to the CR-550 (Pleasant Valley Rd) westbound (WB) approach. This report presents a summary of the project encountered surficial and subsurface conditions and our recommendations for subgrade stabilization and pavement design parameters for the proposed work. In general, the pavement subgrade analysis and recommendations presented are in accordance with ODOT's Geotechnical Design Manual (GDM) (ODOT [2], 2022), *Geotechnical Bulletin 1* (GB1) (ODOT [1], 2021) and *Pavement Design Manual* (PDM) (ODOT, 2022).

The exploration was conducted in general accordance with NEAS's proposal to Burgess & Niple, Inc. (B&N), dated April 15, 2022 and with the provisions of ODOT's *Specifications for Geotechnical Explorations* (SGE) (ODOT [3], 2022).

The scope of work performed by NEAS as part of the referenced project included: a review of published geotechnical information; performing 3 total test borings and 1 pavement core; laboratory testing of soil samples in accordance with the SGE; performing geotechnical engineering analysis to assess subgrade stabilization requirements and pavement design parameters; and, development of this summary report.

2. GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1. Geology and Physiography

The project site is located within the Killbuck-Glaciated Pittsburgh Plateau part of the Glaciated Allegheny (Southern New York Plateaus) with portions located near lake basin/deposits outside of the Huron-Erie Lake Plains. The Killbuck-Glaciated Pittsburgh Plateau region is characterized by ridges and flat uplands of moderate relief generally above 1,200 ft, covered with thin drift and dissected by steep valleys. Valley segments alternate between broad drift-filled and narrow rock-walled reaches. Elevations of the region range from 600 to 1,505 ft above mean sea level (amsl), with moderate relief (200 ft). The geology within this region is described as thin to thick Wisconsinan-age clay to loam till over Mississippian- and Pennsylvanian-age shales, sandstones, conglomerates, and coals. The lake basin/deposits are characterized as extremely flat plains often comprised of sandy beach ridges and dunes formed along the shore of ancient lakes. (ODGS, 1998).

The geology at the project site is mapped as an average of 10 ft of Wisconsinan-age loam till underlain by an average of 270 ft of clay to gravel of an unspecified age, all underlain by Devonian-age Shale bedrock (ODGS, 2005). The loam till is described as an unsorted mix of silt, clay, sand, gravel, and boulders with variable carbonate content and may contain silt, sand, and gravel lenses. Loam till in buried valleys may include undifferentiated and non-specified age till units. The clay to gravel is described as complexly interbedded deposits of clay, sand, gravel, and till in deeper parts of buried valleys. These soils are of an unspecified age and data is insufficient for more detailed differentiation of age assignments.

Based on the Bedrock Geologic Units Map of Ohio (USGS & ODGS, 2006), bedrock within the project area consists of Shale, of the Ohio Shale formation. This formation is comprised of Devonian-age Shale that can be described as brownish black to greenish gray in color which weathers to brown, carbonaceous

to clayey, laminated to thin bedded with fissile parting and having a petroliferous odor. This formation may also contain carbonate and siderite concretions in the lowermost 50 ft. The bedrock appears to follow the natural topography of the site which slopes downward from south to north (ODGS, 2003). Based on the ODNR bedrock topography map of Ohio, bedrock elevations at the project site can be expected at about 550 to 500 ft amsl, putting bedrock at depths ranging from about 200 to 275 ft below ground surface (bgs).

The soils at the project site have been mapped (Web Soil Survey) by the Natural Resources Conservation Service (USDA, 2015) as primarily Celina silt loam in the eastern half of the project and as both Crosby silt loam as well as Kokomo silty clay loam in the western half of the project. Soils in the Celina series are characterized as very deep, moderately well drained soils that are moderately deep to dense till. These soils are formed in loess and the underlying loamy till of high-lime content on till plains and moraines. The Celina series is comprised of primarily fine-grained soils and classifies as A-6 and A-7 type soils according to the AASHTO method of soil classification. The Crosby series is characterized as soils that are very deep, somewhat poorly drained soils that are moderately deep to dense till formed in loess, other silty material and in the underlying loamy till on till plains. The Crosby series is comprised of primarily fine-grained soils and classifies as A-4, A-6 and A-7 type soils according to the AASHTO method of soil classification. Soils in the Kokomo series are characterized as very deep, very poorly drained soils that formed in loamy materials overlying till in depressions on till plains. The Kokomo series is comprised of primarily fine-grained soils and classifies as A-4, A-6 and A-7 type soils according to the AASHTO method of soil classification.

2.2. Hydrology/Hydrogeology

Groundwater elevations at the site are anticipated to be near elevations consistent with that of the most dominant hydraulic influence in the vicinity. The Scioto River is located about two to three miles east of the site and water is at approximate elevations 605 to 615 ft amsl. Additionally, groundwater at the site may also be at an elevation consistent with that of the nearby water well located about 65 ft northwest of the project intersection. Based on the reference water well log, (Ohio Department of Natural Resources Well Log No. 260245) the static water level was recorded at a depth of 107 ft bgs, though no ground surface elevation was recorded on the log. The indicated water levels may be generally representative of the local groundwater table although perched groundwater systems may exist in the area due to the presence of fine-grained soils making it difficult for groundwater to permeate to the natural phreatic surface.

The project site is not located within a regulatory floodway zone based on available mapping by the Federal Emergency Management Agency's (FEMA) National Flood Hazard mapping program (FEMA, 2016).

2.3. Mining and Oil/Gas Production

No abandoned mines are noted on ODNR’s Abandoned Underground Mine Locator in the vicinity of the project site (ODNR [1], 2016).

No active gas wells are noted on ODNR’s Ohio Oil & Gas Locator in the vicinity of the project site (ODNR [1], 2016).

2.4. Historical Records and Previous Phases of Project Exploration

A historic record search was performed through ODOT's Transportation Information Mapping System (TIMS); however, no historic boring information was available for review within the limits of the (ROS-CR550-17.12/18.04, PID 114624) project. Therefore; historic borings are not referenced within this report nor within the project developed Soil Profile Sheets.

2.5. Field Reconnaissance

A field reconnaissance visit for the overall project area was conducted on July 20, 2022 along the project portion of CR-550 (Pleasant Valley Rd) and Clinton Rd. Site conditions, including the existing pavement conditions, were noted and photographed during the visit. Photographs of notable features and a summary of our observations are provided below. The land use of most of the project area consists of a combination of residential, agricultural and commercial (i.e., gas station) properties.

In general, the pavement condition along the project roadways was observed to be fair to poor with varying signs of surface wear. Frequent moderate severity longitudinal cracking, transverse cracking and crack sealing deficiencies were observed along this section as well as low severity rutting and wheel track cracking near the project intersection. Moderate to high severity edge cracking, map cracking and patching were observed along the northern side of CR-550 (Photograph 1). The roadway grades in this area were noted as being relatively consistent with the surrounding land, rising gently from northeast to southwest. The area is lightly to moderately vegetated and noted as well drained with no signs of standing water or ponding in the roadway at the time of our visit.

Photograph 1: Patching and cracking along edge of existing CR-550

3. GEOTECHNICAL EXPLORATION

3.1. Exploration Program

The subsurface exploration was conducted by NEAS on August 11, 2022 and included 3 borings drilled to a depth of 7.5 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 roadway/subgrade improvement areas that were not restricted by underground utilities or dictated by terrain (i.e., steep embankment slopes). Target boring locations were located in the field by NEAS prior to drilling utilizing handheld GPS equipment. Each individual project boring log (included within Appendix B) includes the recorded boring latitude and longitude location (based on the surveyed Ohio State Plane South, NAD83, location) and the corresponding ground surface elevation, as shown in Table 1 below. The boring locations are depicted on the Boring Location Plan provided in Appendix A.

Table 1: Project Boring Locations

Boring Number	Station and Offset	Latitude	Longitude	Elevation (NAVD 88) (ft)	Depth (ft)
B-001-0-21	106+17, 66' LT	39.369337	-83.034412	763.1	7.5
B-002-0-21	105+99, 151'RT	39.368742	-83.034472	772.1	7.5
B-003-0-21	110+56, 30' RT	39.369137	-83.032861	751.3	7.5

Notes: 1. Boring locations and corresponding ground surface elevation were surveyed in the field by NEAS.
2. Station and Offsets refrence CR-550 alignment.

Borings were drilled using a CME 45B truck-mounted drilling rig utilizing 3.25-inch (inner diameter) hollow stem augers. Soil samples for subgrade borings were recovered continuously to a depth of 7.5 ft bgs 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 a CME auto hammer that has been calibrated on January 24, 2022 to be 72.6% efficient as indicated on the boring logs (Appendix B).

Field boring logs were prepared by drilling personnel and included pavement description (where present), lithological description, SPT results recorded as blows per 6-inch increment of penetration and estimated unconfined shear strength values on specimens exhibiting cohesion (using a hand-penetrometer). 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). After completing the borings, the boreholes were backfilled with either auger cuttings, bentonite chips, or a combination of these materials and patched accordingly with cold patch asphalt and/or cement when drilling through the roadway.

3.2. Pavement Coring Exploration Program

The coring investigation program for the project was conducted by NEAS on October 19, 2022 and included one (1) pavement core. The pavement core was performed within the existing CR-550 (Pleasant Valley Rd) roadway and was located and marked in the field by a NEAS field representative prior to coring operations in an area that were not restricted by maintenance of traffic efforts or utilities. The core location was located in the field by NEAS prior to coring utilizing handheld GPS equipment. Measurements, location information, photographs and other details of the core sample can be found on the Pavement Core Log included within Appendix C. The approximate location for the core is depicted on the Boring Location Plan provided in Appendix A.

The core was drilled using a portable, truck-mounted, electric powered coring drill with a 4-inch (outer diameter) diamond tipped drill bit and utilizing water as the circulating fluid. Asphalt thicknesses were measured in the field after the cores were extracted and down-hole measurements were made. The core sample was then photographed, logged, and placed in a core box for transportation to NEAS's laboratory. Following field documentation and photographs, the core hole was backfilled to existing grade asphalt patch. Once in the laboratory the core was: 1) re-measured for thickness verification and photographed; 2) checked for composition; and, 3) reviewed for individual layer identification and subsequent measurements.

3.3. Laboratory Testing Program

The laboratory testing program consisted of classification testing, moisture content and sulfate content determinations. Data from the laboratory testing program were incorporated onto the boring logs (Appendix B). Soil samples are retained at the laboratory for 60 days following report submittal, after which time they will be discarded.

3.3.1. Classification Testing

Representative soil samples were selected for index property (Atterberg Limits) and gradation testing for classification purposes on 50% of the samples. At each boring location utilized for roadway purposes, the upper two samples obtained below the proposed top of subgrade elevation were generally tested while additional samples in each boring 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 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.

3.3.2. Standard Penetration Test Results

Standard Penetration Tests (SPT) and split-barrel (commonly known as split-spoon) sampling of soils were performed continuously 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.

3.3.3. Sulfate Testing

Sulfate testing was generally performed on one sample obtained in each of the borings performed. The selected samples were tested in accordance with ODOT Supplement 1122, "Determining Sulfate Content in Soils" dated July 17, 2015. In general, the upper most sample (within 3 ft of the proposed subgrade elevation) from each boring was tested when feasible. Testing results are summarized in Table 2 below and are provided in Appendix D.

Table 2: Sulfate Test Summary by Boring

Boring ID	Sample	Depth (ft)	Dilution Ratio	Average Sulfate Content (ppm)
B-001-0-21	SS-1	1.5 - 3.0	20	120
B-002-0-21	SS-1	1.5 - 3.0	20	60
B-003-0-21	SS-2	3.0 - 4.5	20	60

4. FINDINGS

The pavement and 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. At the time of the composition of this report, proposed grade and pavement section information has

been assumed to be consistent with that of the existing roadway. It should be noted that for the purposes of this report and our analysis, the term 'proposed subgrade' has been assumed to represent soils and/or soil 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 thicknesses in terms of asphalt and granular base were measured at each boring location performed through the existing pavement and are recorded on the test boring logs provided in Appendix B. A summary of these measurements is provided in Table 3 below.

Table 3: Measured Pavement Thickness at Boring Locations

Boring ID	Proposed Alignment	Asphalt Thickness (in)	Base Thickness (in)	Total Thickness (in)
B-001-0-21	CR-550 (Pleasant Valley Rd)	7.0	9.5	16.5
B-002-0-21	Clinton Rd	7.0	11.0	18.0

4.2. Pavement Core Summary

The thickness of the pavement core was measured at the indicated location shown on the Boring Location Plan provided in Appendix A. A summary of the measurements along with the material encountered is summarized in Table 4. Laboratory photographs and measurements are presented on the pavement core log included within Appendix C.

Table 4: Pavement Core Summary

Core ID	Alignment	Asphalt Thickness (in)	Concrete Thickness (in)	Total Thickness (in)
C-001	CR-550 (Pleasant Valley Rd)	8.00	-	8.00

4.3. Subgrade Conditions

The subgrade conditions in the project area are relatively consistent and are largely comprised of both fill and natural soils consisting of low to moderately plastic cohesive soils. The subgrade soils encountered within the project limits are generally classified as A-4a, A-6a, A-6b or A-7-6. The following subsections present a brief summary of the subsurface conditions encountered at the project.

4.3.1. CR-550 (Pleasant Valley Road) and Clinton Road

Along the project portions of Pleasant Valley Rd and Clinton Rd, one hundred percent (100%) of the samples taken along the roadway were classified as fine-grained, cohesive soils that were comprised of: 1) Sandy Silt (A-4a, 8% of samples); 2) Silt and Clay (A-6a, 58% of samples); 3) Silty Clay (A-6b, 8% of samples); and, 4) Clay (A-7-6, 25% of samples). With respect to the consistency of the cohesive soils, the descriptions varied from soft to very stiff correlating to converted SPT-N values (N_{60}) ranging from 4 to 13 blows per foot (bpf) and unconfined compressive strengths (estimated by means of hand penetrometer) ranging from 1.25 to 4.00 tons per square foot (tsf). Natural moisture contents ranged from 15 to 23 percent. Based on Atterberg Limits test performed on representative samples of the cohesive soils, the liquid and plastic limits range from 23 to 43 percent and from 16 to 19 percent, respectively.

4.3.2. Groundwater

Groundwater measurements were taken during the boring drilling procedures and/or immediately following the completion of each borehole. Groundwater was not encountered within the depths of the borings performed as part of the project exploration.

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.

5. ANALYSES AND RECOMMENDATIONS

We understand that the overall project objective is to improve the existing CR-550 (Pleasant Valley Rd) and Clinton Rd intersection. The proposed improvements will consist of the widening the Clinton Rd NB approach to three lanes including the addition of a shared use path; and, the addition of right and left turn lanes to the CR-550 (Pleasant Valley Rd) WB approach. For this purpose, a subgrade exploration and subsequent analysis was completed for the referenced project. The subgrade analysis was performed in accordance with ODOT's GDM (ODOT [2], 2022) and ODOT's GB1 criteria utilizing the ODOT provided GB1: subgrade analysis spreadsheet (GB1_ SubgradeAnalysis.xls, version 14.5 dated January 18, 2019). Input information for the spreadsheet was based on the soil characteristics gathered during NEAS's exploration (i.e., SPT results, laboratory test results, etc.).

5.1. Subgrade Analysis

A GB1 analysis was performed to identify the method, location, and dimensions (including depth) of required subgrade stabilization for the project. 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 identified within the project limits. GB1 analysis spreadsheets are provided in Appendix E.

Again, it should be noted that for the purposes of this report and our analysis, the term 'proposed subgrade' has been assumed to represent soils and/or soil conditions extending to a depth of 6 ft below the bottom of proposed pavement section (i.e., top of subgrade).

5.1.1. Pavement Design Recommendations

It is our understanding that pavement analysis and design is to be performed to determine the proposed pavement sections for the segments within the project limits to undergo full depth replacement and widening. A GB1 analysis was performed using the subgrade soil data obtained during our field exploration program to evaluate the soil characteristics to develop pavement parameters for use in pavement design. The subgrade analysis parameters recommended for use in pavement design are presented in Table 5 below. Provided in the table are ranges of maximum, minimum and average N_{60L} values for the indicated segments as well as the design CBR value recommended for use in pavement design.

Table 5: Pavement Design Values

Segment	Maximum N_{60L}	Minimum N_{60L}	Average N_{60L}	Average PI Values	Design CBR
CR-550 (Pleasant Valley Rd)/Clinton Rd	13	4	7	15	6

5.1.2. Unsuitable Subgrade

Per ODOT's GB1, the presence of select subgrade conditions are prohibited within the subgrade zone for new pavement construction and will require some form of remediation. These prohibited subgrade conditions generally include the presence of rock, specific soil types (A-4b, A-2-5, A-5, A-7-5, A-8a, A-8b), and soils with a liquid limit greater than 65 percent. With respect to the proposed project roadways and intersection, these subgrade conditions were not encountered within the subgrade depths of the borings performed for the project.

5.1.3. Unstable Soils

The GB1 recommends subgrade stabilization for soils considered unstable in which the N_{60} value of a particular soil sample (SS) at a 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). Based on the specific N_{60} value at the subject boring, *Figure B - Subgrade Stabilization* within the GB1 recommends a depth of subgrade stabilization for ODOT standard stabilization methods. It should be noted that although a soil sample's N_{60} value may meet the criteria to be considered an unstable soil, the depth in which the unstable soil is encountered in relation to the proposed subgrade is considered when each individual subgrade boring is analyzed. For example, if the GB1 recommends an excavate and replace of 12 inches within an unstable soil underlying 18 inches of stable material, it would be unreasonable to recommend the removal of both the stable and unstable material for a total of 30 inches of excavate and replace.

Based on N_{60} values encountered within the project borings, our GB1 analysis suggests the need for 12 to 24 inches of either chemical treatment or excavate and replace along the referenced project roadway segments. A summary of the boring locations where unstable soils were encountered and determined to have a potential impact on subgrade performance are shown in Table 6 below. Also included is the associated GB1 recommended remediation depth at that specific location.

Table 6: Weak Soil Locations Summary

Boring ID	Average HP (tsf)	N_{60}	Moisture Above Optimum (%)	Depth Below Subgrade (ft)	Remediation Depth (inches)		
					Excavate and Replace (Item 204 w/ Geotextile)	Excavate and Replace (Item 204 w/ Geogrid - SS 861)	Chemical Stabilization (Item 206)
CR-550 (Pleasant Valley Rd) / Clinton Rd							
B-001-0-21	1.25	4	1	0.0 - 1.5	24	18	14
	1.75	6	5	1.5 - 3.0			
B-002-0-21	4.00	7	3	0.0 - 1.5	21	-	14
B-003-0-21	2.50	6	3	0.0 - 1.5	18	12	14

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.*

5.1.3.1. 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. Similar to our analysis of weak soils, although a soil sample's moisture content may meet the criteria to be considered high, the depth in which the high moisture soil is encountered in relation to the proposed subgrade is considered when each individual subgrade boring is analyzed for stabilization

recommendations. Based on the subsurface exploration performed, no soils within the proposed subgrade of the project roadways were considered unstable solely due to high moisture contents.

5.2. Stabilization Recommendations

5.2.1. Subgrade Stabilization

Unsuitable soils were not encountered within the proposed roadway subgrade within the project limits. However, unstable subgrade conditions that require stabilization per GB1 guidelines were encountered within the proposed roadway subgrade within the project limits. Unstable soils, as previously indicated in Section 5.1.3. of this report, were encountered within the subgrade depths in each of the borings performed for the project. Therefore, based on: 1) the SPT N_{60} and hand penetrometer values of the subgrade samples obtained; 2) the depth at which the unstable soils were encountered; and, 3) the performance of the existing pavement at the site, it is our opinion that the complete project portions of CR-550 (Pleasant Valley Rd) as well as Clinton Rd should be stabilized via localized undercut consisting of 21 inches of Excavate and Replace (Item 204) with geotextile or 15 inches of Excavate and Replace (Item 204) with geogrid. Actual depths and limits of undercuts should be determined in the field by the Project Engineer based on ODOT's Subgrade Compaction and Proof Rolling specifications (Item 204). Chemical stabilization of the subgrade soils via either Lime or Cement stabilization is also feasible based on the subgrade soils encountered though it is our understanding that chemical stabilization may not be considered for subgrade stabilization due to the planned pavement construction constraints. Subgrade stabilization of proposed subgrade soils should be performed within the proposed subgrade of all pavement sections to undergo full depth replacement and/or widening, *with the exception of the areas planned for 2 ft or greater of fill*.

Subgrade stabilization is estimated to extend to the depths indicated with any excavated material being replaced with material in accordance with Section F "Excavate and Replace (Item 204)" of the ODOT GB1. Stabilization limits should extend 18-inches beyond the edge of the proposed paved roadway, shoulder or median.

6. QUALIFICATIONS

This investigation was performed in accordance with accepted geotechnical engineering practice for the purpose of characterizing the subsurface and groundwater conditions within the project limits. This report has been prepared for B&N, ODOT and their design consultants to be used solely in evaluating the roadway subgrade soils and pavement design parameters that will serve as the basis for development of design and construction of the roadway improvement 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, 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 roadway, 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 Burgess & Niple, Inc. in performing this geotechnical exploration for the ROS-CR550-17.12/18.04 project. Please call if there are any questions, or if we can be of further service.

Respectfully Submitted,

Brendan P. Andrews, P.E.
Project Manager/Sr. Geotechnical Engineer

Kevin C. Arens, P.E.
Geotechnical Engineer

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APPENDIX A

BORING LOCATION PLAN

ROS-CR550-17.12/18.04
(PID 114624)
SURVEY AREA EXHIBIT
2/15/2021 - DRAFT

1/2

SOIL BORING
PAVEMENT CORE
POTENTIAL WORK LIMITS
LEVEL 1 SURVEY AREA
LEVEL 2 SURVEY AREA
LEVEL 3 SURVEY AREA

PLEASANT VALLEY RD (CR-550)
VETERANS PARKWAY
CLINTON RD.
PLEASANT VALLEY RD (CR-550)

B-001-0-21
C-001
B-003-0-21
B-002-0-21

Level 1 Survey is intended to be full topo survey including all overhead an underground utilities. An existing terrain model will be developed for these areas.

Level 2 Survey is intended to be only utilities (overhead and underground) based on OUPS field markings, record plans, and topo features. No existing ground surface or EOP and other topo lines will be included in this area. These features will be drawn in based on the aerial image to supplement the Level 1 Survey areas. The proposed work in these areas is mainly re-striping, however is close enough to subsurface work areas and to the intersection that utilities should be accurately mapped.

Level 3 Survey is intended to only be features such as EOP, EOS, and ditch lines traced from the aerial to supplement the field survey. These areas are only re-striping and potentially resurfacing which would not require full field topo survey or utilities. The team proposes we use the actual aerial image in the plans as needed to show information.

APPENDIX B

BORING LOGS

PROJECT: ROS-CR550-17.12/18.04
TYPE: SUBGRADE
PID: 114624 SFN:
START: 8/11/22 END: 8/11/22

DRILLING FIRM / OPERATOR: NEAS / JL
SAMPLING FIRM / LOGGER: NEAS / JL
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: CME 45B
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 1/24/22
ENERGY RATIO (%): 72.6

STATION / OFFSET: 106+17, 66' LT.
ALIGNMENT: CR-550
ELEVATION: 763.1 (MSL) EOB: 7.5 ft.
LAT / LONG: 39.369337, -83.034412

EXPLORATION ID B-001-0-21

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
7.0" ASPHALT AND 9.5" BASE (DRILLERS DESCRIPTION)	763.1																		
STIFF, BROWN, **SILT AND CLAY**, SOME SAND, LITTLE GRAVEL, DAMP **(FILL)**	761.7	1	2 1 2	4	28	SS-1	1.25	16	13	14	33	24	28	16	12	15	A-6a (5)	120	
STIFF TO VERY STIFF, BROWN AND GRAY, **CLAY**, SOME SILT, SOME SAND, TRACE GRAVEL, MOIST TO DAMP **(FILL)**	760.1	2 3 4 5 6	1 3 2	6	56	SS-2	1.75	4	7	14	34	41	43	19	24	23	A-7-6 (14)	-	
			2 4 2	7	61	SS-3	1.50	-	-	-	-	-	-	-	-	16	A-7-6 (V)	-	
	755.6	EOB 7	0 4 7	13	44	SS-4	3.00	-	-	-	-	-	-	-	-	23	A-7-6 (V)	-	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE. BORING OFFSET 15.0' NW DUE TO OVERHEAD UTILITIES.

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

PROJECT: ROS-CR550-17.12/18.04
TYPE: SUBGRADE
PID: 114624 SFN:
START: 8/11/22 END: 8/11/22

DRILLING FIRM / OPERATOR: NEAS / JL
SAMPLING FIRM / LOGGER: NEAS / JL
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: CME 45B
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 1/24/22
ENERGY RATIO (%): 72.6

STATION / OFFSET: 105+99, 151' RT.
ALIGNMENT: CR-550
ELEVATION: 772.1 (MSL) EOB: 7.5 ft.
LAT / LONG: 39.368742, -83.034472

EXPLORATION ID B-002-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 772.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
7.0" ASPHALT AND 11.0" BASE (DRILLERS DESCRIPTION)	770.6																		
VERY STIFF, BROWN, **SILTY CLAY**, SOME SAND, TRACE GRAVEL, DAMP	769.1	1	5 3 3	7	67	SS-1	4.00	6	9	17	32	36	40	19	21	19	A-6b (11)	60	
VERY STIFF, BROWN, **SILT AND CLAY**, SOME SAND, LITTLE GRAVEL, DAMP TO MOIST	766.1	2	5 2 2	5	56	SS-2	4.00	16	11	15	33	25	31	18	13	15	A-6a (6)	-	
		3	2 2 3	6	61	SS-3	3.50	-	-	-	-	-	-	-	-	21	A-6a (V)	-	
STIFF TO VERY STIFF, BROWN, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, MOIST	764.6	4	0 2 4	7	56	SS-4	2.00	-	-	-	-	-	-	-	-	18	A-4a (V)	-	
		EOB																	

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

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

STANDARD ODOT LOG W/ SULFATES (8.5 X 11) - OH DOT.GDT - 10/26/22 14:46 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\ROS-CR550-17.12-18.04\GINT FILES\ROS-CR550-17.12-18.04.GPJ

PROJECT: ROS-CR550-17.12/18.04	DRILLING FIRM / OPERATOR: NEAS / JL	DRILL RIG: CME 45B	STATION / OFFSET: 110+56, 30' LT.	EXPLORATION ID B-003-0-21
TYPE: SUBGRADE	SAMPLING FIRM / LOGGER: NEAS / JL	HAMMER: CME AUTOMATIC	ALIGNMENT: CR-550	
PID: 114624 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 1/24/22	ELEVATION: 751.3 (MSL) EOB: 7.5 ft.	PAGE 1 OF 1
START: 8/11/22 END: 8/11/22	SAMPLING METHOD: SPT	ENERGY RATIO (%): 72.6	LAT / LONG: 39.369137, -83.032861	

MATERIAL DESCRIPTION AND NOTES	ELEV. 751.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
3.5" TOPSOIL (DRILLERS DESCRIPTION)	751.0																		
VERY STIFF, BROWN, **SILT AND CLAY**, SOME SAND, LITTLE GRAVEL, DAMP	746.8	1	3 3 2	6	17	SS-1	2.50	-	-	-	-	-	-	-	-	17	A-6a (V)	-	
		2	4 3 4	8	22	SS-2	2.75	14	11	14	36	25	32	18	14	16	A-6a (7)	60	
MEDIUM STIFF, BROWN, **SANDY SILT**, LITTLE CLAY, LITTLE GRAVEL, CONTAINS NO INTACT SOIL FOR HP READINGS, DAMP	745.3	3	3 4 3	8	33	SS-3	-	11	16	26	31	16	23	16	7	16	A-4a (2)	-	
VERY STIFF, BROWN, **SILT AND CLAY**, SOME SAND, LITTLE GRAVEL, MOIST	743.8	4	1 3 4	8	28	SS-4	3.25	-	-	-	-	-	-	-	-	19	A-6a (V)	-	
EOB		5																	
		6																	
		7																	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE. BORING OFFSET 10.0' S DUE TO OVERHEAD UTILITIES.

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

APPENDIX C

PAVEMENT CORE LOG

Core Photo: C-001

Core Information				
Core Diameter (in):			**4**	
Core Total Length (in):			**8**	
Layers	Core Composition & Thickness (in)			Condition
	Asphalt	Concrete	Brick	
1	8			Good
2				
3				
4				
Rebar Encountered	N/A			

Pavement & Core Photo Log

National Engineering & Architectural Services Inc.

Roadway Project
ROS-CR550-17.12-18.04

NEAS Project No.:	22-0037
Date:	10/19/2022
Taken By:	LR
Scale:	N/A

APPENDIX D

SULFATE CONTENT DATA

OHIO DEPARTMENT OF TRANSPORTATION

DETERMINING SULFATE CONTENT IN SOILS
SUPPLEMENT 1122

Project C-R-S:	ROS-CR-550-17.12/18.04
PID No:	114624
Report Date:	10/3/2022
Consultant:	NEAS Inc.
Technician:	L. Rosenbeck

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-001-0-21 SS-1					18	20	6	20	6	20	6	**120**
B-002-0-21 SS-1					18	20	3	20	3	20	3	**60**
B-003-0-21 SS-2					18	20	3	20	3	20	3	**60**

APPENDIX E

GEOTECHNICAL BULLETIN 1 (GB1) ANALYSIS SPREADSHEET

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES
Geotechnical Bulletin GB1

ROS-CR550-17.12/18.04
114624

ROS-CR550-17.12/18.04 Intersection Improvements

NEAS, Inc.

Prepared By: Brendan P. Andrews PE
Date prepared: Thursday, October 6, 2022

Brendan P. Andrews PE
1329 East Kemper Road, Suite 4104B
Cincinnati, OH 45246

513.337.9823 Ext. 701
brendan.andrews@neasinc.com

NO. OF BORINGS: 3

#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL	Cut Fill
1	B-001-0-21	CR-550	106+17	66	LT	CME 45B	73	763.1	761.6	1.5 C
2	B-002-0-21	CR-550	105+99	151	RT	CME 45B	73	772.1	770.6	1.5 C
3	B-003-0-21	CR-550	110+56	30	LT	CME 45B	73	751.3	749.8	1.5 C

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	1.5	3.0	0.0	1.5	4		1.25	28	16	12	33	24	57	15	14	A-6a	5	120		HP		**24"**	
	001-0	SS-2	3.0	4.5	1.5	3.0	6		1.75	43	19	24	34	41	75	23	18	A-7-6	14			HP & Mc			
	21	SS-3	4.5	6.0	3.0	4.5	7		1.5							16	18	A-7-6	16						
		SS-4	6.0	7.5	4.5	6.0	13	4	3							23	18	A-7-6	16						
2	B	SS-1	1.5	3.0	0.0	1.5	7		4	40	19	21	32	36	68	19	16	A-6b	11			N_{60} & Mc		**15"**	
	002-0	SS-2	3.0	4.5	1.5	3.0	5		4	31	18	13	33	25	58	15	14	A-6a	6			N_{60}			
	21	SS-3	4.5	6.0	3.0	4.5	6		3.5							21	14	A-6a	10						
		SS-4	6.0	7.5	4.5	6.0	7	5	2							18	14	A-6a	10						
3	B	SS-1	1.5	3.0	0.0	1.5	6		2.5							17	14	A-6a	10			N_{60} & Mc		**18"**	
	003-0	SS-2	3.0	4.5	1.5	3.0	8		2.75	32	18	14	36	25	61	16	14	A-6a	7			N_{60}			
	21	SS-3	4.5	6.0	3.0	4.5	8			23	16	7	31	16	47	16	11	A-4a	2						
		SS-4	6.0	7.5	4.5	6.0	8	6	3.25							19	14	A-6a	10						

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.5 1/18/2019

PID: 114624

County-Route-Section: ROS-CR550-17.12/18.04
No. of Borings: 3

Geotechnical Consultant: NEAS, Inc.
Prepared By: Brendan P. Andrews PE
Date prepared: 10/6/2022

Chemical Stabilization Options		
320	Rubblize & Roll	No
206	Cement Stabilization	Option
	Lime Stabilization	No
206	Depth	14''

Excavate and Replace Stabilization Options	
Global Geotextile Average(N60L):	21''
Average(HP):	0''
Global Geogrid Average(N60L):	15''
Average(HP):	0''

Design CBR	6

% Samples within 6 feet of subgrade			
$N_{60} \leq 5$	17%	HP ≤ 0.5	0%
$N_{60} < 12$	92%	0.5 < HP ≤ 1	0%
$12 \leq N_{60} < 15$	8%	1 < HP ≤ 2	33%
$N_{60} \geq 20$	0%	HP > 2	58%
M+	25%		
Rock	0%		
Unsuitable	0%		

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

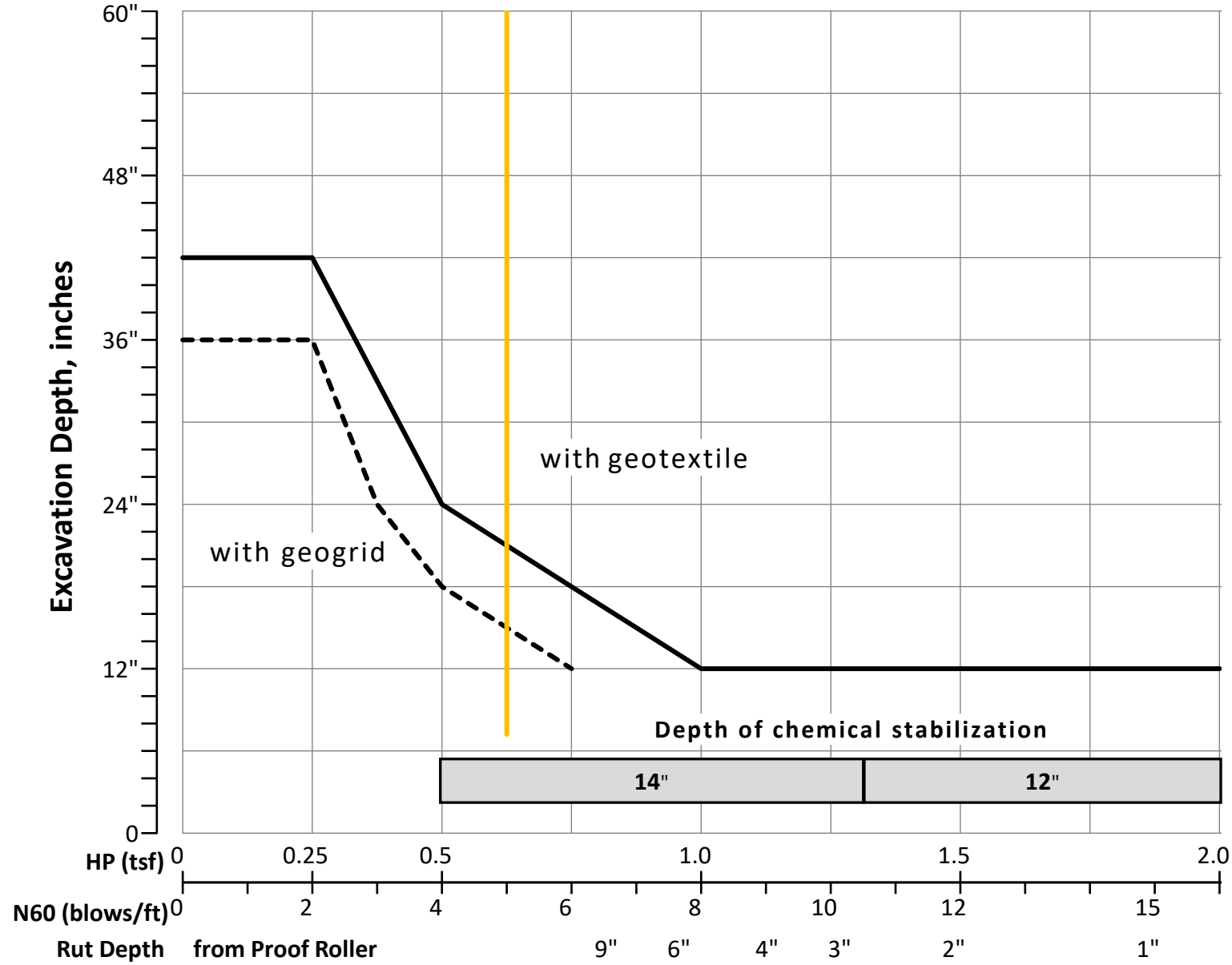
% Proposed Subgrade Surface	
Unstable & Unsuitable	100%
Unstable	100%
Unsuitable	0%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	7	5	2.68	33	18	15	33	28	61	18	15	10
Maximum	13	6	4.00	43	19	24	36	41	75	23	18	16
Minimum	4	4	1.25	23	16	7	31	16	47	15	11	2

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	1	0	0	7	1	0	3	0	0	12
Percent	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	58%	8%	0%	25%	0%	0%	100%
% Rock|Granular|Cohesive	0%	8%									92%								100%
Surface Class Count	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	1	0	0	6
Surface Class Percent	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	67%	17%	0%	17%	0%	0%	100%

GB1 Figure B – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
2.68	0.50	☐ HP
5.00	6.00	☐ N60L

Average HP
Average N_{60L}