FINAL REPORT
STRUCTURE FOUNDATION EXPLORATION
BRIDGE OVER LEATHERWOOD CREEK
LAW-243-10.79
LAWRENCE COUNTY, OHIO

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NEAS PROJECT 22-0003

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National Engineering & Architectural Services Inc.

EXECUTIVE SUMMARY

The proposed project includes the design and replacement of the existing bridge over Leatherwood Creek on SR-243 as the proposed project LAW-243-10.84 (PID 110558) in Union Township, Lawrence County, Ohio. National Engineering and Architectural Services Inc. (NEAS) has been contracted to perform geotechnical engineering services to supplement the design of the proposed bridge. The purpose of the geotechnical engineering services was to perform geotechnical explorations within the project limits to obtain information concerning the subsurface soil and groundwater conditions relevant to the design and construction of the project.

The subsequent document presents the results of a structure foundation exploration with respect to the proposed construction of the bridge over Leatherwood Creek on SR-243. As part of the exploration, NEAS advanced two structure borings, designated B-001-0-21 and B-002-0-21, to depths of approximately 60.5 to 62.5 feet below the existing ground surface at the rear and forward abutments of the referenced bridge and conducted laboratory testing of collected samples to characterize the soils for engineering purposes. The proposed bridge is a single span prestressed concrete girder bridge with new composite reinforced concrete deck on new integral reinforced concrete abutments with HP pile foundations. The new bridge will be approximately 30 feet wide and 85 feet long.

The subsurface profile at the bridge site is generally consistent with the geological model for the project in regard to the materials encountered. The subsurface profile at the bridge site generally consists of seventeen- to eighteen-inch-thick existing pavement section (asphalt and granular base) underlain by primarily cohesive silty-clay loam colluvium with minor non-cohesive gravel and stone fragments with sand and silt. Bedrock was encountered within depths of both the borings performed.

Subgrade analyses were performed for the referenced project site to evaluate the soil characteristics for use in pavement design. Unstable subgrade conditions that may require some form of subgrade stabilization within the subgrade per GB1 guidelines were encountered within the project site. The subgrade conditions encountered along Cadiz-Dennison Road alignment within the project limits include areas of weak soils and high moisture content soils. Therefore, we recommend local stabilization in the form of Excavate and Replace (Item 204 with Geotextile) be performed.

Bridge analyses of deep foundation systems were performed for the two substructure locations for the bridge based on the developed soil profiles at the referenced boring locations. The driven pile foundation system at the proposed substructures will consist of HP14X73 steel piles driven to refusal on bedrock. The factored resistance for piles driven to refusal on bedrock is typically governed by structural resistance as opposed to driving resistance for friction piles. The total factored load (maximum factored structural resistance) for any single HP14X73 steel pile is equal to 530 kips. Based on our analysis, the deep foundation system will consist of end bearing piles and it is our opinion they will be seated on claystone bedrock at the approximate elevations of between 521.8 ft and 522.0 ft amsl.

Global stability was performed for the proposed bridge abutments for long-term (Effective Stress) and short-term (Total Stress) slope stability. Based on our slope stability analyses for the referenced abutment locations, the minimum slope stability safety factors for short-term (Total Stress) and long-term (Effective Stress) conditions exceeded the desired value of 1.54. It is our opinion that the subsurface conditions encountered at the project site are generally satisfactory and the site can be considered to be stable at short-term and long-term condition.

A seismic site class was also determined at the overall bridge site, in which a Seismic Site Class of E is recommended.

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1. INTRODUCTION

1.1. General

NEAS presents our Structure Foundation Exploration Report to supplement the design and replacement of the existing bridge carrying SR-243 over Leatherwood Creek as the proposed project LAW-243-10.84 (PID 110558) in Union Township, Lawrence County, Ohio. This report presents a summary of the encountered surficial and subsurface conditions and our recommendations for bridge foundation design and construction in accordance with Load and Resistance Factor Design (LRFD) method as set forth in AASHTO's Publication *LRFD Bridge Design Specifications, 9th Edition* with 2020 interim revisions (BDS) (AASHTO, 2020) and *ODOT's 2020 LRFD Bridge Design Manual* (BDM) (ODOT, 2022).

The exploration was conducted in general accordance with Barr Engineering, Inc.'s DBA NEAS, Inc. proposal to ms consultants, inc, dated December 8, 2021 and with the provisions of ODOT's *Specifications for Geotechnical Explorations* (SGE) (ODOT, 2022). With respect to the proposed bridge replacement project, two structure borings, designated B-001-0-21 and B-002-0-21, were drilled to depths of approximately 60.5 to 62.5 feet below the existing ground surface at the rear and forward abutments of the referenced bridge.

The scope of work performed by NEAS as the referenced project included: a review of published geotechnical information; performing 2 total test borings; laboratory testing of soil samples in accordance with the SGE; performing geotechnical engineering analysis to assess foundation design and construction considerations; and development of this summary report.

1.2. Proposed Construction

The proposed project consists of the replacement of the bridge over Leatherwood Creek on SR-243. The existing bridge is a three-span reinforced concrete slab bridge on CIP piles. The proposed bridge is a single span prestressed concrete girder bridge with reinforced concrete deck on integral abutments on HP piles driven to refusal on bedrock. The new bridge will be approximately 30 feet wide and 85 feet long.

2. GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1. Geology and Physiography

The project site is located within the Marietta Plateau physiographic region. This area is characterized as a dissected plateau of high-relief (350 to 600 ft near the Ohio River) comprised of mostly fine-grained rocks with red shales and soils common. Remnants of ancient lacustrine clay-filled Teays drainage systems are common as well as landslides. The geology in this region is described as Pleistocene-age Minford Clay or red and brown silty-clay loam colluvium with landslide deposits over Pennsylvanian-age to Permian age red and gray shales, and siltstones, sandstones, limestones, and coals (ODGS, 1998).

Based on the Quaternary geology map of Ohio, the geology at the project site is mapped as Cenozoic-age Colluvium derived from local bedrock in unglaciated area; includes scattered areas of residuum and weathered material, underlain by Pennsylvanian-age shale, siltstone, and mudstone bedrock (Pavey, et al 1999).

Based on the Bedrock Geologic Units Map of Ohio (USGS & ODGS, 2006), bedrock within the project area consists of shale, siltstone, mudstone, sandstone, coal, and limestone of the Conemaugh group. The Conemaugh Group is comprised of Pennsylvanian-age shale, with minor lithologic constituents of limestone, coal, and sandstone. The shale in this formation is described as black, gray, green and red in color, clayey to silty, locally contains marine fossils in lower half of unit, and calcareous in part. The limestone/coal in this group is found in upper interval of this group and is described as black, gray, and green in color, micritic to coarse grained, thin bedded to concretionary with marine fossils common in lower half of interval, thin to medium bedded. Coal is bituminous and impure. The sandstone in this group is described as green-gray and weathers to shades of yellow-brown in color, very fine to medium grained, locally conglomeratic, thin to massive to cross bedded and locally calcareous. Bedrock is anticipated to generally be consistent throughout the project site (ODGS, 2003). Based on the ODNR bedrock topography map of Ohio, bedrock elevations at the project site can be expected to be at about 550 ft amsl, putting bedrock at a depth of about 15 to 20 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 Pope-Stokly combined silt loams throughout the project site. Soils in the Pope series are characterized as very deep, well drained, moderate to moderately rapid permeable soils formed in alluvium on flood plains. Soils in the Stokly series are characterized as very deep, somewhat poorly drained soils on floodplains that have gleyed fine sandy loam, sandy loam, or loam lower B and C horizons. The Pope-Stokly combined series are comprised of both coarse and fine-grained soils and classifies as A-1, A-2 and A-4 type soils according to the AASHTO method of soil classification.

2.2. Hydrology/Hydrogeology

Groundwater at the project site can be expected at an elevation consistent with that of the Leatherwood Creek as it is the most dominant hydraulic influence in the vicinity of the project's boundaries. The water level of Leatherwood Creek may be generally representative of the local groundwater table. However, 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 located within a regulatory floodway (Zone AE) 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 abandoned oil or gas wells are noted on ODNR's Oil and Gas Well Locator in the vicinity of the project site (ODNR [1], 2020).

2.4. Historical Records and Previous Phases of Project Exploration

The following report/plans were available for review and evaluation for this report for estimating bedrock elevation:

- Soil Boring Logs as part of ODOT Landslide Exploration Project LAW-243-10.3-10.4, prepared by CTL Engineering, Inc., dated September 22, 2015.

However, the historical project is over 0.5 miles west of this current project, so the historic boring information may not be representative of the Alluvial valley the current project is located in, therefore; historic borings are not referenced within this report nor within the bridge specific project developed Structure Foundation Exploration Sheets.

2.5. Site Reconnaissance

A field reconnaissance visit for the Bridge LAW-243-1089 replacement was conducted on February 7, 2022, along SR-243 at the Leatherwood Creek crossing in Lawrence County, Ohio. During our field reconnaissance, site conditions including existing pavement conditions were noted and photographed. Land use at the project site can be described as a combination of woodland and agricultural.

The existing bridge carrying SR-243 over the Leatherwood Creek is a three-span, continuous reinforced concrete slab bridge which carries one lane of traffic in each direction on a concrete cast in place bridge deck with an asphalt wearing course. The bridge sits atop concrete stub type abutments and cap and column type piers. The embankment slopes at the site, apart from the northwestern area of the bridge site (roadway embankment and side slope) and eastern spill through slope, generally appeared to be stable with no signs of instability observed during our site visit. Existing embankment slopes appeared to be at grades ranging between 3 Horizontal to 1 Vertical (3H:1V) and 4H:1V with the steeper slopes located at the aforementioned northwestern portion of the site. The northwestern roadway embankment was observed to be eroded at the toe by the drainage ditch running parallel to SR-243 (Photograph 1). The northwest bank of the creek near the bridge was observed to be reinforced with sandbags (Photograph 2). Both the eastern and western spill through slopes were observed to be covered with a granular material with no signs of slope protection observed. The western spill through slope was observed to be in relatively good condition with minor erosion due to runoff from the drainage ditches on each side of the roadway (Photograph 3). The eastern spill through slope was observed to be heavily eroded at the toe by the flow of the creek (Photograph 4). Overall, the bridge appeared to be in fair to poor condition with structural wear observed on the underside of the bridge deck and piers. Scour was observed at the footing of both piers and was noted to be worse at the eastern pier Photographs 5 & 6). However, no apparent signs of structural distress due to geotechnical concerns were observed during our field reconnaissance visit.

In general, the existing bridge structure appeared to be well drained with signs of significant erosion and drainage issues confined to the eastern pier, eastern spill through slope and northwestern roadway embankment. Overall, the pavement at the site was observed to be in fair condition with moderate severity raveling, map cracking and crack sealing deficiencies (Photograph 7). The pavement appeared to be well drained with water directed to drainage ditches on either side of the roadway as well as directly off the southern shoulder of the bridge.

Photograph 1: Toe of Southeastern Embankment and Drainage Ditch

Photograph 2: Northwestern Bank of Creek Reinforced with Sandbags

Photograph 3: Western Spill-through Slope

Photograph 4: Eastern Spill-through Slope and Observed Erosion

Photograph 5: Scour Observed at Western Pier

Photograph 6: Scour Observed at Eastern Pier

Photograph 7: Overall Condition of Asphalt Wearing Course

3. EXPLORATION

3.1. Field Exploration Program

The exploration for proposed bridge was conducted by NEAS between March 3, 2022 and March 4, 2022 and included 2 structure borings drilled to depths between 60.5 and 62.5 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 near the substructure of the proposed bridge in locations that were not restricted by maintenance of traffic, underground utilities or dictated by terrain (i.e. steep embankment slopes). Each as-drilled project boring location and corresponding ground surface elevation was surveyed in the field by NEAS (project surveyor) following completion. Each individual project boring log (included within Appendix B) includes the recorded boring latitude and longitude location (based on the surveyed Ohio State Plane North, NAD83, location) and the corresponding ground surface elevation. Elevations of the borings are shown on Table 1 below.

Table 1: Project Boring Summary

Boring Number	Latitude	Longitude	Elevation (NAVD 88) (ft)	Depth (ft)	Substructure
B-001-0-21	38.495831	-82.488200	568.0	62.5	Rear Abutment
B-002-0-21	38.495791	-82.487797	568.3	60.5	Forward Abutment

Structure borings were drilled using a CME 55X truck mounted drilling rig utilizing 3.25-inch diameter hollow stem augers. In general, soil samples were recovered continuously to a depth of 9.0 ft bgs, then at intervals of 2.5-ft to a depth of 31.5 ft bgs and at 5.0-ft intervals thereafter using a split spoon sampler (AASHTO T-206 “Standard Method for Penetration Test and Split Barrel Sampling of Soils.”). Both borings encountered bedrock and were advanced for sampling using an NQ2-seris core barrel, water circulation method. 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 and possible laboratory testing. Standard penetration tests (SPT) were conducted using a CME auto hammer that has been calibrated to be 79% efficient (indicated on the boring logs) on January 24, 2022.

Field /boring logs were prepared by drilling personnel, and included 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. After completing the borings, the boreholes were backfilled with either auger cuttings, bentonite chips, or a combination of these materials.

3.2. Laboratory Testing Program

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

3.2.1. Classification Testing

Representative soil samples were selected for index properties (Atterberg Limits) and gradation testing for classification purposes on approximately 50% of the samples. At each boring location, samples were selected for testing with the intent of identification and classification of all significant soil units. 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.

A final classification of the soil strata was made in accordance with AASHTO M-145 "Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes," as modified by ODOT "Classification of Soils" once laboratory test results became available. The results of the soil classification are presented on the boring logs provided 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 varying intervals (i.e., 2.5-ft or 5.0-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 presented on the boring logs provided in Appendix B.

3.2.3. D_{50} values for Scour Evaluation

Grain size distribution testing was performed on the obtained streambed samples to develop D_{50} values (i.e., the diameter in the particle-size distribution curve corresponding to 50% finer). Scour critical shear stress and erosion category were determined based upon the equations found in section 1302 of the Geotechnical Design Manual. The calculated D_{50} values as well as the scour critical shear stress and erosion category are shown in Table 2 below and the developed particle-size distribution curves are included with the associated boring logs within Appendix B.

Table 2: D_{50} Values

Boring Number	Specimen Elevation (ft)	ODOT (Modified AASHTO) ~ USCS Classification	D50 (mm)	Scour Critical Shear Stress, τ_C (psf)	Erosion Category (EC)
B-001-0-21	560.5' - 559.0'	A-6a ~ Sandy Lean Clay (CL)	0.025	0.153	3.255
	558.0' - 556.5'	A-6a ~ Clayey Sand (SC)	0.093	0.222	3.255
	555.5' - 554.0'	A-6b ~ Lean Clay with Sand (CL)	0.016	0.345	3.484
	553.0' - 551.5'	A-2-4 ~ Silty, Clayer Sand (SC-SM)	0.137	0.003	1.164
B-002-0-21	562.3' - 560.8'	A-6a ~ Sandy Lean Clay (CL)	0.025	0.308	3.337
	560.8' - 559.3'	A-6a ~ Clayey Sand (SC)	0.083	0.146	3.075
	558.3' - 556.8'	A-6a ~ Clayey Sand (SC)	0.123	0.003	1.108
	555.8' - 554.3'	A-4a ~ Sandy Lean Clay (CL)	0.033	0.035	2.975

4. FINDINGS

The subsurface conditions encountered during NEAS's explorations are described in the following subsections and 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, and consideration of the geological history of the site.

4.1. Subsurface Conditions

The subsurface profile at the bridge site is generally consistent with the geological model for the project in regard to the materials encountered. The subsurface profile at the bridge site generally consists of seventeen- to eighteen-inch-thick existing pavement section (asphalt and granular base) underlain by primarily cohesive silty-clay loam colluvium with minor non-cohesive gravel and stone fragments with sand and silt. Bedrock was encountered within depths of both the borings performed.

4.1.1. Overburden Soil

At the proposed bridge site, the soils encountered below the pavement section comprised of primarily cohesive silty-clay loam colluvium. The only exceptions: 1) Gravel and Stone Fragments with Sand and Silt (A-2-4) were encountered in B-001 at the depths from 14.5 ft to 17.0 ft and from 27 ft to 29.5 ft (elevations from 553.5 ft to 551.0 ft amsl and from 541.0 ft to 538.5 ft amsl); 2) Gravel and Stone Fragments with Sand (A-1-b) were encountered in B-001 at the depths from 25.3 ft to 27.0 ft (elevations from 542.7 ft to 541.0 ft amsl); and, 3) Gravel and Stone Fragments with Sand and Silt (A-2-4) were encountered in B-002 at the depths from 24.5 ft to 29.5 ft (elevations from 543.8 ft to 538.8 ft amsl).

The cohesive natural silty-clay loam colluvium encountered are classified on the borings logs as Sandy Silt (A-4a), Silt and Clay (A-6a), Silty Clay (A-6b) and Clay (A-7-6). The soils of this stratum can be described as having a medium stiff to hard consistency based on N_{60} values between 5 and 12 and unconfined compressive strengths (estimated by means of hand penetrometer) between approximately 1.0 and 3.25 ton per square foot (tsf). Natural moisture contents of the cohesive silty-clay loam colluvium ranged from 15 to 32 percent in moisture. Based on Atterberg Limits test performed on representative samples of the natural till soils, the liquid and plastic limits ranged from 26 to 44 percent and 19 to 24 percent, respectively.

The non-cohesive soils in this stratum are classified on the boring logs as Gravel and Stone Fragments with Sand (A-1-b), Gravel and Stone Fragments with Sand and Silt (A-2-4), as well as Sandy Silt (A-4a) with PI less than 7. These non-cohesive soils are described as very loose to medium dense in compactness correlating to N_{60} values between 3 and 30. The majority natural moisture content of the outwash stratum ranged from 13 to 14 percent.

4.1.2. Groundwater

Groundwater measurements were taken during the boring drilling procedures and immediately following the completion of each borehole. Groundwater was encountered during drilling and after drilling in both bridge borings (see Table 3). Based on these borings, groundwater was encountered between depths of 25.0 and 40.0 ft bgs (between elevations 528.3 ft and 543.0 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.

Table 3: Groundwater Summary

Boring ID	Free Water Depth (ft)	Free Water Elevation (ft)	Static Water Depth (ft)	Static Water Elevation (ft)
B-001-0-21	25.0	543.0	-	-
B-002-0-21	40.0	528.3	-	-

4.1.3. Bedrock

Bedrock was encountered in both of the project borings performed at the proposed bridge substructures and was classified as interbedded claystone and siltstone. Bedrock was presented at depths of between 46.0 and 46.5 ft bgs (elevations 522.0 and 521.8 ft amsl). The claystone was observed to be maroonish brown and gray, moderately to highly weathered, very weak to weak, very thin to medium bedded. The siltstone was observed to be gray, slightly weathered, moderately strong. Recovery of the bedrock core runs performed ranged from 64 to 100 percent while the Rock Quality Designation (RQD) values ranged from 59 to 64 percent. A summary of the bedrock data is presented in Table 4 below.

Table 4: Bedrock Summary

Boring Number	Depth to Bedrock (ft)	Elevation of Top of Rock (ft)	Bedrock Recovery (%)	Bedrock RQD (%)
B-001-0-21	46.0	522.0	84	59
B-002-0-21	46.5	521.8	96	64

5. ANALYSES AND RECOMMENDATIONS

The proposed project consists of the replacement of the bridge over Leatherwood Creek on SR-243 in Lawrence County, Ohio. It is our understanding that the proposed bridge is a single span prestressed concrete girder bridge with new composite reinforced concrete deck on new integral reinforced concrete abutments with HP pile foundations.

Based on the above information in addition to: 1) the soil characteristics gathered during the subsurface exploration (i.e., SPT results, laboratory test results, etc.); 2) the developed generalized soil profile and estimated engineering properties and other design assumptions presented in subsequent sections of this report; and, 3) the proposed bridge site plan (Appendix A) provided by ms consultants via email on May 24, 2022, Geotechnical design elements for the proposed project will include:

- Pavement Design and Recommendations
- Deep Foundation Analysis
- Global Stability Analysis

The geotechnical engineering analyses were performed in accordance with ODOT's BDM (ODOT, 2022) and AASHTO's LRFD BDS (AASHTO, 2020). Design recommendations are provided in the following sections.

5.1. Soil Profile for Analysis

For analysis purposes, each substructure location (boring log) was reviewed and a generalized material profile was developed for analysis. Utilizing the generalized soil profile, engineering properties for each soil strata were estimated based on the field (i.e., SPT N_{60} Values, hand penetrometer values, etc.) and laboratory (i.e., Atterberg Limits, grain size, etc.) test results using correlations provided in published engineering manuals, research reports and guidance documents. The developed soil profile and estimated engineering soil properties for use in analysis (with sited correlation/reference material) is summarized within Tables 5 through 6 below.

Table 5: Soil Profile and Estimated Engineering Properties - At Boring B-001-0-21

Bridge Over Leatherwood Creek: Rear Abutment, B-001-0-21						
Soil Description	**Unit Weight(1) (pcf)**	**Moist Unit Weight(1) (pcf)**	**Saturated Unit Weight(1) (pcf)**	**Undrained Shear Strength(2) (psf)**	**Effective Cohesion(3) (psf)**	**Effective Friction Angle(3) (degrees)**
Clay Elevation (568 ft - 560.5 ft)	108	108	118	1,100	100	22
Silt and Clay Elevation (560.5 ft - 556 ft)	108	108	118	1,200	100	23
Silty Clay Elevation (556 ft - 553.5 ft)	105	105	115	600	75	21
Gravel with Sand and Silt Elevation (553.5 ft - 551 ft)	108	108	118	-	-	28
Silt and Clay Elevation (551 ft - 542.7 ft)	108	108	118	1,050	100	22
Gravel with Sand Elevation (542.7 ft - 541 ft)	118	108	118	-	-	27
Gravel with Sand and Silt Elevation (541 ft - 538.5 ft)	128	118	128	-	-	33
Sandy Silt Elevation (538.5 ft - 534.7 ft)	118	108	118	950	100	22
Sandy Silt Elevation (534.7 ft - 529.7 ft)	118	108	118	800	100	21
Sandy Silt Elevation (529.7 ft - 524.7 ft)	118	108	118	1,300	100	23
Sandy Silt Elevation (524.7 ft - 522 ft)	140	130	140	8000	250	28

Notes:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if $N1_{60}$<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2.*

Table 6: Soil Profile and Estimated Engineering Properties - At Boring B-002-0-21

LAW-243-10.81 Bridge Over Leatherwood Creek: Forward Abutment, B-002-0-21						
Soil Description	**Unit Weight(1) (pcf)**	**Moist Unit Weight(1) (pcf)**	**Saturated Unit Weight(1) (pcf)**	**Undrained Shear Strength(2) (psf)**	**Effective Cohesion(3) (psf)**	**Effective Friction Angle(3) (degrees)**
Silty Clay Elevation (568.3 ft - 562.3 ft)	108	108	118	1,400	100	23
Silt and Clay Elevation (562.3 ft - 556.3 ft)	108	108	118	1,200	100	23
Sandy Silt Elevation (556.3 ft - 543.8 ft)	105	105	115	650	75	21
Gravel with Sand and Silt Elevation (543.8 ft - 538.8 ft)	115	115	125	-	-	31
Sandy Silt Elevation (538.8 ft - 525 ft)	108	108	118	1,000	100	22
Silt and Clay Elevation (525 ft - 521.8 ft)	140	130	140	8,000	250	28

Notes:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if $N1_{60}$<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2.*

5.2. Pavement Design and Recommendations

The subgrade analysis was performed in accordance with 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 subgrade exploration (i.e., SPT results, laboratory test results, etc.), and our geotechnical experience. For analysis purposes, final roadway elevations were determined based on the proposed profiles shown in the profile basemap provided by Korda via email on August 6, 2021.

A GB1 analysis was performed to identify the method, location, and dimensions (including depth) of recommended subgrade stabilization in the referenced project plan. 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 SGE, 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 identified within the project limits. GB1 analysis spreadsheet for the referenced roadway segment is provided in Appendix C.

5.2.1. Pavement Design Recommendations

It is our understanding that pavement analyses and design are to be performed to determine the proposed pavement section of SR-72. GB1 analyses were performed using the subgrade soil data obtained for the referenced roadway segment to evaluate the soil characteristics for use in pavement design. The subgrade analysis parameters recommended for use in pavement design for the referenced roadway segment are presented in Table 7. Provided in the table are average Plasticity Index (PI) values, 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 7: Pavement Design Values

Segment	Maximum N_{60L}	Minimum N_{60L}	Average N_{60L}	Average PI Values	Design CBR
SR-243	9	8	9	17	5

5.2.2. Unsuitable/Unstable Subgrade

Per ODOT's GB1, the presence of select subgrade conditions may require some form of subgrade stabilization within the subgrade zone for new pavement construction. These unsuitable and unstable subgrade conditions generally include the presence of rock, specific soil types, weak soil conditions, and overly moist soil conditions. With respect to the planned roadways, these subgrade conditions are further discussed in the following subsections.

5.2.2.1. Rock

Rock was not encountered within top 2 ft of the proposed grade in both borings performed; therefore, no specialized remediation efforts are required.

5.2.2.2. 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. No prohibited soils were encountered within the subgrade of the referenced project roadway.

5.2.2.3. Weak Soils

Soils for which the lowest N_{60} (N_{60L}) at the referenced boring location is less than or equal to 12 bpf and in some cases less than 15 bpf (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. At the project site, weak soils were encountered in both project borings within the subgrade depth, are summarized in Table 6 below.

Table 8: Weak Soils Summary

Boring ID	N_{60L}	Subgrade Depth (ft)	Remediation Depth (inches)		
			Excavate and Replace (Item 204 w/ Geotextile)	Excavate and Replace (Item 204 w/ Geogrid - SS	Chemical Stabilization (Item 206)
B-001-0-21	9	0.5 - 2.0	12	N/A	14
Note: N/A, Not Applicable based on GB1- Figure B - Subgrade Stabilization					

5.2.2.4. 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. No high moisture content soils were encountered in any of the project borings.

5.2.3. Stabilization Recommendations

5.2.3.1. Summary of Stabilization

Unstable subgrade conditions, specifically weak soils, were encountered in boring B-001 as previously indicated in Section 5.2.2. of this report. Therefore, NEAS recommend local stabilization in the form of Excavate and Replace as summarized in Table 9 below. Chemical stabilization is not recommended due to chemical stabilization is generally more economical when stabilizing large areas (approximately greater than 1 mile of roadway) per ODOT's GB1. Excavations are estimated to extend to a depth of 12 inches below the proposed subgrade with the 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 and it is recommended removing any topsoil, existing pavement materials or abandoned structure foundation materials.

Table 9: Stabilization Recommendations

Segment	Average N_{60L}	Remediation Depth (inches)		
		Excavate and Replace (Item 204 w/ Geotextile)	Excavate and Replace (Item 204 w/ Geogrid - SS 861)	Chemical Stabilization (Item 206)
Begin to Rear Abutment	8	12	N/A	14
Forward Abutment to End	9	N/A	N/A	N/A
Note: N/A, Not Applicable based on GB1- Figure B - Subgrade Stabilization				

5.3. Bridge Foundation Analysis and Recommendations

A foundation review was completed for a deep foundation system for the referenced widening bridge based on the following design information: 1) the Site Plan for Bridge No. LAW-243-1089 conducted by ms consultants; 2) historical plans; and 3) subsequent conversations with ms consultants. A driven pile foundation system was evaluated for all the substructure locations. The proposed deep foundation systems will be designed according to LRFD and ODOT BDM criteria. The summary and results of our deep foundation evaluation are presented in subsequent sections.

5.3.1. Pile Foundation Recommendations

We recommend that a driven pile foundation be used for support of the abutments, with the piles consisting of steel "H" piles driven to bedrock refusal. Refusal is met during driving when the pile penetration is an inch or less after receiving at least 20 blows from the pile hammer. An “H” pile driven to refusal on bedrock is typically governed by structural resistance as opposed to driving resistance for friction piles. The total factored load (maximum factored structural resistance) for any single HP12X53 and HP14X73 steel “H” piles are equal to 380 kips and 530 kips, respectively (ODOT, 2022). This total factored load (single pile) for an HP pile may be used to support the abutment foundation under the following conditions: 1) piles are installed in accordance with Sections 507 and 523 of the ODOT Construction and Material Specifications (CMS); 2) the piles are axially loaded pile with negligible moment; 3) steel piles have a yield strength of 50 kips per square inch (ksi); 4) assumed no appreciable loss of section due to deterioration throughout the life of the structure; 5) steel “H” piles are assumed to be subject to damage due to severe driving conditions equating to a structural resistance factor of 0.5; and, 5) the piles are fully braced along their length. According to the bridge plans provided by ms consultants, the total factored load is 356 kips per pile for the abutment piles. However, due to the scour effect that causes partial of the steel pile section to be not fully braced, the total factored resistance of HP piles driven to refusal is less than fully braced piles. Therefore, HP 14X73 piles are selected to support both abutments.

Driven to bedrock refusal, the pile tip elevations for the abutments are estimated to be about the elevations of top of bedrock shown on the boring logs. Pile lengths based on the "Estimated Length" and "Order Length" definitions and formulas presented in Section 305.3.3 "Pile Foundations" of the BDM, are shown in Table 10. Based on the scour analysis provided by ms consultants on May 23, 2022, at the rear abutments the 25-year design flood scour and 50-year check flood scour are 550.2 ft and 548.3 ft asml, respectively. At the forward abutments, the 25-year design flood scour and 50-year check flood scour are 550.2 ft and 548.6 ft asml, respectively. Therefore, the HP piles at both abutments will penetrate greater than 15-ft blow the maximum estimated scour depth.

Table 10: Estimated HP Pile Lengths and Maximum Factored Structural Resistance

Pile Type	Maximum Factored Structural Resistance (kips)	Bottom of Pile Cap Elevation (ft amsl)	Geotechnical Pile Length (ft)	Estimated Pile Length$^{(2)}$ (ft)	Order Length$^{(2)}$ (ft)
LAW-243-1081 Bridge: Rear abutment, B-001-0-21					
HP14X73	530.0	559	37	45	50
LAW-243-1081 Bridge: Forward abutment, B-002-0-21					
HP14X73	530.0	559	37	45	50

Notes:
1. Based on definitions and formulas presented in Section 305.3.3 of the 2020 BDM.

5.3.2. Pile Drivability

Pile driveability is highly reliant upon the specific equipment used in construction. Therefore, it is recommended that the contractor provide an analysis to demonstrate that the equipment and piles planned for use are capable to driven to refusal on bedrock without overstressing the piles.

The minimum rated energy of the hammer used to install the piles shall be (43,000) foot-pounds. Ensure that stresses in the piles during driving do not exceed (45,000) pounds per square inch.

5.3.3. Global Stability

For purposes of evaluating the stability of the abutments, NEAS reviewed the cross-section and project boring logs to determine the subsurface soil conditions that posed the greatest potential for slope instability. Based on our review, NEAS developed a representative cross-sectional model at each abutment to use as the basis for global stability analyses. The models were developed from NEAS's interpretation of the available information which included: 1) the Bridge Site Plan prepared by ms consultants; and, 2) test borings and laboratory data developed as part of this report. With respect to the soil's engineering properties, the provided Soil Profile Estimated Engineering Properties presented in Section 5.1 of this report were used in our analyses.

The above referenced slope stability models were analyzed for long-term (Effective Stress) and short-term (Total Stress) slope stability utilizing the software entitled Slide 7.0 by Rocscience, Inc. Specifically, the Bishop, Spencer and GLE analysis methods were used to calculate a factor of safety (FOS) for circular type slope failures. The FOS is the ratio of the resisting forces and the driving forces, with the desired safety factor being more than about 1.54 which equates to an AASHTO resistance factor less than 0.65 (per AASHTO, 2017 - the specified resistance factors are essentially the inverse of the FOS that should be targeted in slope stability programs). For this analysis, a resistance factor of 0.65 or lower is targeted as the slope contains or supports a structural element.

Based on our slope stability analyses for the referenced abutment locations, the minimum slope stability safety factors for short-term (Total Stress) and long-term (Effective Stress) conditions exceeded the desired value of 1.54. It is our opinion that the subsurface conditions encountered at the project site are generally satisfactory and the site can be considered to be stable at short-term and long-term condition. The results of the analyses are summarized in Table 11. The graphical output of the slope stability program (cross-sectional model, calculated safety factor, and critical failure plane) is presented in Appendix D.

Table 11: Global Stability Analysis Summary

Global Stability Analsysis at Bridge LAW-243-1081					
Location	**Boring No.**	**Description**	**Minimum Factor of Safety**	**Equivalent Resistance Factor**	**Status (OK/NG)**
Rear Abutment	B-001-0-21	Short Term	3.69	0.27	OK
		Long Term	1.65	0.61	OK
Forward Abutement	B-002-0-21	Short Term	3.71	0.27	OK
		Long Term	1.75	0.57	OK

Note that slope stability analysis was performed without scour depth considerations at the abutments. Estimated scour depth at the 25-year design flood would extend 8.8 ft below the bottom of the footing which would result in the loss of embankment material below and behind the proposed abutment triggering the requirement that the structure shall not collapse although may not remain in service. As the abutments will be supported on piles driven to refusal on bedrock, the sudden collapse of the structure is not envisaged.

5.4. Seismic Design Parameters

It is NEAS's opinion that the subsurface conditions encountered at the proposed Bridge LAW-243-1089 site are characterized as a Seismic Site Class of E in accordance with Section 3.10.3.1, Method B, of the LRFD BDS. For the overall bridge site, seismic site class parameters were determined at each substructure and subsequently averaged to obtain an overall global Site Class Definition.

6. QUALIFICATIONS

This investigation was performed in accordance with accepted geotechnical engineering practice for the purpose of characterizing the subsurface conditions at the site of LAW-243-1089 bridge carrying SR-243 over Leatherwood Creek. This report has been prepared for ms consultants, ODOT and their design consultants to be used solely in evaluating the soils underlying the bridge site 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 tests result 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 in the nature, design or location of the proposed bridge is made, 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 ms consultants in performing this geotechnical exploration for LAW-243-10.84 Bridge Replacement project. Please call if there are any questions, or if we can be of further service.

Respectfully Submitted,

STATE OF OHIO
CHUNMEI
HE
E-79190
REGISTERED
PROFESSIONAL ENGINEER

Chunmei He

Chunmei He, Ph.D., P.E.
Project Manager/Geotechnical Engineer

National Engineering and Architectural Services Inc.

REFERENCES

AASHTO. (2020). *Standard Specifications for Highway Bridges, 17th Edition.* Washington, D.C.: American Association of State Highway and Transporation Officials.

AASHTO LRFD. (2020). *LRFD Bridge Design Specifications, 9th Edition.* The American Association of State Highway and Transportations Officials.

ATC. (2019, January). ATC Hazards by Location. Retrieved from https://earthquake.usgs.gov/designmaps/us/application.php

FEMA. (2016). *National Flood Hazard Layer kmz v3.0.* Federal Emergency Management Agency.

FEMA. (2019). *National Flood Hazard Layer kmz v3.0.* Federal Emergency Management Agency.

ODGS. (1998). Physiographic regions of Ohio: Ohio Department of Natural Resources, Division of Geological Survey. page-size map with text, 2p., scale 1:2,100,00.

ODGS. (2002). Shaded elevation map of Ohio—earth-tone version: Ohio Departmentof Natural Resources, Division of Geological Survey Map MG-1. generalized page-size version with text, 2 p., scale 1:2,000,000.

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]. (2016). Ohio Abandoned Mine Locator Interactive Map. *Mines of Ohio*. Ohio Department of Natural Resources, Division of Geological Survey & Division of Mineral Resources. Retrieved from https://gis.ohiodnr.gov/MapViewer/?config= OhioMines

ODNR [2]. (2016). Ohio Oil & Gas Locator Interactive Map. *Ohio Oil & Gas Wells*. Ohio Department of Natural Resources, Division of Oil and Gas. Retrieved from https://gis.ohiodnr.gov/MapViewer/?config= oilgaswells

ODOT [2]. (2016). *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. (2022). *2020 Bridge Design Manual.* Columbus, OH: Ohio Department of Transportation: Office of Structural Engineering.

ODOT. (2022). *2022 Bridge Design Manual.* Columbus, OH: Ohio Department of Transportation: Office of Structural Engineering. Retrieved from http://www.dot.state.oh.us/Divisions/Engineering/ Structures/standard/Bridges/Pages/BDM2004.aspx

ODOT. (2022). *Specifications for Geotechnical Explorations.* Ohio Department of Transportation: Office of Geotechnical Engineering.

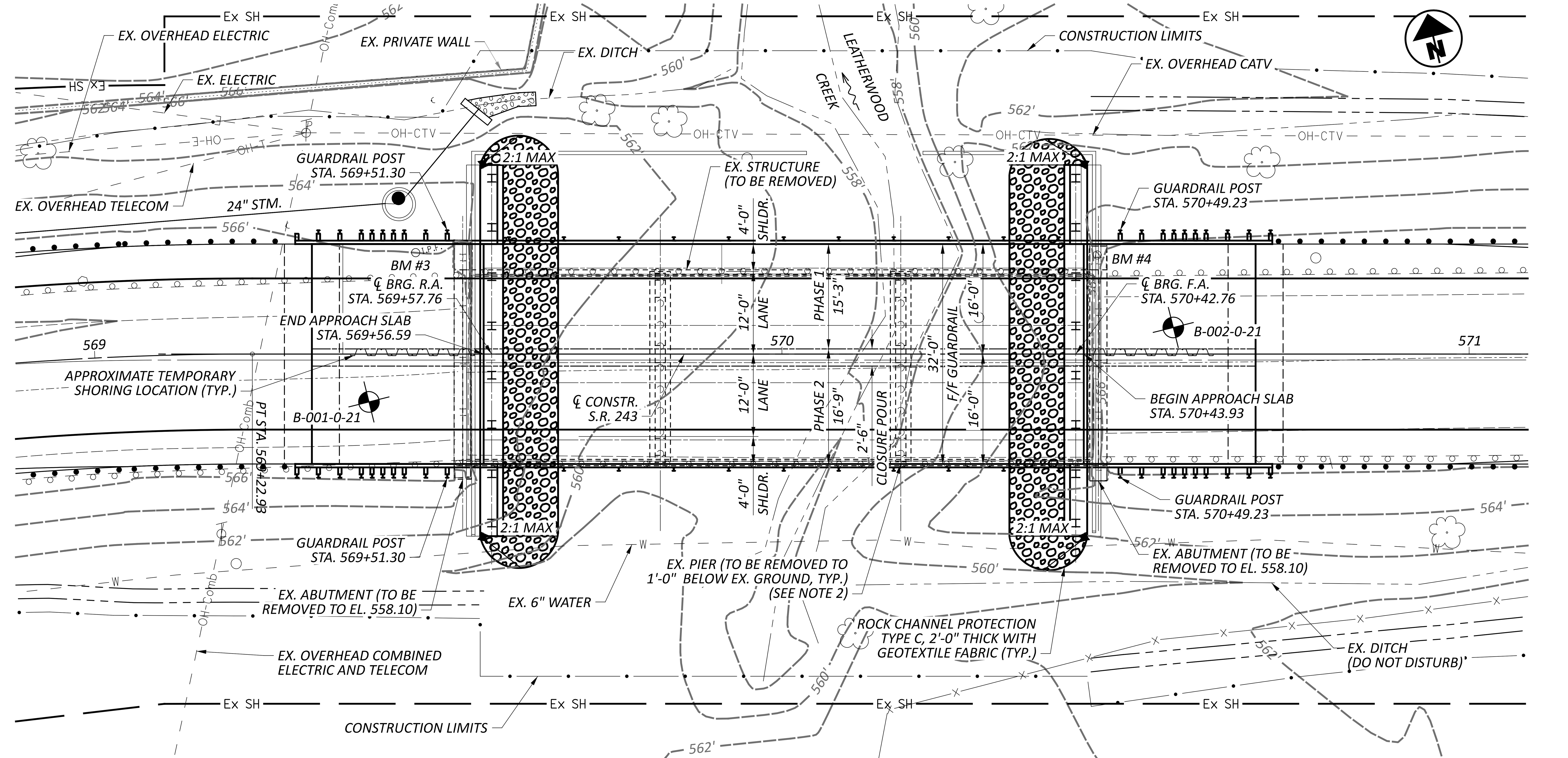
USDA. (2015, September). Web Soil Survey. Retrieved from http://websoilsurvey.nrcs.usda.gov

USGS & ODGS. (2005, June). Geologic Units of Ohio. *ohgeol.kmz*. United States Geologic Survey.

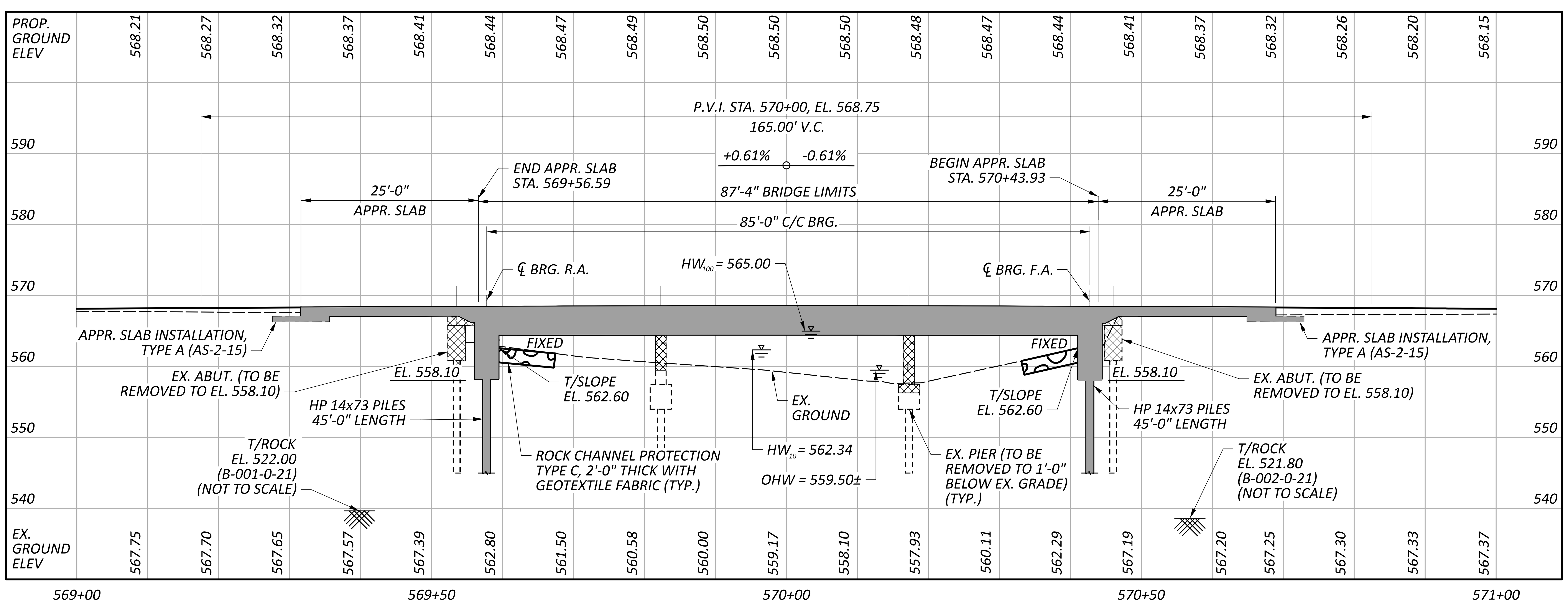
USGS & ODGS. (2006, June). Geologic Units of Ohio. *ohgeol.kmz*. United States Geologic Survey.

APPENDIX A

SITE PLAN



PLAN



PROFILE ALONG ℄ CONSTR. S.R. 243

BENCHMARK DATA

BM #1	STA. 565+93.86	ELEV.	568.11	OFFSET.	20.76' LT.
BM #2	STA. 567+01.23	ELEV.	568.11	OFFSET.	20.79' LT.
BM #3	STA. 569+46.70	ELEV.	568.50	OFFSET.	14.75' LT.
BM #4	STA. 570+45.88	ELEV.	567.82	OFFSET.	14.41' LT.
BM #5	STA. 572+98.56	ELEV.	568.14	OFFSET.	15.03' LT.
BM #6	STA. 573+51.26	ELEV.	568.14	OFFSET.	32.18' LT.

HORIZONTAL SCALE IN FEET 0 5 10 20

NOTES:

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.
2. FOR EXISTING PIER REMOVAL LIMITS, SEE SHEET 7/25.

DESIGN TRAFFIC:
2044 ADT = 1,000 2044 ADTT = 50
2024 ADT = 950 2024 ADTT = 47
DIRECTIONAL DISTRIBUTION = 0.55

LEGEND:

BORING LOCATION
EX. STRUCTURE REMOVAL LIMITS

HYDRAULIC DATA:

DRAINAGE AREA = 4.06 SQ. MILES

Q (100) = 1860 CFS V(100) = 10.69 FT/S
Q (10) = 894 CFS V(10) = 7.77 FT/S

STRUCTURE CLEARS THE 10 YEAR DESIGN HW BY 1.51 FEET

EXISTING STRUCTURE

TYPE: 3 SPAN CONTINUOUS CONCRETE SLAB WITH REINFORCED CONCRETE SUBSTRUCTURE ON FRICTION PILES

SPANS: 28'-0"±, 35'-0"±, 28'-0"± c/c BEARINGS

ROADWAY: 28'-0"± FACE/FACE GUARDRAIL

LOADING: S-12-46

SKEW: NONE

WEARING SURFACE: 1/4" MONOLITHIC WEARING SURFACE

APPROACH SLABS: NONE

ALIGNMENT: TANGENT

SUPERELEVATION: VARIES

STRUCTURE FILE NUMBER: 4403541

DATE BUILT: 1948

DISPOSITION: TO BE REPLACED

PROPOSED STRUCTURE

TYPE: SINGLE SPAN CONTINUOUS PRESTRESSED CONCRETE GIRDER WITH REINFORCED CONCRETE DECK ON INTEGRAL ABUTMENTS FOUNDED ON PILE TO ROCK

SPANS: 85'-0" C/C BEARINGS

ROADWAY: 32'-0" FACE/FACE GUARDRAIL

LOADING: HL93 AND 0.06 KSF FUTURE WEARING SURFACE

SKEW: NONE

WEARING SURFACE: 1" MONOLITHIC CONCRETE WEARING SURFACE

APPROACH SLABS: 25' LONG (AS-1-15) AND TYPE A INSTALLATION (AS-2-15)

ALIGNMENT: TANGENT

SUPERELEVATION TABLE: 1.60%

DECK AREA: 2,620 SF

COORDINATES: LATITUDE 38°29'45.01" LONGITUDE 82°29'17.36"

SITE PLAN
BRIDGE NO. LAW-243-1089 OVER LEATHERWOOD CREEK

SFN	4403542
DESIGN AGENCY	ms consultants, inc.
DESIGNER ATM	CHECKER DEA
REVIEWER YSJ	03/17/23
PROJECT ID	110558
SUBSET 1	TOTAL 25
SHEET 32	TOTAL 64

LAW-243-10.84

APPENDIX B

BORING LOGS AND TEST RESULTS

PROJECT: LAW-243-10.84	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 569+41, 8' RT.	EXPLORATION ID B-001-0-21
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / J. HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT:	
PID: SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/24/22	ELEVATION: 568.0 (MSL) EOB: 62.5 ft.	PAGE 1 OF 3
START: 3/3/22 END: 3/3/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 79	LAT / LONG: 38.495831, -82.488200	

MATERIAL DESCRIPTION AND NOTES	ELEV. 568.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
12.0" ASPHALT AND 5.0" BASE (DRILLERS DESCRIPTION)	566.6																	
VERY STIFF, LIGHT BROWN MOTTLED WITH GRAY, **CLAY**, SOME SILT, LITTLE SAND, TRACE TO LITTLE GRAVEL, CONTAINS TRACE IRON STAINING AND ROOTS, DAMP			2 4 3	9	28	SS-1	3.25	4	12	7	35	42	44	23	21	18	A-7-6 (13)	
			2 3 3	8	44	SS-2	3.25	-	-	-	-	-	-	-	-	19	A-7-6 (V)	
			2 4 4	11	100	SS-3	2.25	-	-	-	-	-	-	-	-	21	A-7-6 (V)	
	560.5		2 3 4	9	33	SS-4	2.50	-	-	-	-	-	-	-	-	22	A-7-6 (V)	
STIFF TO VERY STIFF, BROWN MOTTLED WITH GRAY AND ORANGISH BROWN, **SILT AND CLAY**, SOME TO "AND" SAND, TRACE GRAVEL, CONTAINS IRON STAINING, DAMP			2 3 3	8	100	SS-5	2.00	1	15	19	40	25	34	21	13	20	A-6a (7)	
	556.0		1 4 5	12	100	SS-6	3.25	8	19	26	28	19	32	19	13	15	A-6a (3)	
MEDIUM STIFF TO STIFF, BROWN, **SILTY CLAY**, SOME SAND, TRACE GRAVEL, MOIST	553.5		3 2 2	5	100	SS-7	1.00	0	1	24	45	30	37	21	16	29	A-6b (10)	
VERY LOOSE, GRAY AND BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, LITTLE CLAY, WET	551.0		2 2 1	4	100	SS-8	-	1	18	48	19	14	26	19	7	28	A-2-4 (0)	
STIFF TO VERY STIFF, GRAYISH BROWN, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, DAMP TO MOIST			2 3 6	12	100	SS-9	3.25	-	-	-	-	-	-	-	-	22	A-6a (V)	
			2 3 2	7	100	SS-10	1.50	0	0	1	53	46	37	24	13	27	A-6a (9)	
		W 543.0	2 3 3	8	100	SS-11	1.75	-	-	-	-	-	-	-	-	26	A-6a (V)	
SS-12A BECOMES VERY SOFT, WET	542.7		2 1 1	3	100	SS-12A	0.20	-	-	-	-	-	-	-	-	32	A-6a (V)	
VERY LOOSE, GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, WET	541.0					SS-12B	-	-	-	-	-	-	-	-	-	24	A-1-b (V)	
MEDIUM DENSE, GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP	538.5		4 10 13	30	100	SS-13	-	-	-	-	-	-	-	-	-	15	A-2-4 (V)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/23/23 12:24 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\LAW-243-10.79 (WAS 10.81)\GINT FILES\LAW-243-10.79.GPJ

PID:	SFN:	PROJECT: LAW-243-10.84	STATION / OFFSET: 569+41, 8' RT.	START: 3/3/22	END: 3/3/22	PG 2 OF 3	B-001-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 538.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
STIFF, BROWN AND GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, MOIST *(continued)*		31	4 3 3	8	100	SS-14	1.25	1	15	26	33	25	30	20	10	24	A-4a (5)	
LOOSE, BROWN AND GRAY, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, MOIST	534.7	33																
		35–36	1 2 3	7	100	SS-15	-	1	28	34	26	11	NP	NP	NP	18	A-4a (0)	
MEDIUM STIFF TO STIFF, GRAY AND BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, MOIST	529.7	38																
		40–41	2 4 4	11	100	SS-16	1.00	5	16	28	32	19	28	21	7	22	A-4a (3)	
HARD, MAROONISH GRAY, **SANDY SILT**, SOME CLAY, LITTLE STONE FRAGMENTS, RELIC ROCK STRUCTURE, DAMP	524.7	43																
		45–46	7 30 50/4"	-	100	SS-17	4.25	-	-	-	-	-	-	-	-	13	A-4a (V)	
CLAYSTONE, MAROONISH BROWN, SEVERELY WEATHERED, VERY WEAK.	522.0	TR 46																
INTERBEDDED CLAYSTONE (68%) AND SILTSTONE (32%), CONTAINS INTERBEDDED 0.125"-0.25" CLAY SEAMS, SLICKENSIDED AT 52.1', 54.4', AND 61.3', BEDDING DISCONTINUITIES: LOW ANGLE, HIGHLY FRACTURED TO SLIGHTLY FRACTURED, OPEN TO NARROW, SLIGHTLY ROUGH TO SLICKENSIDED, BLOCKY/DISTURBED/SEAMY, FAIR TO POOR SURFACE CONDITION, RQD 59%, REC. 84%; **CLAYSTONE**, MAROONISH BROWN AND GRAY, MODERATELY TO HIGHLY WEATHERED, VERY WEAK TO WEAK, VERY THIN TO MEDIUM BEDDED; **SILTSTONE**, GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG.	517.5	50	50	-	83	SS-18	-	-	-	-	-	-	-	-	-	8	Rock (V)	
	512.5	51–60	51		81	NQ2-1											CORE	
POTENTIAL VOID OR VERY SOFT UNIT OF CLAY THAT WASHED OUT DURING DRILLING. DEPTH IS APPROXIMATED	510.5	57																
		61	100		100	NQ2-2											CORE	

PID:	SFN:	PROJECT: LAW-243-10.84	STATION / OFFSET: 569+41, 8' RT.	START: 3/3/22	END: 3/3/22	PG 3 OF 3	B-001-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 505.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
	505.5	EOB																

NOTES: GROUNDWATER ENCOUNTERED AT 25.0' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 100 GAL. BENTONITE GROUT

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-001-0-21

Run #:	Depth		Recovery		RQD	
NQ2-1	50.5'	60.5'	97/120	81%	61/120	51%
LAW-243-10.84						

Ohio Department of Transportation
Division of Engineering

Office of Geotechnical Engineering

B-001-0-21

BR: NQ2-2
60.5’

ER: NQ2-2
62.5’

Run #:	Depth		Recovery		RQD	
NQ2-2	60.5’	62.5’	24/24	100%	24/24	100%

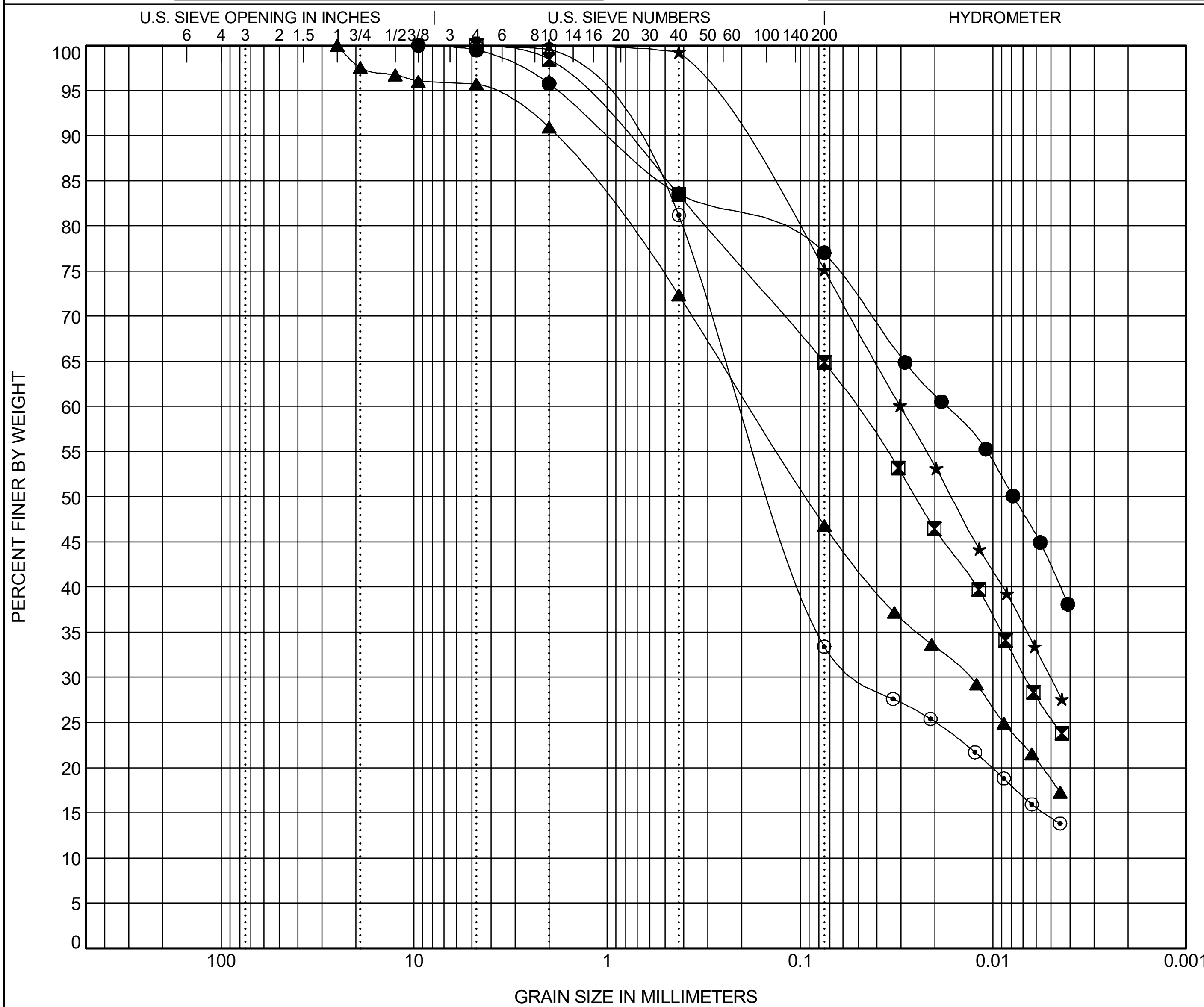
LAW-243-10.84

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT LAW-243-10.84 **PID**

OGE NUMBER 0 **PROJECT TYPE**



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

	Specimen Identification		ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	**B-001-0-21**	**1.5**	**A-7-6 ~ LEAN CLAY with SAND(CL)**	**44**	**23**	**21**
⧗	**B-001-0-21**	**7.5**	**A-6a ~ SANDY LEAN CLAY(CL)**	**34**	**21**	**13**
▲	**B-001-0-21**	**10.0**	**A-6a ~ CLAYEY SAND(SC)**	**32**	**19**	**13**
★	**B-001-0-21**	**12.5**	**A-6b ~ LEAN CLAY with SAND(CL)**	**37**	**21**	**16**
⊙	**B-001-0-21**	**15.0**	**A-2-4 ~ SILTY, CLAYEY SAND(SC-SM)**	**26**	**19**	**7**

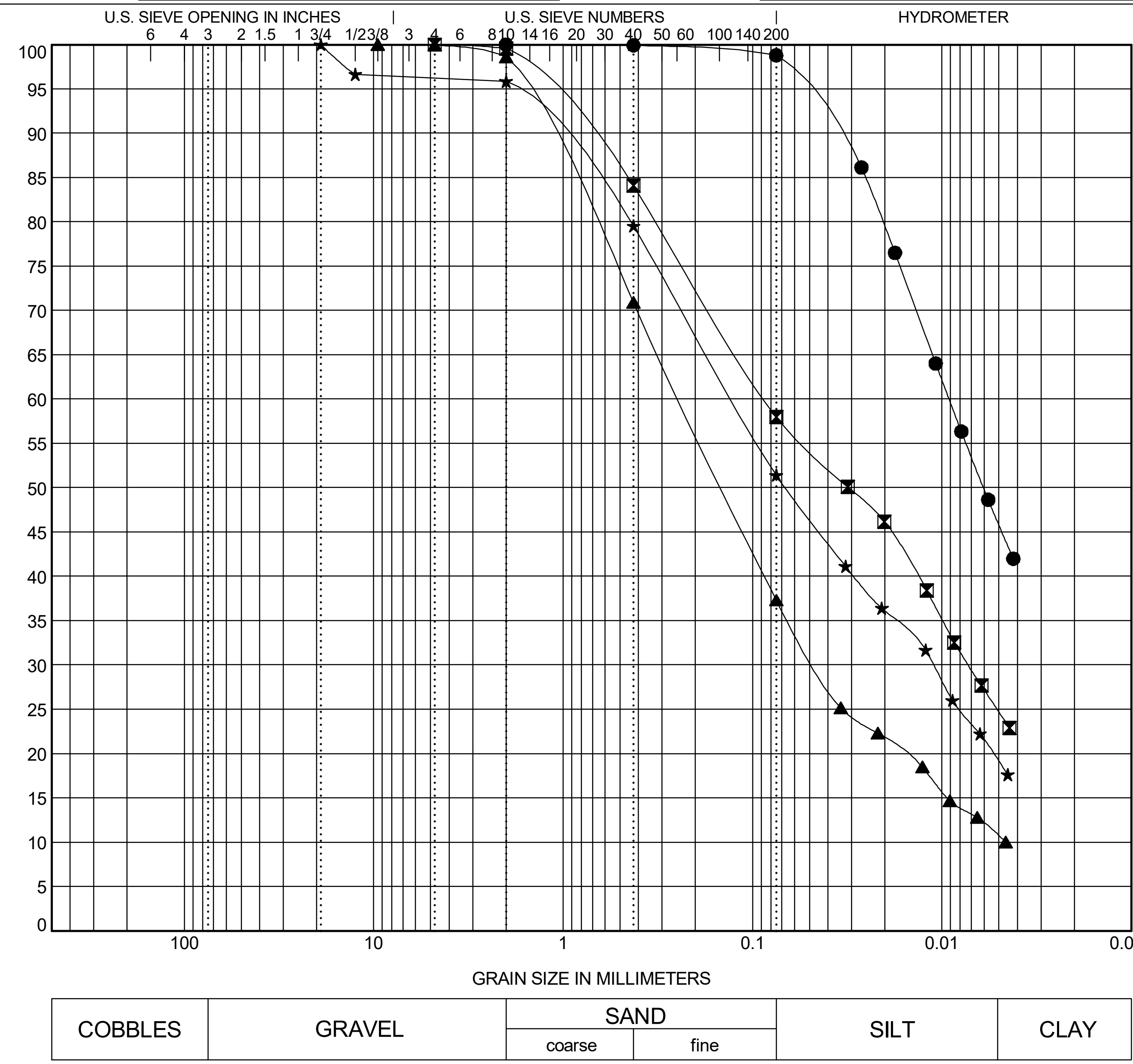
	Specimen Identification		D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	**B-001-0-21**	**1.5**	**0.963**	**0.008**			**4**	**12**	**7**	**35**	**42**		
⧗	**B-001-0-21**	**7.5**	**0.834**	**0.025**	**0.007**		**1**	**15**	**19**	**40**	**25**		
▲	**B-001-0-21**	**10.0**	**1.85**	**0.093**	**0.013**		**8**	**19**	**26**	**28**	**19**		
★	**B-001-0-21**	**12.5**	**0.218**	**0.016**	**0.005**		**0**	**1**	**24**	**45**	**30**		
⊙	**B-001-0-21**	**15.0**	**0.892**	**0.137**	**0.046**		**1**	**18**	**48**	**19**	**14**		

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT LAW-243-10.84 **PID**

OGE NUMBER 0 **PROJECT TYPE**



Specimen Identification		ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
● B-001-0-21	20.0	**A-6a ~ LEAN CLAY(CL)**	37	24	13
⧗ B-001-0-21	30.0	**A-4a ~ SANDY LEAN CLAY(CL)**	30	20	10
▲ B-001-0-21	35.0	**A-4a ~ SILTY SAND(SM)**	NP	NP	NP
★ B-001-0-21	40.0	**A-4a ~ SANDY SILTY CLAY(CL-ML)**	28	21	7

Specimen Identification		D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
● B-001-0-21	20.0	0.037	0.006			0	0	1	53	46		
⧗ B-001-0-21	30.0	0.769	0.031	0.007		1	15	26	33	25		
▲ B-001-0-21	35.0	1.236	0.144	0.047	0.005	1	28	34	26	11	1.96	52.49
★ B-001-0-21	40.0	1.147	0.067	0.011		5	16	28	32	19		

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/23/23 12:25 - X:\ACTIVE SOIL PROJECTS\LAW-243-10.79 (WAS 10.81)\GINT FILES\LAW-243-10.79.GPJ

PROJECT: LAW-243-10.84	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 570+57, 5' LT.	EXPLORATION ID B-002-0-21
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / J. HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT:	
PID: SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 1/24/22	ELEVATION: 568.3 (MSL) EOB: 60.5 ft.	PAGE 1 OF 2
START: 3/4/22 END: 3/4/22	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 79	LAT / LONG: 38.495791, -82.487797	

MATERIAL DESCRIPTION AND NOTES	ELEV. 568.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
12.0" ASPHALT AND 6.0" BASE (DRILLERS DESCRIPTION)	566.8	1																
VERY STIFF, LIGHT BROWN AND GRAY, **SILTY CLAY**, SOME SAND, TRACE TO LITTLE GRAVEL AND STONE FRAGMENTS, CONTAINS TRACE ROOTS, DAMP		2, 3	3 4 5	12	28	SS-1	3.50	8	17	13	31	31	38	21	17	14	A-6b (8)	
		4	3 4 7	14	44	SS-2	3.25	-	-	-	-	-	-	-	-	16	A-6b (V)	
	562.3	5, 6	2 3 4	9	22	SS-3	3.00	-	-	-	-	-	-	-	-	21	A-6b (V)	
STIFF TO HARD, BROWN, **SILT AND CLAY**, SOME TO "AND" SAND, TRACE TO LITTLE GRAVEL, DAMP		7	3 3 5	11	44	SS-4	2.75	3	14	17	37	29	33	19	14	16	A-6a (8)	
		8, 9	3 3 6	12	89	SS-5	1.75	6	23	22	29	20	30	19	11	15	A-6a (3)	
	556.3	10, 11	2 2 4	8	100	SS-6	4.25	13	22	21	26	18	31	19	12	14	A-6a (2)	
SOFT TO VERY STIFF, GRAY BECOMING MAROONISH GRAY, **SANDY SILT**, LITTLE TO SOME CLAY, TRACE GRAVEL, WET TO DAMP		12, 13, 14	2 2 1	4	100	SS-7	0.25	0	1	35	40	24	30	20	10	30	A-4a (6)	
		15, 16, 17	1 2 1	4	100	SS-8	0.50	0	13	36	31	20	30	21	9	31	A-4a (3)	
		18, 19	1 2 3	7	100	SS-9	2.00	0	17	29	30	24	27	18	9	17	A-4a (4)	
		20, 21, 22	2 3 2	7	100	SS-10	2.25	-	-	-	-	-	-	-	-	16	A-4a (V)	
	543.8	23, 24	2 2 3	7	100	SS-11	1.75	-	-	-	-	-	-	-	-	27	A-4a (V)	
MEDIUM DENSE, GRAY AND BLUEISH GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP		25, 26, 27	2 6 7	17	100	SS-12	-	-	-	-	-	-	-	-	-	14	A-2-4 (V)	
	538.8	28, 29	2 7 7	18	100	SS-13	-	-	-	-	-	-	-	-	-	13	A-2-4 (V)	

PID:	SFN:	PROJECT: LAW-243-10.84	STATION / OFFSET: 570+57, 5' LT.	START: 3/4/22	END: 3/4/22	PG 2 OF 2	B-002-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 538.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
SOFT TO STIFF, BROWN, **SANDY SILT**, SOME TO "AND" CLAY, TRACE GRAVEL, MOIST *(continued)*		31	3 2 3	7	100	SS-14	1.25	0	6	23	42	29	28	19	9	22	A-4a (7)	
		32 – 34																
		35 – 36	3 3 4	9	100	SS-15	1.00	-	-	-	-	-	-	-	-	24	A-4a (V)	
		37 – 39																
		W 528.3 / 40 – 41	2 3 4	9	100	SS-16	0.50	-	-	-	-	-	-	-	-	23	A-4a (V)	
	525.0	42 – 43																
HARD, MAROONISH GRAY, **SILT AND CLAY**, TRACE STONE FRAGMENTS, TRACE SAND, RELIC ROCK STRUCTURE, DAMP		44																
	521.8	45 – 46 (TR)	12 32 50/5"	-	94	SS-17	4.50	-	-	-	-	-	-	-	-	13	A-6a (V)	
CLAYSTONE, MAROONISH BROWN, SEVERELY WEATHERED, VERY WEAK.		47 – 49																
	517.8	50	50/3"	-	67	SS-18	-	-	-	-	-	-	-	-	-	10	Rock (V)	
INTERBEDDED CLAYSTONE (70%) AND SILTSTONE (30%), BEDDING DISCONTINUITIES: LOW ANGLE, HIGHLY FRACTURED TO SLIGHTLY FRACTURED, OPEN TO NARROW, SLIGHTLY ROUGH TO SLICKENSIDED, BLOCKY/DISTURBED/SEAMY, FAIR TO POOR SURFACE CONDITION, RQD 64%, REC. 96%; **CLAYSTONE**, MAROONISH BROWN AND GRAY, MODERATELY TO HIGHLY WEATHERED, VERY WEAK TO WEAK, VERY THIN TO MEDIUM BEDDED; **SILTSTONE**, GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG. @52.9' - 53.5'; BROWNISH GRAY CLAY SEAM @55.3' - 56.6'; SEVERELY WEATHERED, EXTREMELY WEAK	507.8	51 – 60 (EOB)	64		96	NQ2-1											CORE	

NOTES: GROUNDWATER ENCOUNTERED AT 40.0' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 100 GAL. BENTONITE GROUT

Ohio Department of Transportation
Division of Engineering

Office of Geotechnical Engineering

B-002-0-21

Run #:	Depth		Recovery		RQD	
NQ2-1	50.5’	60.5’	115.5/120	96%	77.25/120	64%

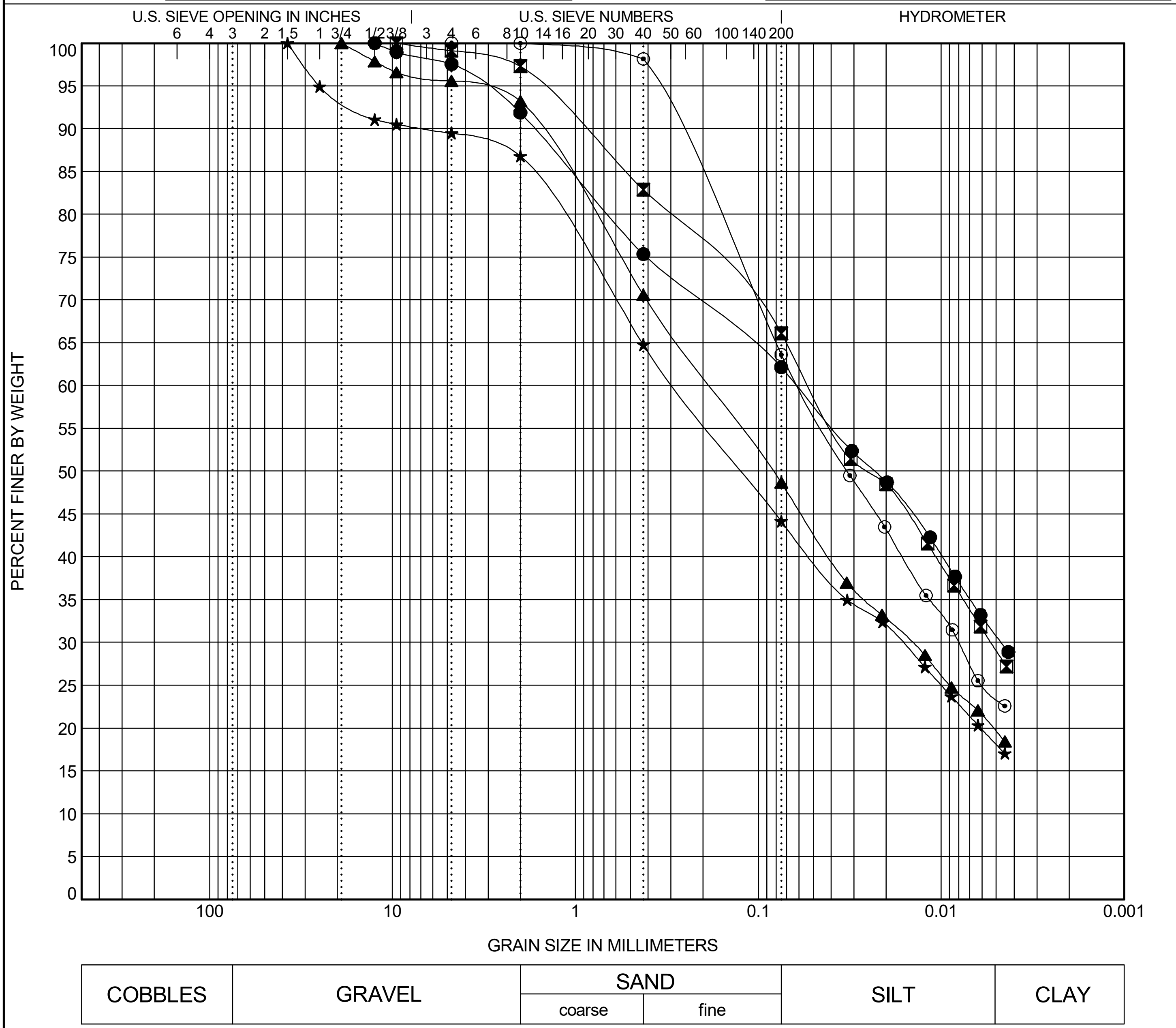
LAW-243-10.84

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT LAW-243-10.84 **PID**

OGE NUMBER 0 **PROJECT TYPE**



	Specimen Identification		ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	**B-002-0-21**	**1.5**	**A-6b ~ SANDY LEAN CLAY(CL)**	**38**	**21**	**17**
⧗	**B-002-0-21**	**6.0**	**A-6a ~ SANDY LEAN CLAY(CL)**	**33**	**19**	**14**
▲	**B-002-0-21**	**7.5**	**A-6a ~ CLAYEY SAND(SC)**	**30**	**19**	**11**
★	**B-002-0-21**	**10.0**	**A-6a ~ CLAYEY SAND(SC)**	**31**	**19**	**12**
⊙	**B-002-0-21**	**12.5**	**A-4a ~ SANDY LEAN CLAY(CL)**	**30**	**20**	**10**

	Specimen Identification		D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	**B-002-0-21**	**1.5**	**1.677**	**0.023**	**0.005**		**8**	**17**	**13**	**31**	**31**		
⧗	**B-002-0-21**	**6.0**	**0.915**	**0.025**	**0.005**		**3**	**14**	**17**	**37**	**29**		
▲	**B-002-0-21**	**7.5**	**1.607**	**0.083**	**0.015**		**6**	**23**	**22**	**29**	**20**		
★	**B-002-0-21**	**10.0**	**6.78**	**0.123**	**0.016**		**13**	**22**	**21**	**26**	**18**		
⊙	**B-002-0-21**	**12.5**	**0.282**	**0.033**	**0.008**		**0**	**1**	**35**	**40**	**24**		

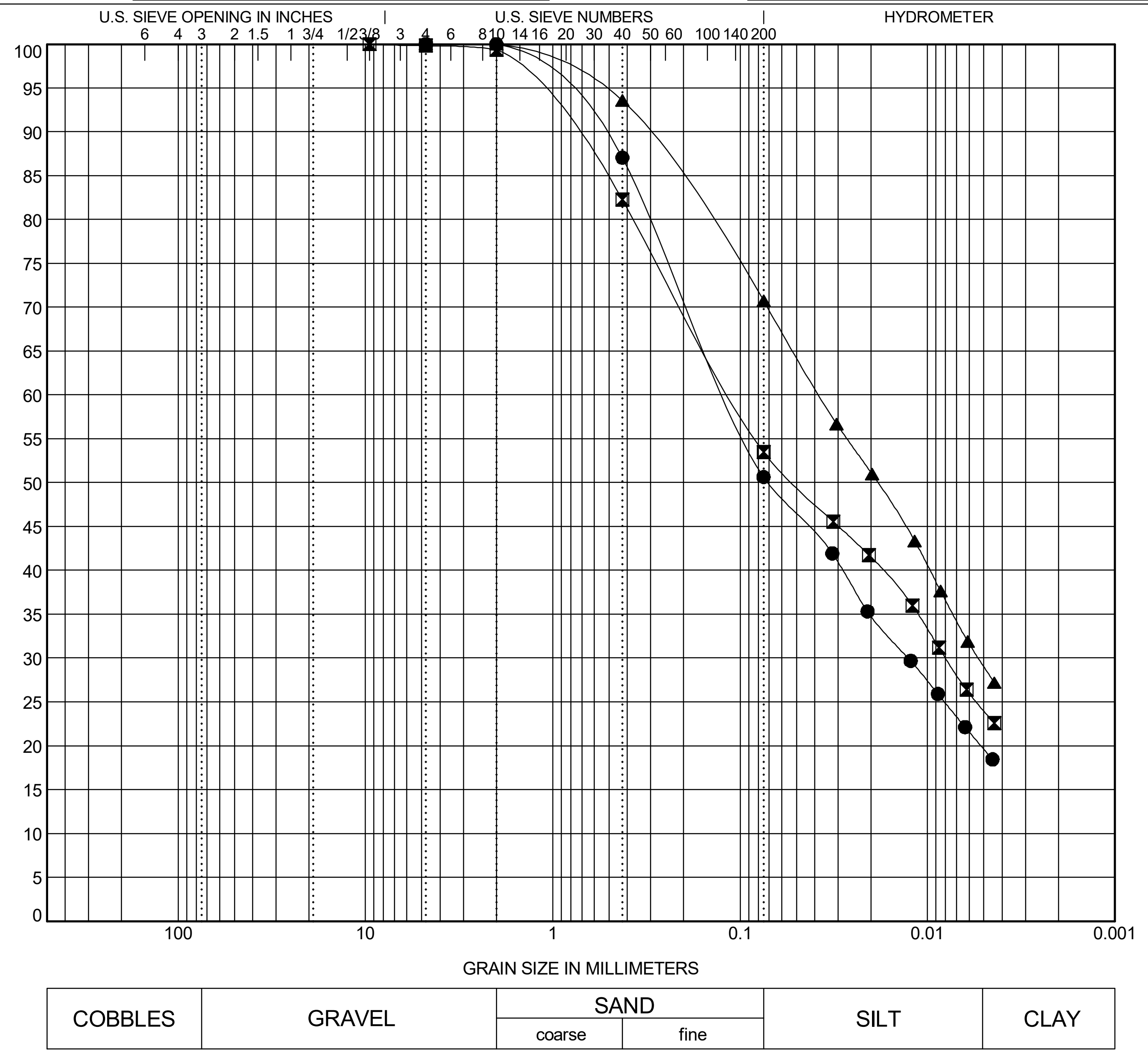
GRAIN SIZE - OH DOT.GDT - 6/8/22 11:02 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\LAW-243-10.81\GINT FILES\LAW-243-10.81.GPJ

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT LAW-243-10.84 **PID**

OGE NUMBER 0 **PROJECT TYPE**



	Specimen Identification		ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	**B-002-0-21**	**15.0**	**A-4a ~ SANDY LEAN CLAY(CL)**	**30**	**21**	**9**
⊠	**B-002-0-21**	**17.5**	**A-4a ~ SANDY LEAN CLAY(CL)**	**27**	**18**	**9**
▲	**B-002-0-21**	**30.0**	**A-4a ~ LEAN CLAY with SAND(CL)**	**28**	**19**	**9**

	Specimen Identification		D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	**B-002-0-21**	**15.0**	**0.605**	**0.071**	**0.013**		**0**	**13**	**36**	**31**	**20**		
⊠	**B-002-0-21**	**17.5**	**0.856**	**0.051**	**0.008**		**0**	**17**	**29**	**30**	**24**		
▲	**B-002-0-21**	**30.0**	**0.324**	**0.018**	**0.005**		**0**	**6**	**23**	**42**	**29**		

APPENDIX C

GB1 ANALYSIS

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES
Geotechnical Bulletin GB1

Instructions: Enter data in the shaded cells only.
(Enter state route number, project description,county, consultant's name, prepared by name, and date prepared. This information will be transferred to all other sheets. The date prepared must be entered in the appropriate cell on this sheet to remove these instructions prior to printing.)

LAW-243-10.84
110558

Bridge Replacement: LAW-243-1089 carrying SR-243 over Leatherwood Creek

NEAS, INC.

Prepared By: Melinda He
Date prepared: Friday, June 03, 2022

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: 2

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.6 2/11/2022

#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL	Cut Fill
1	B-001-0-21	SR 243				CME 55X	79	568.0	567.0	1.0 C
2	B-002-0-21	SR 243				CME 55X	79	568.3	566.8	1.5 C

#	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	0.5	2.0	9		3.25	44	23	21	35	42	77	18	20	A-7-6	13			N_{60}		12''	
	001-0	SS-2	3.0	4.5	2.0	3.5	8		3.25							19	18	A-7-6	16			N_{60}			
	21	SS-3	4.5	6.0	3.5	5.0	11		2.25							21	18	A-7-6	16						
		SS-4	6.0	7.5	5.0	6.5	9	8	2.5							22	18	A-7-6	16						
2	B	SS-1	1.5	3.0	0.0	1.5	12		3.5	38	21	17	31	31	62	14	16	A-6b	8						
	002-0	SS-2	3.0	4.5	1.5	3.0	14		3.25							16	16	A-6b	16						
	21	SS-3	4.5	6.0	3.0	4.5	9		3							21	16	A-6b	16						
		SS-4	6.0	7.5	4.5	6.0	11	9	2.75	33	19	14	37	29	66	16	14	A-6a	8						

PID: 110558

County-Route-Section: LAW-243-10.81
No. of Borings: 2

Geotechnical Consultant: NEAS, INC.
Prepared By: Melinda He
Date prepared: 6/3/2022

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

Excavate and Replace Stabilization Options	
Global Geotextile Average(N60L): Average(HP):	 12" 0"
Global Geogrid Average(N60L): Average(HP):	 0" 0"

Design CBR	5

% Samples within 6 feet of subgrade			
$N_{60} \leq 5$	0%	HP ≤ 0.5	0%
$N_{60} < 12$	75%	0.5 < HP ≤ 1	0%
$12 \leq N_{60} < 15$	25%	1 < HP ≤ 2	0%
$N_{60} \geq 20$	0%	HP > 2	100%
M+	0%		
Rock	0%		
Unsuitable	0%		

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

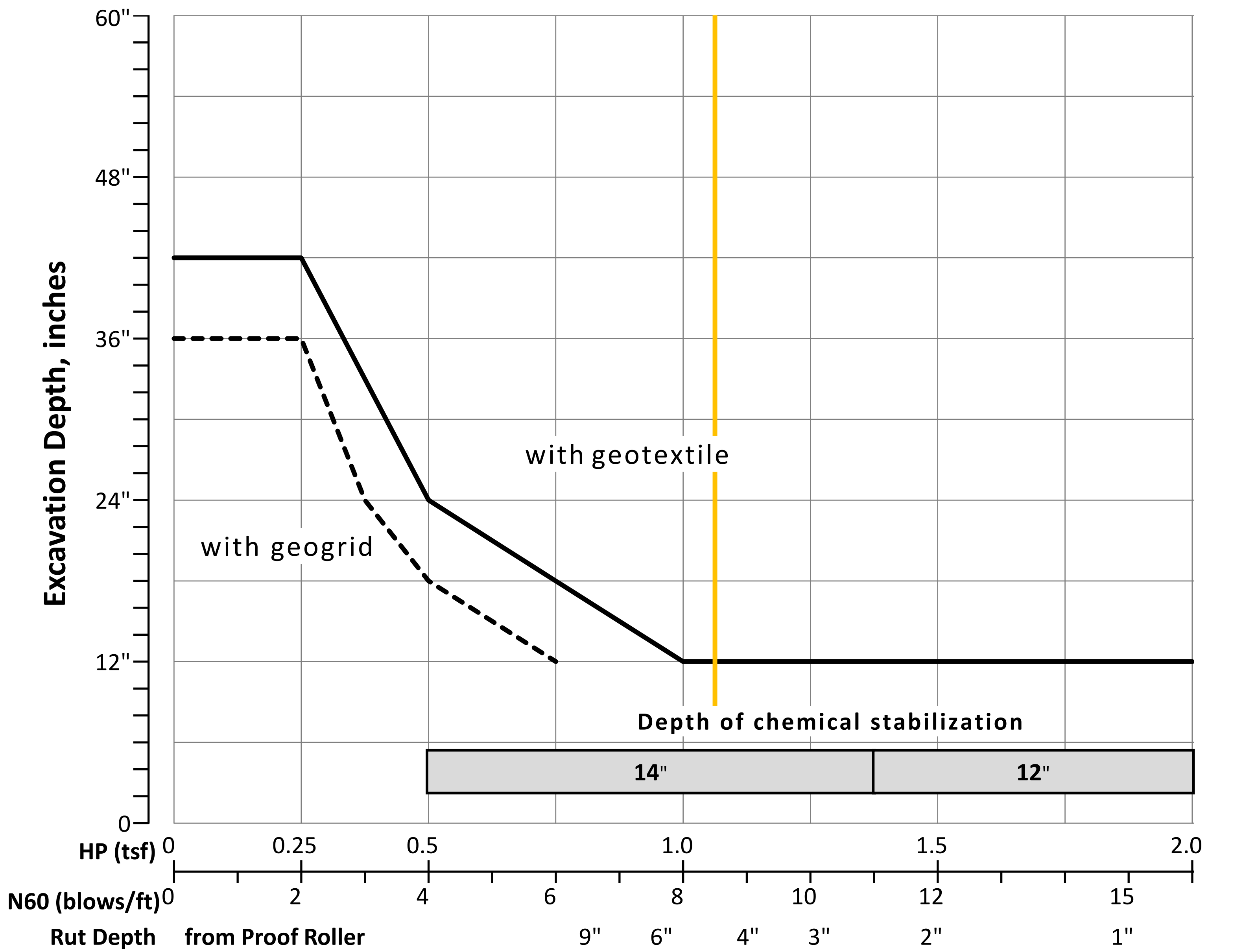
% Proposed Subgrade Surface	
Unstable & Unsuitable	50%
Unstable	50%
Unsuitable	0%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	10	9	2.97	38	21	17	34	34	68	18	17	14
Maximum	14	9	3.50	44	23	21	37	42	77	22	20	16
Minimum	8	8	2.25	33	19	14	31	29	62	14	14	8

Classification Counts by Sample

ODOT Class	Rock	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7	A-3	A-3a	A-4a	A-4b	A-5	A-6a	A-6b	A-7-5	A-7-6	A-8a	A-8b	Totals
Count	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	4	0	0	8
Percent	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	13%	38%	0%	50%	0%	0%	100%
% Rock|Granular|Cohesive	0%	0%									100%								100%
Surface Class Count	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	4
Surface Class Percent	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	0%	50%	0%	0%	100%

GB1 Figure B – Subgrade Stabilization

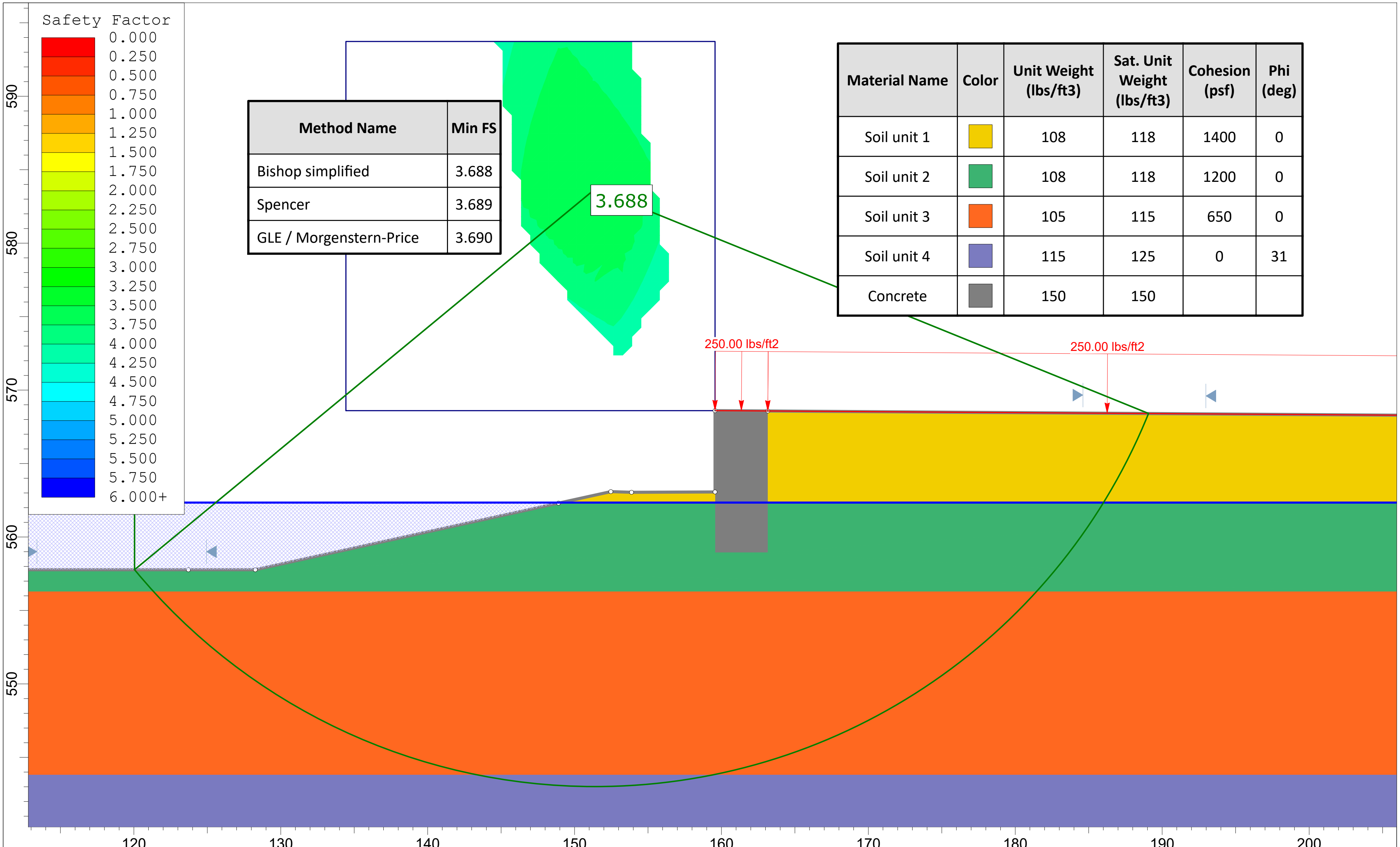


OVERRIDE TABLE

Calculated Average	New Values	Check to Override
2.97	0.50	☐ HP
8.50	6.00	☐ N60L

APPENDIX D

GLOBAL STABILITY ANALYSIS

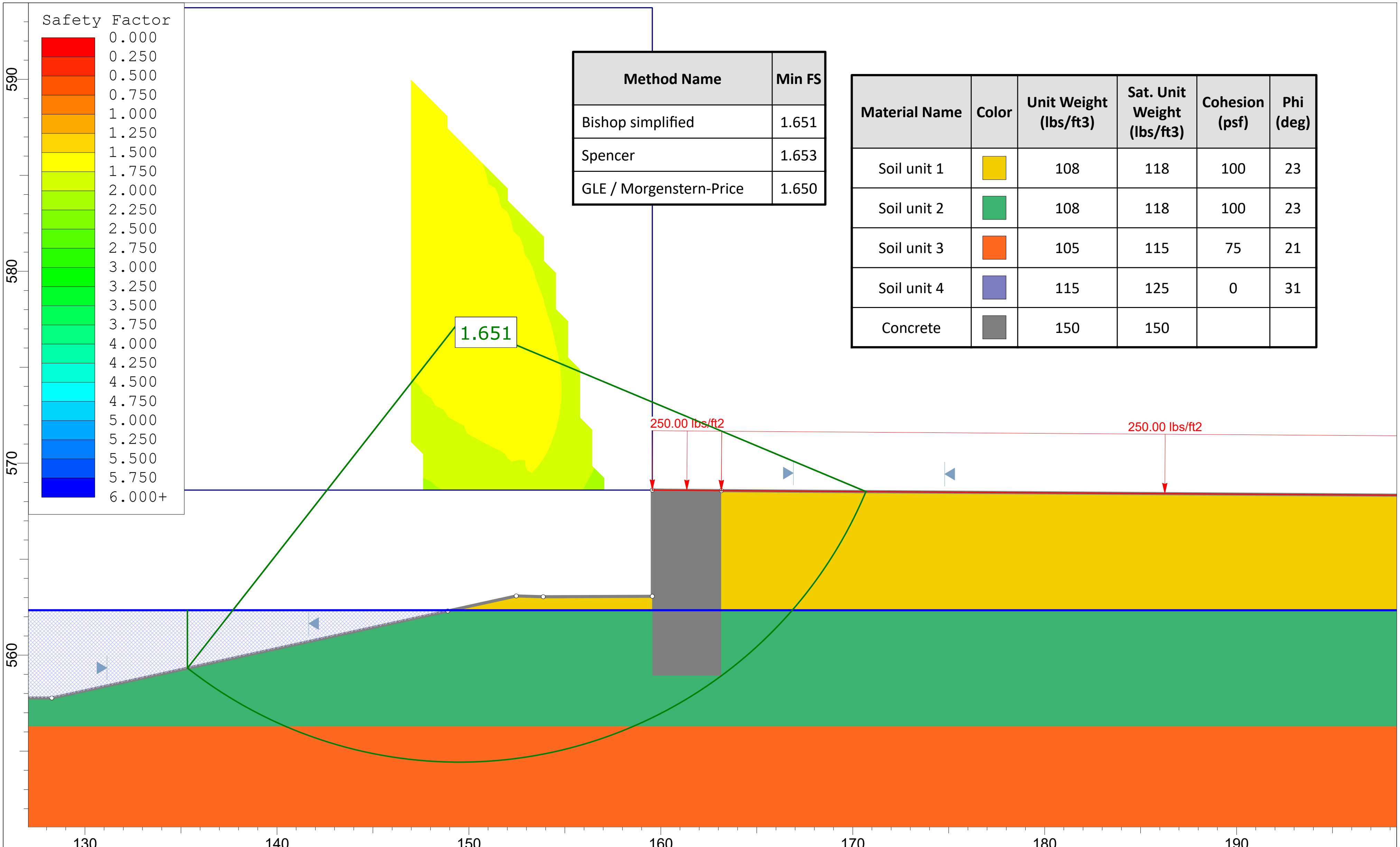


Method Name	Min FS
Bishop simplified	3.688
Spencer	3.689
GLE / Morgenstern-Price	3.690

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Soil unit 1		108	118	1400	0
Soil unit 2		108	118	1200	0
Soil unit 3		105	115	650	0
Soil unit 4		115	125	0	31
Concrete		150	150		

Project	LAW-243-10.81		
Analysis Description	East abutment short term (total) stability (circular)		
Drawn By	M. Jasiewicz	*Scale* 1:108	*Company* NEAS Inc.
Date	5/26/2022, 4:08:03 PM		*File Name* EastAbutmentShortTermCircular.slim

SLIDEINTERPRET 7.037

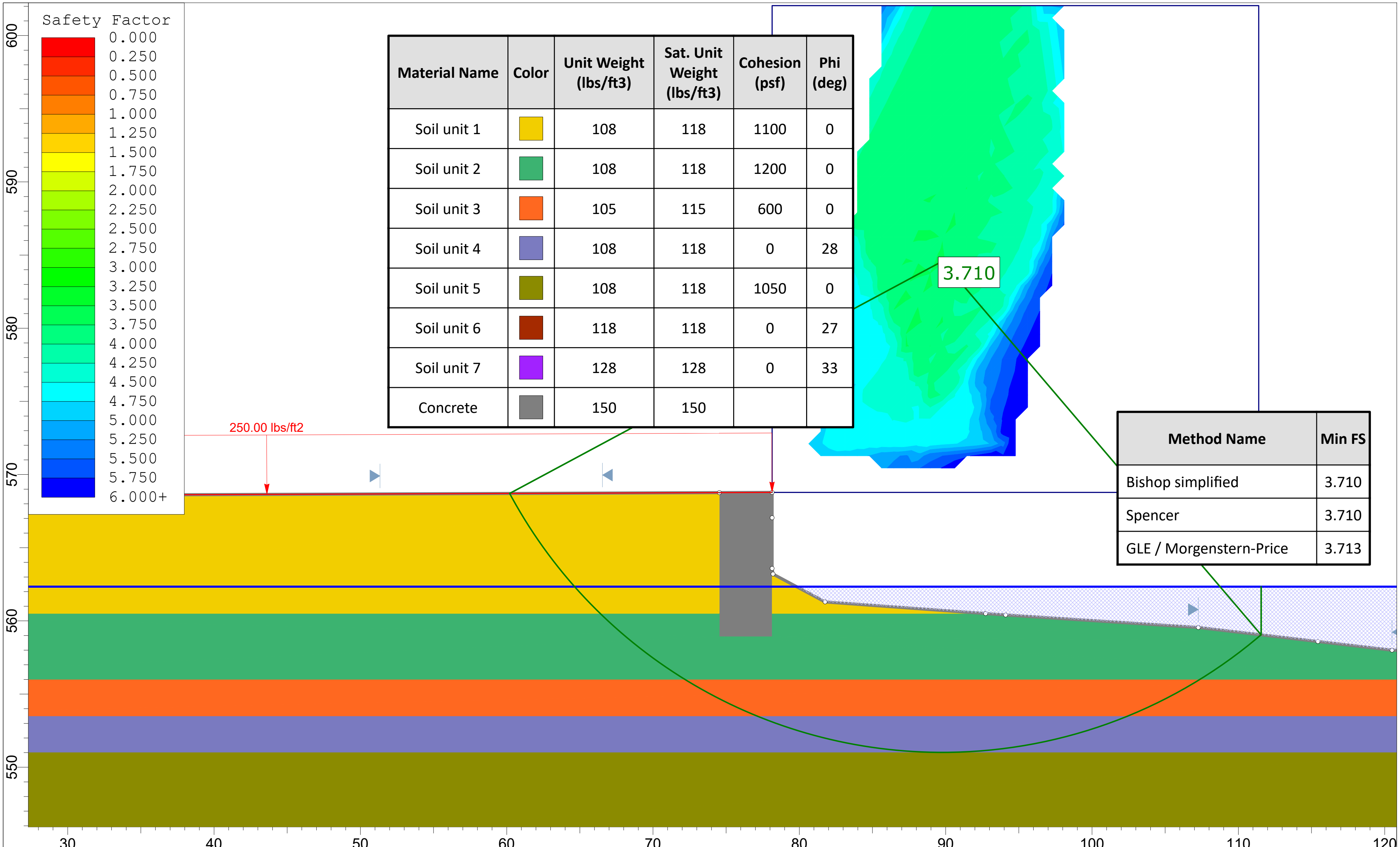


Method Name	Min FS
Bishop simplified	1.651
Spencer	1.653
GLE / Morgenstern-Price	1.650

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Soil unit 1		108	118	100	23
Soil unit 2		108	118	100	23
Soil unit 3		105	115	75	21
Soil unit 4		115	125	0	31
Concrete		150	150		

Project	LAW-243-10.81		
Analysis Description	East abutment long term (effective) stability (circular)		
Drawn By	M. Jasiewicz	*Scale* 1:83	*Company* NEAS Inc.
Date	5/26/2022, 4:08:03 PM	*File Name*	EastAbutmentLongTermCircular.slim

SLIDEINTERPRET 7.037



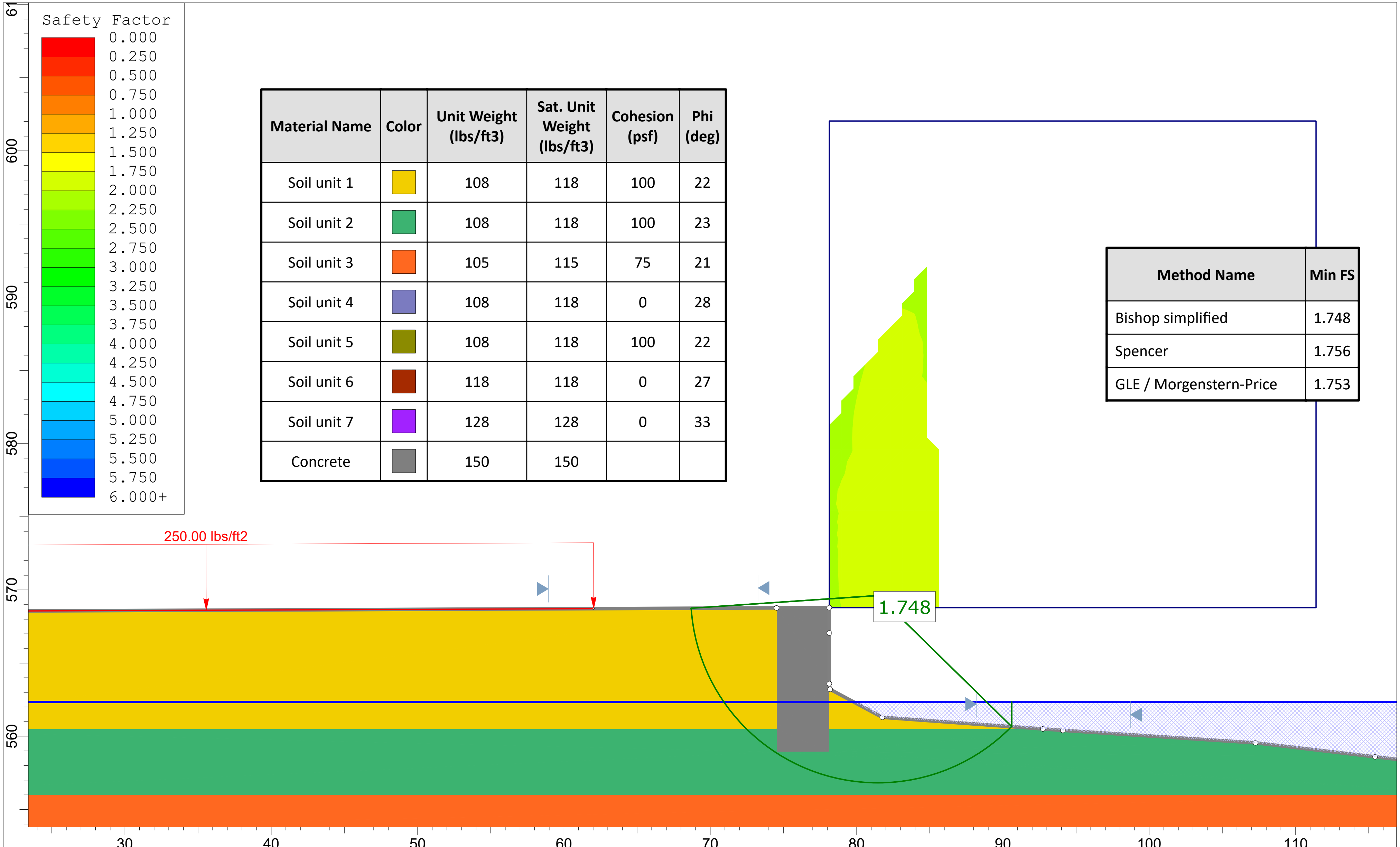
Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Soil unit 1		108	118	1100	0
Soil unit 2		108	118	1200	0
Soil unit 3		105	115	600	0
Soil unit 4		108	118	0	28
Soil unit 5		108	118	1050	0
Soil unit 6		118	118	0	27
Soil unit 7		128	128	0	33
Concrete		150	150		

Method Name	Min FS
Bishop simplified	3.710
Spencer	3.710
GLE / Morgenstern-Price	3.713

rocscience

SLIDEINTERPRET 7.037

Project	LAW-243-10.81		
Analysis Description	West abutment short term (total) stability (circular)		
Drawn By M. Jasiewicz	*Scale* 1:109	*Company*	NEAS Inc.
Date	5/26/2022, 4:08:03 PM	*File Name*	WestAbutmentShortTermCircular.slim



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Soil unit 1		108	118	100	22
Soil unit 2		108	118	100	23
Soil unit 3		105	115	75	21
Soil unit 4		108	118	0	28
Soil unit 5		108	118	100	22
Soil unit 6		118	118	0	27
Soil unit 7		128	128	0	33
Concrete		150	150		

Method Name	Min FS
Bishop simplified	1.748
Spencer	1.756
GLE / Morgenstern-Price	1.753

rocscience

SLIDEINTERPRET 7.037

Project	LAW-243-10.81
Analysis Description	West abutment long term (effective) stability (circular)
Drawn By	M. Jasiewicz
Scale	1:109
Company	NEAS Inc.
Date	5/26/2022, 4:08:03 PM
File Name	WestAbutmentLongTermCircular.slim